PURSUING URBAN SUSTAINABLE MOBILITY. ANALYZING THE IMPACTS OF ROAD DESIGN IN PEDESTRIAN CASUALTIES IN THE CITY OF LISBON (PORTUGAL).

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ABSTRACT

The individual use of private vehicles is rapidly and constantly increasing in everyday life *post-Fordist* cities, promoting the excessive fragmentation of local communities and producing immediate impacts on the public health. In 2008 more than 37,000 deaths were recorded as a result of road accidents in the U.S. and over 39,000 in the European Union. That is why road safety is nowadays a matter of crucial concern across Europe, and therefore considered a priority area of intervention by the European Commission. In the case of the city of Lisbon (Portugal), the riverfront constitutes a place of confluence of major road infrastructures considered essential to the everyday metropolitan mobility not only during daytime but also during night-time. This might lead us to hypothesize that the verified elevated number of accidents (involving not only vehicles as well as pedestrians) is directly related with several structural factors that together characterize the area of downtown Lisbon. The present study analyzes road accidents in this area of the Portuguese capital by providing a detailed statistical analysis and a thorough georeferenced representation of all the accidents involving pedestrians in this area using geographic information referring to the years of 2006 to 2009.

Keywords: road accidents; pedestrian safety; road design; leisure activities; alcohol abuse

1. INTRODUCTION

The contemporary metropolization of post-Fordist cities has undoubtedly involved the increasing of hyperautomobility in their societies [1]. Some authors have recently suggest that the social construction of urban and metropolitan space is based in, among others, a motorized matrix (re)produced by the increasing needs of local, regional, national and supranational mobility, accessibility and territorial connectivity [2]. However there are several social, economical, territorial consequences of such process of hypermotorization in the society. For instance, Mimi Sheller and John Urry [3] warn about an excessive motorization of the urban and suburban society of post-Fordist cities, whereas Peter Merriman [4] warns about its deeper effects on global mobility. On the other hand, the association between social organization of cities and the needs of urban space for its spread led to the emergence of what Freund and Martin calls as "hyperautomibility", which is defined as an increasing daily use of private-motorized transport by individuals. For them, "the social organization of locomotion – walking, motoring, cycling, etc.– customizes human behavior and it has meaningful impacts on communities and on health" [2].

In line with this, during the last decade many European authorities have raised concerns with the increasing human and economic costs of road accidents. The 39,000 deaths caused by road accidents in 2008 and the 180 billion Euros (about 2% of EU GDP) spent in social-economical costs (road accidents related) has led to consider such issue as a major priority concern for the European Union [5]. In fact, those numbers in the latter decades should be related to the emergence of a *hypermotorized global society*, although the economic causality of this process is not very clear. As example, Joyce Dargay and Dermot Gately [6] highlighted the fact that the higher rates of motorization were found in lower income European countries, namely Portugal, Greece and Ireland. Despite of the regional differences, the European Commission has been increasingly emphasizing the fact that nowadays the involvement in traffic accidents constitutes the leading cause of death and hospitalization for EU-citizens under the age of 45. Such concerns expressed by the European Commission have recently produced immediate positive results which seem very promising until now, such as a medium decrease of 35% of victims in almost every one of the 27 countries of the EU between 2001 and 2009.

However, in the last decades the accomplishment of such reduction in all European countries has found some difficulties in lower-income EU-countries like Portugal, which have been characterized for decades to have higher rates of road accidents. An historical analysis of the major interventions in road policies in Portugal highlights two specific periods [7] [8]. The first one –started in 2003- aimed to decrease the number of crash-related fatalities to 50% until 2010. The second one started in 2009, when the Portuguese National Road Strategy was approved and was mainly featured for a development of a strategic plan which will be implemented along these next seven years. Moreover, among the public authorities with effective concerns about the road victims there is a special one about the pedestrians and their safety while walking in central urban spaces. In that sense, as Racciopi [9] asserts, these new concerns are justified by the comparatively higher risk for cyclists and pedestrians to be killed or sustain severe injury in roads crashes compared with car occupants.

