PEDESTRIAN PARTICIPATION IN MOBILITY SYSTEMS: THE CASE OF BOGOTA

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ABSTRACT

Pedestrian systems as a part of mobility systems is a key issue for the development of cities. Traditional planning and public policies based on modernist approaches have directed most efforts to improve motorised transport systems, reducing the participation of the non-motorised ones, including pedestrians, in the modal split. However, with the saturation of those approaches, there has been a clear trend worldwide regarding awareness about the importance of walking to raise liveability and efficiency in the urban areas. The shortage of parking in relation to the increasing amount of vehicles, fuel costs, congestion, limitation for infrastructure expansion and environment appeal have shifted attention to pedestrian systems. This paper presents a discussion on pedestrian systems design and its representation on the modal split in the City of Bogotá, considering for the analysis the "gaps“ in modelling these systems. The methodologies used were descriptive and a case study. In spite of increasing investments towards pedestrian infrastructure in Bogotá, the results of this study indicate that there is a tendency to analyse pedestrian systems with a microscopic view and to neglect their recognition as a transport system and its integration to other transport modes for the whole urban area.

1. INTRODUCTION

Fast urbanisation has also raised traffic densities in cities. As a consequence, travel time for passenger and freight transport has increased substantially, affecting traffic safety, organisations' efficiency and socioeconomic development in urban areas. To face these problems, researchers, public and private authorities from developed as well from developing countries have worked to find solutions for the betterment of urban mobility (Carsten, Sherborne, & Rothengatter, 1998). International organizations are coming together, combining efforts to make joint analysis to propose public policies in order to support the development that can reach the needs of cities, regions and countries.

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The transformation of urban environments have motivated people to look for new alternatives of transport modes, including walking. In spite of being an intrinsic alternative to humans, pedestrian transport has gained special attention because of its contribution to the standard of living in cities, considering the environment sustainability and health appealing aspects thereof. The literature shows results of discussions and studies on the issue coming from researchers and transport planners, trying to deliver ideas to support decision making processes on public policies and planning. However, despite the current importance of pedestrian systems, it is not planned as an integrated system in most mobility plans and the solutions delivered are not consistent with the needs of people and cities.

Therefore, this study seeks to contribute to the development of an approach to design pedestrian transport solutions considering walking within a systemic and integrated transport view. This paper provides an overview of pedestrian systems represented in literature, starting with a general context and ending with the analysis of its conception in Bogotá, Colombia. The analysis of the case study seeks to contribute to the understanding of the current planning approach for pedestrian transport and its results, focussing on the gaps and the effects of this type of approach in terms of people behaviour and pedestrian accidents.

2. PEDESTRIAN SYSTEMS ANALYSIS

The transport modelling approach refers not only to the estimated demand of users who want to move from one place to another in the city, but it considers its complexity, involving other variables like actors and events (Duarte, 2011); the costs and externalities generated for users and operators (Novaes & Gonçalves, 1996). Moreover, the object of study of transport modelling is the actions of transport systems users, but planners might consider it involves institutions, regulations and even cultural aspects that directly or indirectly affect the management of transport systems (Hensher & Button, 2005).

Land use has a strong correlation with transport systems in cities (Montezuma, 2000). The transport modelling process seeks to find a balance between demand and supply for specific land use and transport (Beimborn & Kennedy, 1996). In fact, trip forecasts are the heart of transport modelling. Given its complexity, traditional methods divide a studied area into trip analysis zones (TAZ - Trip Analysis Zones), seeking to establish what are the interactions mediated by transport means between the TAZs. The problem seen by some authors in these type of analyses is that trips occurring within each TAZ and their interactions with land use are dismissed like those of walking and cycling quantified as “access” or “egress time” (Goncalves, 2014). This means that trip arrangements walking and cycling are not always represented in the models, what is a major weakness of this type of models (Duarte, 2011).

