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Unfolding barriers for urban mobility plan in small and medium municipalities – A case study in Brazil

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ABSTRACT

This paper investigated barriers for the design and implementation of Urban Mobility Plans in small and medium-sized cities in the State of São Paulo, Brazil. To achieve this objective an exploratory survey was carried out with specialists involved in the urban planning processes of such cities. A total of 22 barriers were listed, and, using the Keiser criterion, these barriers were grouped into seven factors: (1) resources availability; (2) practical and technological; (3) city characteristics; (4) budget constrains; (5) social and cultural; (6) organizational; and (7) lack of infrastructure for sustainable vehicles; a grouping that, in general, was similar to those found in the literature. The first main barrier encountered in the municipalities analyzed were difficulties in finding mobility solutions that adequately meet all stakeholders' needs, followed by budget constraints for implementing actions toward more sustainable transport modes. Even though the complexity of the actors involved is seen as one of the main barriers to urban planning, it is still necessary to effectively involve the population in the decision-making process, so that all needs are considered, and consensual solutions are reached. Through the Spearman correlation method, other barriers closely associated with the first main barrier were reconciling the mobility needs of the population with the already existing infrastructure and preference for motor vehicles. For the second main barrier, other closely correlated variables were insufficient data collection for the preparation of urban mobility plans and lack of qualified workforce within municipal agencies to both elaborate and implement the actions contained in the plans. These correlations suggest that a deficient budget hinders the development of sustainable urban mobility in several stages of the process, including the diagnosis phase (data collection).

1. Introduction

The continuous sprawl of urban areas pressures urban systems (Bibri and Krogstie, 2017), especially the transport system, which directly impacts urban mobility (Forsey, 2017). In addition, urban transportation accounts for about 80% of congestion costs, 23% of CO_2 emissions and 38% of traffic deaths worldwide (May et al., 2017). Consequently, adequate urban mobility planning is essential to achieve more sustainable cities.

Urban mobility has been the subject of extensive academic, and research and development efforts around the world, deriving models, systems, methodologies, techniques, guidelines and awareness campaigns addressing different aspects of mobility management (Tyrinopoulos and Antoniou, 2013). Current debates on urban and academic circles focus on the role of sustainability in

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urban planning and development, and on the search for answers to the main challenges deriving from a rapidly evolving urbanization and to the unsustainability of the existing urban structures (Bibri and Krogstie, 2017).

Promoting an environment based on sustainable urban mobility goes beyond providing effective solutions for public transport. It must also include adaptive transport services, modern infrastructures, tools for managing traffic, awareness campaigns, well-coordinated mobility schemes, and advanced intelligent transport system solutions, thus allowing the population to satisfy its mobility needs (Tyrinopoulos and Antoniou, 2013). Urban mobility is a vital component of any city, not just of the city's physical form, but also of its social and economic development.

Even though urban mobility has already been the subject of extensive research, there is a gap in the literature regarding the governance of urban mobility, due to its complexity and political and technical conflicts, which arise in a multifaceted socio-technical arrangement (Forsey, 2017).

In addition, the improvement toward sustainable urban mobility is a general environmental concern on both local and international levels. Some examples are the Sustainable Urban Mobility Plan in European countries (May et al., 2017), the ecoMOBILITY program in Canada, the Indian Sustainable Urban Transport Project in India (Marletto and Mameli, 2012) and the Australian Public bicycle-sharing programs (Mateo-Babiano et al., 2016). Although the development of urban mobility plans is not mandatory in some developed countries, such as Germany (May et al., 2017), it plays a key role in developing countries due to its social benefits.

Brazil implemented in April of 2012 the Urban Mobility Law No. 12,587/2012 (Brasil, 2015) that requires cities with more than 20,000 inhabitants to develop urban mobility plans. Although this law represents an advance toward a more sustainable mobility in the country, in reality several municipal agencies face practical challenges to develop and implement the necessary measures.

Even though the challenges and barriers to urban planning are discussed in the literature, the barriers are not presented in a comprehensive way (Tilaki et al., 2014), that is, they are presented in different taxonomies and in general are elaborated through a literature review. Other papers discuss specific barriers, such as barriers to the integration of climate change into urban planning (Uittenbroek et al., 2013) or barriers to population participation in the planning process (Morrison and Xian, 2016). Therefore, a quantitative study about barriers to the urban mobility plans is a gap in the literature, especially for small and medium-sized cities in developing countries.

Thus, the objective of this research is to perform a quantitative analysis of barriers to the implementation of urban mobility plans in small and medium-sized cities. To achieve this objective, a survey-type exploratory research was carried out, with specialists involved in the urban planning process of small and medium-sized cities in Brazil.

Following this introduction, Section 2 presents the literature review about barriers in urban and transportation planning. Section 3 presents the methodology, emphasizing sample definition, data collection procedures and research instruments. Section 4 presents the research results in the form of descriptive statistics, correlation analysis, factor analysis and the Kruskal-Wallis test. Section 5 analyses the results in the light of the literature on barriers for urban mobility plans. The final section presents the conclusions and the limitations of this research.

2. Theoretical background

2.1. The Brazilian urban mobility Plan

Brazil is a predominantly urban country, with over 80% of its population living in the cities (Brasil, 2015). Considering this scenario, the main challenge concerns the planning of and intervention in mobility, housing and infrastructure (LIMA, 2014). The Brazilian urban planning model is not conducive to an egalitarian and sustainable growth, notably because the majority of the population resides on areas far from their recreation and work places, which are usually concentrated in the city center (Brasil, 2015). Thus, a new concept was needed: that of sustainable urban mobility. This concept is an alternative mobility plan that privileges people, with their singularities and fragilities, instead of vehicles. Sustainable urban mobility is also the main aspect to consider in urban development policies (Machado and Lima, 2015). Over the last few years, the need to elaborate measures and laws targeted to sustainable mobility has grown.

The inclusion in the 1988 Constitution of a chapter specific to urban politics represented an advance in this direction (Brasil, 2007). The 1990's marked the transition of the urban transport responsibility from the federal government to the municipalities, as proposed by the 1988 Constitution (Gomide and Galindo, 2013). Another mark on the political sphere was the elaboration of the City Statute in 2001, which through law no. 10,257/2001 determined the need for a directive plan approved for cities with over 20,000 people, regulated urban procedures and defined instruments for urbanism and intervention, partnerships, participative planning, land use and management (Lima, 2014). This statute also determined that cities with over 500,000 inhabitants needed to develop a transport plan. It was in this environment of strengthening urban politics that the Ministry of Cities was created in 2003, bringing together the most relevant areas from the social and economic spheres with urban development strategies. This was effected through the National Urban Development Policy (PNDU for the initials in Portuguese), whose goals were to improve the material and individual living conditions in the cities, reduce social inequalities, and guarantee environmental, social and economic sustainability (Brasil, 2007).

Notwithstanding, the greatest mark towards urban mobility was law no. 12,587/2012, known as the National Law of Urban Mobility. This law makes it mandatory for cities with over 20,000 inhabitants to elaborate a Urban Mobility Plan (UMP) and it defines the directives to guide the regulation and planning of urban mobility in Brazilian cities. The law does not deal exclusively with management of transport systems, as the concept of sustainability is also linked to the efficiency of city management and human necessities, relating other concepts, such as participative management and environmental aspects. The recent implementation of this

policy demonstrates the concern that the federal government has about sustainable urban mobility in an increasingly urbanizing context. Because it is recent, the concept of urban mobility is still commonly associated to transport mobility, specifically the motorized modes, restricting the practical analysis to automobile circulation and collective transport use. However, mobility can also occur not only through the use of less polluting or more efficient modes, but also through compliance with people's needs, without the need for long trips.

