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Implementation of car-free neighbourhoods in medium-sized cities in Brazil, a case study in Florianópolis, Santa Catarina

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The aim of this study was to investigate the best conditions for the success of a car-free neighbourhood and the profile of the potential residents who would live in it. In this context, questionnaires were applied to a sample of the population of Florianópolis. We attempted to determine the profile of potential residents through a logistic regression. The gathered data were complemented by the literature review regarding the already existent car-free neighbourhoods that led to some adaptations required by the Brazilian context in relation to the European car-free neighbourhoods.

Keywords: sustainable development; sustainable mobility; urbanism; urban planning; car-free

1. Introduction

Neighbourhoods without cars lie within a relatively new concept designated as 'car-free'. The current mobility policies of most cities already provide some car-free urban areas and this fact passes unnoticed by most people. The historic and/or commercial centres of cities, for example, already have large car traffic restrictions (Crawford 2009). There is also a series of measures that may be considered to be intermediates of the car-free concept, such as home zones, the new concept of shared space or traffic calming measures. All through the world, we see temporary car-free measures, such as the pedestrian area of Copacabana, Rio de Janeiro, where cars have been barred from the surrounding area on weekends. This temporality varies from a day per year (car-free day) to a certain number of days per week or, even, to longer periods of time, normally due to major events taking place, such as the annual carnival. At the extreme of the car-free spectrum, there are cities that are permanently closed to car traffic, such as Venice, in Italy, Fez, in Morocco, and several islands, some of them touristic. That is to say, there are various degrees of car-free measures, both in temporal and spatial terms (Wright 2005).

Car-free neighbourhoods are the ultimate expression of sustainable mobility, since they gather and synthesise a series of measures to promote equitable and universal mobility. In fact, car-free neighbourhoods are some of the most interesting urban concepts already existing in some European countries, where attempts are being made to return to human-scale urbanism, focused on the person and not on the vehicle. People use cars for an ensemble of reasons, practical as well as psychological, and this decision is influenced not only by the circumstances and the conditions that are endowed to the several modes of transportation, but also by people's values and social surroundings. Through regression analyses, Collins and Chambers (2005) reached the conclusion that, in order to use the car to give way to the

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use of public transportation, public strategies should focus on individuals′ transport-related environmental beliefs and on the conditions that are afforded to public transportation, especially as concerns, costs and accessibility. Well, car-free neighbourhoods are a very effective way to act upon those two elements, since they constitute a platform of education and belief changing, and a space that offers the utmost conditions to sustainable modes. Indeed, studies have shown that these neighbourhoods result in a decrease in car ownership and car-use (Scheurer 2001; Nobis 2003). Melia et al. (2010) and Hazel (1998) mentioned, based on the analysis of some research studies, that the benefits of car-free neighbourhoods go far beyond mobility, especially in relation to certain social aspects such as well-being among neighbours, social cohesion and the fact that a more favourable environment is created for children. Ornetzeder et al. (2008), based on a study on the car-free neighbourhood in Floridsdorf, concluded that the families that reside in this kind of neighbourhood have lower CO_2 emissions than the control group (reference settlement – a neighbourhood with similar characteristics, but without the car-free feature) and the national average. This is not only due to the differences in the mobility patterns, but also to the popularity that clean energies enjoy in these neighbourhoods.

The first car-free residential neighbourhood was designed for Bremen, Germany, in 1992. However, the project was subsequently cancelled, not due to the lack of support, but due to market issues (Morris et al. 2009). After this pioneering project others followed, notably Vauban, the largest and most emblematic case study, in the city of Freiburg, Germany, Floridsdorf in Vienna, Austria, and Gemeente Water Leiding (GWL)-Terrein in Amsterdam, Netherlands.

