Air quality, deprivation and health

Presentation by
Dr Jo Barnes

Air Quality Management Resource Centre, UWE, Bristol

Public Health England South West Air Quality Event

Tackling poor air quality and the basic inequality in life

13th June 2018

UWE Bristol University of the West of England

Universitat Autònoma de Barcelona

Trinomics

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Contributing research

- *Qualitative assessment of links between exposure to noise and air pollution and socioeconomic status* **(European Environment Agency - Specific Contract under Framework Contract No EEA/ACC/13/003, 2017-18)**

- Science for Environment Policy (SEP) In-depth Report 13, *Links between noise and air pollution and socioeconomic status,* 2016 (European Commission http://ec.europa.eu/science-environment-policy)

- *Enhancing Local Air Quality Management in Wales through better public health integration, interaction and support* (PhD Thesis, Huw Brunt, Public Health Wales, 2014-18)

- *MOT motoring and vehicle ownership trends in the UK* (EPSRC award EP/K000438/1, 2012-15, http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/K000438/1

UWE Bristol University of the West of England

UAB Universitat Autònoma de Barcelona

Trinomics

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

EEA Review Project team

Air Quality Management Resource Centre, University of the West of England (UWE Bristol)

Dr Jo Barnes (PI) jo.barnes@uwe.ac.uk

Dr Laura De Vito laura.devito@uwe.ac.uk

Universitat Autònoma de Barcelona (UAB)

Dr Núria Blanes Guàrdia Nuria.Blanes@uab.cat

Dr Jaume Fons Esteve jaume.fons@uab.cat

National Institute for Public Health and the Environment (RIVM)

Dr Irene van Kamp irene.van.kamp@rivm.nl

Trinomics

Jeroen van der Laan Jeroen.vanderlaan@trinomics.eu

UWE Bristol University of the West of England

UAB Universitat Autònoma de Barcelona

Trinomics

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Background

- Air and noise pollution have many of the same sources, such as heavy industry, aircraft, railways and road vehicles.
- Research suggests that the social cost of noise and air pollution in the EU — including death and disease — could be nearly €1 trillion. For comparison, the social cost of alcohol in the EU has been estimated to be €50-120 billion and smoking at €544 billion.
- Air pollution and noise pollution have negative health impacts on all socioeconomic groups, rich and poor.
- However, the risks may not be evenly shared; it is often society's poorest who live and work in the most polluted environments.
- Furthermore, these same people may be more impacted by pollution's damaging effects than more advantaged groups of society.

Science for Environment Policy report

- In September 2016, UWE Bristol produced the European Commission Science for Environment Policy (SEP) In-depth Report 13, *'Links between noise and air pollution and socioeconomic status'* (http://ec.europa.eu/science-environment-policy)
- Air and noise pollution have a negative impact on all of society, but some groups are more affected than others.
- Lower socioeconomic status is generally associated with poorer health.
- But do these health inequalities arise because of:
    - increased exposure to pollution,
    - increased sensitivity to exposure,
    - increased vulnerabilities, or
    - some combination?

UWE Bristol University of the West of England
UAB Universitat Autònoma de Barcelona
Trinomics
National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Purpose of the EEA review

- To provide an updated qualitative review of the latest evidence and state of knowledge regarding the role of SES in determining exposure, susceptibility and vulnerability to air pollution and noise, documenting research that explores the multiple factors and drivers that can lie behind these linkages.
  - SES and exposure
  - SES and generation
  - Recommendations for research and policy development

UWE Bristol University of the West of England
UAB Universitat Autònoma de Barcelona
Trinomics
National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

EEA Review Methodology

Building on the findings of the 2016 SEP report

Systematic review of:

- 256 peer-reviewed papers relating to air pollution and 150 peer-reviewed papers relating to noise (covering at least 18 of the EEA-33 countries)

- Analysis of 40 EU-level environmental policy documents

- Request for evidence → responses from contacts from 8 Member states (France, Switzerland, Slovenia, Germany, Austria, Malta, Belgium and Sweden)