The concept of sustainable urban mobility, specifically in Brazil, possesses four complements, which are equally structured in the policies development by the Federal Government: social inclusion, environmental sustainability, participative management, and democratization of the public space (Brasil, 2007). Accessibility is related to three of these complements, namely social inclusion, participative management, and democratization of the public space. From an egalitarian transport system perspective, accessibility can be understood as equality in the access to transport options and trips, as well as the conditions of such access (Viegas, 2001), that is, it is the quantity and diversity of spatial opportunities that can be reached within a given time frame. Combining the objectives of sustainability and accessibility is central to overcoming the existing barriers between the environmental, social, and economic aspects (Bertolini and Clercq, 2003). Urban sustainability, as mentioned before, is not just about making cities more efficient regarding resource utilization; the main objective is to improve the quality of live by providing housing at accessible prices, job opportunities, and facilities and services in a safe and good environment (Banister, 1998). In this way, sustainable mobility is mobility in conformity with the main demands for sustainable development (Høyer, 1999), which is essential for the proper functioning of the local and national economies (Trynopoulos and Antoniou, 2013). In other words, sustainable urban mobility fulfills the basic individual necessities and allows for the freedom of movement for society as a whole, including free choice of transportation modes in an environment that is safe and harmless to human health and the ecosystems (Silva et al., 2015).

The establishment of PNDU in Brazil is relatively recent and there is not a specific tool for the evaluation of urban mobility projects yet (Brasil, 2012), even more so because the Urban Mobility Plan (UMP) can be elaborated with different levels of detail. The plan may present a strategic vision only, being limited to establishing general directives for the mobility system, financing model, and public management, and establishing the actions, programs, and projects needed for the implementation of such directives. Or, the plan may present an executive vision by adding to the strategic vision greater detail to the proposals, such as developing an investment plan and a financing model in the operational or technological areas for the public transport network and all the associated urban mobility infrastructure (Brasil, 2007). With the objective of incentivizing and guiding the municipalities in the process of elaborating a UMP, the Ministry of Cities has created and made available a Reference Manual (Brasil, 2015), containing an organized set of information about the elements that compose a mobility plan, the work methods and the planning process. The Reference Manual is important in the formulation of principles and concepts that need to be approached and in the description, through a methodology chapter, of the activities that should be followed in the elaboration of the plan. Notwithstanding, it is little effective in giving the fundamentals of how to proceed with the plan, not emphasizing an integrated planning of land and transport use (Mello and Portugal, 2017).

Despite the visible need and the legal requirement, the plans are most often not carried through or do not meet the established requisites (Mello and Portugal, 2017). One of the main probable causes regarding this issue, considering the Brazilian scenario, is the lack of autonomy of the municipalities, due to low fiscal, financial, and institutional capacity to handle all their constitutional functions, including urban politics (Fernandes and de Araújo, 2015). The lack of a planning culture (Rubim and Leitão, 2013) also interferes in this situation. Other factors contributing negatively to this problem are an undervalued technical staff and budget, management, and methodological resources that are incompatible with their attributions (Filippin and Gemelli, 2011). In this way, similarly to what happened to the directive plans, there is a possibility that the results from the UMPs will be just pre-formatted documents that may even be implemented, but do not have the assertiveness to transform the mobility and quality of life of the population (Rubim and Leitão, 2013). The UMP was not thought out as the final objective of a reflection and planning work, but rather it is the initial point for the municipal administration to implement its policies and rethink and continually update its proposed measures.

Analysis of the international literature presented points of similarity with the problems encountered in Brazil, specially problems concerning the elaboration and implementation of urban mobility plans.

2.2. Barriers to Urban mobility plans

A literature review was performed to list barriers to the urban mobility plan, in order to provide a foundation for the research work. A barrier in transport policy is an obstacle, which prevents a given policy instrument from being implemented, or limits its implementation in such a way that some policy measures are overlooked and the designed strategies are less effective (May et al., 2006). Yet, for Banister (2005), a barrier is a force that prevents a measure from being implemented in its ideal form, either reducing its potential once implemented or making it impossible, at least in its most effective form. These barriers can be grouped and classified, according to these authors as follows.

May et al. (2005), in a study for the European Commission, grouped the barriers into four main categories: legal and institutional barriers, financial barriers, political and cultural barriers, and practical and technological barriers. Banister (2005) divided them into six: resource barriers, institutional and political barriers, social and cultural barriers, legal barriers, side effects and other physical barriers. The authors' classifications are quite equivalent. The category of "legal and institutional" barriers from May et al. (2005) is similar to Banister's "institutional and political" and "legal" barriers. May et al.'s (2005) "financial" barrier is equivalent to Banister's "resource" barrier, while their "political and cultural" barrier is similar to Banister's "social and cultural" and "physical" barriers. The "side effects" barrier of Banister (2005) does not clearly present a corresponding one from May et al. (2005), but refers to some

variables repositioned in other groups.

Resource Barriers can be represented by the lack of investments, infrastructure or resources available for the realization or continuity of initiatives in urban mobility. It may involve minimum requirements of structure or demand in order to ensure the financial viability of new public transport models (Lohrey and Creutzig, 2016). In addition, it also deals with situations where production costs are determinant barriers to the development of mobility plans, which also involves pressure on other variables (Browne et al., 2012). A study on the progress of mobility in 22 Italian cities identified the limitation of resource barriers by highlighting that the amount of financial resources allocated is responsible for the differences, among cities, in the capacity to promote projects in urban areas and to improve sustainable mobility (Pinna et al., 2017).

Nieuwenhuijsen et al. (2017) described the need for a comprehensive view in policy decisions about the links between urban planning and transport planning, environmental exposure, behavior and human health to understand to what level and extent actions can be formulated most effectively. This factor is important because poor technical and administrative capacity can easily discourage innovative measures (LIMA, 2014), which are characterized as political and institutional barriers.

The literature suggests that it is necessary to encourage stakeholders to participate actively in the formulation of urban mobility strategies, to achieve consensus towards the requirements of urban mobility (Doi and Kii, 2012). The mitigation of cultural barriers includes the implementation of measures that restrict or discourage car use, for example, which will have to overcome some resistance by some citizens, mainly because a general improvement in urban mobility will only occur in the long term (Rubim and Leitão, 2013). The approach of this class of barrier tries to identify the difficulties encountered with the lack of public acceptability or cultural and interest conflicts, in order to overcome these situations (Mello and Portugal, 2017).

Jones (2014) highlights the importance of technology as the solution to mobility challenges. Technology plays a crucial role and has straightforward impacts on transport efficiency, ensuring the best available solution in terms of engine design, alternative fuels and the use of renewable energy sources (BANISTER, 2008). Thus, the literature dealing with technical barriers also includes the availability of cleaner technologies as an important point for sustainable urban mobility (Corazza et al., 2016a). The difficulty in collecting valid and sufficient data related to pollutant emissions and the characteristics of urban journeys (Silva et al., 2015) is also a technical and practical barrier to the development of urban mobility plans.

In summary, through the literature review it was possible to divide the barriers in two levels: those related to the makings of the urban mobility plans, as in May et al. (2017), and those related to the selection of specific policy measures, as in Banister (2005).

3. Methods

The research used a quantitative approach, and the data collection method was based on a self-administered survey questionnaire. The use of questionnaires for data collection is a widely used method in the area of management (Baruch, 1999). The method of analysis is quantitative, using descriptive statistical techniques, multivariate analysis, factor analysis, bivariate analysis, with correlation coefficient analysis, and adequacy tests of the sample.

3.1. Sample definition

The state of São Paulo is the most densely inhabited Brazilian federal unit and has the highest number of vehicles per capita. The survey focused on 193 municipalities classified as small and medium-sized cities (up to 750 thousand inhabitants). One of the reasons to choose small and medium-sized cities is that urban planning is more effective there than in large-scale and metropolitan cities, and they have different problems and issues than metropolitan areas (Cardoso et al., 2017).

3.2. Research instrument preparation

The first step to elaborate the research instrument was the survey of barriers to the adoption of the Urban Mobility Plan. Based on the barriers found in the literature, 41 assertions were originally formulated. However, in order to improve the adequacy of the variables, the assertions were reformulated, and some were grouped, reducing the assertions to 22. This reduction was made through a focal group with 4 experts in urban planning. Thus, it was possible to guarantee the comprehensiveness of the set of variables and to increase the specificity of each one, in order to conduct an exploratory factor analysis.