There are a handful software and IT tools for transport modelling available in the market. Some of them have made progress in achieving more detailed representation of different transport means and their specific variables. For instance, it can be mentioned some especially based on simulation: MEPLAN, INTEGRATION, IHDSM, TWOPAS, TRANSIMS, VISSIM, TEAPAC, AIMSUN,

HCM/Cinema, WATSIM, and CORSIM. It is important to highlight that these tools do not allow for the introduction of variables representing the internal dynamics of pedestrian systems in the simulations, as they focus primarily on vehicles and infrastructure. Although, these systems are largely used by technicians, it still require IT tools and software to enable more powerful transport modelling for the development of pedestrian transport system and to integrate them with the whole transport network.

In general, the studies available in literature and practical experiences show an analysis of pedestrian systems focussing on specific perspectives of pedestrians like: studies of behaviour, technical standards for dimensioning infrastructure, awareness campaigns and mobility plans. However, although these approaches recognize certain features of the system, it does not give a global view of it. The following sections high lights some of the studies selected for this research.

2.1.1 Intelligent Transport Systems (ITS)

Intelligent Transport Systems (ITS) are part of a research stream devoted to propose solutions to the problems of mobility by analysing the relationship between infrastructure and vehicles through the use of software, hardware, devices and algorithms to improve the efficiency of these relationships. The given studies using the ITS approach took into account people from the point of view of traffic safety and accessibility. However, it has found few studies on pedestrian interaction, considering their own logic and needs. In general, the solutions proposed by ITS are not based on an overview of the problem. Even though new efforts have been made to broaden the analysis, for example, through the merger of models and data (Yang & Wang, 2012), the solutions presented focussed on operational approach to solve specific problems.

In general, the ITS approach has not comprehensively consider pedestrian systems, but it has focused on evaluating the response of pedestrians and vehicles to the implementation and adjustment of devices, like traffic lights, and infrastructure facilities.

2.1.2 Academic studies

The second approach for the analysis of pedestrian systems representation is related to academic studies. The academic studies have mostly attempted to respond to specific problems and have made adaptations of techniques, usually of a mathematical type, to represent them. One of the techniques used for making decisions regarding pedestrian mobility is simulation, especially used to represent the behaviour of pedestrians in specific situations rather to make representations of macro pedestrian systems.

Most of studies treat a particular characteristic of pedestrians. For instance, the modelling of features affecting pedestrian movements (Löhner, 2010); individual behaviour in relation to the own interaction to collective behaviours (Zhang & Han, 2011); the displacements (Jian, Lizhong, & Daoliang, 2005) (Suma, Yanagisawa, & Nishinari, 2012) (Ezaki, Yanagisawa, Ohtsuka, & Nishinari, 2012) (Gotoh, Harada, & Andoh, 2012) (Tian, Huang, & Liu, 2010); social influence, speed and the density of groups (Seyfried, Steffen, & Lippert, 2006); and types of pedestrians on crosswalks (J. Yang, Deng, Wang, Li, & Wang, 2006). Furthermore, other studies presenting

simulations, seek to present a more global vision although they concentrated on the operational analyses of pedestrian systems (Guo & Tang, 2012) (Lovas, 1994) (Fang, Li, Li, Han, & Wang, 2011) (Tian et al., 2010) (López-Neri, Ramírez-Treviño, & López-Mellado, 2010) (Ishaque & Noland, 2007). There are also studies that make important contributions on the differentiating and characterization of pedestrians, by providing good information about pedestrian behaviour (Tom & Granié, 2011) (Jesins, 1973) (Hatfield & Murphy, 2007) (Cambon de Lavalette et al., 2009) (Milligan, Poapst, & Montufar, 2012).