UWE Bristol University of the West of England

UAB Universitat Autònoma de Barcelona

Trinomics

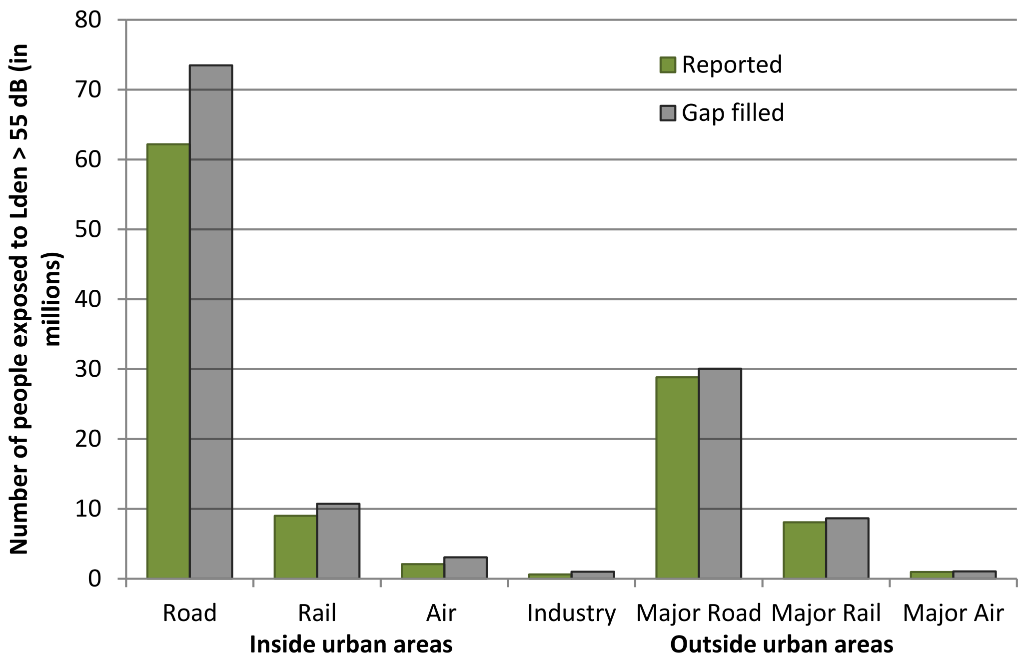
National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

SES and exposure to noise and air pollution

UWE Bristol University of the West of England
Universitat Autònoma de Barcelona
Trinomics
National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Key sources of noise and air pollution (p.37)

- Road traffic is the most significant source of both noise and air pollution in urban areas, where exposure is highest due to high population density.
- Agriculture is the main source of increasing ammonia (NH_3), itself an increasing source of secondary $PM_{2.5}$.



Number of people exposed to noise in Europe > 55 dB L_{den} in EEA member countries (2012): reported and estimated data

UWE Bristol University of the West of England

UAB Universitat Autònoma de Barcelona

Trinomics

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Types of health impact

- Exposure to air and noise pollution may be associated with similar health impacts, e.g. cognitive performance, hypertension and cardiovascular and cerebrovascular disease and mortality.
- Emerging evidence associates $PM_{2.5}$ and diabetes, decreased cognitive function, attention-deficit or hyperactivity disorder and autism in children, and dementia, in adults.
- Many of these are also associated with living in urban areas.
- Relationships between air and noise pollution exposures (and other environmental exposures and health impacts) are likely to be more complex than additive.

SES and environmental conditions

- **Spatial scales of exposure to both air and noise pollution are complex (e.g. uncertain exposure routes)**

- **Evidence of links between low SES and worse environmental conditions, particularly in urban areas**
  - For example, in the UK annual mean NO_2 concentrations in areas in breach of the annual limit values have fallen more in more affluent areas, and
  - PM_{10} annual average concentrations are highest and exceedances of the 24h limit values are more likely to occur in areas of higher deprivation

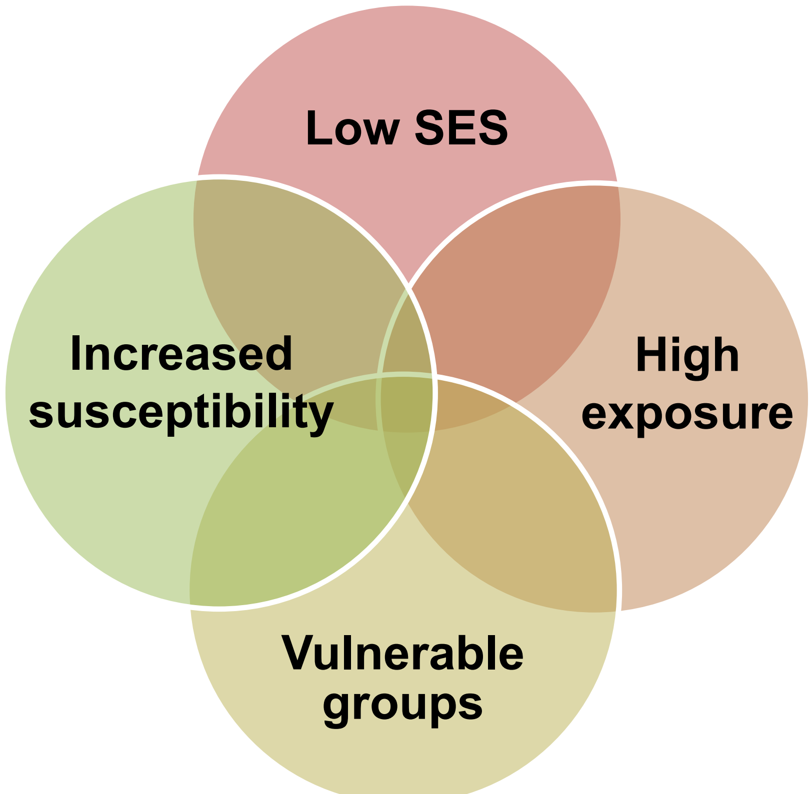
- Effects of pollution on the house market and Willingness to Pay (WTP)
  - Noise impacts house values and WTP
  - No evidence on the effects of air pollution on house values and WTP