When referring to car-free neighbourhoods, we usually mean a predominantly residential neighbourhood that occasionally also has businesses, which restricts the use and, in some cases, the possession of cars, and/or limits or does not provide parking areas. Within the very concept of car-free neighbourhoods there are several groups and divisions, depending on the definition of each country and the type of restrictions imposed, lacking a common definition accepted by all (Melia et al. 2012). Nevertheless, it is considered that the definition given above encompasses and resumes the different existing possibilities.

Restrictions vary from low-car areas (neighbourhoods with a reduced number of parking spaces) and visually car-free areas (where the circulation but not the possession of cars is banned within its borders, as is the case with GWL-Terrein), to a complete prohibition of car ownership (as is case with the Floridsdorf project) (Wright 2005; Morris et al. 2009; Melia et al. 2010). It should be noted that the legal structures differ between European countries and only in some of them it is possible to create a legally binding contract restricting car possession.

Another variant is the Vauban system, where the areas are not exactly car-free, but rather parking-free, which means that one can only stop the car for delivery and loading. The parking areas are limited to neighbourhood garages. Nevertheless, as there is no through traffic and the traffic of residents only makes sense when one wants to load/unload something, there is, in practice, very little car traffic. Still, this can be considered to be a car-free neighbourhood because, despite the local population not using the term car-free, there are many areas only for pedestrian and bicycles traffic (Scheurer 2001; FWTM 2009).

Using the stated choice approach, Borgers et al. (2008) studied the effects of restrained car access on preferences for new residential areas. The study concludes that the majority of the residents in four Dutch cities would prefer to reside in non-car restrained residential areas. Nevertheless, the study shows that the negative effects arising from the concentration of parking facilities outside the residential areas can be compensated for, at least partly, by providing secured parking facilities, good non-motorised transport facilities and access to public transport at a short distance from home.

Car-free neighbourhoods are an under-studied issue in Brazil, partly due to the absence of practical implementation. Thus, there are no data

available regarding the profile of potential residents neither the necessary conditions for the successful implementation of this type of neighbourhood.

The two main objectives of this study are as follows:

(1) To identify the profile of potential residents of a car-free neighbourhood.
(2) To identify the conditions necessary for the successful implementation of this type of project (particularly regarding the adaptations required in relation to car-free neighbourhoods of the European models).

It should be noted that medium-sized cities (with between 100,000 and 500,000 inhabitants as defined by the Instituto Brasileiro de Geografia e Estatística (IBGE)) are those that have grown the most in Brazil (IBGE 2011), and in these cities, it is easier to introduce new concepts of mobility compared with already established large cities.

2. Research methodology

This study was based on a standard questionnaire applied to a representative sample of the population of the city of Florianópolis.

In most questions, the format of a typical Likert scale was used, i.e. a scale of agreement (from strongly disagree to strongly agree). In the chapter 'Analysis and interpretation of the results', the exact sentences that the interviewees were provided with can be found in the tables therein. There are also open questions on which conditions should be provided in such neighbourhoods and on the potential difficulties associated with living in them. The answers were analysed mainly through frequency tables.

In order to identify the profile of potential residents, another objective of our study, a logistic regression was carried out using Statistical Package for the Social Sciences software, so as to verify whether there are variables that can be used to predict the dependent variable (the acceptance of the population to live in car-free neighbourhoods). Studies by Scheurer (2001) indicate that the residents of European car-free neighbourhoods are predominantly young people (and few people are older than 60 years), parents of young children, users of sustainable modes (many of whom do not possess a car) and with a degree of education above average (this characteristic was not proved or quantified, but it is highlighted in several documents that are based on field observations). We attempted to test this profile in the Brazilian context by introducing the following independent variables in the regression model: age, existence of children not older than 15 years, most frequently used mode of transport, possession (or not) of an individual motorised vehicle at the residence (users of motorbikes were included in this group), the education level and gender (though the latter was not referred to in the reviewed literature, it was added to the model).

The questionnaires were conducted by interviewers, approaching people on the street (non-randomly), between the months of June and November of 2011. Firstly, the interviewers were trained and test-questionnaires were used to assess their applicability.