2.3 Technical Guidelines

A third approach to look at is the technical guidelines for dimensioning pedestrian systems. The Highway Capacity Manual (HCM) is a well known reference publication largely used by transport systems planners and decision makers. The HCM contains concepts, guidelines and procedures for designing and calculation of level of service of pathways and the effects of mass transit, pedestrians and bicycles in the performance of infrastructure for these modes. The analyses presented in this manual are focused primarily toward vehicles; so that does not explicitly identify the components of the pedestrian transport. It identifies three basic components that affect driving: the vehicle, the environment and the driver. Within the component environment are pedestrians, bicycles and buses, as well as physical spaces. In fact, the HCM Manual proposes the aggregation of individual elements of urban systems for the analysis (Transportation Research Board, 2000).

Furthermore, there are manuals and publications on pedestrian systems available in different counties. Within these are the Colombia's Planning and Design Manual for traffic management and transport, developed by the Ministry of Transport, which aims to strengthen the activities of planning, designing, implementation and monitoring of transport systems, adapted to the City of Bogotá (Department of Transit Transport , 2005); the Colombian Manual of Urban Pedestrian Infrastructure, developed at the Pedagogical and Technological University of Colombia, that takes into account important features of pedestrian systems infrastructure, based on an extensive literature review, for instance the HCM (Jerez & Torres, 2011). Although these documents are very valuable publications, their scope do not extend beyond the characterization of infrastructure.

2.4 Mobility plans

Pedestrian mobility plans compiled by certain cities worldwide also provide important tools to analysing and planning pedestrian systems. However, similar to the above guidelines, the publications examined by this study do not consider certain features of pedestrian systems.

Even though some important features of pedestrian systems are taken into account in the mobility plans analysed, the relationships between them in most of the cases were missing. Therefore, the analysis showed that in general the plans lack a comprehensive vision of the mobility system and the integrated approach for the whole city (Goncalves, 2014).

3. BOGOTÁ PEDESTRIAN SYSTEM CONCEPT

Bogotá, Colombia has a Land Use Plan, a Mobility Master Plan and a Development Plan for the mayor's government term. However, apart from the Mobility Plan including pedestrians, there are no explicit guidelines for the issue in the plans.

The mobility policy for Bogotá is defined in the Land Use Plan and basically focuses on facilitating access to goods and services to ensure efficient intermodal urban projects and improving the competitiveness of freight. The policy guidelines state prioritisation of non-motorized transport (pedestrian and cyclist) in regard to investment and other decisions on mobility, public transport, freight transport and the private car. The guidelines include road infrastructure projects, public transport supply, facilities for the accessing of people with disabilities and reduced mobility. Finally, it also highlights the demand and differentiated patterns for mobility and gender in a way to promote adequate access in terms of distance, time and costs for local and regional levels (Bogotá, 2005).

In the master plan the definition for the pedestrian spaces subsystem refers only to the infrastructure of the city. Article 224 describes the subsystem of pedestrian spaces as follows: *It is the set of public spaces available for the movement and stop/remaining of pedestrians and people with disabilities, which are functionally integrated with parks, elements of the main green urban area, and buildings in the urban space. The architectural elements of private property that are part of the public space, such as porches, walls and roofs. Pedestrian spaces complement and determine the quality of urban space. The pedestrian areas are: plazas and pavilions, malls, sidewalks and crosswalks, pedestrian pathways, including ramps and stairways, pedestrian underpass links, areas of environmental control and covered shopping galleries and passages of a public green area (Bogotá, 2005).* Articles 232 and 233 of the same document define specific rules for sidewalks and crosswalks and set specific rules for pedestrian links respectively and general rules on infrastructure used by pedestrians. Similarly, the general rules applicable to the so-called "pedestrian spaces subsystem" are stated in Article 229 of the same plan which refers to infrastructure to ensure security, free movement and inclusion for people with disabilities. The article also include criteria for interventions on infrastructure aimed at preventing crime and conflict, promoting social ownership and proper use, in order to reduce the factors of insecurity and conflict in the built public space (Bogotá, 2005).