Starting from the barriers identified in the literature review, the assertions were formulated in such a way as to expand their scope and better fit them to the Brazilian reality. In this way, the literature barriers can be used to substantiate one or more of the final assertions. For example, one of the barriers identified by May (2015) is the poor integration between transport planning and land use. According to Brasil (2007), the local topography can represent a barrier, specially in regards to modal choice, which in conjunction with other natural existing barriers can direct urban growth and consequently limit the adoption of new mobility measures, even more so because some measures might be easier to implement considering the already consolidated built urban environment (Brasil, 2007). Based on these literature barriers, two assertions were formulated: b18 “Due to its well-defined built environment, the city restricts / impedes the options for changes in infrastructure to implement actions contained in the Urban Mobility Plan” and b19 “The lack of space limits the provision of infrastructure for walking and cycling modes.” In assertion b19, the term “lack of space” refers to the unavailability of space in the already existing urban area to build appropriate cycling and walking infrastructures, such as sidewalks and cycleways.

Table 1 shows the 22 assertions developed and their respective literature source.

Table 1
Barriers assertions formulated from the literature.

Assertions	Source
b1) The city faces budget constraints to the development of the Urban Mobility Plan.	López-Lambas et al. (2013), May et al. (2017), Pinna et al. (2017)
b2) The city faces budget constraints to implement the measures proposed in the Urban Mobility Plan.	López-Lambas et al. (2013), May et al. (2017), Pinna et al. (2017)
b3) The city faces budget constraints to invest in more sustainable transport modes.	(Silva et al., 2015), (Browne et al., 2012)
b4) Actions and improvements in the field of mobility are limited by the insufficient transfer of Federal Government funds.	López-Lambas et al. (2013), May et al. (2017), Pinna et al. (2017)
b5) Data collection budget are insufficient for preparation and implementation of the Urban Mobility Plan.	López-Lambas et al. (2013), May et al. (2017), Pinna et al. (2017)
b6) Training budget is insufficient for preparing the professionals working in the Urban Mobility Plan.	López-Lambas et al. (2013), May et al. (2017), Pinna et al. (2017)
b7) The segmentation of municipal agencies hinders the flow of information to the Urban Mobility Plan.	(Hull, 2005), (Hull, 2008), (May, 2015), (May et al., 2017), (Brasil, 2015)
b8) Dependence on other governmental agencies makes it difficult to adopt mobility solutions.	(Hull, 2008), (May, 2015), (May et al., 2017)
b9) There is a lack of qualified workforce within the municipal agencies for the elaboration of the Urban Mobility Plan.	(Lima, 2014), (May et al., 2017), (Brasil, 2015), (Rubim and Leitão, 2013)
b10) There is a lack of skilled labor in the market for the elaboration of the Urban Mobility Plan.	(LIMA, 2014), (MAY et al., 2017), (Brasil, 2015), (Rubim and Leitão, 2013)
b11) There is a lack of qualified workforce within the municipal agencies for the implementation of the actions contained in the Urban Mobility Plan.	(LIMA, 2014), (MAY et al., 2017), (Brasil, 2015), (Rubim and Leitão, 2013)
b12) There is a lack of skilled labor in the market for the implementation of the actions contained in the Urban Mobility Plan.	(LIMA, 2014), (MAY et al., 2017), (Brasil, 2015), (Rubim and Leitão, 2013)
b13) It is difficult to give voice to the desires of the population.	(BANISTER, 2008), (Doi and Kii, 2012), (Baumann and White, 2012), (Mello and Portugal, 2017)
b14) It is difficult to reconcile the mobility needs of the population with the available services and infrastructure.	(Escobar et al., 2013)
b15) By involving many stakeholders (population, NGOs, public agencies, and companies) it is complex to adopt solutions in the Urban Mobility Plan that please everyone.	(Baumann and White, 2012), (Rubim and Leitão, 2013), (Mello and Portugal, 2017)
b16) The preference for motor vehicles (private or collective) is an obstacle to investing in more sustainable infrastructure and modes of transport.	(Banister, 2008), (Corazza et al., 2016b), (Baumann and White, 2012), (Escobar et al., 2013)
b17) Lack of infrastructure for more sustainable vehicle adoption	(Jones, 2014), (Corazza et al., 2016a)
b18) Due to its well-defined built environment, the city restricts / impedes the options for changes in infrastructure to implement the actions contained in the Urban Mobility Plan.	(Brasil, 2007), (Mello and Portugal, 2017), (MAY 2015)
b19) The lack of space limits the provision of infrastructures for walking and cycling modes.	(Brasil, 2007), (Mello and Portugal, 2017), (MAY 2015)
b20) The city's topography is an obstacle to alternative mobility modes such as walking and cycling.	(Brasil, 2015)
b21) The average temperature of the city prevents sustainable modes of transport such as walking and cycling.	(Brasil, 2015)
b22) The urban violence (in the city) prevents sustainable modes of transport such as walking and cycling.	(Brasil, 2015)

3.3. Data collection

The questionnaire was prepared using the assertions in Table 1. Those assertions were validated and checked for clarity, meaning and interpretation, in order to minimize problems of comprehension, by four independent researchers. The finalized questionnaire was disseminated to the municipalities via “Google forms”, after a previous contact. The questions were structured on a five-point Likert scale, where five alternatives are given: 1) “I completely disagree”; 2) “I disagree”; 3) “I neither agree nor disagree”; 4) “ I agree”; 5) “I fully agree”.

The questionnaire also included control variables about the characteristics of the municipality (number of inhabitants, whether or not the Urban Mobility Plan is being developed and how this process was or is being carried out). These control variables made it possible to verify differences among the respondents. The total number of questionnaires sent was 193, of which 59 offered valid answers, a response rate of 30.6%. This number is acceptable according to the literature on exploratory factor analysis (De Winter et al., 2009; Hair et al., 2005), which can be used to identify the underlying relations between variables, and interpretation of these correlations.

3.4. Data analysis

The results were analyzed using the SPSS 21.0 statistical software. First, a descriptive analysis of the data was performed, calculating the mean, mode, median, and standard deviation. Second, the degree of correlation between variables was measured through the Spearman’s rank correlation method. The relevant significance values were highlighted and a two-tailed significance test was used to estimate the p value. At last, an exploratory factor analysis was performed in order to obtain patterns among variables, aiming to group the variables in barrier categories. Kaiser-Meyer-Olkin (KMO), commonality and Cronbach’s alpha tests were also performed to indicate, respectively, the adequacy of the sample size, which is the reliability measure of the factor analysis, the total

Table 2
Descriptive statistic (n = 59).

