TRAFFIC RESTRICTION POLICIES IN THE LISBON CITY CENTRE: OPPORTUNITY LOST OR MISTAKE AVOIDED?

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1. INTRODUCTION AND BACKGROUND

Area-wide traffic restriction policies close a whole neighbourhood to some or all motorized traffic. The introduction of these policies is usually justified with their potential economic, social and environmental benefits. However, while the existence of the first two of these benefits is supported by a large and consistent body of evidence obtained in many cities in the world, there are doubts regarding the effectiveness of the policies in improving environmental quality at the city scale. It is often argued that the policies redistribute traffic to alternative routes and increase cruising for parking at the fringes of the restricted areas, leading to an increase of traffic levels, congestion and pollution. In most cases, there is a considerable degree of uncertainty in the patterns of redistribution of pollution linked to traffic restriction measures, creating the need for a detailed modelling of traffic distribution and noise dispersion (Chiquetto 1997).

This type of policies may also lack the required social and political feasibility for their implementation if the redistribution of their environmental effects is biased towards certain groups in society. Existing research on the equity aspects of traffic policies have focused on road pricing scheme, producing evidence on their overall redistributive effects (see review in Levinson 2010) and in a few cases also on the social and spatial patterns in the redistribution of pollution (Bonsall and Kelly 2005, Mitchell 2005).

There is little evidence for the case of area-wide traffic restriction policies. In most cities in Europe, where city centres tend to have a disproportionately high proportion of elderly populations, the effect of these policies in the reduction of local environmental nuisances in these areas may address concept of social justice based on attention to vulnerability, as the elderly are more vulnerable to losses in local environmental quality (Sugiyama and Thompson 2007). However, the potential redistribution of traffic among other areas of the city may collide with other concepts of social justice, as certain groups may be disproportionately affected by the increase of traffic levels along the routes used as alternative to the restricted links in the city centre.

The objective of this paper is to study the effects of a policy restricting car traffic in the Lisbon old city centre, focusing on the distribution of environmental quality, measured as population exposures to noise. The distribution is compared for two different segmentations of the population, based on age and on qualification levels.

The rest of the paper is organised into four sections. The next section describes the proposed policy and its geographic and socio-political context.

The following section summarizes the methods used to estimate the effects of the policy on noise exposures. The spatial and social distribution of these effects is then analysed. The last section sums up the main points to retain from the analysis and discusses some of their implications for policy and research.

2. THE LISBON CITY CENTRE CIRCULATION PLAN

Due to the central position of Lisbon within its metropolitan area, the concentration of employment in the geographic centre of the city, and a radial pattern of suburban growth, commuting traffic is funnelled to Lisbon through a small number of motorways. These motorways then redistribute the traffic through another small set of arterial roads. The potential for increasing the number or the capacity of these roads is limited due to the hilly relief and to the high housing densities in the old neighbourhoods of the city. The rapid increase in road traffic in the last few decades has aggravated traffic circulation problems and led to increased congestion and pollution. While proposals for the application of area-wide traffic restriction policies have had prominent place in the political agenda, due to the lack of social and political consensus, they have never progressed beyond the discussion stage, with the exceptions of two small neighbourhoods in the oldest parts of the city.

The object of this paper is a traffic restriction policy proposed for the Lisbon old city centre, known as Baixa (downtown). Although the geographic centre of the city is now the prime location for business and employment, the old Baixa still maintains some of the roles of a traditional city centre. Nevertheless, the area has been steadily losing residents, while the densely populated and built-up neighbourhoods in the surrounding areas are inhabited by a rapidly ageing population. The maps prepared for the revision of the Lisbon Municipal Master Plan reveal that the Baixa neighbourhood is a collection of superlatives within Lisbon: highest ratio of workers to residents, second highest number of jobs and retail businesses, highest proportion of vacant dwellings, origin or destination for the second highest number of trips, destination for the highest proportions of both non-work trips and public transport trips, and highest number of buses per hour at both peak and off-peak times (CML 2004, pp. 28-30, 51-52, 63-64, 68, 73, 156).

The traffic problems in this area arise from the context described above. The roads in the Baixa are vital to workers living in the areas to the west and east, as they are part of the main route connecting those areas with each other and with workplaces in the geographic centre of the city. The Baixa is therefore crossed by a large volume of car and bus traffic. In particular, the main square at the riverfront (Terreiro do Paço) is one of the road links with the highest congestion indices in the city (CML 2004, p. 103).