3. Selected case study data set and characterisation

The city of Florianópolis was chosen for this research because, despite the particular characteristics associated with being located on an island, it has mobility characteristics similar to most medium-sized cities in Brazil, in which a lack of urban planning and public transport contributes to increasing the rate of motorisation, increasing the congestion and the difficulties associated with the general locomotion of the population. Florianópolis is situated in the South Region of Brazil and is the capital of the State of Santa Catarina. In 2010, its population of approximately 421,000 inhabitants was distributed as follows: 96.21% in urban areas and 3.79% in rural areas. The rate of population growth between the years

1997 and 2011 was 2.10% per year. The total area of Florianópolis is 436.5 km^2 and it is divided into two parts. The smaller part is located on the continent and the larger part on the Island of Santa Catarina (97.23%), separated by a strait of approximately 500 m width (IBGE 2011). The human development index of the city is 0.875, one of the highest of the country. The automobile fleet in July 2011 was around 195,000 cars, with a growth rate between the years 1997 and 2011 of 4.31% per year (average value), and around 40,000 motorcycles with a growth rate of 10.51% per year for the same period (average value), amongst other vehicles. The motorisation rate is 0.46 automobiles/inhabitant (Departamento de Trânsito do Estado de Santa Catarina 2011). The city of Florianópolis has a system of public transportation comprised of buses operated by five private companies, with a fleet around 500 buses, which carries around 4,500,000 passengers/month (Prefeitura Municipal de Florianópolis 2011).

The questionnaires were carried out using a representative sample of the population in the city of Florianópolis, which consisted of 385 interviews, with a 95% confidence level. All respondents were aged 15 or above. In order to isolate the sampling error from variables believed to have high variability, the following variables were controlled: age, gender and type of transport. Data on the first two variables were obtained from the statistics published by IBGE (2011), and data on the last variable were taken from IPEA (2011), recognised public agencies in Brazil, and both sets of data related to 2010. Thus, the division of the questionnaires, which is exactly the same as the percentages found in the population for those variables, is shown in Tables 1–3.

Table 1. Division of questionnaires according to the gender of the interviewees.

Gender	Frequency	%
Female	205	53.25
Male	180	46.75
Total	385	100.00

Table 2. Division of questionnaires according to the age range of the interviewees.

Age	Frequency	%
15–19	34	8.83
20–24	48	12.47
25–34	92	23.90
35–44	69	17.92
45–54	64	16.62
55–64	43	11.17
Over 65	35	9.09
Total	385	100.00

Table 3. Division of questionnaires according to the mode of transport used by the interviewees.

Mode of transport	Frequency	%
Car as driver	102	26.49
Car as passenger	18	4.68
Bicycle	9	2.34
Motorbike	48	12.47
Walking	31	8.05
Public transport	177	45.97
Total	385	100.00

4. Analysis and interpretation of the results

4.1. Profile of potential residents – logistic regression

Based on the data collected, nearly 90% of the population of the city of Florianópolis has never heard of this concept. After reading a sentence describing briefly what a car-free neighbourhood is (without restriction on car possession), people were asked if they would accept living in a neighbourhood of this kind, provided that the neighbourhood would have all due conditions. A total of 57% stated that they would 'probably' or 'certainly' do so, 39% said that they 'probably' or 'certainly' would not and 4% did not know or did not answer.

This question was principally aimed at determining the profile of people who would be most predisposed to living in a car-free neighbourhood. That is, attempts were made to identify the variables which can be used to predict the response to

the previous question, this being the dependent variable. This profile is fundamental for identifying the characteristics of the potential target public and to better understand how to direct campaigns aimed at providing information on increasing awareness of and publicising the neighbourhood. For this aim, a forward stepwise (conditional) logistic regression was carried out. This is a stepwise selection method with entry testing based on the significance of the score statistic, and removal testing based on the probability of a likelihood-ratio statistic based on conditional parameter estimates.