The recurrent use of the car on day-to-day base should also be understood as a cause and consequence of the new patterns of organization of large metropolis such as the city of Lisbon (Portugal). Actually the requirements for mobility and development of populations living in the Lisbon Metropolitan Area should be seen as a reflection of structural constraints of a political, economic and social nature which largely influence not only the urban structure and the organization of everyday (segmented) cities [10,11,12,13].

Figure 1. Localization and pictures of case studies: 24 de Julho Avenue and Dom Infante Henrique Avenue.

Source: Victor

Meirinhos, Jordi Nofre and Josep Puig (2011).

Figure 2 - Case study 1 - Avenue 24 de Julho.

Source: Streetview Tool, Google Maps © (2010)

Figure 3 - Case study 2 - Dom Infante Henrique Avenue.

Source: Streetview Tool, Google Maps © (2010)

Notwithstanding, during latter decades the use of road infrastructures in the access to Lisbon reached high levels of saturation by reaching today 2.3 million trips recorded everyday in the Portuguese capital. While in 1991 the individual car was used by 20% of the metropolitan population and public transport was the choice of 46%, in 2001**,** 39% of the Lisbon Metropolitan Area inhabitants choose to use the private motorized vehicle, whereas the use of public transportation decreased to 35% [14]. The growing car-dependency in Lisbon Metropolitan Area should be therefore related to the fact that, according to what Carvalho and Gomes [15] points out, only a small number of the Portuguese metropolitan population use to work in the same town where they live with exception of those who live in Lisbon (87.7%). Mobility studies as Xerez's [16] on Lisbon Metropolitan Area underline the increasing of time spent in the day-to-day common trips: a 31,9% its inhabitants use to spend 15 minutes; a 39.3%, 30 minutes; a 19%, 60 minutes and only a 2,5% spend 90 minutes to do a day-to-day common trip. Moreover, an inquiry, named Inquéritos Gerais de Mobilidade, promoted in 2008 revealed that almost 40% of the capital's families didn't have any car, 44% had one and 16% had two or more. However, only 16% of the families didn't have any car in Palmela –located at 42km from Lisbon city centre-, whereas around 50% had one and 34% had two or more [15]. On the other hand, and according to the same study, the average number of day trips varies from 2.4 to 2.9 – this last one, in municipalities with high presence of finance and services activities. Yet it is important to underline that almost 14% of the total metropolitan population does almost 4 day trips to Lisbon [15].

Undoubtedly, the central localization of some metropolitan public transport hubs in Lisbon may provide some hypothesis about the existence of potential critical areas regarding pedestrian-involved crashes. For instance, the major passenger movement coming from Cais do Sodre hub [17]– clustered along city riverfront- and going to nearby Lisbon downtown represents an almost 67% of the total pedestrian movement in this area of the Portuguese capital. On the other hand, the Lisbon downtown riverfront (named Baixa neighborhood) is crossed over by 6.100 cars/hour in the morning rush-hour and 6.600 in the afternoon [17]. Half of those use either Avenue Infante D. Henrique or Avenue 24 de Julho and 25% use both avenues in their access to downtown itself. Hence the junction of private and public transport

users that everyday meet in the rush hours should not be overlooked. Inevitably, due to the traffic congestion and the high number of pedestrians in this area of Lisbon, several health problems as high rates of pollution, road stress associated to traffic congestion and high prevalence of road accidents (pedestrian and other) should be taken into account as one of the most important issues on mobility and public health in Lisbon to be studied.

A previous analysis of all pedestrian accidents in the city of Lisbon [18,19] does not differ from the findings in several world cities: Hong Kong [20,21], London [22], and New York [23]. All of these authors points out a high prevalence of casualties among the elder (above 65 years old) and, within this group, especially among females in pedestrian-involved accidents that take place in rush-hours during weekend days. However, a first preliminary analysis for the case study of Lisbon [19] indicates the existence of a high level of pedestrian fatalities among men under the age of 40, who are mostly involved in accidents some of them related to drunk-driving crashes on Friday and Saturday night.