UWE Bristol University of the West of England | UAB Universitat Autònoma de Barcelona | Trinomics | National Institute for Public Health and the Environment, Ministry of Health, Welfare and Sport

Lifestyle/occupational factors

- Limited evidence specifically on the role of lifestyle or occupation
- While lifestyle may be linked to SES, lifestyle factors (e.g. smoking) may be independently related to exposure and may have an additive effect in terms of health impact
- Occupational risk factors generally captured by health and safety thresholds
- Higher blood pressure was observed in traffic-police *cf.* other outdoor workers; cardiovascular disease mortality associated with women in routine jobs, and anxieties related to job insecurity and traffic-related exposures observed

SES and vulnerable groups



Triple Jeopardy Effect
+
Vulnerable groups

Quadruple Jeopardy Effect

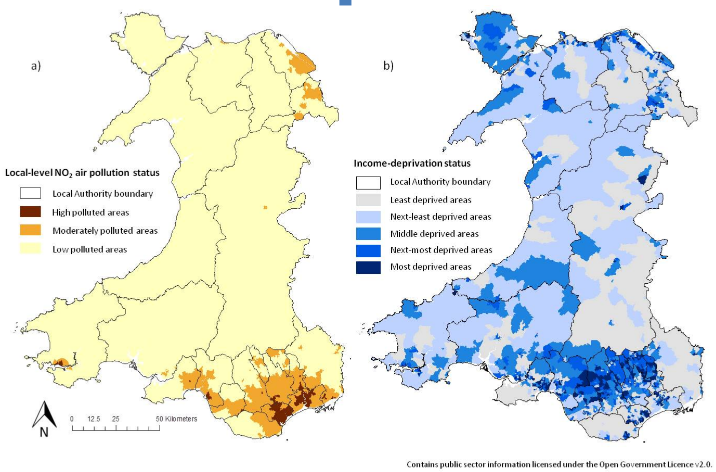
- Children, including prenatal, the elderly and those with existing health conditions may be more represented in lower SES groups and in areas with higher exposure to noise/air pollution and are more susceptible to the resulting health impacts

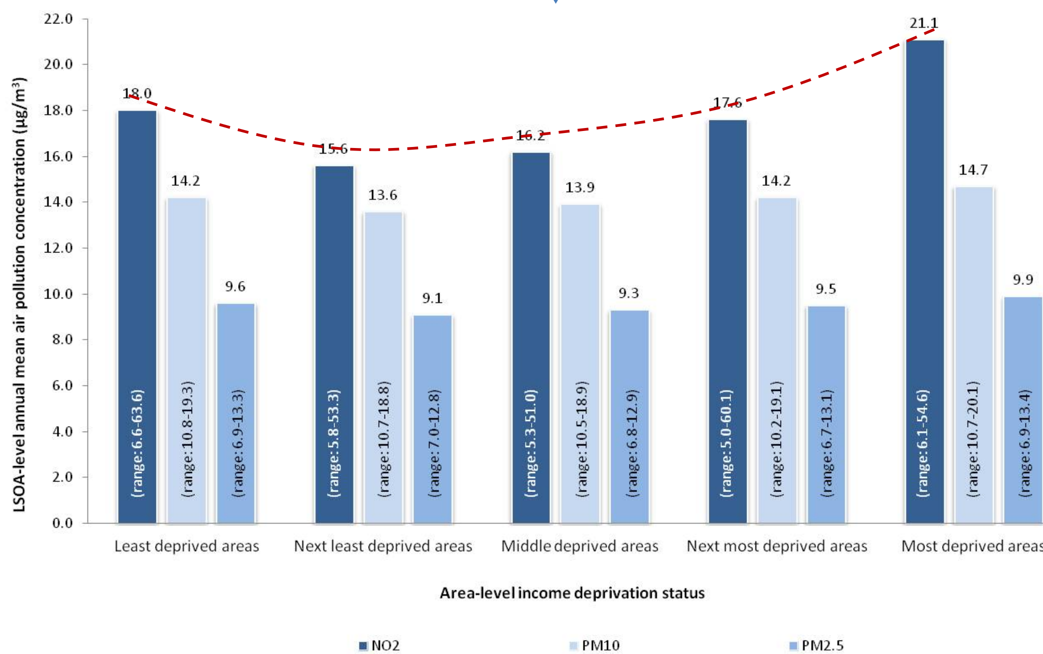
PhD Research Strand 1 – methods

Data	Geography	Lower Super Output Areas (LSOA)
	Air pollution	Modelled population-weighted 3-year (2011 to 2013) averaged annual mean concentrations for NO_2, PM_{10}, $PM_{2.5}$
	Health outcomes	All-cause mortality; Cardiovascular, cerebrovascular, respiratory and chronic liver disease mortality and hospital admissions
	Socioeconomic status	Welsh Index of Multiple Deprivation (income deprivation as proxy)