The interviewees who did not know how to respond or did not respond were removed, this group comprising 17 interviewees, and the responses 'would probably live' and 'would certainly live' were combined into a single group (would live) and the responses 'probably wouldn't live' and 'certainly wouldn't live' were also combined into a single group (wouldn't live). A total of 368 interviews were subsequently considered.

Initially, the number of groups that compose the 'age' variable was narrowed down (the categories presented in Table 2 were aggregated) in order to allow for the realisation of the regression, since the previous number of categories was very high. The 'age' variable is hence composed of four groups: 15–24, 25–44, 45–64 and ≥65. Table 4 shows the final output.

The p-value of the omnibus test is 0.001, which indicates that the independent variables are useful for the model. The p-value for the Hosmer and Lemeshow tests is 0.989(>0.05), thus suggesting that the model is adjusted to the data. The value of Nagelkerk R^2 is 0.090, which indicates that, although the independent variables that were considered are useful, there might be other variables that were not considered and could in some way explain the variability reflected in our data (Hosmer & Lemeshow 2000). Though relatively low, the value is considered to be normal, since this is the first study in Brazil on the topic and there are not yet any references on the profile of the people who would be more willing to live in car-free neighbourhoods. Hence, the necessity of assessing the European experience. When we analyse the significance values, we see that the variables that are capable of predicting the dependent variable are the mode of transportation (though not all categories present statistical significance), the existence of children in the family (*children*) and age, since they present values lower than 0.05. Gender, degree of education and the individual vehicle ownership do not present statistical significance and were excluded from the model. Analysing the values of exp(B), which indicate the values of odds ratio, one must take into account that the category of the variable with the highest value is the one with which all the others are compared to. When the value of exp(B) is higher than 1, it means that the odds of such a category accepting to reside in a car-free neighbourhood increase; when it is lower than 1, those odds decrease; and when it is equal to 1, the odds neither increase nor decrease. We hereby present the interpretation of those values.

For the variable 'mode of transportation':

- The odds of accepting to reside in a car-free neighbourhood decrease 60% $((1 - 0.403) * 100)$ if the person is a user of public transportation, in comparison to a pedestrian.
- The odds decrease 66% if the person is a driver, in comparison to a pedestrian.
- The odds decrease 72% if the person is a motorcyclist, in comparison to a pedestrian.
- The odds increase 42% if the person is a user of a bicycle, in comparison to a pedestrian.
- Therefore, for the variable 'mode of transportation', the descending order of odds of accepting to reside in a car-free neighbourhood is: bicycle, foot, public transportation, car and motorcycle. It must be stressed that the only comparison that is statistically significant is the comparison of pedestrians with motorcyclists (p-value = 0.019, with a confidence interval of 95% (0.097; 0.809)) and the comparison of pedestrians with drivers (p-value = 0.025, with a confidence

Table 4. Output of the forward stepwise logistic regression.