Given these official statistics [24], this paper aims to geo-reference epidemiological data of road accidents occurred in downtown Lisbon from 2006 to 2009 in order to contribute to the debate about how to achieve safer, healthier and more responsible nightlife consumption should be implemented. After a previous reading on national and local public policies regarding road safety that pretend to specially combat to pedestrian-involved road accidents, this paper will show an aged and gender description of epidemiological data to then be mapped by GIS. Because of its very complex urban morphology and its high level of motorized traffic, this paper will focus on two case studies regarding downtown Lisbon: Infante Dom Henrique Avenue and July 24 Avenue. These great urban arteries are connecting the main night-time leisure areas in Lisbon, Docas, Cais do Sodré and Santa Apolónia. Moreover, the relevance of taking into account both avenues is based on a higher drunk-driving crash risk due to high levels of alcohol and drugs consumption among adolescents and younger adults. [25]. As conclusion, this paper will open a new scenario to aim to propose creative, innovative and proactive guidelines to re-order nightlife consumption and road traffic in Lisbon.

2. METHODOLOGY AND DATA SOURCE.

Following a methodology already used by some authors [26,27,28], a GIS-based epidemiological data analysis is developed in this paper mainly using ArcGIS10^{TM}, which has been used to display geo-referenced pedestrian-involved crashes. This kind of data is provided by the database of the Portuguese National Police [24] are used, being regarded to the all pedestrian accidents (casualties and severely injured victims only) occurred in the city of Lisbon during the years 2006 and 2009 which were dully reported to the police authorities. In fact, as many cities and countries worldwide, this kind of data is primarily collected by the police, who computerize following an official protocol. This pedestrian-involved crashes data is organized according to several categories, as place, day and hour of occurrence and age, gender and level of injury of victims, among others. For this paper, an epidemiological database has been created (see figure 2) in order to then facilitate a GIS-based analysis.

Table 1. Structure of database.

IDAcc	VITIMA	IDADE	SEXO	IdRua	LOCAL	DATA	DIA	DIANUM	HORA
1	G	71	F	1	Av. 24 de Julho	03-02-2006	sexta-feira	6	16:50:00
2	G		F	1	Av. 24 de Julho	06-02-2006	segunda-feira	2	18:35:00
3	G	77	M	1	Av. 24 de Julho	22-02-2006	quarta-feira	4	18:15:00
4	G	40	M	1	Av. 24 de Julho	06-03-2006	segunda-feira	2	17:30:00
5	G	53	M	1	Av. 24 de Julho	15-05-2006	segunda-feira	2	20:10:00
6	M	35	F	1	Av. 24 de Julho	25-05-2006	quinta-feira	5	23:08:00
7	G	17	M	1	Av. 24 de Julho	30-06-2006	sexta-feira	6	0:30:00
8	G	32	M	1	Av. 24 de Julho	14-07-2006	sexta-feira	6	17:40:00
9	G	20	F	2	Av. Da India	05-06-2006	segunda-feira	2	0:10:00
10	G	30	M	2	Av. Da India	05-06-2006	segunda-feira	2	0:10:00
11	M		M	2	Av. Da India	01-10-2006	domingo	1	3:48:00
12	G	29	M	3	Av. Infante D. H	16-09-2006	sábado	7	4:30:00
13	G	47	F	3	Av. Infante D. H	20-10-2006	sexta-feira	6	7:10:00
14	G	65	M	3	Av. Infante D. H	24-05-2006	quarta-feira	4	8:45:00

Observations: IDAcc (Crash identification code) ; VITIMA (Kind of Victim: G = Severus injury; M = fatality); IDADE (age); SEXO (gender); IdRua (Street identification code); LOCAL (street name); DATA (date); DIA (day of week); DIANUM (day of week in numeric); HORA (hour of occurrence).
Source: Meirinhos, V., Nofre, J. et Puig-Farré, J. (2011).