	Variable	Average	Median	Mode	Std. Deviation
b1	The city faces budget constraints to the development of the Urban Mobility Plan.	3.593	4	5	1.328
b2	The city faces budget constraints to implement the measures proposed in the Urban Mobility Plan.	4.169	4	5	1.020
b3	The city faces budget constraints to invest in more sustainable transport modes.	**4.254**	4	5	0.883
b4	Actions and improvements in the field of mobility are limited by the insufficient transfer of Federal Government funds.	4.017	4	5	1.042
b5	Data collection budget are insufficient for preparation and implementation of the Urban Mobility Plan.	3.661	4	3	1.198
b6	Training budget is insufficient for preparing the professionals working in the Urban Mobility Plan.	3.949	4	5	1.121
b7	The segmentation of municipal agencies hinders the flow of information to the Urban Mobility Plan.	3.119	3	4	1.288
b8	Dependence on other governmental agencies makes it difficult to adopt mobility solutions.	3.627	4	4	1.049
b9	There is a lack of qualified workforce within the municipal agencies for the elaboration of the Urban Mobility Plan.	3.847	4	4	1.172
b10	There is a lack of skilled labor in the market for the elaboration of the Urban Mobility Plan.	2.864	3	1	1.432
b11	There is a lack of qualified workforce within the municipal agencies for the implementation of the actions contained in the Urban Mobility Plan.	3.712	4	5	1.204
b12	There is a lack of skilled labor in the market for the implementation of the actions contained in the Urban Mobility Plan.	2.983	3	3	1.239
b13	It is difficult to give voice to the desires of the population.	3.356	4	4	1.310
b14	It is difficult to reconcile the mobility needs of the population with the available services and infrastructure.	4.034	4	4	0.964
b15	By involving many stakeholders (population, NGOs, public agencies, and companies) it is complex to adopt solutions in the Urban Mobility Plan that please everyone.	**4.305**	5	5	0.933
b16	The preference for motor vehicles (private or collective) is an obstacle to investing in more sustainable infrastructure and modes of transport.	3.695	4	4	1.221
b17	Lack of infrastructure for more sustainable vehicle adoption	4.051	4	5	1.057
b18	Due to its well-defined built environment, the city restricts / impedes the options for changes in infrastructure to implement the actions contained in the Urban Mobility Plan.	3.424	4	4	1.192
b19	The lack of space limits the provision of infrastructures for walking and cycling modes.	3.576	4	4	1.367
b20	The city's topography is an obstacle to alternative mobility modes such as walking and cycling.	2.915	3	1	1.654
b21	The average temperature of the city prevents sustainable modes of transport such as walking and cycling.	2.864	3	4	1.444
b22	The urban violence (in the city) prevents sustainable modes of transport such as walking and cycling.	**2.356**	2	1	1.214

variance that one variable shares with others, and the measurement of factor analysis whose lower acceptability values range from 0.6 to 0.7.

4. Results

4.1. Descriptive analysis

Table 2 shows that the highest average values were calculated for variables b15, “By involving many stakeholders (population, NGOs, public agencies, and companies) it is complex to adopt solutions in the Urban Mobility Plan that please everyone.”, with an average of 4.305, and b3, “The city faces budget constraints to invest in more sustainable transport modes”, with 4.254. This indicates that these are the main barriers to Urban Mobility Plans according to the respondents.

The lowest mean values were presented by variable b22, “The urban violence (in the city) prevents sustainable modes of transport such as walking and cycling.”, with 2.356, and by variables b10, “ There is a lack of skilled labor in the market for the elaboration of the Urban Mobility Plan” and b21 “The average temperature of the city prevents sustainable modes of transport such as walking and cycling”, both with 2.864. The lowest mean values represent the least determinant barriers to the development of the Urban Mobility Plan according to the respondents.

4.2. Correlation analysis

The correlation analysis showed a large number of significant correlations, for bilateral significance < 0.05. In total it resulted in 88 significant correlations out of a total of 231, about 38.1%. However, significant correlations of the loads were relatively low, between 0.3 and 0.454, as shown in Table 3. It is important to note that variables with similar descriptions have a high significant correlation with each other.

The highest significant load ($p < 0.01$) is located between variable b7 “The segmentation of municipal agencies hinders the flow of information to the Urban Mobility Plan” and b8 “Dependence on other governmental agencies makes it difficult to adopt mobility solutions”, with a load of 0.608. Besides this, other correlations with high loads occur between variable b18 “Due to its well-defined built environment, the city restricts / impedes the options for changes in infrastructure to implement the actions contained in the Urban Mobility Plan” and b19 “The lack of space limits the provision of infrastructures for walking and cycling modes”, with a load of 0.599. The variable with the highest number of significant correlations ($p < 0.01$) with other variables is b14 “It is difficult to reconcile the mobility needs of the population with the available services and infrastructure”, with a total of 15 significant

Table 3
Correlation coefficients.

Spearman's Correlation Coefficients											
	b1	**b2**	**b3**	**b4**	**b5**	**b6**	**b7**	**b8**	**b9**	**b10**	**b11**
b1	1										
b2	**0.396****	1									
b3	**0.413****	**0.545****	1								
b4	**0.379****	0.143	**0.333***	1							
b5	**0.454****	**0.443****	**0.523****	**0.419****	1						
b6	**0.368****	0.143	**0.379****	**0.399****	**0.578****	1					
b7	0.160	0.313*	**0.367****	0.268*	**0.340****	**0.339****	1				
b8	0.186	0.318*	0.197	0.179	0.241	**0.365****	**0.608****	1			
b9	0.259*	0.166	0.155	0.285*	0.319*	**0.414****	0.206	0.234	1		
b10	0.125	0.264*	0.246	0.210	0.315*	0.329*	0.308*	0.184	**0.450****	1	
b11	0.260*	**0.392****	**0.411****	**0.526****	**0.541****	**0.513****	**0.523****	0.268*	**0.372****	**0.337****	1
b12	0.132	0.071	0.256	0.294*	0.228	0.235	0.282*	−0.031	0.307*	**0.533****	**0.505****
b13	0.273*	0.225	0.204	0.071	0.265*	0.153	0.046	−0.027	0.193	**0.403****	0.186
b14	0.078	0.327*	0.152	0.102	0.309*	0.289*	0.261*	0.268*	**0.386****	**0.440****	**0.454****
b15	0.046	0.162	0.176	0.225	0.140	0.180	0.113	0.118	0.217	0.186	**0.463****
b16	0.220	0.015	0.137	0.262*	0.152	**0.354****	0.188	0.313*	0.220	0.153	0.209
b17	0.297*	0.200	0.208	0.093	0.204	0.322*	0.097	**0.359****	0.076	0.164	0.120
b18	0.078	0.011	−0.039	0.175	0.054	0.145	0.124	0.170	0.306*	0.236	0.111
b19	0.065	−0.047	−0.166	0.235	−0.016	0.053	0.068	0.128	0.260*	0.199	0.186
b20	0.118	0.019	−0.079	0.081	−0.067	−0.142	0.175	0.031	0.011	0.024	0.005
b21	0.205	0.168	0.055	0.277*	0.162	0.113	0.176	0.103	−0.023	−0.117	0.185
b22	0.059	0.118	0.188	0.063	−0.046	0.064	0.204	0.214	−0.070	−0.101	0.119

(*continued on next page*)

Table 3 (*continued*)

Spearman's Correlation Coefficients											
	b12	**b13**	**b14**	**b15**	**b16**	**b17**	**b18**	**b19**	**b20**	**b21**	**b22**
b1											
b2											
b3											
b4											
b5											
b6											
b7											
b8											
b9											
b10											
b11											
b12	1										
b13	0.301*	1									
b14	0.304*	**0.454****	1								
b15	**0.363****	0.206	**0.525****	1							
b16	0.042	0.198	**0.448****	**0.446****	1						
b17	−0.131	0.323*	0.320*	0.071	0.319*	1					
b18	0.145	**0.366****	**0.467****	0.254	**0.434****	0.188	1				
b19	0.108	0.326*	**0.430****	0.292*	0.241	0.170	**0.599****	1			
b20	0.100	0.213	0.132	0.151	0.149	−0.007	0.290*	**0.579****	1		
b21	0.037	0.190	0.140	0.070	0.123	0.106	0.104	0.224	**0.530****	1	
b22	−0.053	0.060	0.107	0.161	0.074	0.080	0.013	0.300*	0.204	0.264*	1

*Significance of correlation for $p < 0.05$.
**Significance of correlation for $p < 0.01$ (in bold).

Table 4
Commonality of the variables.

Variables-Commonalities			
b1	0.667	**b12**	0.742
b2	0.700	**b13**	0.739
b3	0.682	**b14**	0.767
b4	0.711	**b15**	0.821
b5	0.674	**b16**	0.697
b6	0.685	**b17**	0.672
b7	0.801	**b18**	0.653
b8	0.833	**b19**	0.757
b9	0.565	**b20**	0.779
b10	0.740	**b21**	0.660
b11	0.765	**b22**	0.544

correlations with other variables, followed by variable b11 “There is a lack of qualified workforce within the municipal agencies for the implementation of the actions contained in the Urban Mobility Plan”, with a total of 13 significant correlations.