Analysis	Variation	Data linked and mapped at local level
	Rates	European age-standardised rates (EASR)
	Rate ratios	Comparison of EASR in most deprived/most polluted and least deprived/least polluted

PhD Research Strand 1 – results (1)





PhD Research Strand 1 – results (2)

			Deprivation status	Low polluted areas (reference)	Moderately polluted areas	High polluted areas
Nitrogen dioxide (NO_2)	Mortality rate ratio (95%CI)	*All-cause*	Least	-	1.01 (0.92 to 1.07)	1.09 (0.28 to 2.09)
			Most	**1.41 (1.36 to 1.45)**	**1.43 (1.34 to 1.52)**	**1.62 (1.37 to 1.89)**
		Cardiovascular disease	Least	-	0.94 (0.84 to 1.06)	1.17 (0.03 to 3.95)
			Most	**1.40 (1.32 to 1.48)**	**1.26 (1.14 to 1.40)**	1.32 (0.93 to 1.78)
		Cerebrovascular disease	Least	-	1.04 (0.83 to 1.27)	0.41 (0.01 to 2.84)
			Most	**1.15 (1.03 to 1.29)**	**1.31 (1.05 to 1.59)**	1.39 (0.67 to 2.44)
		Respiratory disease	Least	-	1.14 (0.97 to 1.32)	1.17 (0.04 to 15.94)
			Most	**1.70 (1.57 to 1.84)**	**1.80 (1.58 to 2.06)**	**2.10 (1.38 to 3.03)**
		Chronic liver disease	Least	-	1.00 (0.54 to 1.88)	0.67 (0.22 to 4.58)
			Most	**2.33 (1.81 to 3.17)**	**2.33 (1.49 to 3.62)**	3.56 (0.88 to 8.94)
	Morbidity rate ratio (95%CI)	*Cardiovascular disease*	Least	-	**0.92 (0.86 to 0.98)**	1.05 (0.24 to 2.22)
			Most	**1.51 (1.47 to 1.56)**	**1.39 (1.31 to 1.47)**	**1.44 (1.20 to 1.69)**
		Cerebrovascular disease	Least	-	**0.80 (0.68 to 0.94)**	0.95 (0.01 to 6.81)
			Most	**1.42 (1.32 to 1.53)**	**1.22 (1.05 to 1.39)**	1.37 (0.87 to 2.05)
		Respiratory disease	Least	-	**0.92 (0.87 to 0.97)**	1.02 (0.11 to 1.65)
			Most	**1.80 (1.75 to 1.85)**	**1.73 (1.66 to 1.80)**	**1.70 (1.49 to 1.93)**
		Chronic liver disease	Least	-	0.75 (0.42 to 1.25)	0.81 (0.13 to 6.44)
			Most	**3.25 (2.66 to 4.11)**	**2.69 (1.96 to 3.71)**	**4.13 (1.79 to 8.24)**
Particulate matter (PM_{10})	Mortality rate ratio (95%CI)	*All-cause*	Least	-	1.02 (0.96 to 1.08)	1.06 (0.91 to 1.24)
			Most	**1.56 (1.46 to 1.66)**	**1.58 (1.50 to 1.66)**	**1.65 (1.50 to 1.80)**
		Cardiovascular disease	Least	-	0.95 (0.86 to 1.05)	1.05 (0.78 to 1.38)
			Most	**1.54 (1.37 to 1.73)**	**1.46 (1.33 to 1.61)**	**1.38 (1.16 to 1.64)**
		Cerebrovascular disease	Least		1.02 (0.82 to 1.24)	1.21 (0.68 to 1.96)
			Most	**1.33 (1.04 to 1.68)**	**1.36 (1.11 to 1.64)**	1.33 (0.91 to 1.87)
		Respiratory disease	Least	-	**1.19 (1.02 to 1.39)**	1.35 (0.86 to 1.95)
			Most	**2.05 (1.73 to 2.41)**	**2.21 (1.92 to 2.53)**	**2.38 (1.89 to 2.95)**
		Chronic liver disease	Least	-	1.14 (0.60 to 2.17)	1.57 (0.28 to 5.50)
			Most	**3.71 (2.07 to 7.16)**	**2.71 (1.62 to 5.04)**	**4.71 (2.32 to 9.79)**
	Morbidity rate ratio (95%CI)	*Cardiovascular disease*	Least	-	1.04 (0.98 to 1.10)	1.03 (0.80 to 1.20)
			Most	**1.65 (1.55 to 1.76)**	**1.68 (1.60 to 1.77)**	**1.57 (1.43 to 1.72)**
		Cerebrovascular disease	Least	-	0.97 (0.85 to 1.11)	0.93 (0.61 to 1.35)
			Most	**1.58 (1.35 to 1.84)**	**1.48 (1.30 to 1.68)**	**1.31 (1.03 to 1.66)**
		Respiratory disease	Least	-	1.04 (0.98 to 1.09)	0.96 (0.84 to 1.09)
			Most	**2.03 (1.92 to 2.15)**	**2.11 (2.01 to 2.21)**	**2.02 (1.88 to 2.18)**
		Chronic liver disease	Least	-	1.08 (0.70 to 1.82)	0.83 (0.16 to 2.82)
			Most	**5.17 (3.39 to 8.16)**	**4.58 (3.12 to 7.01)**	3.92 (0.22 to 6.84)
Particulate matter ($PM_{2.5}$)	Mortality rate ratio (95%CI)	*All-cause*	Least	-	1.04 (0.98 to 1.10)	1.08 (0.91 to 1.18)
			Most	**1.57 (1.49 to 1.70)**	**1.58 (1.50 to 1.67)**	**1.61 (1.48 to 1.74)**
		Cardiovascular disease	Least	-	0.96 (0.87 to 1.07)	0.97 (0.79 to 1.18)
			Most	**1.57 (1.38 to 1.78)**	**1.48 (1.34 to 1.63)**	**1.40 (1.20 to 1.62)**
		Cerebrovascular disease	Least	-	1.05 (0.86 to 1.29)	1.11 (0.74 to 1.59)
			Most	**1.41 (1.07 to 1.84)**	**1.33 (1.09 to 1.63)**	**1.50 (1.09 to 2.01)**
		Respiratory disease	Least	-	**1.21 (1.04 to 1.42)**	1.26 (0.89 to 1.60)
			Most	**2.15 (1.79 to 2.59)**	**2.19 (1.90 to 2.53)**	**2.34 (1.91 to 2.85)**
		Chronic liver disease	Least	-	1.14 (0.60 to 2.08)	1.43 (0.40 to 4.09)
			Most	**4.29 (2.33 to 8.30)**	**2.86 (1.67 to 5.20)**	**3.71 (1.92 to 7.50)**
	Morbidity rate ratio (95%CI)	*Cardiovascular disease*	Least	-	1.05 (0.99 to 1.11)	0.95 (0.77 to 1.06)
			Most	**1.60 (1.48 to 1.72)**	**1.71 (1.62 to 1.80)**	**1.56 (1.44 to 1.69)**
		Cerebrovascular disease	Least	-	0.99 (0.86 to 1.13)	0.79 (0.59 to 1.06)
			Most	**1.54 (1.29 to 1.83)**	**1.50 (1.32 to 1.71)**	**1.76 (1.46 to 2.12)**
		Respiratory disease	Least	-	**1.06 (1.01 to 1.12)**	0.94 (0.85 to 1.04)
			Most	**2.03 (1.91 to 2.15)**	**2.14 (2.04 to 2.24)**	**2.04 (1.91 to 2.18)**
		Chronic liver disease	Least	-	1.17 (0.72 to 1.88)	0.83 (0.63 to 1.88)
			Most	**4.75 (2.99 to 7.67)**	**4.58 (3.15 to 7.05)**	**4.58 (2.86 to 7.56)**