The proposal for restricting traffic in this area has suffered several modifications over the years. The analysis that follows uses the version contained in the public presentation of the policy by the Lisbon Municipal Council (CML 2009). This proposal was abandoned due to social and political protest. Fig.1 illustrates the geographic context of the policy and the proposed changes in traffic circulation. While the policy would only restrict the connectivity of a couple of links, this restriction ensured that car traffic would not be able to cross the Baixa or to use the waterfront road that links the western and eastern parts of the city. Access to the old neighbourhoods bordering the city centre would still be possible (yellow links), while public transport routes would remain largely unchanged. The policy would be implemented in conjunction with the increase of parking space, so that access to the city centre itself would still possible for car users.

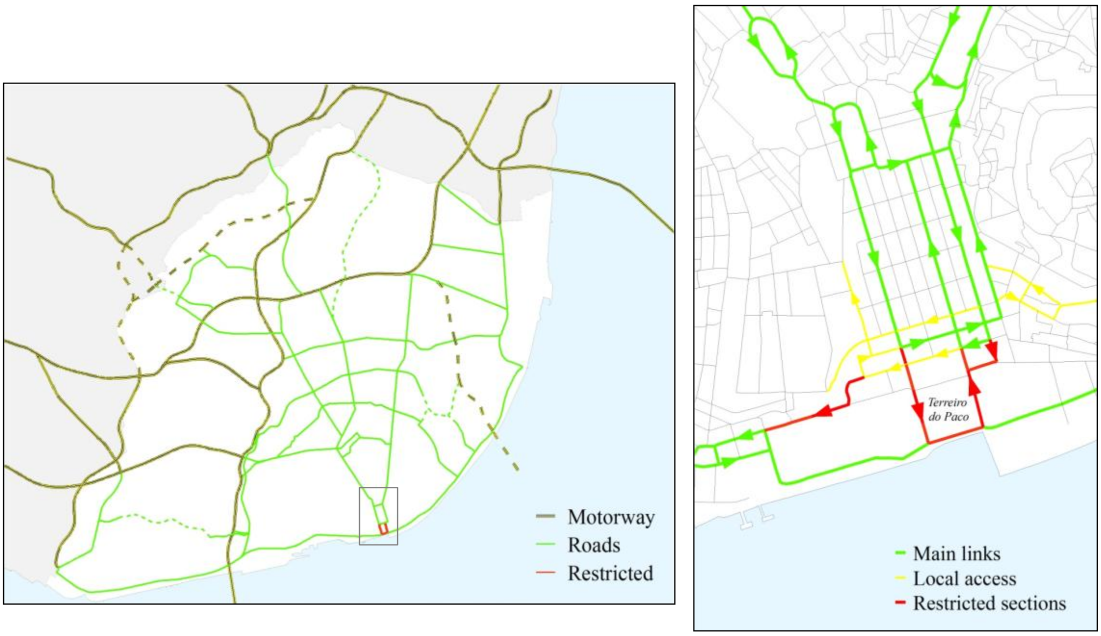


Figure 1: The Lisbon City Centre Traffic Circulation Plan

The main question is therefore the effect of the policy on road users crossing the area to access other destinations. The proportion of crossing traffic has been one of the points of contention between the municipality and the automobile lobby, which have presented traffic studies where crossing traffic is estimated at respectively 74% and 35% of all traffic in the Baixa area (CML 2008, CESUR 2009). The left side of Fig.1 shows that the alternatives for this traffic are a series of circular routes, some of which are (or where in 2009) still at the planning stage (dashed lines in the map). However, the existing circular roads are some of the most congested road links in Lisbon (CML 2004, p.103), and there are no viable alternatives in the hilly, densely constructed areas closer to the river. Judgements on the desirability of the policy are then dependent on its effects on neighbourhoods far from the area of application (CML 2005a, p.147-156).

The motivation of the present study is to add to this debate by studying the effects of the policy on populations with different ages and qualification levels. The public and political discussion of the policy has remained focused on efficiency issues related to the restructuring of road traffic patterns within the city and to the potential effects on local retail businesses, and very seldom have groups pro or against the policy used arguments dealing with spatial and social equity. Although issues of local environmental quality are implicit to the overall objectives of promoting the liveability of the old city centre, these issues have also not been assessed quantitatively.

3. **MODELLING**

The analysis was conducted at the level of the census enumeration district, using the boundaries of the 2011census. Districts with less than three residents were excluded from the analysis. The remaining 3273 districts have an average population of 167 residents. Noise exposures were obtained through the modelling of commuting and non-commuting flows, motorised traffic, noise levels and noise exposures in the pre- and post-policy scenarios. The modelling process is synthesized in Fig.2.

