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Spatial and temporal associations of road traffic noise and air pollution in London: Implications for epidemiological studies

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ABSTRACT

Road traffic gives rise to noise and air pollution exposures, both of which are associated with adverse health effects especially for cardiovascular disease, but mechanisms may differ. Understanding the variability in correlations between these pollutants is essential to understand better their separate and joint effects on human health. We explored associations between modelled noise and air pollutants using different spatial units and area characteristics in London in 2003–2010.

We modelled annual average exposures to road traffic noise ($L_{Aeq,24\,h}$, L_{den}, $L_{Aeq,16\,h}$, L_{night}) for ~190,000 postcode centroids in London using the UK Calculation of Road Traffic Noise (CRTN) method. We used a dispersion model (KCLurban) to model nitrogen dioxide, nitrogen oxide, ozone, total and the traffic-only component of particulate matter ≤ 2.5 μm and ≤ 10 μm. We analysed noise and air pollution correlations at the postcode level (~50 people), postcodes stratified by London Boroughs (~240,000 people), neighbourhoods (Lower layer Super Output Areas) (~1600 people), 1 km grid squares, air pollution tertiles, 50 m, 100 m and 200 m in distance from major roads and by deprivation tertiles.

Across all London postcodes, we observed overall moderate correlations between modelled noise and air pollution that were stable over time (Spearman's rho range: |0.34–0.55|). Correlations, however, varied considerably depending on the spatial unit: largest ranges were seen in neighbourhoods and 1 km grid squares (both Spearman's rho range: |0.01–0.87|) and was less for Boroughs (Spearman's rho range: |0.21–0.78|). There was little difference in correlations between exposure tertiles, distance from road or deprivation tertiles.

Associations between noise and air pollution at the relevant geographical unit of analysis need to be carefully considered in any epidemiological analysis, in particular in complex urban areas. Low correlations near roads, however, suggest that independent effects of road noise and traffic-related air pollution can be reliably determined within London.

1. Introduction

Road traffic is a source of both noise and air pollution, particularly in urban areas. Air pollution is a long studied environmental exposure with well-known health effects, including effects on cardiovascular morbidity and mortality (WHO, 2013). There is a smaller evidence base for road traffic noise, but studies both at the individual level and the community level have linked long-term exposure to annoyance (WHO, 2011), increased blood pressure (Babisch et al., 2012), cardiovascular disease (Vienneau et al., 2015) and mortality (Halonen et al., 2015b). Suggested mechanisms for effects of noise and air pollution differ — noise may result in release of stress hormones, activation of the autonomic nervous system and (at night) interference with sleep (Babisch, 2002), whilst suggested mechanisms for air pollution are through oxidative stress and inflammation (Kelly and Fussell, 2015). These different mechanisms may lead to differences and/or interactions in respective health impacts.

Studies have previously explored spatial associations between traffic-related noise and air pollution for specific measurement locations (Allen et al., 2009; Kheirbek et al., 2014; Shu et al., 2014; Weber and Litschke, 2008). To investigate population level health effects,

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however, epidemiological studies have to rely on residential exposure estimates from ambient exposure models because personal exposure or fixed-site measurements are not feasible (Beelen et al., 2009; Bilenko et al., 2015; De Roos et al., 2014; Gan et al., 2012).

75% of the population in Europe live in urban areas but few studies have assessed correlations of modelled data across large geographical areas such as cities (Gan et al., 2012). Thus, the extent to which the spatial unit chosen and spatial characteristics of the study area influence correlations is not clear. Correlations might vary substantially depending on the local geography and presence of major traffic sources. If noise and air pollution are, for example, highly correlated near roads where levels are highest, the choice of spatial unit of analysis will have important implications for results of epidemiological studies. Understanding the variability and differences in correlations between noise and air pollution levels over space and time is therefore essential to investigate potential for confounding or interactions, that will affect exposure-response estimations used to inform policy interventions.

We provide a detailed exploration of associations between modelled exposures to traffic-related noise and air pollution for residential postcodes in London; overall and within different spatial units and area characteristics including air pollution exposure bands, specific distance bands from heavily trafficked roads and deprivation bands.

2. Methods

2.1. Setting

We investigated the associations between annual average road traffic noise and air pollution levels between 2003 and 2010 for ~9 million residents in London.

Our study region was the area within the M25 ring motorway surrounding Greater London (see Fig. 1) and covered approximately 2000 km^2. Traffic is the main source of noise and air pollution variability in London.