- Air pollution interacted with deprivation status to modify and strengthen associations with all-cause and respiratory disease mortality.
- Evident in 'most' deprived areas where Wales' most vulnerable people live.

		Air pollution status (PM_{10})		
		Low	Moderate	High
All-cause mortality	Least deprived	-	RR = 1.02 (0.96 to 1.08)	RR = 1.06 (0.91 to 1.24)
	Most deprived	RR = **1.56** (1.46 to 1.66)	RR = **1.58** (1.50 to 1.66)	RR = **1.65** (1.50 to 1.80)
Respiratory disease mortality	Least deprived	-	RR = **1.19** (1.02 to 1.39)	RR = 1.35 (0.86 to 1.95)
	Most deprived	RR = **2.05** (1.73 to 2.41)	RR = **2.21** (1.92 to 2.53)	RR = **2.38** (1.89 to 2.95)

BOLD = Statistically significant result

BOLD UNDERLINED = statistically significant result; rate ratio (RR) increased as area-level air pollution status worsened

Brunt et al., 2017. *Journal of Public Health*, 39 (3). pp. 485-497. Available from: http://eprints.uwe.ac.uk/30133

SES and generation of noise and air pollution

UWE Bristol University of the West of England
Universitat Autònoma de Barcelona
Trinomics
National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Mixed evidence

- No evidence was found on the relationship between SES and generation of noise pollution

For air pollution:

- Mixed evidence on domestic heating

- Research from England and Wales on traffic-related pollution suggests that:
  - More affluent households are net-polluters
  - People from lower SES are more likely to use sustainable modes
  - But the picture is not clear-cut → second-hand car market