		Variables in the equation							
								95% CI for EXP(*B*)	
		B	SE	Wald	df	Sig.	Exp(*B*)	Lower	Upper
Step 1	Age			9.179	3	0.027			
	Age (15–24)	1.088	0.415	6.884	1	0.009	2.968	1.317	6.689
	Age (25–44)	1.130	0.383	8.713	1	0.003	3.096	1.462	6.557
	Age (45–64)	1.056	0.401	6.936	1	0.008	2.875	1.310	6.309
	Constant	−0.571	0.347	2.704	1	0.100	0.565		
Step 2	Mode			10.614	4	0.031			
	Mode (public transport)	−0.800	0.469	2.910	1	0.088	0.449	0.179	1.126
	Mode (car)	−0.960	0.480	4.009	1	0.045	0.383	0.150	0.980
	Mode (motorbike)	−1.086	0.533	4.149	1	0.042	0.338	0.119	0.960
	Mode (bike)	0.391	0.665	0.346	1	0.557	1.478	0.402	5.443
	Age			9.086	3	0.028			
	Age (15–24)	1.058	0.423	6.252	1	0.012	2.880	1.257	6.598
	Age (25–44)	1.146	0.390	8.619	1	0.003	3.146	1.464	6.761
	Age (45–64)	1.106	0.409	7.331	1	0.007	3.023	1.357	6.735
	Constant	0.173	0.543	0.101	1	0.750	1.189		
Step 3	Mode			12.574	4	0.014			
	Mode (public transport)	−0.909	0.472	3.711	1	0.054	0.403	0.160	1.016
	Mode (car)	−1.082	0.483	5.010	1	0.025	0.339	0.131	0.874
	Mode (motorbike)	−1.273	0.541	5.530	1	0.019	0.280	0.097	0.809
	Mode (bike)	0.354	0.665	0.283	1	0.595	1.424	0.387	5.249
	Age			7.120	3	0.068			
	Age (15–24)	1.056	0.424	6.196	1	0.013	2.876	1.252	6.608
	Age (25–44)	0.891	0.408	4.776	1	0.029	2.437	1.096	5.419
	Age (45–64)	1.013	0.412	6.045	1	0.014	2.755	1.228	6.178
	Children (no)	−0.576	0.266	4.676	1	0.031	0.562	0.334	0.948
	Constant	0.825	0.622	1.761	1	0.184	2.283		

interval of 95% (0.131; 0.874)). However, there seems to be a tendency for the odds to increase when it comes to users of sustainable modes.

For the variable 'existence of children not older than 15 years', the odds of accepting to reside in a car-free neighbourhood decrease 44% if the person does not have any children, in comparison to a person who does. This result, which meets the 'European profile' identified in the literature, is all the more interesting when we note, through the contingency tables, that people with children are the ones who mostly have a car and who tend the least to not having a car by option (the level of significance for the chi square test is 0.006, thus the dependence of the distribution of those two variables is statistically significant). The introduction of a new variable in the logistic regression model (=1 possession of both children and car; = 0 otherwise) shows that it has statistical significance (significance value = 0.016): the odds of accepting to reside in a car-free neighbourhood decrease by 48% if a person possesses neither any children nor car (or only one of these), in comparison to a person who possesses both.

For the variable 'age':

- The odds of accepting to reside in a car-free neighbourhood increase 188% if the person is 15 to 24 years old, in comparison to a person older than 65 years.
- The odds increase 144% if the person is 25 to 44 years old, in comparison to a person older than 65 years.
- The odds increase 178% if the person is 45 to 64 years old, in comparison to a person older than 65 years.
- Therefore, for the variable 'age', the descending order of odds of accepting to reside in a car-free neighbourhood is: 15–24, 45–64, 25–44 and ≥65.

4.2. The necessary conditions for the successful implementation of a car-free neighbourhood in the Brazilian reality

More specific aspects were assessed considering only those who responded that they would probably or certainly live in a car-free neighbourhood (57% – 219 interviews). When asked whether they would prefer to live in a car-free neighbourhood located in the centre or on the outskirts of the city, on a 5-point scale from the most peripheral location to the most central, around 51% said they would prefer more central locations and around 29% more peripheral ones (Table 5).

Another issue that we investigated was whether or not people would accept, in addition to restrictions on car use, a restriction on car possession. The interviewees were made to read the following sentence: 'within this type of neighbourhoods it is not possible to use a car/motorcycle (restricted use). If you lived in a neighbourhood of this kind, you would accept car ownership to be also prohibited'. The answer was clear: 82% said 'strongly disagree' or 'partially disagree'.

The interviewees were also asked an open question: what would be the three necessary conditions for you to accept living in this neighbourhood? The most

Table 5. Assessment of opinions regarding the best location for a car-free neighbourhood (in %).