4.3. Factor analysis

Tests were performed on the sample in order to determine its adequacy for the factor analysis, as well as its validity. The first test was the commonality test, which presented relatively high values, mostly values above 0.7, with no value below 0.5. These values are considered high (Jung & Lee, 2011) and are arranged as shown in Table 4.

The Kaiser-Meyer-Olkin (KMO) sample suitability test gave a result of 0.679, and Bartlett’s sphericity test had a significance of 0.01, both indicating the adequacy of the sample (Sangle, 2010). Values of KMO over 0.6 are considered significant by the literature (Ugulu, 2015). The Cronbach’s alpha test returned a value of 0.858, indicating good sample consistency for use in factor analysis (Biasutti & Frate, 2017).

To define the variables into factor groups the Kaiser criterion was used (Kaiser, 1960), in which the combination of variables into factor groups are considered for eigenvalues equal to or < 1. This resulted in a total of 7 factors, which were classified as: 1) resources availability; 2) practical and technological; 3) city characteristics; 4) budget constrains; 5) social and cultural; 6) organizational; and 7) lack of infrastructure for sustainable vehicles. The results of the factor analysis are presented in Table 5.

Table 6 presents the composition of factor 1, which is a grouping of 5 variables. The variables present in this factor refer mainly to

Table 5
Factors and loadings of the variables used in the research (relevant values in bold).

Matrix of Rotation Component[a]							
Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
b1	**0.576**	0.044	0.185	0.422	−0.159	−0.094	0.296
b2	0.046	0.119	0.047	**0.789**	0.044	0.218	0.100
b3	0.359	0.017	−0.103	**0.711**	0.139	0.131	0.006
b4	**0.793**	0.058	0.208	0.020	0.146	0.075	−0.095
b5	**0.602**	0.225	−0.065	0.487	0.014	0.097	0.095
b6	**0.679**	0.197	−0.153	0.115	0.142	0.262	0.246
b7	0.208	0.197	0.141	0.245	0.055	**0.788**	−0.125
b8	0.135	0.058	0.023	0.095	0.042	**0.826**	0.342
b9	0.395	**0.600**	−0.025	−0.076	0.069	0.174	0.083
b10	0.095	**0.808**	−0.062	0.215	0.070	0.153	−0.016
b11	**0.515**	0.259	0.040	0.324	0.443	0.291	−0.211
b12	0.252	**0.575**	0.059	0.169	0.298	−0.034	−0.476
b13	−0.027	**0.518**	0.317	0.399	0.140	−0.306	0.310
b14	−0.021	0.506	0.142	0.196	**0.582**	0.147	0.303
b15	0.117	0.122	0.081	0.078	**0.883**	−0.018	−0.024
b16	0.312	0.055	0.080	−0.160	**0.535**	0.116	0.514
b17	0.096	0.062	0.019	0.247	0.048	0.101	**0.765**
b18	0.060	**0.473**	0.372	−0.263	0.251	0.039	0.392
b19	0.005	0.343	**0.679**	−0.249	0.264	0.063	0.208
b20	−0.046	0.085	**0.874**	−0.049	0.008	0.036	−0.041
b21	0.256	−0.203	**0.720**	0.183	−0.001	0.036	0.003
b22	−0.115	−0.333	**0.408**	0.224	0.312	0.325	0.013

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Standardization.
[a]Converted rotation in 13 iterations.

Table 6
Composition of Factor 1 - Resources availability aspects.

Variable	Barrier	Loading
b1	The city faces budget constraints to the development of the Urban Mobility Plan	0.576
b4	Actions and improvements in the field of mobility are limited by the insufficient transfer of Federal Government funds	0.793
b5	Data collection budget are insufficient for preparation and implementation of the Urban Mobility Plan.	0.602
b6	Training budget is insufficient for preparing the professionals working in the Urban Mobility Plan	0.679
b11	There is a lack of qualified workforce within the municipal agencies for the implementation of the actions contained in the Urban Mobility Plan	0.515

limitations directly related to availability of resources.

Factor 2 is also composed of 5 variables as shown in Table 7. The variables share common characteristics that refer to aspects related to: the training of labor to act in the elaboration and implementation of the mobility plans; the difficulty of identifying the population's wishes and transforming them into practical actions; and the constraints imposed by the consolidated (built) urban environment, which prevents or hinders the development of urban mobility plans. In this way, factor 2 covers practical and technological aspects that make it difficult to develop mobility plans.

Factor 3, as presented in Table 8, is composed of 4 variables that describe characteristics of structural aspects of the city. These aspects are intrinsic to each city, making it difficult to adopt good practices or successful implementations elsewhere. Hence, it involves the topography of the city, temperature, urban violence and lack of space for the implementation of alternative modes of transport such as walking and cycling.

Table 9 shows the formation of budgetary aspects, a predominant characteristic of the 2 variables that compose factor 4. In this sense, budget constraints are one of the main barriers to the implementation of the mobility plans developed.

Three variables compose factor 5 (Table 10), which deals with social and cultural aspects that impact the urban mobility policy. This item includes the preference for motor vehicles (b16) and the difficulty in reconciling the mobility needs of the population with the available services and infrastructure (b14). Within the cultural and social aspects, one of the variables with a relevant load factor is the complexity in aligning and conciliating the conflict of interests between all urban actors who compete for urban space (b15). For example, car users want more traffic lanes and do not accept a reduction in the number of lanes for the incorporation of exclusive bus lanes and/or cycle lanes. Shopkeepers want bus stops and parking lots available near their shops. Residents want bus stops near their homes, but not in front of their homes. Bus users want closer bus stops and at the same time faster travel times.

Organizational integration is the common theme among the 2 variables that compose factor 6 (Table 11). Thus, this aspect points out that segmentation of sectors (b7) and dependence between them (b8) hinders the flow of information and decision making.

Factor 7 (Table 12) is composed of a single variable, which is the lack of infrastructure for the adoption of sustainable vehicles, such as: the implementation of cycle lanes; bicycle parking in bus terminals, workplaces, metro and train stations; and electrical points for charging electric cars.

5. Discussion

The factor analysis grouped variables b1 through b22 into categories very similar to the ones found in the literature, such as those from May et al. (2006) and Banister (2005), already mentioned in the introduction. Factor 6 (Organizational aspects) is similar to May et al.'s "legal and institutional" barrier and Banister's "institutional and political" and "legal" barriers. Factor 1 (Resources availability aspects) and Factor 4 (Budget constrains aspects) are similar to May et al.'s "financial" barrier and Banister's "Resources" barrier. Factor 5 (Social and cultural aspects) resembles May et al.'s "political and cultural" barrier and Banister's "social and cultural" barrier, while Factor 2 (Practical and technological aspects) is similar to May et al.'s "practical and technological" barrier and Banister's "physical" barrier. Banister's "side effect" barrier had no clear corresponding barriers identified. The city characteristics aspects (Factor 3) and the lack of infrastructure for sustainable vehicles aspects (Factor 7) can be combined into a second level barrier (selection of specific policy measures), specially because Factor 7 includes a single variable that is conceptually very close to the city's characteristics. However, the particularities of this last correlation should be examined further in future works, as this present work demonstrated a low correlation between the variables in Factors 3 and 7. This can suggest that there are complex aspects in the relation and interpretation of these variables.

Table 7
Composition of Factor 2 - Practical and technological aspects.

Variable	Barrier	Loading
b9	There is a lack of qualified workforce within the municipal agencies for the elaboration of the Urban Mobility Plan	0.600
b10	There is a lack of skilled labor in the market for the elaboration of the Urban Mobility Plan.	0.808
b12	There is a lack of skilled labor in the market for the implementation of the actions contained in the Urban Mobility Plan.	0.575
b13	It is difficult to give voice to the desires of the population	0.578
b18	Due to its well-defined built environment, the city restricts/impedes the options for changes in infrastructure to implement the actions contained in the Urban Mobility Plan.	0.473

Table 8
Composition of Factor 3 - City characteristics aspects.

