Environmental Pollution 198 (2015) 201–210

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Associations between air pollution and socioeconomic characteristics, ethnicity and age profile of neighbourhoods in England and the Netherlands

Daniela Fecht [a,*], Paul Fischer [b], Léa Fortunato [a], Gerard Hoek [c], Kees de Hoogh [a,1], Marten Marra [b], Hanneke Kruize [b], Danielle Vienneau [a,1], Rob Beelen [c], Anna Hansell [a,d]

[a] UK Small Area Health Statistics Unit, MRC-PHE Centre for Environment and Health, Department of Epidemiology and Biostatistics, Imperial College London, St Mary's Campus, Norfolk Place, London W2 1PG, UK

[b] Centre for Sustainability, Environment and Health, National Institute for Public Health and the Environment (RIVM), Antonie van Leeuwenhoeklaan 9, 3721 Bilthoven, The Netherlands

[c] Institute for Risk Assessment Sciences (IRAS), Utrecht University, Yalelaan 2, 3584 CM Utrecht, The Netherlands

[d] Honorary Consultant, Imperial College Healthcare NHS Trust, London, UK

ARTICLE INFO

Article history:
Received 29 April 2014
Received in revised form
28 November 2014
Accepted 11 December 2014
Available online 24 January 2015

Keywords:
Environmental justice
Deprivation
Socioeconomic status
Ethnic inequity
Air pollution

ABSTRACT

Air pollution levels are generally believed to be higher in deprived areas but associations are complex especially between sensitive population subgroups.

We explore air pollution inequalities at national, regional and city level in England and the Netherlands comparing particulate matter (PM_{10}) and nitrogen dioxide (NO_2) concentrations and publicly available population characteristics (deprivation, ethnicity, proportion of children and elderly).

We saw higher concentrations in the most deprived 20% of neighbourhoods in England (1.5 $\mu g/m^3$ higher PM_{10} and 4.4 $\mu g/m^3$ NO_2). Concentrations in both countries were higher in neighbourhoods with >20% non-White (England: 3.0 $\mu g/m^3$ higher PM_{10} and 10.1 $\mu g/m^3$ NO_2; the Netherlands: 1.1 $\mu g/m^3$ higher PM_{10} and 4.5 $\mu g/m^3$ NO_2) after adjustment for urbanisation and other variables. Associations for some areas differed from the national results.

Air pollution inequalities were mainly an urban problem suggesting measures to reduce environmental air pollution inequality should include a focus on city transport.

1. Introduction

Ambient particulates and nitrogen dioxide have been linked to multiple health effects ranging from respiratory irritation to cardiovascular diseases and premature death (COMEAP, 2009). The European Environment Agency (EEA) estimated that in 2005 alone five million years of life were lost due to fine particulate pollution across the EU (EEA, 2010).

Environmental inequality – that more vulnerable communities are more likely to be exposed to higher air pollution levels – is well attested by studies from many parts of the world, in particular the USA, Canada and UK (Jerrett et al., 2001; Marshall, 2008; Richardson et al., 2013). Environmental inequality implies disadvantages in many societies because both increased environmental exposure and socioeconomic deprivation may lead to impaired health (O'Neill et al., 2003). Social gradients in health are well-established (Lynch et al., 2006; Marmot, 2005) and socially and economically disadvantaged people may experience increased susceptibility to the negative air pollution-related health effects because of higher baseline disease rates (O'Neill et al., 2003). Forastiere et al. (2007) showed this effect modification on mortality risks for the city of Rome where individuals of high social class were not as affected by the negative health effects of particulate matter pollution as individuals of lower social classes.

The relationships between the geographical distribution of vulnerable communities and air pollution levels are, however, more complex, and less universal than often implied. Associations

* Corresponding author. Room 531, MRC-PHE Centre for Environment and Health, Department of Epidemiology and Biostatistics, Imperial College London, St Mary's Campus, Norfolk Place, London W2 1PG, UK.

E-mail address: d.fecht@imperial.ac.uk (D. Fecht).

[1] Present addresses: Swiss Tropical and Public Health Institute, Socinstrasse 57, 4002 Basel, Switzerland; University of Basel, Petersplatz 1, 4003 Basel, Switzerland.

http://dx.doi.org/10.1016/j.envpol.2014.12.014
0269-7491/

between environmental risk factors and socioeconomic characteristics have been shown to vary between environmental pollutants (Briggs et al., 2008; Kruize et al., 2007; Vrijheid et al., 2012), study areas (Stroh et al., 2005), measures of socioeconomic status (Jerrett et al., 2004) and scales of measurement (Goodman et al., 2011; Hajat et al., 2013) but population characteristics which explain these relationships at a local level are still not fully understood. It is these local associations that are of particular interest to public health researchers and policy makers in order to understand the public health implications, to specifically target policy needs and to apply mitigation measures. Comparisons have to be made between different societies and countries to identify the societal and political impact on environmental inequality. Due to differences in study design and data this is difficult based on published study results.