The structure of the mobility system of Bogotá consists of the road infrastructure, transport modes, regulation and control of traffic and pedestrian infrastructure (consisting of the platforms, plazas, parks, pedestrian crossings, pedestrian bridges and trails). The mobility system intends to respond to the connection with internal and external mobility flows of passengers and cargo aiming to consolidate the urban area, control sprawling and fast conurbation, improve productivity, seeking to increase the competitiveness of the region Bogotá-Cundinamarca (Gonçalves, 2014).

The Traffic and Transport Secretary (STT - Secretaría de Tránsito y Transporte) has the task of formulating the Mobility Master Plan (PMM - Plan Maestro de Movilidad) coordinated with the Administrative Department of District Planning (DAPD - Departamento Administrativo de Planeación Distrital). The plan was approved by Decree 319 of 2006. It is valid for 20 years. It is stated in the plan that its political priority must be pedestrians. The PMM aims to prepare infrastructure and services to meet the needs of accessibility and mobility of the City and connecting with the regional transport network, the rest of the country and abroad (Bogotá, 2005).

The PMM defines the criteria for ranking the investments in road infrastructure, indicating priority for roads that share use with traffic of pedestrians and cyclists. Likewise, the maintenance for non-motorised transport infrastructure must be prioritised. However, within the road infrastructure projects presented in the City it is not seen as a great priority for building sidewalks and pedestrian areas. Nevertheless, they are classified as priority for investments in the mobility plan the investments concentrate in higher amount in the city centre.

The strategies for regulation and control determine that the City must develop a road safety plan and the implementation of "SIMUR" which is an integrated pedestrian information system for regional and urban mobility. The objective of this plan is proposing continuous and intensive road safety measures for pedestrians, cyclists, car owners and public transport, looking for developing a comprehensive road safety education system. The plan also seeks to encourage research initiatives regarding the causes of road accidents. Furthermore, it is proposes the development of long-term campaigns, implementation of a permanent system for the dissemination of information, the development of mathematical models for the monitoring of traffic accidents and the development of an integrated system for traffic safety education.

The Development Plan 2012-2016 has a program called Human Mobility, which gives priority to pedestrians and proposes the construction, operation and maintenance of pedestrian public spaces to promote safety for non-motorized transport by creating the “safe pedestrian environmental networks” (RAPS); as well as the construction of sidewalks and pedestrian bridges. On the other hand, it seeks to make a cultural change in mobility management through actions to address the way of using the infrastructure and mobility system, so that it impinges on social dynamics and individual behaviours that unfold daily users.

Furthermore, education programs regarding mobility have focused on the dissemination of the correct use of infrastructure. Basically, prevention campaigns are performed in schools and businesses, and corrective campaigns in places with high risks of accident. The high risk spots are identified through maps like the one in Figure 2. The Mobility Secretariat monitors these spots in the City and runs campaigns and actions with pedestrians, aiming the change of undesirable behaviour. In response to the critical accidents points, the Mobility Secretariat along with the traffic police can propose to the Urban Development Institute (IDU) to make changes like infrastructure interventions, such as signalling, construction of barriers to prevent pedestrian access to unsafe areas, or building pedestrian bridges, for instance.