'Variable	Barrier	Loading
b19	The lack of space limits the provision of infrastructures for walking and cycling modes	0.679
b20	The city's topography is an obstacle to alternative mobility modes such as walking and cycling.	0.874
b21	The average temperature of the city prevents sustainable modes of transport such as walking and cycling	0.720
b22	The urban violence (in the city) prevents sustainable modes of transport such as walking and cycling.	0.408

Table 9
Composition of Factor 4 - Budget constrains aspects.

Variable	Barrier	Loading
b2	The city faces budget constraints to implement the measures proposed in the Urban Mobility Plan.	0.789
b3	The city faces budget constraints to invest in more sustainable transport modes.	0.711

Table 10
Composition of Factor 5 - Social and cultural aspects.

Variable	Barrier	Loading
b14	It is difficult to reconcile the mobility needs of the population with the available services and infrastructure.	0.582
b15	By involving many stakeholders (population, NGOs, public agencies, and companies) it is complex to adopt solutions in the Urban Mobility Plan that please everyone.	0.883
b16	The preference for motor vehicles (private or collective) is an obstacle to investing in more sustainable infrastructure and modes of transport.	0.535

Table 11
Composition of Factor 6 - Organizational aspects.

Variable	Barrier	Loading
b7	The segmentation of municipal agencies hinders the flow of information to the Urban Mobility Plan.	0.788
b8	Dependence on other governmental agencies makes it difficult to adopt mobility solutions	0.826

Table 12
Composition of Factor 7 - Lack of infrastructure for sustainable vehicles.

Variable	Barrier	Loading
b17	Lack of infrastructure for more sustainable vehicle adoption	0.765

Budget constraint is likely one of the main barriers to the implementation of more sustainable transport options, since the two variables that agreed the most, b2 (budget constraints for implementation of proposals) and b3 (budget constraints for sustainable transport), were grouped together in Factor 4 (Budget constrains aspects). In addition to being correlated to each other, these two variables were also correlated with other variables, such as b5 (that deals with lack of resources for data collection) and b11 (that deals with the lack of skilled labor in the municipalities for the implementation of actions). The lack of skilled labor within municipalities, both for elaboration (b9) and for implementation (b11) of the Urban Mobility Plan, is a very relevant and present barrier in the reality of the city halls, and it is influenced by the lack of funds for training the workforce (b6), which is also correlated with the federal government's insufficient transfer of financial resources (b4). This scenario is very clear in the small number of municipalities that have drawn up their own plan without the help of some outsourced company. However, the Federal Government itself offers several courses, in the "distance learning" mode, in areas related to urban planning and management and urban mobility. Even so, it is necessary to think about the possibility of setting up teams to conduct face-to-face training in Brazilian municipalities, given the importance of having qualified technical staff. In addition, with a limited budget, it is difficult to outsource the urban mobility plan (UMP), hindering the capacity of the cities towards a sustainable development.

Factor 1 (Resources Availability) and Factor 4 (Budget Constraints) might potentially be seen as relatable and joined as a single factor. However, the higher-loading variables in Factor 4 achieved low loadings in Factor 1. Still, the variables in Factor 4 had significant correlations with the variables from Factor 1, specially variables b3, which deals directly with budget, and b2, which deals with the planning process. Those barriers are in accordance to the findings of López-Lambas et al. (2013), May et al. (2017), and Pinna et al. (2017).

Variable b11 (lack of qualified workforce within municipal agencies to implement the UMP) might appear to be related to the variables in Factor 2 (Practical and technological barriers), but it had a low loading in this factor and, in fact, it had a better

correlation with variables b4, b5, and b6, which are associated with resource availability (Factor 1). From this perspective, the results from the analysis of the survey responses indicate that variable b11 concerns the lack of workforce availability within the organization from an operational standpoint, while the variables in Factor 2, which are related to workforce, concern the workforce availability or the ability of local government planning sectors and the society to provide the necessary workforce.

As mentioned before, another point strongly influenced by the restricted budget is data acquisition (b5). Municipalities do not have sufficient financial resources available to collect the necessary data to prepare the UMP. The lack of good data and/or data integration is a major barrier especially in the diagnosis phase, which is carried out to identify the situation of urban mobility in the city. This barrier is also encountered in the literature in European countries, however this barrier is linked to lack of data to support decisions for specific solutions (May et al., 2017), which is different from the Brazilian context where the lack of data affects the diagnosis phase. In the open questions, the survey respondents pointed out that lack of data about road and traffic signs conditions, characteristics and sizing of public transport lines, and start and end points of public transport lines are the greatest difficulties in developing an UMP. The absence of an integrated data base, as well as the lack of data, significantly hinders the elaboration of an UMP, because without them it is not possible to analyze the current mobility condition to propose solutions that will be part of the UMP. With regards to more sustainable transport systems, the limitations are diverse. First, cities do not have the financial resources to invest in the development of more sustainable alternatives (b2) and, for options already available, cities do not have enough infrastructure (b17) for these options to be viewed as potential alternatives to users. At the same time, the preference for motor vehicles (b16) is an obstacle to investment in more sustainable infrastructure and modes of transport in the cities. As long as municipalities and other levels of government do not invest in marketing to promote other modes of transportation, the cultural valorization of the private vehicle will remain strong among the population. To reverse this scenario, it may be necessary to give priority to sustainable modes of transportation in the municipal transport policy, and to raise awareness among the population about the damages that private vehicles cause to the sustainable development of the cities and their citizens.

There is also a strong dependency on other sectors inside and outside the municipal authority (b8), and this situation can act as a barrier that hinders the adoption of solutions in the area of mobility. This barrier is also found in the literature (May et al., 2005; May et al., 2017; Hull, 2005).

In addition to promoting more sustainable means of transport, municipalities need to encourage the participation of the population in the elaboration of their UMPs. However, the challenge is to guarantee real and effective participation (b13). Thus, it becomes necessary to ponder means to stimulate effective participation. One way to achieve this, for example, is through meetings with resident associations and NGOs, in order to reach a diverse spectrum of inhabitants. Moreover, it is necessary to make people understand the meaning of an UMP, its implication to urban development, and the causes and effects of individual motor vehicles in the inhabitant's quality of life. It is worth mentioning that the participation of all segments of the population is essential, as it is a means of trying to listen to the needs of all and seeking consensual solutions that meet different interests.

Even though in theory variable b13, which concerns the difficulty in giving voice to the population, could be understood through social and cultural variables, and could, therefore, be included in Factor 5 (Social and cultural aspects), the results indicate that for this specific survey, a deciding aspect in understanding variable b13 is the technical aspect. The reason is that there was a low correlation of variable b13 with the other variables from Factor 5, specially b15 and b16, indicating its weak correlation with social and cultural aspects, while there was a higher correlation with the practical and technical variables. Despite some similar variables having high correlation coefficients, other similar variables have low correlation coefficients, which might indicate an emphasis in specific dimensions. One such example is variable b13, in which there is a potential emphasis in the operational dimension of the collective decision-making process.

Additionally, the well-defined built environment makes it difficult to implement the actions that can be contained in the UMP, and, at the same time, the lack of available space (b19) within this built environment limits the provision of infrastructure for walking and cycling. This last barrier, in conjunction with b16 (the preference for motor vehicles), suggests that city authorities are currently giving priority to motor vehicles over more sustainable modes, since this is a cultural trait of the population and of the urban planning employed thus far.

Despite the new legislation and some urban interventions toward sustainable transportation, Brazil has a long way to change its mobility patterns. The urban growth pattern of Brazilian cities, characterized by little or no planning, has favored this scenario, highlighting the importance of incentivizing the planning for people-oriented cities, especially in medium and small-sized cities, since they can grow their infrastructure in the future focusing on sustainable transportation modes.

5.1. Implications for theory and practice

The quantitative research performed through the factor analysis presented results that are coherent with those found on the literature on barriers to urban mobility plans. Thus, this research can be useful for researchers of this topic.

It was possible to identify that the factor analysis was able to isolate the variables into first level barriers (barriers to the development of urban mobility plans) and second level barriers (barriers to urban transport policy). The first level barriers, b1 through b16, were grouped in factors 1, 2, 4, 5, and 6, while the second level variables, b17 through b22, were grouped in factors 3 and 7. Variable b18 is an exception, since it belongs to factor 2, but should be in factor 3, for affinity reasons.