This paper investigates neighbourhood (small area) associations in England and the Netherlands between concentrations of long-term ambient particulate matter with aerodynamic diameter $\leq$ 10 μm (PM_{10}) and nitrogen dioxide (NO_2) and population characteristics to identify subpopulations at higher risk of environmental inequality. Our hypothesis is that the deprived and ethnic minorities are subpopulations more likely to experience higher air pollution levels. Little is known about age-related air pollution inequalities and we include children and the elderly in our analysis to explore associations between air pollution and these vulnerable age groups. To explore previously reported differences in direction and patterns of associations mostly observed at the city level (Forastiere et al., 2007; Havard et al., 2009), we conducted our analysis at the national level, the regional level and the city level. England and the Netherlands are two European countries that are of comparable wealth but have historically a different political system; England has a market oriented, libertarian approach, the Netherlands is known as an egalitarian oriented country. This provided the ideal setting to explore the underlying geographical relationships in environmental inequality.

2. Methods

2.1. Study areas

The unit of analysis for this study was the neighbourhood level. In England, Lower Super Output Areas (SOA) ($N = 32{,}482$) represent socially homogeneous neighbourhoods that are comparable throughout the country because of similar population sizes. In the Netherlands, neighbourhoods (buurt) are administrative areas for which population characteristics are routinely reported ($N = 11{,}132$). Dutch buurten are comparable in population size to the English SOAs (mean of 1500 residents in both countries).

We defined regions in England and the Netherlands using the first level of the EU's Nomenclature for Territorial Units for Statistics (NUTS 1) boundaries (England $N = 8$, Netherlands $N = 4$). We included all cities in both countries that have more than 400,000 residents within their official city boundaries based on the English Census 2001 urban areas statistics (Office for National Statistics (ONS) 2001) and 2004 figures from Statistics Netherlands (Centraal Bureau voor de Statistiek (CBS) 2006) (England $N = 6$ (note that London is included in the city analysis although it is officially classified as a NUTS 1 region), Netherlands $N = 3$). The study areas are shown in Fig. 1. All spatial data were linked using the geographic information system ArcGIS version 10 (ESRI, Redlands, CA).

2.2. Air pollution maps

We used high resolution air pollution maps (100 m × 100 m) of annual mean concentrations for PM_{10} and NO_2 in 2001 modelled in a consistent manner for both countries. These are the most recent high resolution air pollution data available for both countries and correspond to the time period of the population characteristics. Details of air pollution model development and validation are

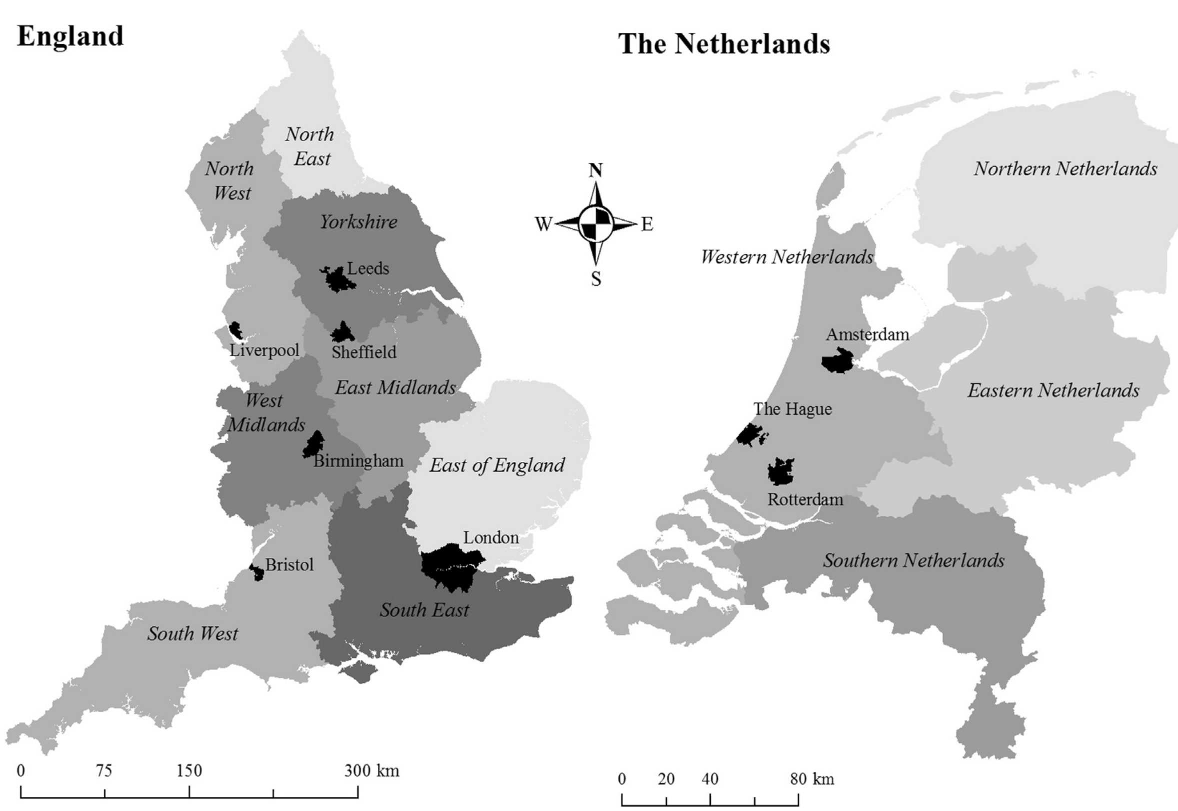

Fig. 1. Study areas in England and the Netherlands: national level, regional level (shown in grey scales) and city level (shown in black).