	Most peripheral location possible		Intermediate		Most central location possible	Don't know/no answer
Would you prefer to live in a car-free neighbourhood in a more central or more peripheral area?	20	9	18	22	29	2

frequently mentioned aspects were the presence of businesses and services (61%), excellent public transportation (38%), absence of criminality (27%), good conditions for bicycles and pedestrians (16%), the existence of a system that would not be an obstacle for emergency situations (14%), short distances (12%) and green and leisure areas (10%). One more open question was posed to the interviewees: what would be the three major difficulties associated with residing in a car-free neighbourhood? The most common answers were the occurrence of emergency situations (16%), the transportation of heavy materials (16%), the distances (14%) and the population's acceptance/adaptation (11%).

We also assessed whether or not the car-sharing system and home deliveries would be perceived as beneficial by the population, as seen in Table 6 (same sample – 219 interviews).

Both systems received very positive responses, with home deliveries obtaining better results, probably due to the city's population being unaware of the car-sharing system. In a previous question, it was acknowledged that only 7% of the sample had ever heard of this system and knew what it consisted of. Taking into account that the home delivery services are extremely popular, and a common practice for the majority of shops and supermarkets, we considered this system to be known among the inhabitants of Florianópolis.

Finally, returning to the original sample (385 interviews), we collected data on some perceptions regarding the car-free neighbourhood (Table 7).

Table 6. Assessment of the perception of potential mitigation measures for the absence of cars (in %).

	Strongly disagree	Partially disagree	Neither agree nor disagree	Partially agree	Strongly agree	Don't know/no answer
The car-sharing system is a system where cars can be rented for just a few hours, according to the user's needs. This system could help those who live in a car-free neighbourhood and need to go to another place in the city	10	16	6	33	33	2.
Home deliveries could help to overcome some difficulties for those who live in a car-free neighbourhood	1	6	3	43	45	2

Table 7. Assessment of some perceptions regarding car-free neighbourhoods (in %).

	Strongly disagree	Partially disagree	Neither agree nor disagree	Partially agree	Strongly agree	Don't know/no answer
Nowadays, the city of Florianópolis has conditions for implementing a car-free neighbourhood	36	37	3	13	5	6
A car-free neighbourhood would have a positive impact on the image of the city of Florianópolis	4	12	11	35	35	3
Most people would accept living in a neighbourhood of this kind, if all the conditions were met in that place	18	37	3	22	10	10

The general perception is that the city cannot meet the conditions required for a car-free neighbourhood, most people wouldn't accept living in a neighbourhood of this kind, but that it would have positive effects on the city's image.

5. Analysis of the conditions to be provided in car-free neighbourhoods in the reality of medium-sized cities in Brazil

Based on the analysis and interpretation of the data gathered from the questionnaires and on the existing literature on this topic for European countries, some general guidelines were drawn up regarding the conditions required for the success of a car-free neighbourhood in Florianópolis and cities with similar characteristics.

In a country like Brazil, where there are no examples of car-free neighbourhoods, it appears to be more feasible to opt for the construction of a new neighbourhood (rather than the restriction of cars in an existing/consolidated one), so as to ensure that people who live there agree with the implementation of the system. What the questionnaires revealed is that we are still far from reaching a consensus. The literature too seems to support the idea of building a new neighbourhood.[1] Furthermore, it would be politically very difficult to remove the right to circulate in cars from the existing residents. The construction of this type of neighbourhood in a new location allows for a long-term strategy, specifically at the urbanistic level, without the constraints that an already established and developed urban environment entails. The car-sharing system is one option which could be practised in the neighbourhood. In relation to home deliveries, it is recommended that at least one commercial centre in the area elaborates an agreement with the neighbourhood, so that this service can be made available to the residents. The entire neighbourhood has to be conceived around sustainable modes of transportation if these places are to become viable. Indeed, the existence of a good public transportation system and good conditions for pedestrians and cyclists are basic requirements that must be fulfilled from the moment residents move into the neighbourhood.[2] It is even possible to offer residents free passes for public transportation during the first months of their staying.[3] The replacement of car infrastructures (roads and parking areas) with green and leisure areas is also highly regarded by the general population. Considering the results obtained for the logistic regression, a future neighbourhood would tend to comprise a fair number of children and infrastructure for them, such as children's parks and schools, would thus be important.