UWE Bristol University of the West of England

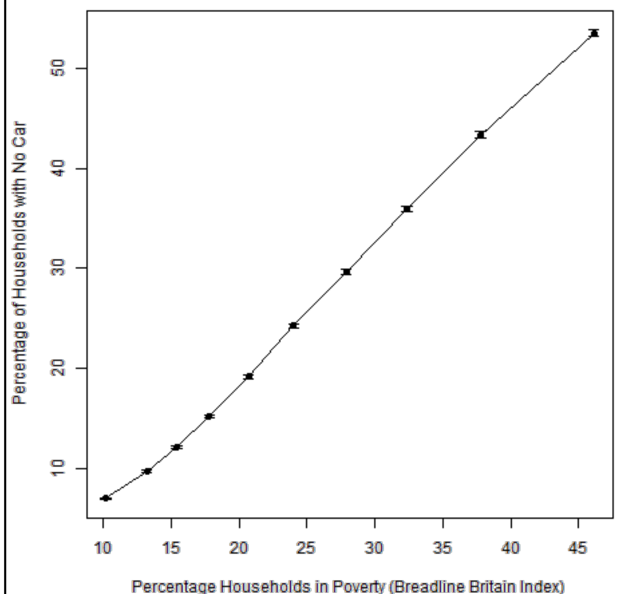
UAB Universitat Autònoma de Barcelona

Trinomics

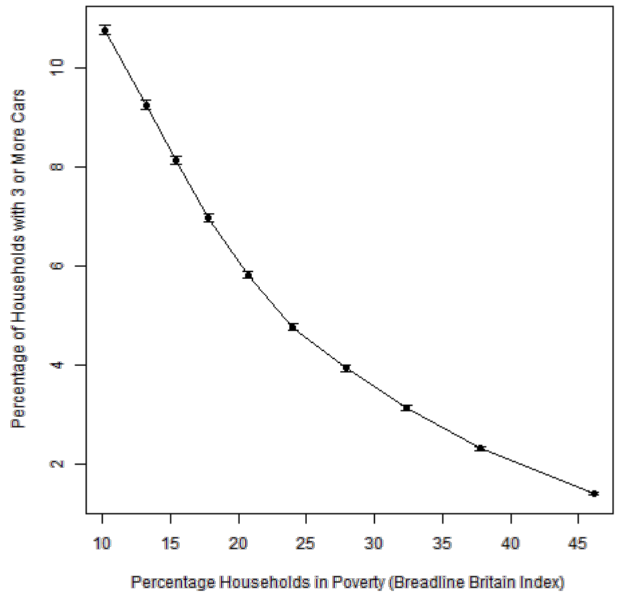
National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Car Ownership and Poverty