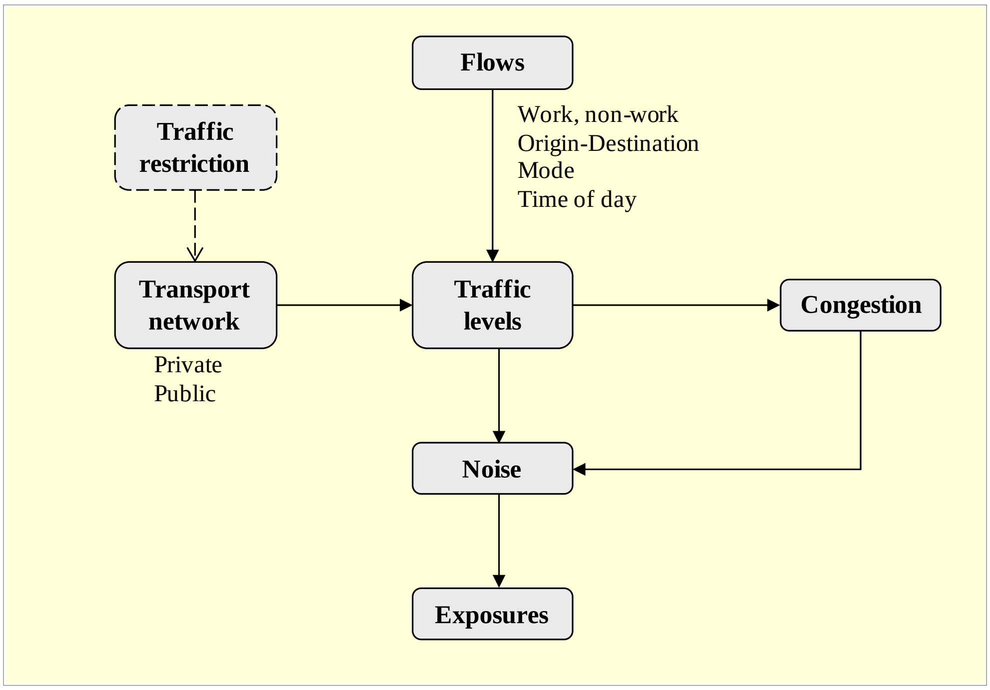


Figure 2: Modelling the effects of a traffic restriction policy

Commuting data is available from the census at the level of administrative areas. In a first step, commuting flows by private and public transport were disaggregated into flows between enumeration districts and a set of 267 destinations representing major centres of employment. This set includes places outside the AML, as there are important commuting flows from some peripheral areas in the metropolitan areas to nearby municipalities. The identification of the centres was based on employment levels at the municipality level by sector of activity, which were then disaggregated based on the number of employees and sector of activity of companies registered at smaller areal units. Jobs were then assigned to specific locations, taking into account the information in land use maps, satellite images, municipal master plans, and maps with the location of each type of businesses and urban facilities. Commuting flows were finally split by travel mode and by period of day (peak and off-peak), considering census data and the results of mobility surveys.

Commuting flows in each period of day were then assigned to the private and public transport networks, modelled in a Geographic Information System. It was assumed that individuals use the fastest route to work. The estimated optimal routes for private transport users include walking time to parking areas, and the routes for public transport users include walking to stops and stations, waiting, and interchange time. The routes using the motorway and road networks were based on theoretical crossing times for each link, the calculation of which considered speed limits for each type of road, location and vehicle, assumptions about the proportion of users driving above the speed limit, the classification and characteristics of the road (lane width, surface quality and existence of central reservation), slopes, and time lost at intersections.

The car traffic flows resulting from the estimation of the optimal routes for private transport trips to work were then aggregated for each link of the road and motorway networks. Other traffic flows were modelled separately, including student commuting flows, non-commuting personal trips, business trips, freight transport, and bus traffic. The resulting road traffic levels and compositions were compared with road capacity in order to derive a new dataset with congested crossing times for cars and buses in the peak and off-peak periods. The reduction of average speeds used a simple speed-flow relationship, given by the UK Department of Transport (UK DOT 1985, cited in Ortúzar and Willumsen 2006, p.325-327). The private and public transport flows were then re-assigned to the respective networks, generating new values for the traffic crossing each link of the road network.

The final set of traffic data was then used to estimate peak and off-peak noise emission levels in each link of the road and motorway networks. The estimation considered traffic levels, compositions and speeds, and the characteristics of the road infrastructure. Railway noise was also modelled, considering number of tracks, train types, speeds, and number of vehicles in the train. The two types of noise emission were combined with information about noise from industrial sources and along flight paths (extracted from data ceded by the Lisbon Municipal Council), in order to estimate a noise surface covering the study area. The noise propagation from each source was modelled considering distance from source, ground absorption, screening by obstacles, and site layout. The modelling used a large set of geographic datasets representing local conditions. The procedures in each step of the modelling of noise emission and propagation adapted the methods proposed by the UK Department of Transport (UK DOT 1995, 1998).