All pedestrian-involved crashes from 2006 to 2009 occurred in Lisbon[1] have been systematized in a new geo-referenced database in which epidemiological data has been classified in order to then debug and carry out some queries for gender and age-epidemiological analysis as well according to the time of the day and the day of the week by roads. Then all pedestrian-involved accidents have been homogenously distributed along each avenue primarily due to different lengths of 24 de Julho Av. and Dom Infante Henrique. [2] After being created a new field called "Field Acc_M1000" by means of Calculator tool of ArcMap™, pedestrian-involved accidents have been mapped by using Smooth Line tool with a PAEK value of 200m. Epidemiological databases have been linked with the cartographic base through the ID of Road field (called IdRua).

3. DISPLAYING PEDESTRIAN-INVOLVED CRASHES IN DOWNTOWN LISBON: A GIS-BASED EPIDEMIOLOGICAL ANALYSIS

A primary analysis of the pedestrian accidents occurred in the Lisbon Riverfront area revealed a high prevalence of male victims under age of 49 years old, in accidents occurred primarily in the evening period. (20:00 – 08:00 am). Although the available data may induct a relation between those accidents and the leisure night activities, it should be important to highlight several patterns that maybe related to the characteristics of the terrain as well as with those of road infrastructures. In the first case study, Infante D. Henrique, the distribution of victims and accidents and the fatality level should be take in account some road conditions like: the presence of physically separated road lanes, the presence of speed radars, and the industrial and heavy transport facilities. In the second case study, the 24 de Julho Avenue (length 2.4Km) , representing the higher number of victims (46.5%) of all riverfront (in a 12.9 km length studied), there are several infrastructural conditions to be taken in

[1] Epidemiological data provided by the Public Security Police of Portugal (PSP, 2010).
[2] Lisbon road network database has been provided by the Geographic Institute of Portuguese Army (IGEOE, in Portuguese, 2010) thanks a protocol of collaboration between the Faculty of Social and Human Sciences of the New Lisbon University and the Geographic Institute of Portuguese Army itself.

account: the presence of several public transport hubs; the location of both governmental and municipal buildings; separated road lanes crossed by several pedestrian crossings.
In the subject of leisure night activities, highly represented in both avenues, there are still some differences that should be taken in account. Mostly in the 24 de Julho Avenue, the leisure establishments are primarily located adjacently to the road. That location promotes an easy access of customers to the road were they should share the public space with all vehicles, especially in the evening, and therefore increasing the risk for all pedestrian in those leisure areas following described.

Infante D. Henrique Avenue

The Infante D. Henrique Avenue has almost 5.3 Km long linking two central areas of the city (Parque das Nacões and Downtown). During the period studied (2006-2009) there were 12 severely injured pedestrian victims in accidents which occurred mostly on Friday and Saturday evenings (66.6% of the cases). The analyses of the time period has taken into account four major periods: morning rush hour [8:00-10:00am); day period [10:00am-5:00pm); afternoon rush hour [5:00-8:00pm) and night-time period [8:00pm-8:00am). The time-distribution of data revealed that 83.3% of all pedestrian-involved accidents occurred in the night-time period [[8:00pm-8:00am), whereas another 16.7% were equally distributed in the morning rush hour (08:00 10:00 a.m) and the day period (10:00a.m – 5:00pm). A gender-analysis underlines a higher prevalence of casualties among men (58.3%) under 49 years of age (57.1% of the men's total number of accidents). The distribution of pedestrian accidents involving male victims showed that 57.1% of them occurred during the weekend (Friday, Saturday and Sunday) and all of them (100%) occurred in the night period (20:00 – 08:00am). Among the female victims (41.7 % of the total victims in this avenue) the time-distribution of the data revealed that all pedestrian accidents occurred in the night period (20:00 – 08:00am) and 80% of them were in Fridays. The distribution of female victims has shown a high prevalence of victims among the age groups 40-59 years old (60%) and a fatality rate of 16.6%[3].