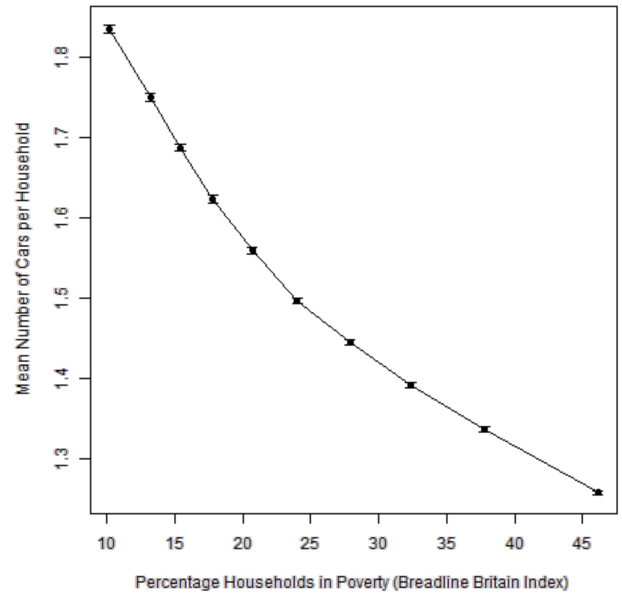
% HHs with No Car



% HHs with ≥ 3 Cars



Mean No. Cars per HH*

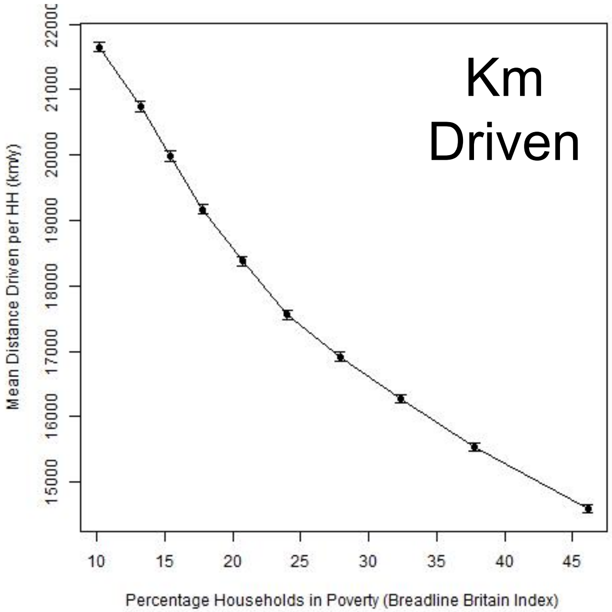


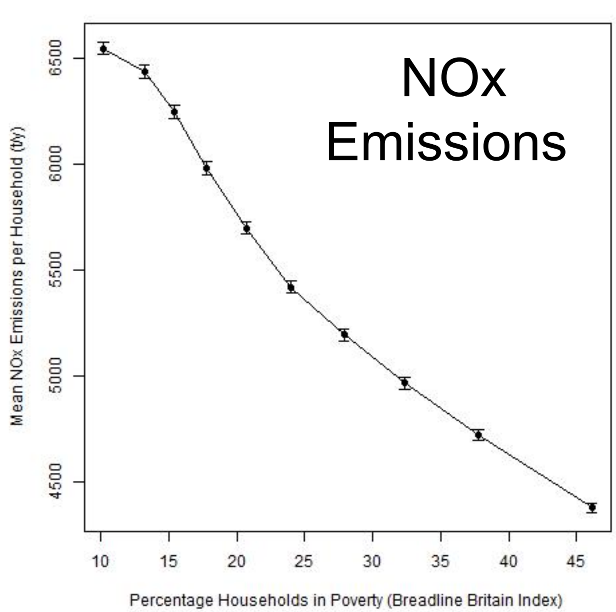
* For households with cars

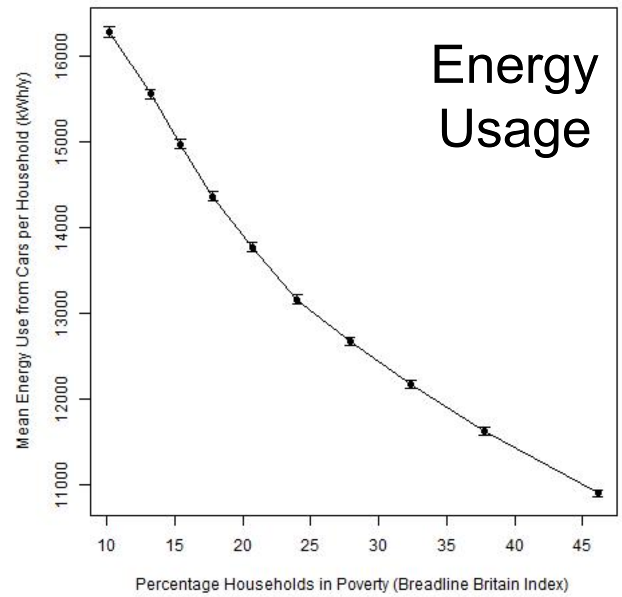
MOT
Motoring and Vehicle Ownership Trends in the UK