The noise exposures of the population living in each enumeration district are weighted averages of noise levels at peak and off-peak times in the residential parts of each district. The identification of these areas took into account land use maps and information on the Lisbon Municipal Master Plan and in studies and geographic information published by the Lisbon Municipal Council.

The modelling was done separately for two moments in time, interpreted as the pre- and post-policy scenario. The pre-policy scenario corresponds to 2009, the year when the proposal was presented. The post-policy scenario used the same data but excluded the restricted roads from the private transport network. In the cases where the final destination is the Baixa, the journey by car is restricted to end at one of the existing or proposed car parks and the rest of the trip is made on foot. It was assumed that private transport users shift to public transport if the optimal route to their destinations by car becomes longer than the optimal route by public transport. It was also assumed that the public transport network is not affected by the policy (a point that was not made clear in the proposal for the policy as presented in 2009).

The change in noise exposures in the post-policy scenario is then the product of two types of changes: a) changes in the routes used by car users (in the cases where the new optimal routes by car are still shorter than public transport routes) and b) shift from car to public transport (in the cases where the new optimal routes by car take longer than the optimal public transport routes).

The distribution of the effects of the policy on local populations is assessed considering two dimensions: age and qualification levels. Four age groups (0-19, 20-24, 25-64, and over 65) and four qualification levels (illiterate, primary school, secondary school, and higher education) are considered, using data from the 2011 census. The population below 20 years of age was not considered in the distribution of noise according to qualification levels.

4. RESULTS

Fig.3 shows the distribution of noise exposures of the population in each enumeration district in the pre-policy scenario. The Baixa has low exposures (below 55 db (A)), but the area along the road linking this neighbourhood with the geographic centre of the city has exposures above 65 db (A). In the rest of the city, the exposures are highly variable, even within each neighbourhood. The highest exposures occur near the airport in the northeast extreme and in the areas near motorways. A curve of high exposures can be identified in the areas crossed by the motorway that links the southwest and the northeast extremes of the city. The hilly neighbourhoods to the west and east of the Baixa have the lowest exposures. The exposures rise as we move away from these neighbourhoods towards the roads and then the motorways circling the Baixa. Overall, the maps suggests that the population living in the area of application of the policy and in the surrounding areas are already the least affected by noise, while the population living in the areas near the roads that are alternatives for the restricted traffic are already the most affected by the problem.

Fig.4 shows the effects of the policy, expressed as the changes in noise exposures of the population in each district. The classes in the map were defined in order to have a middle class centred on zero and containing approximately with 1/7 of the districts, and to distribute the other positive and negative values in three equal-size classes each. The map shows that the effect of the policy on the area of application is modest. The policy also causes a redistribution of noise exposures among the residents in other neighbourhoods, as exposures decrease in some regions and increase in others. The effects are felt throughout the city and are highest in districts far from the area of application.

If the changes in exposures are analysed alongside the map with the major links in the motorway and road networks (left part of Fig.1), it becomes clear that the effects of the policy are related with the reassignment of traffic to routes that act as alternative to the route currently used to link the western and eastern parts of the city along the riverfront. The distribution of positive and negative effects of the policy is mainly explained by increased traffic levels in circular arterial roads and motorways.

The area with the highest change in noise exposures is the eastern area of the city, which is crossed by three of those circular roads. The population of this area has also the lowest socio-economic status and highest unemployment rates in the city (CML 2005b, p.43-44) and is likely to be affected by the negative environmental effects of the planned bridge linking Lisbon with the south bank of the River Tejo, which will accommodate a dual-carriageway road and railway lines. The policy also affects a small cluster of affluent neighbourhoods in the southwest extreme of Lisbon and some of the old neighbourhoods to the northwest of the Baixa. The areas with the highest decreases in exposures include the neighbourhoods along the riverfront road, with an exception of a small cluster in the East. The neighbourhoods in the northwest part of the city also show substantial improvements in exposures.

Figures 5-7 illustrate the distribution of the effects of the policy among different age and qualification groups. Fig.5 shows the cumulative distribution of the changes in noise exposures, that is, the proportion of the city-wide population of each group affected by a change in exposures equal of below a given value. The distribution of the changes according to the age of the population affected is balanced. However, the distribution according to qualification levels suggests that the lower the qualification levels, the lower the benefits from the policy and the higher the costs, as the distribution curves are vertically ordered according to qualification levels. In particular, the population with higher qualifications is relatively spared from the highest increases in exposures (those above 0.5 dB (A)).