Although this research was elaborated for the Brazilian context and based on the previous literature (May et al., 2017), general implications of this research for the mitigation of the main barriers to the development of UMP involve:

1. Promote policies that encourage political support and engagement for UMPs;
2. Improve institutional coordination and cooperation among agencies in the Federal, State and Municipal levels;

3. Support the municipal authorities in the development and implementation of the UMP through financial and investment streams;
4. Ensure adequate training for engineers, architects and other professionals linked to UMP development and implementation;
5. Conduct workshops and meetings to encourage effective public participation, share knowledge on best practices, and raise awareness about the importance of mobility polices to be implemented;
6. Improve data collection and analysis for the development of the UMP, research and monitoring the measures implemented;
7. Prioritize infrastructure measures that enable non-motorized modes of transport; and
8. Prioritize investments and uses of the road system that favor pedestrians and collective transport.

5.2. The way ahead

The next ten years should be a tipping point regarding the technological leap towards big data and remote sensing use in urban data science (Creutzig et al., 2019), specially regarding urban sustainability, which encompasses several disciplines, such as urban planning and mobility plans.

This tendency should be highlighted in the data protocols of governmental and non-governmental agencies worldwide (Jacoby et al., 2002). In the Brazilian case the government will need to enforce the current Brazilian legislation on Spatial Data Infrastructures (SDI) and establish a new legislation to conform to international protocols about remote sensing procedures and big data collection and sharing (Davis et al., 2011). One important point regarding SDI is the possibility to access geographic and spatial data without technological restrictions, in a neutral and technologically-standardized codification format (Klopfer, 2005). These data are independent of specific technology and software proprietor, and use free and open-code sources (Bezerra et al., 2015). These are essential steps to overcome missing data and to reduce the cost of urban mobility plans.

Another important barrier, the cultural preference of the Brazilian population towards car use, could be addressed by enacting policies that make car travels more expensive and less attractive, while prioritizing public transport and walking/cycling. Good examples of such measures can be seen in Denmark and the Netherlands (Saelens and Handy, 2008; Pucher and Buehler, 2008). The success of such policies, however, would require adequate and accessible infrastructure to the new modes, so that the transition could occur in a sustainable and inclusive way.

6. Conclusions

This research aimed to identify the barriers that hinder the development and implementation of Urban Mobility Plans in accordance with Law 12,587/2012, in small and medium-sized municipalities in Brazil.

The barriers related to budget constrains have a significant impact in the reality of these cities. This issue stands out because it impacts and influences other barriers and hinders the compliance with the Law within the stipulated deadline (April 2019). The lack of compliance then prevents municipalities from receiving Federal funds for urban mobility, which can have repercussions in the development of more sustainable and accessible cities. Smaller cities feel these limitations in an even more pronounced way than medium-sized municipalities. Only 5% of Brazilian cities have already complied with Law 12,587/2012. Of all the municipalities surveyed in this research, almost half (49.2%) have already elaborated their UMP to date.

The preparation of the UMP itself is not seen as a barrier to the municipalities covered by this research, since for their managers it is clear who is responsible for elaborating the UMP, what are the points that should be covered and what are the objectives that must be achieved through the preparation and implementation of the UMP. In this way, the greatest difficulty lies in putting into practice the measures contained in the plan due to budget restrictions.

This research was exploratory and covered only the small and medium-sized municipalities of the State of São Paulo. For future research it is suggested extending the study area to include municipalities in other states that face very different realities, as well as expanding the analysis to other types of barriers that were not considered in this study, such as lack of political commitment and lack of integration between policy sectors, which appeared transversally in assertions b4 and b7, and lack of integration for the prioritization of sustainable transportation modes. In addition, it is suggested addressing actions and measures to promote engagement and political support for UMPs. Another suggestion for future work is to investigate the necessary data that urban managers need to elaborate the UMP and analyze the possibility of acquiring missing data through new technologies such as big data and remote sensing. Also, it is important to highlight the role that the development of new tools, such as platforms for gathering data, and the implementation of common global protocols and standards for those new technologies will have on the municipal level, not only on the implementation of the UMP, but also on other areas, such as climate change and urban metabolism.

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CRediT authorship contribution statement

Barbara Stolte Bezerra: Conceptualization, Supervision, Formal analysis, Writing - review & editing, Project administration, Funding acquisition, Resources. **Ana Laura Lordelo dos Santos:** Conceptualization, Methodology, Investigation, Writing - original draft. **Diego V.G. Delmonico:** Software, Validation, Formal analysis, Writing - original draft.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tra.2019.12.006.

References

Banister, D., 1998. Barriers to the implementation of urban sustainability. Int. J. Environ. Pollut. 10 (1), 65–83.

Banister, D., 2005. Overcoming barriers to the implementation of sustainable transport. In: Rietveld, P., Stough, R.R. (Eds.). Barriers to sustainable transport: institutions, regulations and sustainability. Routledge.

Banister, D., 2008. The sustainable mobility paradigm. Transp. Policy 15 (2), 73–80.

Baruch, Y., 1999. Response rate in academic studies-A comparative analysis. Hum. Relat. 52 (4), 421–438. https://doi.org/10.1177/001872679905200401.

Baumann, C., White, S., 2012. Making better choices: a systematic comparison of adversarial and collaborative approaches to the transport policy process. Transp. Policy 24, 83–90.

Bertolini, L., LE Clercq, F., 2003. Urban development without more mobility by car? Lessons from Amsterdam, a multimodal urban region. Environ. Plann. A 35 (4), 575–589.

Bezerra, B.S., Cunto, F.C., Barbosa, H.M., Davis, C., Lança, J.F., 2015. Main stumble blocks for a good traffic accident database system - Evidences from Brazil. Latin Am. J. Manage. Sustain. Develop. 2 (2) pp 10.150/LAJMSD.2015.071986.

Biasutti, M., Frate, S., 2017. A validity and reliability study of the Attitudes toward Sustainable Development scale. Environ. Educ. Res. 23 (2), 214–230. https://doi.org/10.1080/13504622.2016.1146660.

Bibri, S.E., Krogstie, J., 2017. Smart sustainable cities of the future: An extensive interdisciplinary literature review. Sustain. Cities Soc.

Brasil. Lei Federal n° 12.587 de 3 de janeiro de 2012. Dispõem sobre as diretrizes da Política Nacional de Mobilidade Urbana. Diário Oficial da União, Brasília, DF, 13 abril, 2012.

Brasil. Ministério das Cidades. PlanMob – Construindo a cidade sustentável. Secretaria Nacional de Transporte e da Mobilidade Urbana, 2007.

Brasil. Ministério das Cidades. PlanMob - Caderno de referência para elaboração de plano de mobilidade, 2015.

Browne, D., O'Mahony, M., Caulfield, B., 2012. How should barriers to alternative fuels and vehicles be classified and potential policies to promote innovative technologies be evaluated? J. Cleaner Prod. 35, 140–151.

Cardoso, R.S., Dorigon, L.P., Teixeira, D.C.F., Amorim, M.C.C.T., 2017. Assessment of urban heat islands in small-and mid-sized cities in Brazil. Climate 5 (1), 1–13.

Corazza, M.V., Guida, U., Musso, A., Tozzi, M., 2016a. A new generation of buses to support more sustainable urban transport policies: A path towards “greener” awareness among bus stakeholders in Europe. Res. Transport. Econom. 55, 20–29.

Corazza, M.V., Guida, U., Musso, A., Tozzi, M., 2016b. A European vision for more environmentally friendly buses. Transport. Res. Part D: Transp. Environ. 45, 48–63.

Creutzig, F., Lohrey, S., Bai, X., Baklanov, A., Dawson, R., Dhakal, S., Lamb, W., McPhearson, T., Minx, J., Munoz, E., Wlash, B., 2019. Upscallingurban data science for global climate solutions. Glob. Sustain. 2 (E2), 1–25. https://doi.org/10.1017/sus.2018.16, 2019.

