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Environmental noise inequity in the city of Barcelona

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ABSTRACT

Environmental noise is a growing concern for urban planners and public health experts. Continuous noise exposure has implications for people's physical and mental health. Urban planning strategies are also involved in the need for regular noise assessments within urban areas. The objective of this study is to evaluate the exposure to noise of vulnerable population groups in the city of Barcelona, and to determine whether they are affected by an environmental inequity regarding this nuisance. Assessment of noise levels was performed by two methods of analysis—real measures and simulation—in order to build the noise database at block level for the 10 districts of the city. The results obtained by various statistical tests and spatial regression analysis show that children and low-income individuals are not affected by environmental inequity. On the other hand, we found a positive relationship between noise levels and the other groups considered: namely, the unemployed and people over age 65.

1. Introduction

Environmental Equity (EQ) has become an important concern for academics in many different disciplines (Sze et al., 2009; Walker, 2012; Schlosberg, 2013). The scope of EQ has evolved and expanded (Walker, 2012), with one of its main components being the "inequitable and disproportionately heavy exposure of poor, minority, and disenfranchised populations to toxic chemicals, contaminated air and water, unsafe workplaces, and other environmental hazards" (Landrigan et al., 2010). Urban areas tend to cluster individuals and families with lower levels of education, occupation, or income (Hornberg and Pauli, 2007). Therefore, socioeconomic characteristics have a direct impact on the unequal distribution of populations in cities and, thus, their unequal exposure to environmental hazards. Socioeconomic inequalities have increasingly been recognized as one of the key factors forming the basis of health inequalities (Evans and Kantrowitz, 2002; O'Neill et al., 2007). These health inequities are more marked in urban areas because of the clustering of deprived and poor populations in certain neighbourhoods (Borrell and Arias, 1995).

Noise, defined as "unwanted sound" of different types and intensities, including noise from transport, industry, and neighbours, is perceived as a pollutant and as an environmental stressor that is a prominent feature of the urban environment (Stansfeld et al., 2000). Regardless of the related air pollution, exposure to noise should be considered an important environmental factor in itself that has a significant impact on health (Foraster et al., 2011; Tobías et al., 2015). Environmental noise pollution has been proved to affect human behaviour, well-being, productivity, and health (European Commission, 1996; Stansfeld and Matheson, 2003). The influence of environmental noise on public health is probably the most significant reason that environmental noise has emerged as a major issue in environmental legislation and policy in recent years (Berglund et al., 1999; World Health Organization, 2011).

With the aim of defining local action plans on urban noise control, the European Commission issued the 2002/49/EC directive, also known as the Environmental Noise Directive (END), requiring major cities to gather real world data on noise exposure (European

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Commission, 2002). A working group was also created to assess the production of data on noise exposure (European Commission Working Group, 2007). The END determines noise indicators and levels of exposure to environmental noise through those common indicators. The directive also requires competent authorities in each member state to provide estimates of the number of people living in dwellings that are exposed to different levels of noise.

Environmental equity has been assessed in the cities of Barcelona and Madrid, Spain, in terms of exposure to air pollution (Moreno-Jiménez et al., 2016), access to green spaces and green gentrification (Anguelovski et al., 2017; Cole et al., 2017), playgrounds and community centers (Anguelovski, 2013), crime and security perception (Valera et al., 2018). Borrell et al. (2013) reported evidence of health inequalities in the city of Barcelona, with socioeconomic inequalities seen to have a direct impact on disease and mortality rates. A short-term relationship between socioeconomic factors and mortality caused by air pollution has also been found in Barcelona (Barceló et al., 2009; Borrell et al., 2010; Rodríguez-Fonseca et al., 2013). But in regard to the noise standards defined by the European Commission, no studies relating socioeconomic factors and urban noise have yet been conducted in Barcelona.

The city of Barcelona experienced many demographic changes during the decades from 1990 to 2010 (Catalán et al., 2008; Bayona-i-Carrasco and Pujadas-i-Rúbies, 2014). Urban saturation and immigration and economic crises meant that the urban configuration of the city shifted towards a sprawl model, as observed in other Mediterranean cities. The mononuclear compact city and the accompanying continuous metropolis lost their previous and almost absolute dominance. Sub-centres with a significant historical background, located outside the traditional city centre, have taken over this urban expansion.