Fig. 6 shows the proportion of the city-wide population of each group exposed to each interval of noise levels. The values of noise exposures were grouped into intervals of 5 db (A) and the curves linking data points were smoothed in order to facilitate the interpretation of the chart. The proportion of the population exposed to the lowest noise levels (below 60 dB (A)) decreased or remained constant for all age and qualification groups. The proportions of the population exposed to noise levels between 60 and 75 db (A) increased for all groups. In addition, the elderly population is the one showing the highest increases in exposures between 70 and 75 db(A) and the illiterate population is the one with the highest increased in exposures between 60 and 65 db(A).

Fig. 7 shows the proportion of each group in the total population in Lisbon affected by each type of change. The values of the changes in exposure levels were grouped into intervals of 0.1 db (A) and the curves were smoothed to facilitate the interpretation. Elderly population in the population are more than proportionately represented in the areas affected by some of the highest improvements but also in the population affected by some of the highest deterioration on exposure levels. Populations with higher education are more than proportionally represented in the areas with moderate improvements (decrease in exposure up to -1db (A)) but not in areas with the greatest improvements. The other groups are disproportionately represented both in the areas with the highest positive and negative changes.

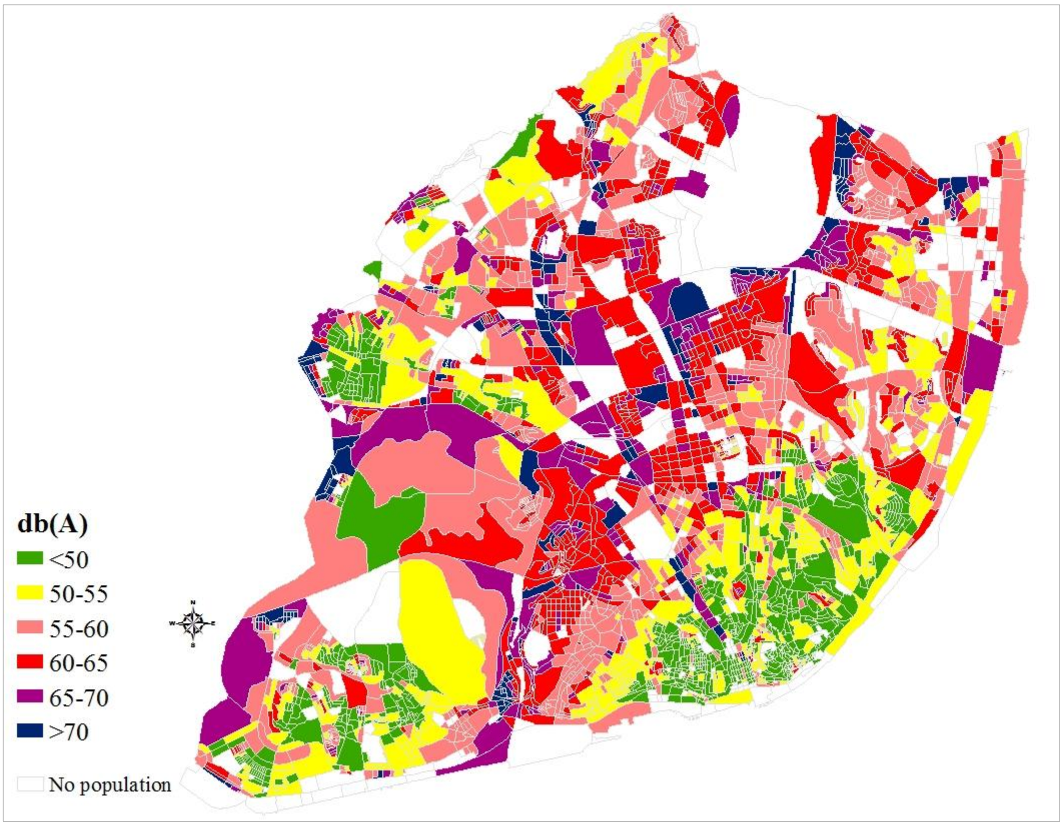


Figure 3: Distribution of noise exposures in the pre-policy scenario

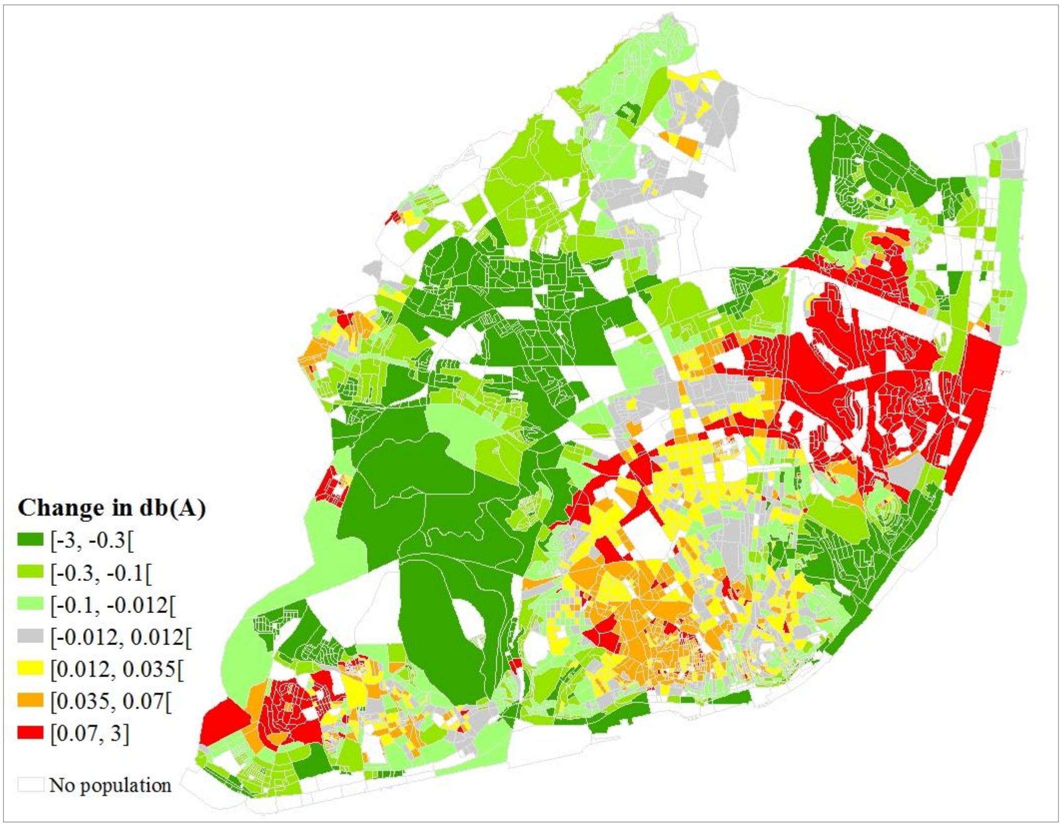


Figure 4: Effects of the policy on noise exposures

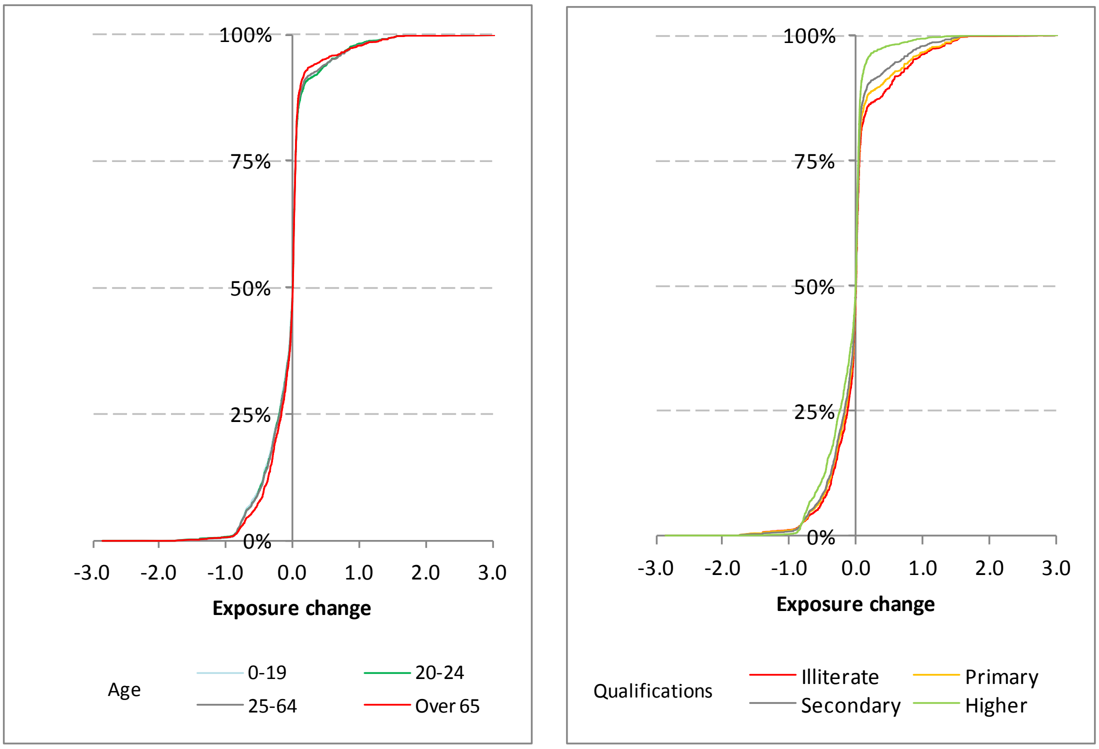


Figure 5: Cumulative distribution of city-wide population of each group by value of exposure change