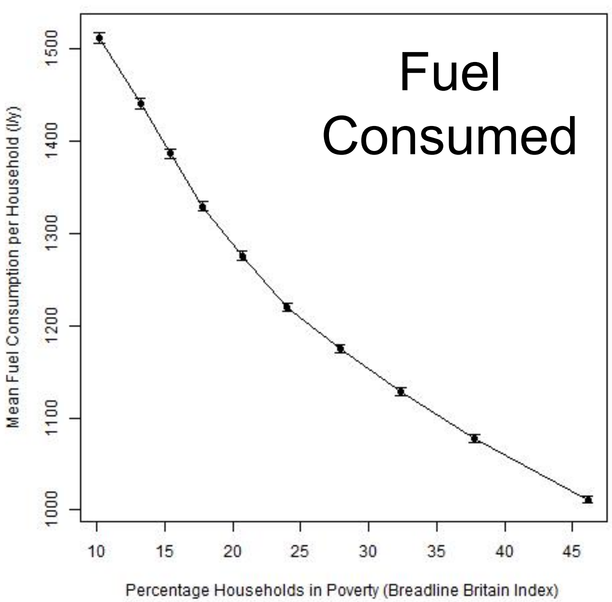
Vehicle Impacts per Household*

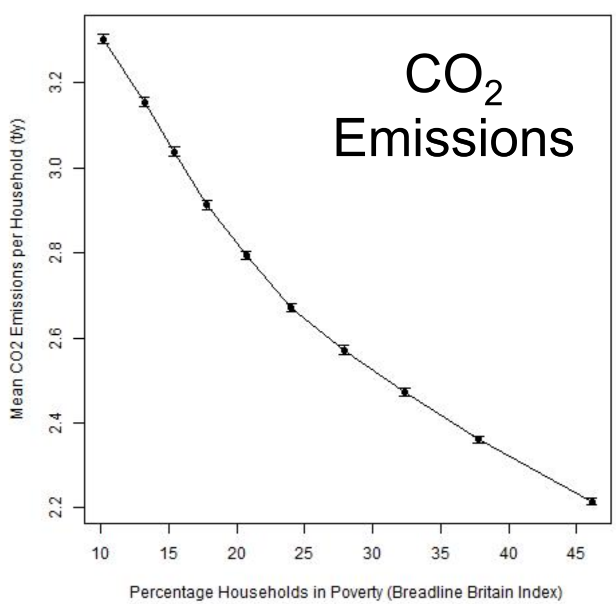
*for those households with cars



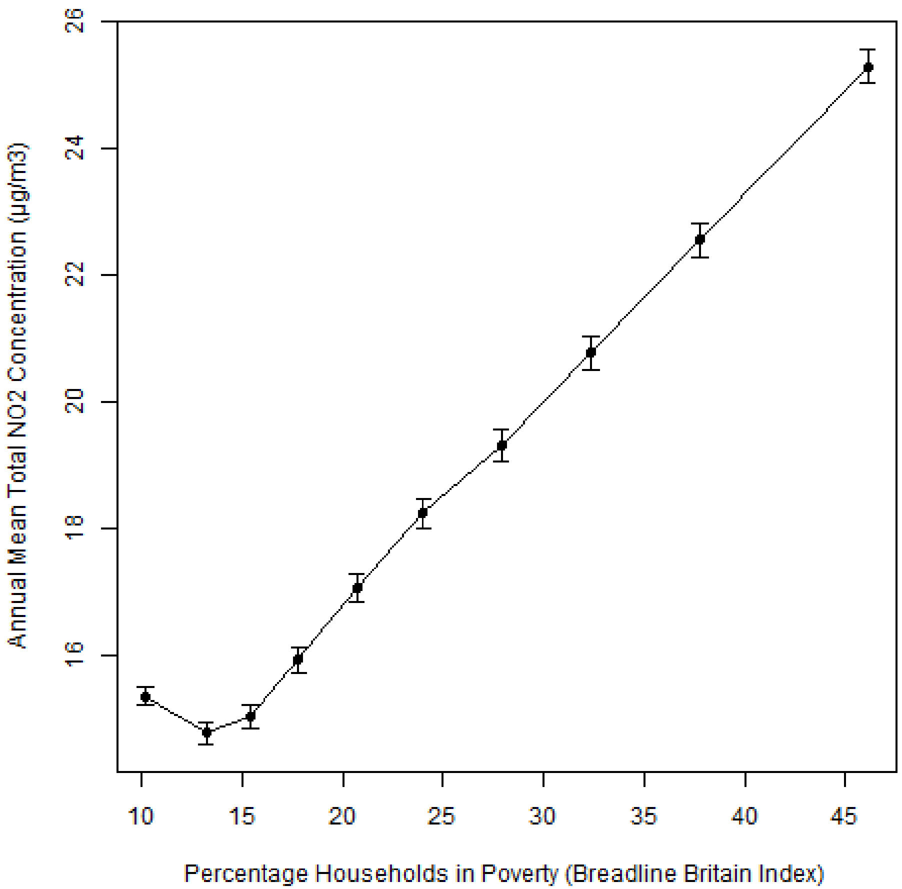








Poverty Against NO_2



Barnes and Chatterton, 2017. *WIT Transactions on Ecology and the Environment*. Available from: http://eprints.uwe.ac.uk/28882

EU policies and environmental justice

- Environmental justice considerations feature in high-level and longer-term strategies
- Air quality and noise policies rarely incorporate the socioeconomic dimension and environmental justice considerations

An integrated and combined approach to air and noise pollution, public health and social inequality is still underdeveloped in Europe

UWE Bristol University of the West of England
UAB Universitat Autònoma de Barcelona
Trinomics
National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

To recap:

- There is a relationship between exposure to both air and noise pollution and SES, particularly in urban areas

- Other environmental and lifestyle factors can exacerbate health impacts in low SES groups

- Vulnerable people risk a *quadruple jeopardy effect*

- Some evidence suggests that there might be an environmental justice issue related to generation, particularly for traffic-related pollution, but the picture is not clear-cut

Links between exposure to noise and air pollution and SES are highly complex and present significant research and policy challenges.

Recommendations for research

Future studies should focus on the interplay of SES and:

- Air <u>and</u> noise pollution (and other stressors)
- More evidence on exposure routes
- Lifestyle factors and occupational exposure should also be investigated
- Use of biomass, including the changing nature of domestic heating and its consequences on pollution concentrations
- More evidence evaluating the effectiveness of policy measures to reduce exposure to environmental hazards such as noise and air pollution
- Noise interventions with long-term health impacts (other than annoyance) to cover all sources of environmental noise, especially aircraft and rail

Policy recommendations

Particular focus on urban areas to tackle inequalities in exposure and vulnerability to pollution

Potential measures should aim to:

- Reduce the number of cars on the roads
- Reduce car dependency to improve public health and encourage more sustainable modes of transport
- Improve energy efficiency in households
  - Consider impact on air quality when developing energy policies
- Consider potential asymmetric impacts when developing policies
- Who is causing the pollution vs. where is the pollution emitted?

Policies need more joined-up thinking to integrate an environmental justice dimension, and to ensure that decisions outside the health sector do not have harmful or unfairly distributed impacts on public health

UWE Bristol | University of the West of England

UAB Universitat Autònoma de Barcelona

Trinomics

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Air quality, deprivation and health

Presentation by
Dr Jo Barnes

Air Quality Management Resource Centre, UWE, Bristol

Public Health England South West Air Quality Event

Tackling poor air quality and the basic inequality in life

13th June 2018

Thank you – any questions?

E: jo.barnes@uwe.ac.uk

T: @jobarnes_uwe

S: jo5.barnes

P: 0117 32 81626