Davis Jr., C.A., and Fonseca, F.T., 2011. National Spatial Data Infrastructures: the case of Brazil. Washington, D.C.: InfoDEV/The World Bank. Available at http://www.infodev.org/publications.

de Winter, J.C.F., Dodou, D., Wieringa, P.A., 2009. Exploratory factor analysis with small sample sizes. Multivariate Behav. Res. 44, 147–181.

Doi, K., Kii, M., 2012. Looking at sustainable urban mobility through a cross-assessment model within the framework of land-use and transport integration. IATSS Res. 35 (2), 62–70.

Escobar, N., Flórez, J., Portugal, L. Silva, 2017. Reasons for choosing the car in access to mega-events: case of the Confederations Cup 2013, Rio de Janeiro. urbe. Revista Brasileira de Gestão Urbana 9 (1) (in Portuguese).

Fernandes, A.S.A., de Araújo, S.M.V.G., 2015. A criação de municípios e a formalização de regiões metropolitanas: os desafios da coordenação federativa. Revista Brasileira de Gestão Urbana 7 (3), 295–309.

Filippin, E.S., Gemelli, I.M.P., 2011. People management in public administration: the challenge of municipalities. RACE-Revista de Administração, Contabilidade e Economia 9 (1–2), 153–180 (in Portuguese).

Forsey, M., 2017. Education in a mobile modernity. Geograph. Res. 55 (1), 58–69.

Gomide, A.A., Galindo, E.P., 2013. Urban mobility: an unfinished agenda or the return of what never was. Estudos Avançados 27 (79), 27–39.

Hair, J.K., Black Anderson, R.E., Tatham, R.I., 2005. Multivariate Data Analysis, Bookman, 2005.

Høyer, K.G., 1999. Sustainable mobility: the concept and its implications. Phd Thesis. Institute of Environment, Technology and. Society, Roskilde University Centre, Roskilde.

Hull, A., 2005. Integrated transport planning in the UK: From concept to reality. J. Transp. Geogr. 13 (4), 318–328.

Hull, A., 2008. Policy integration: what will it take to achieve more sustainable transport solutions in cities? Transp. Policy 15 (2), 94–103.

Jacoby, S., Smith, J., Ting, L., Williamson, I., 2002. Developing a common spatial data infrastructure between State and Local Government – an Australian case study. Int. J. Geographic Inform. Sci. 16 (4), 305–322.

Jones, P., 2014. The evolution of urban mobility: The interplay of academic and policy perspectives. IATSS Res. 38 (1), 7–13.

Jung, S., Lee, S., 2011. Exploratory factor analysis for small samples. Behav. Res. Methods 43 (3), 701–709. https://doi.org/10.3758/s13428-011-0077-9.

Kaiser, H.F., 1960. The application of electronic computers to factor analysis. Educ. Psychol. Measur. 20 (1), P.141-151. https://doi.org/10.1177/001316446002000116.

Klopfer, M., 2005. Interoperability & Open Architectures: an analysis of existing standardisation processes & procedures. OGC White Paper. O. G. Consortium, Open Geospatial Consortium 26p.

Lima, F.R., 2014. Briefing: Municipal engineering in Brazil. In: Proceedings of the Institution of Civil Engineers-Municipal Engineer. Thomas Telford Ltd, pp. 123–124.

Lohrey, S., Creutzig, F., 2016. A ‘sustainability window’ of urban form. Transport. Res. Part D: Transp. Environ. 45, 96–111.

López-Lambas, M.E., et al., 2013. Rebalancing urban mobility: a tale of four cities. Urban Des. Plann.-Proc. ICE 166 (5), 274–287.

Machado, M.H., Lima, J.P., 2015. Multicriteria evaluation of people with reduced mobility accessibility: A study in downtown Itajubá (MG). Urbe 7 (3), 368–382.

Marletto, G., Mameli, F., 2012. A participative procedure to select indicators of policies for sustainable urban mobility. Outcomes of a national test. Eur. Transp. Res. Rev. 4 (2), 79–89.

Mateo-Babiano, I., et al., 2016. How does our natural and built environment affect the use of bicycle sharing? Transport. Res. Part A: Policy Pract. 94, 295–307.

May, A., Boehler-Baedeker, S., Delgado, L., Durlin, T., Enache, M., van der Pas, J.-W., 2017. Appropriate national policy frameworks for sustainable urban mobility plans. Eur. Transp. Res. Rev. 9 (1). https://doi.org/10.1007/s12544-017-0224-1.

May, A.D., Kelly, C., Shepherd, S., 2006. The principles of integration in urban transport strategies. Transp. Policy 13 (4), 319–327.

May, A.D., et al., 2005. Developing sustainable urban land use and transport strategies: a decision-makers’ guidebook. Institute for Transport Studies, Leeds.

May, A.D., 2015. Encouraging good practice in the development of Sustainable Urban Mobility Plans. Case Stud. Transp. Policy 3 (1), 3–11. https://doi.org/10.1016/j.cstp.2014.09.001.

Mello, A., Portugal, L., 2017. A procedure based on accessibility for the design of Strategic Urban Mobility Plans: the case of Brazil. EURE (Santiago) 43 (128), 99–125 (in Portuguese).

Morrison, N., Xian, S., 2016. High mountains and the faraway emperor: Overcoming barriers to citizen participation in China’s urban planning practices. Habitat Int. 57, 205–214. https://doi.org/10.1016/j.habitatint.2016.08.001.

Nieuwenhuijsen, M.J., et al., 2017. Participatory quantitative health impact assessment of urban and transport planning in cities: a review and research needs. Environ. Int. 103, 61–72.

Pinna, F., Masala, F., Garau, C., 2017. Urban policies and mobility trends in Italian smart cities. Sustainability 9 (4), 494.
Pucher, J., Buehler, R., 2008. Making cycling irresistible: lessons from the Netherlands, Denmark and Germany. Transp. Rev. 28 (4), 495–528. https://doi.org/10.1080/01441640701806612.
Rubim, B., Leitão, S., 2013. The urban mobility plan and the future of cities. Estudos Avançados 27 (79), 55–66 (in Portuguese).
Saelens, B.E., Handy, S.L., 2008. Built environment correlates of walking: a review. Med. Sci. Sports Exerc. 40 (7 SUPPL.1), S550–S566. https://doi.org/10.1249/MSS.0b013e31817c67a4.
Sangle, S., 2010. Critical success factors for corporate social responsibility; a public sector perspective. Corporate Soc. Responsabilitu Environ. Manage. 17 (940), 205–214. https://doi.org/10.1002/csr200.
Silva, A.N.R., et al., 2015. A comparative evaluation of mobility conditions in selected cities of the five Brazilian regions. Transp. Policy 37, 147–156.
Tilaki, M.J.M., Abdullah, A., Bahauddin, A., Marzbali, M.H., 2014. An evaluation to identify the barriers to the feasibility of Urban development plans: Five decades of experience in Urban planning in Iran. J. Urban Environ. Eng. 8 (1), 38–47. https://doi.org/10.4090/juee.2014.v8n1.038047.
Tyrinopoulos, Y., Antoniou, C., 2013. Factors affecting modal choice in urban mobility. Eur. Transp. Res. Rev. 5 (1), 27–39.
Uittenbroek, C.J., Janssen-Jansen, L.B., Runhaar, H.A.C., 2013. Mainstreaming climate adaptation into urban planning: Overcoming barriers, seizing opportunities and evaluating the results in two Dutch case studies. Reg. Environ. Change 13 (2), 399–411. https://doi.org/10.1007/s10113-012-0348-8.
Ugulu, I., 2015. Development and validation of an instrument for assessing attitudes of high school students about recycling. Environ. Educ. Res. 21 (6), 916–942. https://doi.org/10.1080/13504622.2014.923381.
Viegas, J.M., 2001. Making urban road pricing acceptable and effective: Searching for quality and equity in urban mobility. Transp. Policy 8 (4), 289–294.