Despite the concern for safety expressed by the population, the neighbourhood should be completely open to the community, as this is an essential requirement with respect to the educational feature of the neighbourhood. The more people are moving through the streets, leaving their condos or cars, the less the streets will be prone to criminality. Streets will no longer be merely a place to pass through and instead they will become a place of conviviality, with the street furniture playing a key role (Wright 2005; Crawford 2009). However, in view of the Brazilian reality, all measures deemed necessary for ensuring the safety of residents need to be adopted (for example the use of private security).

The neighbourhood must be located in an area that is relatively close to the central area (the results of this question show that there is a slight preference for central areas, consistently with what is mentioned in some literature[4]). However, a balance must be reached, because people want to enjoy the advantages of an environment without cars and being too close to the centre may exclude some of these advantages. In addition, a more central location always has the advantage of reducing the expenses associated with infrastructure and services, whose construction would be indispensable in more peripheral locations, in order to reduce the translocation needs (people wish to have services near them).

The size of the neighbourhoods seems to represent the only significant difference which needs to

be considered in relation to the European models, since most of these are relatively small, and exclusively residential, but in order to optimise the educational role of the neighbourhood, to establish economically viable services (the neighbourhood must have a population large enough to make it possible) and considering the aspects revealed in the literature review in relation to this point,[5] it appears that Brazil would need to construct larger neighbourhoods, as verified in Vauban, although always taking into account that the distances need to be compatible with non-motorised modes of transport. In summary, the neighbourhoods would be mixed and compact developments, in order to reduce travelling needs and distances. In order to ensure short distances within the neighbourhood (an aspect which is both one of the conditions and a concern of the general population), concentrating a significant population, the densities must be relatively high.

Of the models described in the literature review in relation to car-free neighbourhoods in Europe, the one which appears to be most suitable for the Brazilian reality is visually car-free areas. It is not feasible to opt for an absolutely car-free neighbourhood, that is, with restricted car ownership (restrictions on the residents possessing a car were rejected by the majority of the population), or for the concepts of low-car or parking-free areas. The advantages of the latter two are inferior to those associated with a neighbourhood with cars visually absent, including from the educational aspect. Furthermore, the population seems to support the proposed concept and thus a 'lighter' concept is not required.

Regardless of the penetration level of cars into the area, exceptions to the use of cars inside the neighbourhood should be allowed for cases of emergency, one of the major concerns of the population. Therefore, the control of the access to the neighbourhood should not have permanent physical barriers. Regarding accessibility for elderly people or people with disabilities and for transportation of goods (another concern of the general population), one solution would be to allow the circulation of small electric cars. The residents' cars would have to remain in car parks located on the periphery of the neighbourhood.

Considering the concern of the population itself regarding the support of the latter for this type of project and the information obtained from the literature review,[6] the population around the neighbourhood and, more importantly, future residents should take part in the planning process, participating in the decision processes before and during the operation of the neighbourhood. The participation of the future residents in the planning process increases the probability that they agree with the measures that will be imposed.

It should be emphasised that it is essential for the implementation of a car-free neighbourhood to be preceded by a broad legal framework at numerous levels (one of the concerns cited by several publications in this area – see AddHome 2011), starting with a master plan for the city which promotes (or, at least, enables) a project of this kind and then moving on to the necessary amendments to the traffic legislation, traffic signals and certain legal limits, such as the replacement of the requirement according to which buildings shall have a minimum number of parking spaces for one establishing that they cannot have more than a given maximum number of those spaces. Car-free neighbourhoods must also be promoted on a national level. They could be included, for example, in the National Policy for Sustainable Urban Mobility, of the Ministry of Cities.

At an early stage, the city needs the effective promotion of sustainable modes of transportation and intermediate car-free measures, which, for the sake of the success of a car-free neighbourhood, ought to be implemented in a fractional and progressive manner and should begin some years prior to the implementation of the neighbourhood, in order to prepare the population and sensitise them to an urban environment with less cars. People who live in the neighbourhood must be able to move around to other parts of the city in non-motorised

means of transport or in public transport, without suffering losses at the level of mobility.

