Journal of Transport Geography 51 (2016) 1–8

Contents lists available at ScienceDirect

Journal of Transport Geography

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

Road traffic noise in Montreal and environmental equity: What is the situation for the most vulnerable population groups?

Mathieu Carrier *, Philippe Apparicio, Anne-Marie Séguin

385 rue Sherbrooke Est, Montréal, QuébecH2X 1E3, Canada

ARTICLE INFO

Article history:
Received 23 February 2015
Received in revised form 23 October 2015
Accepted 28 October 2015
Available online xxxx

Keywords:
Road traffic noise
Environmental equity
Montreal
GIS
Transportation
Low-income individuals

ABSTRACT

Road traffic noise is one of the most detrimental environmental nuisances for the population. Prolonged exposure to high road noise levels can lead to various problems in people's health and well-being. The objective of this article is to determine whether the groups most vulnerable to road noise, that is, children under 15 years old, people 65 years old and over, and the groups most likely to experience high nuisance levels, visible minorities and low-income individuals, are affected by an environmental inequity related to this nuisance. The method of estimating this nuisance employed in the study is based on a combination of several elements: that is, average traffic flows, road geometries, normal atmospheric conditions, and the characteristics of the urban environment. All of these parameters were considered for the 14 boroughs that make up the central portion of the Island of Montreal. Modelling was used to calculate the maximum daily road noise, based in part on the LimA software predictive model and according to the XPS 31-133 computation method. The results obtained from three different statistical tests and spatial regression analyses show that, on the one hand, the groups chosen on the basis of age are not affected by any environmental inequity related to the phenomenon of road traffic noise. On the other hand, low-income individuals and visible minorities live in city blocks marked by road traffic noise levels that are slightly higher than those experienced by the rest of the population.

1. Introduction

Noise can be defined as an unwanted sound produced by human activities that has notable effects on sleep, work and communication (Michaud et al., 2008). Road noise is moreover considered by the World Health Organization (WHO) as the second most problematic nuisance for people's health and well-being, after air pollution (WHO, 2011). The impacts of road noise on affected populations increase according to the noise intensity, measured in decibels (dB(A)). The consequences for health and well-being are minimal at levels under 50 dB(A). Various European studies indicate that the physiological effects of road noise are more strongly felt starting at the 65 dB(A) threshold: on average, 35% of individuals exposed to such intensities claim to experience negative effects (WHO, 2011). In addition, Canadian transportation agencies recommend keeping daily road noise levels under 65 dB(A). At such a road noise threshold, mitigation measures are often put in place along highways by transportation authorities (MTQ, 2003), such as noise barriers that reduce road traffic noise levels by nearly 10 dB(A) between the source and the first row of buildings (BKSV, 2013).

Prolonged exposure to road noise can have a variety of impacts on people's health and well-being. Loss of sleep (Öhrström and Skånberg, 2004), high blood pressure (Bluhm et al., 2007), development of cardiovascular disease (Babisch, 2006), increased cognitive difficulties in children (Evans et al., 2001), issues with diabetes (Sorensen et al., 2012), and hearing loss (Seto et al., 2007) are some of the main problems mentioned. High noise levels can also trigger psychological stress and impair local residents' quality of life (Passchier-Vermeer and Passchier, 2000). Children and the elderly are among the population groups most likely to develop health issues stemming from prolonged exposure to road noise. Problems with language, reading and concentration have been found in children exposed to high road traffic noise levels (Evans and Maxwell, 1997). Children are in fact more vulnerable to the effects of road noise due to the fact that their organs and nervous systems are not fully developed (Bolte et al., 2010). The WHO has also noted that older people are more likely to feel the negative impacts of road noise at levels as low as 45 dB(A) (WHO, 2011). In addition, because of their more limited mobility, these two groups tend to be more restricted to their residential areas (Day, 2010; Philipps et al., 2005). If there are poor conditions in these areas, these groups are more affected than other age categories that spend less time there.

1.1. Road noise and environmental equity

The literature on environmental equity attempts to determine whether nuisances are distributed inequitably, and whether they therefore impact certain populations more strongly (Walker, 2011). Road

* Corresponding author.
E-mail addresses: mathieu.carrier@ucs.inrs.ca (M. Carrier), philippe.apparicio@ucs.inrs.ca (P. Apparicio), Anne-marie.seguin@ucs.inrs.ca (A.-M. Séguin).

http://dx.doi.org/10.1016/j.jtrangeo.2015.10.020
0966-6923/

noise has only recently been considered a nuisance of interest in the environmental equity literature. In one of the studies on place of residence, Brainard et al. (2004) examined the level of urban noise pollution in Birmingham, England, taking into account people of Asian (Bangladeshi, Indian and Pakistani) background, Whites, Blacks, young people under 15 years old and persons over 65 years of age, as well as socioeconomic deprivation. The results indicate that in Birmingham, Blacks and low-income households tend to be located in environments where road noise levels are higher in the daytime than is the case for the rest of the population. Lam and Chan (2006) analyzed the relationship between socioeconomic disadvantage and the level of road noise in Hong Kong. They found that the relationship between a low-income level and road noise is positive and significant, but nonetheless weak (Lam and Chan, 2006). Finally, the results of Nega et al. (2013) in Minneapolis point to a positive association between road noise levels and the proportion of individuals from the non-White population (African-Americans, Hispanics and Asians). Mean household income levels are also negatively associated with an increase in road noise, meaning that lower-income households tend to live in areas where the intensity of this nuisance is greater (Nega et al., 2013).