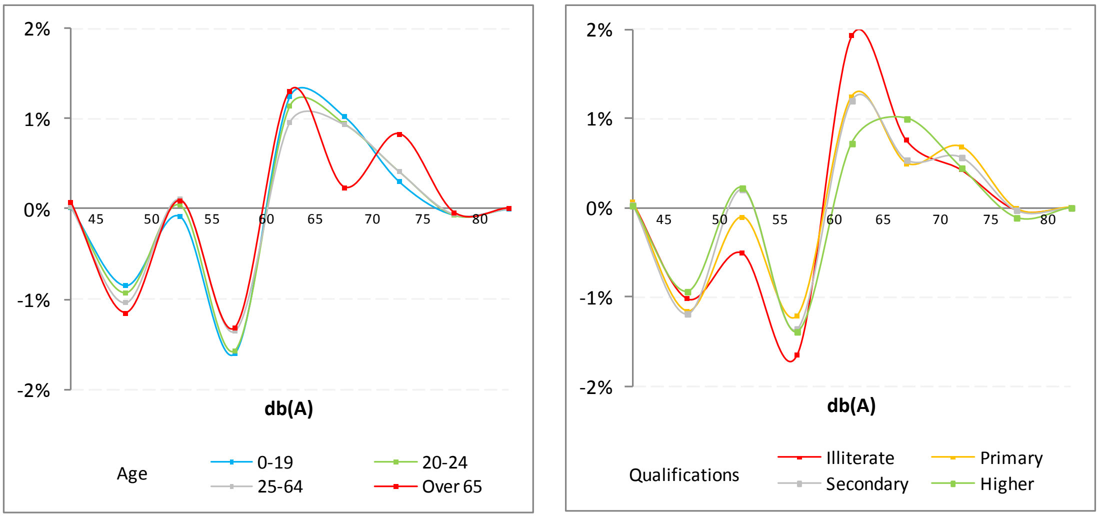
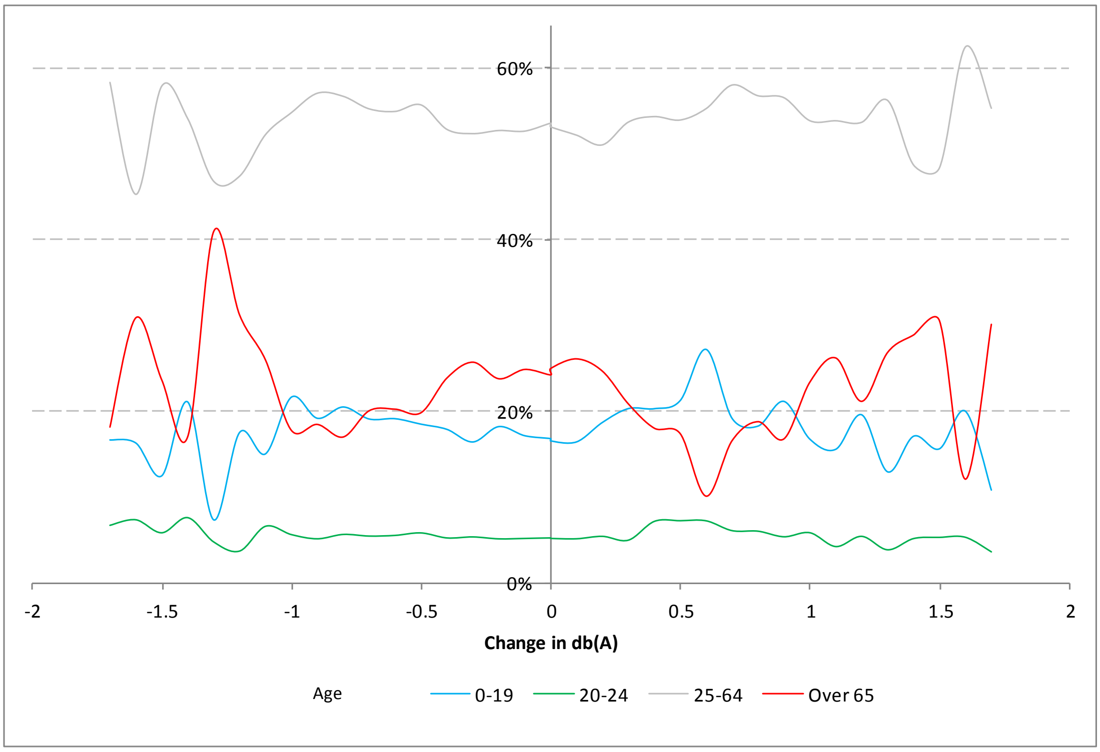