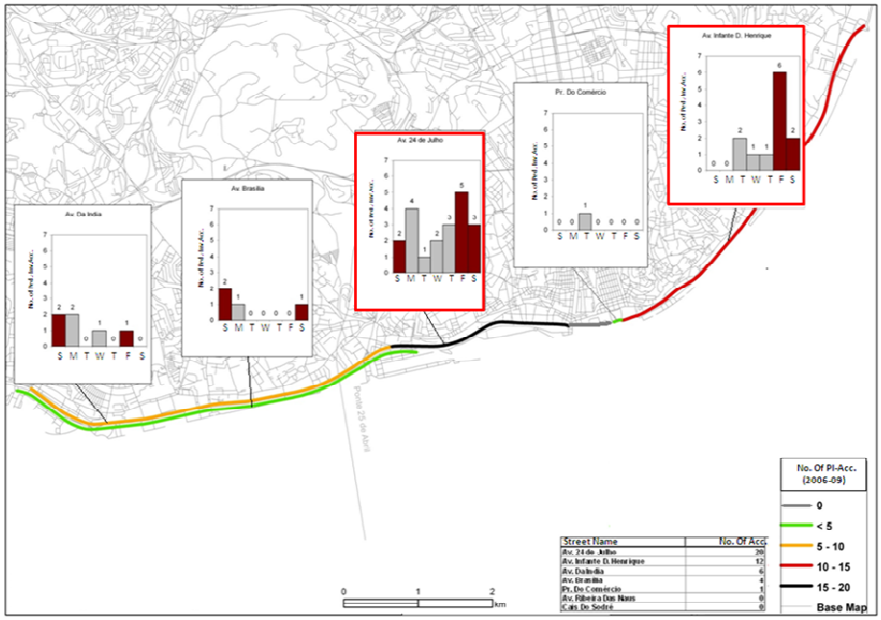
24 de Julho Avenue

Data time-space distribution of pedestrian-involved crashes in 24 de Julho (2.4 km) shows that 46.5% occurred in all Lisbon waterfronts took place in the 24 de Julho Avenue. 20 severe injured victims were identified from 2006 to 2009, representing nearly 9 victims per kilometer and the fatality rate of this avenue was lower than the found for Infante D. Henrique (10%). The 45% of pedestrian-involved crashes occurred primarily in weekend days (Friday, Saturday and Sunday) and 30 % during the evening period.
Regarding time-distribution of pedestrian-involved crashes in 24 de Julho Avenue, 45% of them occurred in the afternoon rush-hour period (17h00- 20h00), a reality which may be related to the fact that the major hub of public transport in all Lisbon Metropolitan Area is accessible from this avenue itself. On the other hand, as it has been previously pointed out in this paper, the pedestrian movement is divided to achieve several city destinations and local and national governmental buildings.

[3] The gendered analyses of the pedestrian accidents highlight the fact that all deaths, verified in this avenue, were among female, in the night period (20:00-08:00am) and on Fridays.