Other studies have however qualified the results obtained relating to potential environmental inequities concerning road noise experienced by low-income households. In The Netherlands, Kruize et al. (2007) only found an environmental inequity for low-income households at night near railway lines. In their respective studies, Havard et al. (2011) and Bocquier et al. (2012) did not measure any environmental inequities for low-income households in Paris and Marseilles, France.

Despite their observed physiological vulnerability in terms of the effects of noise on their state of health, people under 15 years old and individuals 65 years old and over have rarely been considered in studies on noise, or in environmental equity studies in general (Cutter, 2006). Paradoxically, we only found two studies, those by Brainard et al. (2004) and Nega et al. (2013), that examined one or the other of these two groups. Moreover, the two studies did not identify any environmental inequities for these groups.

1.2. Research question and objectives

The analysis of road noise is of particular interest, given that traffic flows have continued to increase on the Island of Montreal's arterial road network since the 1990s (MTQ, 2013). Although noise barriers have been set up by the Québec Transportation Minister along a few sections of highway, the increase in traffic flows on the arterial and collector networks means that road noise levels remain high along major traffic arteries. The intensity of this nuisance experienced in some locations may thus have negative impacts on the well-being of the people most exposed to this nuisance. The vulnerability of young people and seniors to the effects of noise at their place of residence, as well as the likelihood of visible minorities and low-income individuals living in the areas most polluted by various nuisances, require that attention be accorded to these population groups. The objective of this study is therefore to verify the existence of environmental inequities relating to estimated road traffic noise levels for low-income individuals, visible minorities, people under 15 years old and persons 65 years old and over by using various statistical methods.

2. Methodology

A number of methodological issues surround the measurement of the existence of environmental inequities for a given population group. Among the important criteria for a rigorous evaluation of environmental equity, Walker (2010) emphasizes the issue of the choice of the scale of analysis. In concrete terms, this spatial division has to be as fine as possible in order to obtain a good degree of variability of the indicator of exposure to the nuisance across the spatial units in the area under study. This issue, the modifiable area unit problem (MAUP), has been raised on several occasions in the environmental equity literature (Schweitzer and Valenzuela, 2004) and, more recently, in the field of transportation (Wang et al., 2011). Walker (2010) also considers it appropriate to compare the levels of exposure to the nuisance in the target group with the levels for a control population, in order to establish whether these levels are in fact higher in the target group. Chakraborty (2009) has also underscored the importance of controlling for the effect of spatial dependence in the statistical tests used in environmental equity, in order to confirm the independence of the associations.

2.1. Study area, groups targeted, and scale of analysis

Our study focuses on 14 of the 19 boroughs forming the territory of the Island of Montreal (Canada). Due to the lack of data on traffic flows for collector and arterial roads located in the autonomous municipalities in the western part of the Island of Montreal and for some City of Montreal boroughs that were recently merged with the central city, we were unable to include the entire territory of the island. Our study does however cover an area that, in 2006, included 1.41 million inhabitants out of a total of 1.8 million for the island as a whole. Fig. 1 shows the areas covered by the study.

The study area includes the principal generators of road noise: that is, all the highway sections and the main arterial and collector roads that link the Island of Montreal to its suburbs (Carrier et al., 2014). The central Island of Montreal boroughs also represent a major employment pole for the 3.92 million inhabitants of the Montreal Metropolitan Community, with its 1.1 million jobs (City of Montreal, 2011). The Island of Montreal's socioeconomic profile is another element of interest, given the sufficiently large numbers of the four population groups examined in our study (low-income individuals, persons claiming to be members of visible minorities, people under 15 years old, and individuals 65 years old and over). We are thus focusing on two "classic" groups considered in environmental equity studies: that is, low-income individuals and members of visible minorities[1] (the reality in Canada making this group a more relevant category than African-Americans or Hispanic populations). We also selected two groups presenting particular vulnerabilities to road noise: that is, the elderly and children. The numbers of these groups and of the total population were taken from the 2006 Statistics Canada census at the level of the dissemination area: that is, the finest spatial division for which socioeconomic data are available. It should be noted that a dissemination area usually includes between 400 and 700 people and is generally made up of several city blocks (Statistics Canada, 2006).

Checking for environmental inequities for a given population group requires that analyses be performed at a fine geographic scale, as road noise levels can vary greatly at the scales of a neighbourhood, a census tract, or a dissemination area. We therefore decided to use the city block as the spatial unit from which both pollution indicators and variables related to the four groups studied are generated. The city block refers to an area equivalent to a block of homes and is delimited by the surrounding road network (Statistics Canada, 2006). It should however be noted that Statistics Canada only provides data on the total population and the number of dwellings at the city block level. To address this issue, we estimated the numbers of each group as follows, as recently proposed by Pham et al. (2012):

$$t_b = t_d \frac{T_b}{T_d}$$

where t_b represents the estimated population of the group (low-income individuals, for example) in city block b, t_d is the group's

[1] The "visible minorities" variable refers to all non-White individuals, except Aboriginal people: that is, the census categories of Chinese, South Asian, Filipino, Latin American, Black, Arab, Korean, Japanese, Southeast Asian and West Asian individuals, and persons of Oceanic origin (Statistics Canada, 2006).