Figure 6: Change in proportion of city-wide population of each group exposed to each noise level



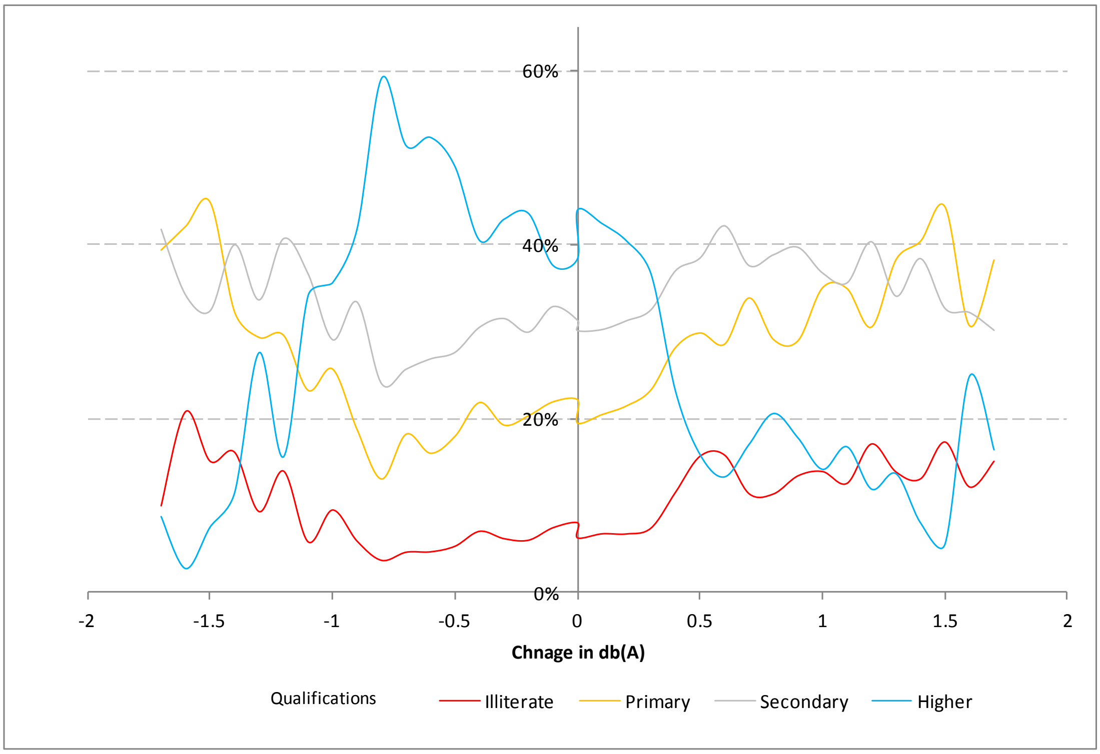


Figure 7: Proportion of each group in the city-wide population affected by each type of change

5. DISCUSSION AND CONCLUSIONS

This paper analysed the effects on noise exposures of a proposal for an area-wide traffic restriction policy. The analysis assumed that car users react to the policy by seeking alternative routes or shift to public transport. Under this assumption, there is an extensive reorganization of traffic within the city, leading to a redistribution of noise levels. The benefits in the area of application of the policy are relatively modest, but other areas face substantial benefits and costs. The effectiveness of the policies in the reduction of exposures throughout the city is therefore dependent on the provision of alternatives for the suppressed traffic. In an urban area such as Lisbon, characterized by severe bottlenecks in the distribution of road traffic, due to geographic barriers and a radial pattern of incoming traffic from the suburbs, it is therefore crucial that traffic restriction policies are designed in conjunction with measures to improve and increase the capacity of the public transport system.

The policy also redistributes noise among different groups in society. Low-qualified populations tend to be at disadvantage in this redistribution, although there are areas of city where higher-qualified populations are also affected. The policy has little effects on the distribution of noise exposures among different age groups, even though the area of application and the surrounding neighbourhoods have the oldest populations in the city. These findings emphasize the multidimensional distributive aspects of area-wide traffic restriction policies. These policies might increase noise exposures in neighbourhoods that may be inhabited by populations belonging to the same groups that the policy is targeting in its area of application. In addition, the achievement of equity in the distribution of exposures among age and qualification groups may be incompatible. The evaluation of the social desirability of the policy is then dependent on the degree of priority attached to different groups of concern.

The study confirmed the importance of adopting a geographic perspective in the evaluation of this type of policies. This perspective complements evidence coming from studies focusing on road pricing and economic aspects, as it stresses the relevance of distributive effects that are linked to choices over the areas where individuals live.

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