Concerning segregation, the case of Barcelona is particularly relevant: the percentage of immigrants in the total population has increased significantly within a very short period of time (from 4.83% in 2001 to 17.22% in 2011). The percentage of immigrants from non-EU countries in the total population rose from 4% in 2001 to 12.92% in 2011. Immigrants are currently concentrated in two types of areas: in the historical centre, where housing is of poor quality, and in peripheral districts close to public transport and composed of relatively cheap housing built in the 1960s and 1970s. Martori and Apparicio (2011) demonstrated that rapid and strong population growth has resulted in significant changes in patterns of segregation and in the emergence of ethnic enclaves. This segregation has also changed the landscape of low-income groups. Most immigrants from non-EU countries only have access to a highly informal labour market associated with low levels of income (Canal-Domínguez and Rodríguez-Gutiérrez, 2008).

Therefore, the aim of this study is, first, to build a mean noise level index for all the street grid blocks in the city of Barcelona and draw up a framework to assess urban planning policies related to noise reduction; second, to analyze the spatial distribution of noise pollution in the different neighbourhoods; and, third, to evaluate the exposure to noise nuisances of vulnerable population groups.

The remainder of this paper is structured as follows. The second section reviews the theoretical framework on environmental inequities and noise pollution. The third section overviews the empirical data and the statistical methodology used in the study. The fourth section presents the results obtained, which are later discussed in the fifth section. Finally, the last section draws conclusions and suggests some future lines of research.

2. Theoretical framework

The goal of environmental justice is to ensure that all people, regardless of race, origin, age, or income, are protected from disproportionate impacts of environmental hazards (Melnick, 2002). Environmental justice is a major concern in academic research and political decision-making, and has become a basis for urban planning (Forkenbrock and Schweitzer, 1999; Antweiler et al., 2001; Schlosberg, 2013). The term environmental justice connotes some remedial actions to correct injustice for specific group of people, while environmental equity implies an equal sharing of risk burdens without pursuing its reduction (Cutter, 1995). The impacts of environmental inequalities in health and urban policies are one of the main challenges for public health throughout Europe (Judge et al., 2006). The World Health Organization (2008) stated that people with lower levels of education, occupation, and/or income tend to die at a younger age, and to have a higher prevalence of most types of health problems. The impact of the socioeconomic characteristics of the living environment and of exposure to environmental pollution is recognized as a crucial factor in the production of health inequalities (Evans and Kantrowitz, 2002; O'Neill et al., 2007).

According to the WHO and the UN-Habitat report, *Hidden Cities*, all urban environments have the ability to produce health inequities that are "systematic, socially produced (and therefore modifiable), and unfair" (World Health Organization. UN-Habitat, 2010).

Noise is considered to be an environmental pollutant of major importance in urban environments (Stansfeld et al., 2000). Chronic noise exposure has implications for physical and mental health (Ising and Kruppa, 2004). Direct noise effects on health have been reviewed by many authors and different consequences have been pointed: hearing impairment, annoyance, sleep disturbances (awakenings or sleep-cycle shifts), hypertension, cardiovascular risks (blood pressure increase, hypertension, subcortical stress reactions, heart diseases), disturbances in mental health, impaired task performance, chronic stress (Stansfeld and Matheson, 2003; Ising and Kruppa, 2004; Goines et al., 2007; Haralabidis et al., 2008; Basner et al., 2014). Basner et al. (2014) propose a review of observational and experimental studies on various diseases caused by noise exposure, pointing to the importance of noise prevention and mitigation strategies for public health. In New York City, McAlexander et al. (2015) stated that street-level noise has the potential to cause auditory and non-auditory health effects. Tobías et al. (2015) also quantify the direct relationship between the mortality index and road traffic noise in the city of Madrid, Spain.

Noise exposure consequences may be worse for particular subgroups such as children, older people, and lower socioeconomic groups (World Health Organization, 2011). Van Kamp and Davies (2013) reviewed studies on evidence of noise effects on health, suggesting that vulnerable groups, such as, for instance, children, older people and lower socioeconomic population, should be