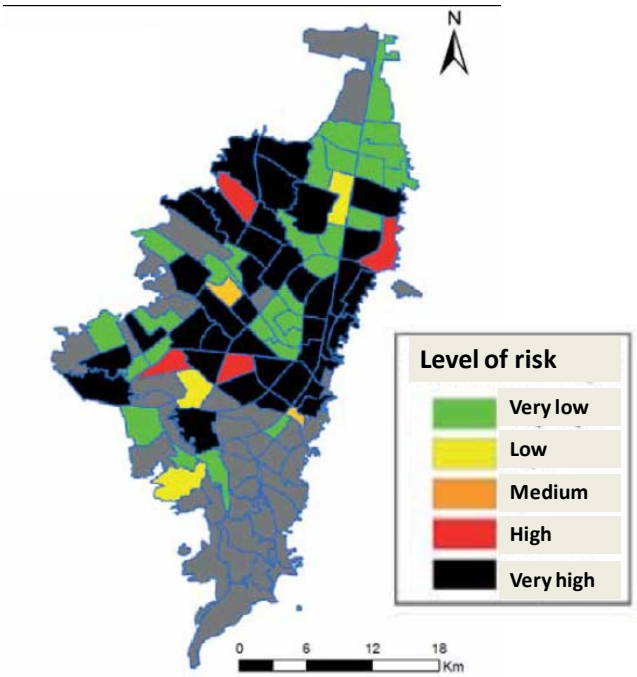

Figure 1. Map of critical accidents risk per traffic zones (UPZ) Bogotá 2013.
Source: Observatorio de Movilidad de Bogotá (Andes, 2014)

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However, in general, what the data shows is the behaviour change during the days of the campaign, but it is not sustainable over time. The numbers of pedestrian accidents between 2005 and 2013 show there was no relevant decreasing trend in the period, as seen in Figure 3.

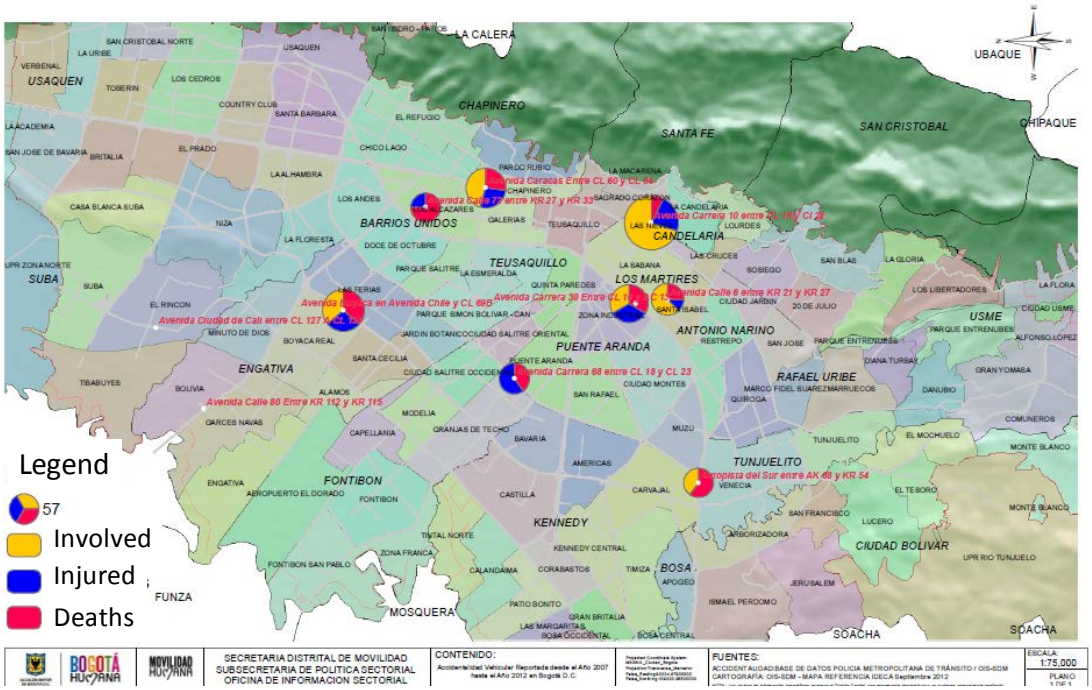

Figure 2. Critical points for pedestrians in Bogotá - 2012
Source: Secretaría de movilidad de Bogotá