During the study period 2003–2010 major road traffic schemes were implemented by the Greater London Authority and Transport for London that aimed to reduce congestion and air pollution emissions and improve road safety across London. These included the introduction of the Congestion Charging Zone in February 2003 in central London with a Western Extension introduced in February 2007 (in operation until January 2011) (http://www.tfl.gov.uk/modes/driving/congestion-charge/congestion-charge-zone); the creation of the Low Emission Zone in 2008, which approximately follows the Greater London boundary (https://www.tfl.gov.uk/modes/driving/low-emission-zone); as well as the introduction of various 20 miles per hour speed limit zones across the city (Grundy et al., 2008). All these schemes had varying impacts on traffic speed, flow and composition (Transport for London, 2008a; Transport for London, 2008b), emissions of air pollution (Tonne et al., 2008) and potentially noise levels within London.

2.2. Unit of analysis

Postcodes were the highest level of resolution in this study. There are 190,122 residential postcodes within the study area each of which represents ~56 residents or ~22 households (Office for National Statistics (ONS), 2011). The postcode is a point location representing the geometric centroid of a postcode area (i.e. mid-point of all addresses associated with a postcode). We explored associations across all postcodes in London and within each London Borough, each neighbourhood, and within each 1 km × 1 km grid cell to analyse the effect of spatial

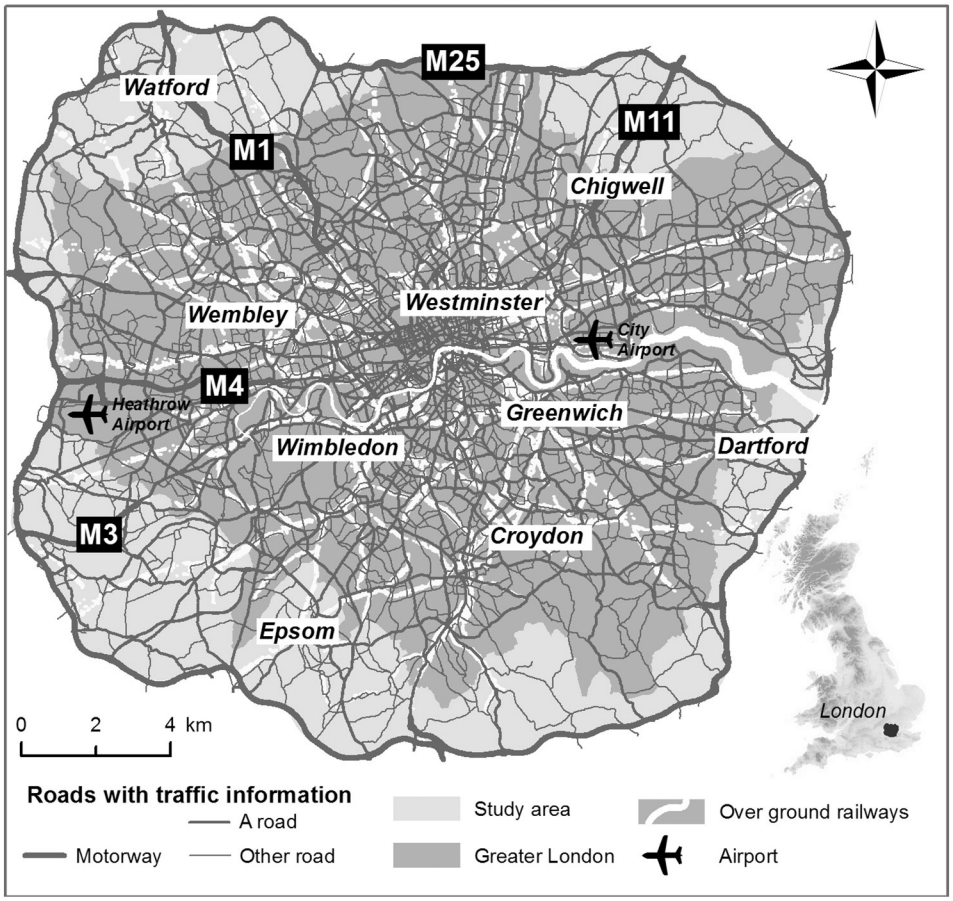

Fig. 1. London study area showing potential sources of traffic-related noise and air pollution.