In addition to promoting an urban form that fosters a more sustainable mobility, the neighbourhood is an opportunity for the implementation of the latest and most innovative measures of eco-construction and energy.

6. Conclusions

Although the concept of car-free neighbourhoods dates from the nineties, its actual implementation is still circumscribed to a restricted number of countries, mainly in the north of Europe.

In a country like Brazil, unlike European countries where the implementation of this concept is the result and consequence of good mobility policies, a car-free neighbourhood will have to be a starting point and not a point of arrival. This will be an opportunity for re-education and changes in the attitude of the population towards cars. The model for car-free neighbourhoods that best suits the Brazilian reality is a visually car-free area. Its characteristics, with the exception of its size (Brazil would need to construct larger neighbourhoods), are similar to the ones already found in European countries. The neighbourhoods would be mixed and compact developments, in order to reduce travelling needs and distances, located in an area that is relatively close to the central area. Some of the neighbourhood characteristics were defined after the analysis of open questions. The most common methodology to treat these kinds of studies is the stated choice approach that proves itself to be very reliable. However, it restricts the analysis to predefined variables. This study being the first of the kind in Brazil and having no knowledge about the population preferences, we decided to analyse open questions, complemented by questions in the Likert scale and the bibliographic analysis of the good practices adopted in the already existent car-free neighbourhoods.

Through the logistic regression, the conclusion has been reached that users of sustainable modes of transportation, people younger than 65 and parents are more likely to live in a car-free neighbourhood.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. A Reutter research (2003) stated that the only existing project where there was an attempt to convert an existing neighbourhood into a car-free model occurred in Johannesplatz, in the city of Halle, Germany. Based on later surveys, it was concluded that the majority of the residents regarded the traffic-calming measures as positive, but the measures for reducing car dependence were not as successful.
2. The characteristics, specifically related to mobility, present in this type of neighbourhood, already existent in Europe, vary greatly, especially regarding the penetration level of cars in the area. Nevertheless, there are a number of general characteristics that can be noted (Glotz-Richter 1995; Wright 2005; Morris et al. 2009; AddHome 2011; Melia et al. 2012):

    - effective measures for promoting sustainable mobility which affect the entire city and not only the neighbourhood;
    - restrictions on the use and, in some cases, on the possession of automobiles;
    - large-scale traffic calming measures;
    - very effective management of the parking system;
    - existence of car-sharing clubs;
    - high quality public transportation at all levels;
    - existence of bicycle paths and all kinds of infrastructure for promoting bicycle use, such as bicycle racks, bicycle parking spots, drinking fountains and bike-sharing places;
    - a very well structured pedestrian network, prepared for universal mobility.

3. Free bus ticket for the first months is a feature of some European car-free neighbourhoods (AddHome 2011). Bamberg (2006) reported a study whereby new residents of a regular neighbourhood were offered a free bus ticket and

customised information on the use of public transportation. The results indicate that, in comparison with the control group, the studied group used public transportation significantly more. This means that when due conditions and information thereon are provided for at the time of decision making on mobility, the use of sustainable modes is enhanced.

4. Wood (1997) discussed whether the best location for a car-free neighbourhood is central or peripheral. This author analyses some examples of its application and concludes that most people prefer the most central areas for the implementation of such zones, although this is not consensual.
5. Morris et al. (2009) stated that small neighbourhoods do not present all of the advantages of larger ones, since it is more difficult to isolate external interference from the surrounding areas, particularly in terms of noise and air pollution.
6. One feature of the European car-free neighbourhoods is the openness to public participation in their implementation and maintenance, which is highly valued by the inhabitants. This approach, where the use of sustainable means and refraining from car use seem to have been maximised, has proven to be more effective towards achieving sustainable mobility patterns (Scheurer 2001).

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