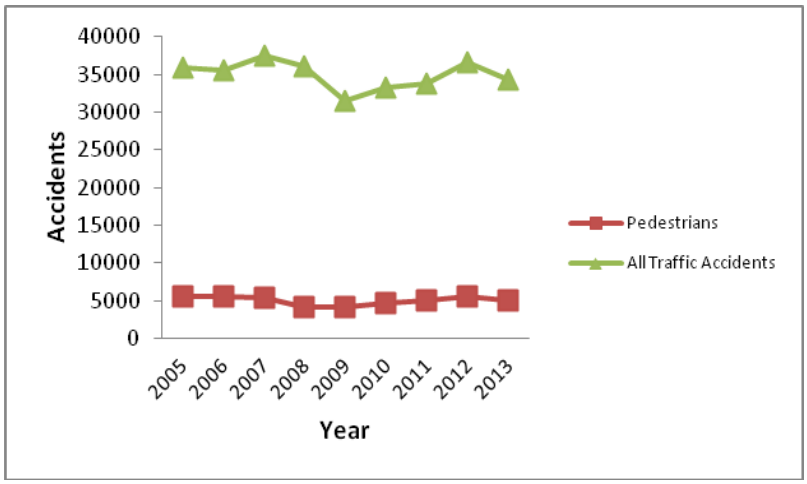

Figure 3. Number of pedestrians accidents 2005 to 2013
Source: Based on data of Secretaría de Movilidad de Bogotá

In fact, the percentage of pedestrian accidents out of the total accidents from 2005 to 2013, showed in Figure 4 has not undergone significant changes, although in the last three years a slight downward trend is evident.

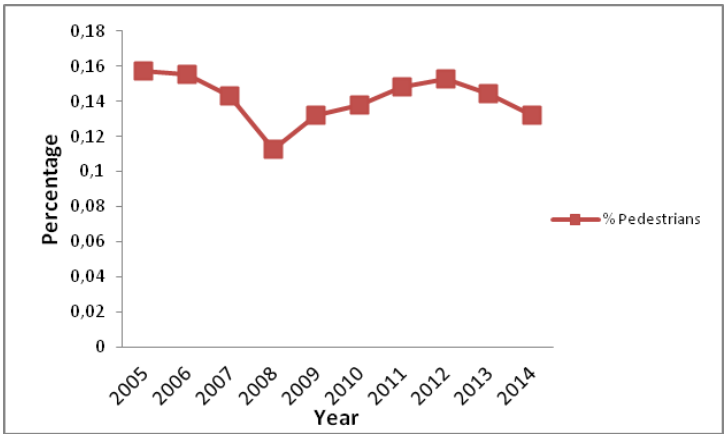

Figure 4. Number of pedestrians accidents 2005 to 2013
Source: Based on data of Secretaría de Movilidad de Bogotá

However, it is not possible to attribute this behaviour to the effects of the educational campaigns, as the total number of accidents has no decreasing trend. A possible reason to explain the trend is due to the general increasing of accidents (Figure 3) and because the number of vehicles has risen up in the city from 2009 on (Figure 5).

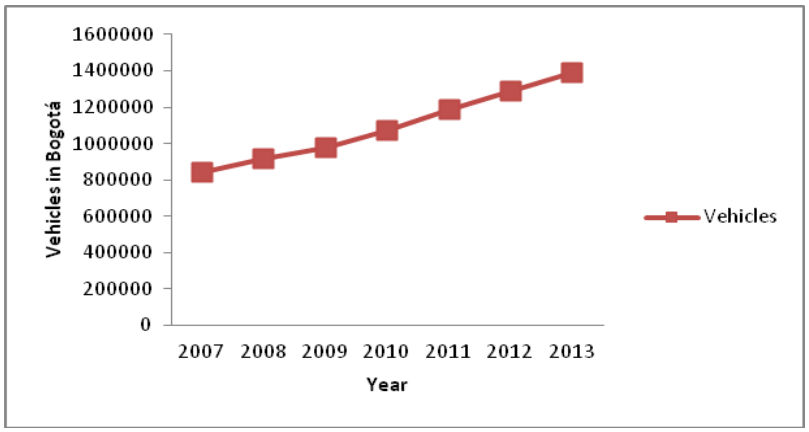

Figure 5. Number of vehicles in Bogotá 2007 to 2013
Source: Based on data of Secretaría de Movilidad de Bogotá

The growth in the number of vehicles in Bogota has resulted in traffic jams that have led people to seek for alternative roads and means of transport such as bicycles, going on foot and public transport like TransMilenio. For instance, people sometimes prefer walking to access or leaving the main public transport network when the distance is less than 5 km. In fact, this choice is made to avoid making use of feeder buses, as the average time spent during a trip is about 33 minutes, compared to about 20 minutes walking. In fact 35.3% of the trips lower than 15 minutes are made with non-motorized means, according to the survey of mobility applied in 2011 (Andes, 2014).

According to the survey, 84% of traffic accidents in Bogota are related to vehicles and 12% involve pedestrians (Andes, 2014). The increasing number of vehicles has raised traffic densities on the roads causing traffic congestion. Under these conditions accidents are more frequent and pedestrians are usually the most affected due to their vulnerability in the traffic. This situation is an example of the need for a broader view for transport planning in Bogotá, taking an integrated

approach for the whole City and transport modes, recognizing key elements that affect the transport system (Gonçalves, 2014) and, above all, conducting a systemic analysis of the transport system in order to understand pedestrian systems as a key part of the urban mobility system.

The classical planning process, based on the analysis of travel through origin-destination, recognises pedestrian trips as a means to access, to change or to egress modes of transport. However, it is clear that planning activities for pedestrian require a broader approach in order to analyse its internal dynamics and recognise it as a system. Today people are changing behaviour related to urban mobility. Walking has become the main mean of transport for the displacement of a high share of the population in many cities around the world. Therefore, it should be treated as a subsystem of urban transport, within urban or transport planning approaches. In fact, city planning should search for finding ways of minimizing the trip time, according to proper land use and the location of activities and to ensure that people can move great distances quickly through mobility (Gonçalves, 2014).

4 CONCLUSIONS

The different approaches that have studied pedestrian systems have in common the study for decision-making on infrastructure. Although some studies take into account the behaviour of pedestrians, as central players, it only do so with respect to certain characteristics, usually those related to their displacement. However, other players in the system, as decision makers or those doing the monitoring, are not taken into account, except in some cases considered in mobility plans and guidelines. Furthermore, the influence of other features, such as budget and comprehensive system design, are rarely considered in the analyses. Therefore, it requires an approach for planning for pedestrian systems which considers a global review of their internal dynamics and their integration into the mobility system.

In the last decade pedestrian systems are being considered in mobility plans in some countries. Bogotá does not have a specific plan for pedestrian mobility and it has not been yet recognised in practice as a specific urban transport system such as the vehicular or the public transport systems, as in most cities worldwide. The urban and mobility master plans state that non-motorised transport is a priority for investments. However, it was observed that cycling receives more attention than pedestrians, in spite of a greater representation of walking in the modal split.

The concept of pedestrian systems in Bogotá is oriented to operational level and to set infrastructure and lacks a systemic approach. Indeed, analyses made of trips between UPZ generate information inter-zones but those within them are not taken into account (Herce, 2009). Based on the planning practice, it is possible to say that there is a tendency to microscopic view for planning, which is far from the classic analysis of transport systems. Furthermore, planning is based on risk to accidents and development of infrastructure, missing the concept of pedestrian as a separate travel mode within the transport system.

In Bogotá, accident statistics in decision-making, show a reactive trend, regardless analyses and prospective based on actors behaviour and the relations of pedestrian system features and the environment. An exception is the pedagogical intervention strategies developed in schools involving children and teenagers. However, the results of this program have not yet been systematically evaluated to determine the real impact on the reduction of pedestrian accidents.

Finally, policies proposed in the Land Use Plan, Mobility Master Plan and the Plan of the current Government of Bogotá lack consistency and adherence to the proposed priority given to pedestrians. Moreover, there is a lack of integration and effectiveness in the implementation of measures to reinforce walking as an alternative for the daily displacements, what could great contribute to the improvement of mobility in the city.

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