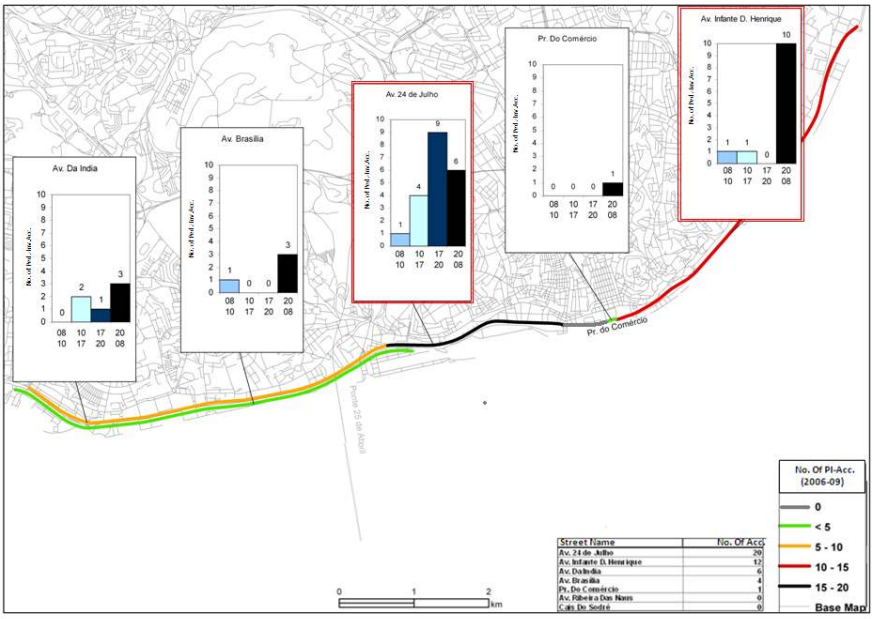
Notwithstanding, the data distribution of the victims shows the same patterns as above stated, i.e. almost 65% of all the victims were male and the age distribution was particularly centered on the 30-49 years old age groups (46.1%) for male victims and 42.8% for the above 69 years old among female victims. The analysis of gender fatality distribution has also highlight the fact that, as previously found, all death victims were among female victims and all of them occurred in the night period (20:00-08:00am).

Figure 4. GIS-based representation of pedestrian-involved accidents occurred in Lisbon waterfront. 24 de Julho (2006-2009).



Source: Meirinhos,V, Nofre, J. and Puig-Farré, J. (2011

Figure 5. GIS-based representation of pedestrian-involved accidents occurred in Lisbon waterfront. 24 de Julho (2006-2009).



Source: Meirinhos,V, Nofre, J. and Puig-Farré, J. (2011).

CONCLUSIONS

John Urry [29] highlights the fact that the mobility needs of contemporary societies should not be dissociated from the motorization process inevitable in our modern societies. One single manufactured object, the car, has been responsible for many changes in the modern societies and also inevitably in the landscapes. In this sense, it is possible to highlight that the success of the automobile is greatly due to the attribute of individuality when compared to other public transportations [30].
It is our belief that in Lisbon metropolitan area the easy access to the private transport in day-to-day trips to the city centre as well as the great improvements which, in the last decade, have been performed in the major road infrastructures confluent to the Portuguese capital from the peripherals municipalities is in some way responsible for the excess of private cars accessing Lisbon everyday. .
Across the years different strategic and political options produced a phenomenon of inequality in what concerns accessibility to the essential services by the peripheral dwelling population. The ageing of the population in the city of Lisbon, the extreme dependency that the peripheral populations have of essential services which are centrally located (e.g. governmental services and schools), the central location of most work places, are all par of an equation which inevitably leads to high levels of traffic congestion and pollution, as well as to high accident rates in the city centers [17, 31].

The analysis of the levels of motorization in the metropolitan area revealed the fact that in the last decades the number of users of public transportation has dramatically decreased and the number of private transport users has grown in the same order. The traffic data regarding the two available road infrastructures which connect southern peripheral cities to the centre of Lisbon, [32] the bridge Vasco da Gama (eastern access) and the bridge 25 de Abril (western access) reveal a interesting pattern. The southern access to the capital is primarily done by using the western access and the exit from Lisbon to the southern cities is primarily done by the eastern access. There could be two main reasons for this choice. The first is that the

bridge 25 de Abril, which is only payable from the south side (as its eastern counterpart), is cheaper than the Vasco da Gama Bridge. Although the economical advantage is certainly one important part of this choice, the simple fact that the latter has less traffic could be the most important aspect to be taken in account. Although the above pattern should be subject to a more focused analysis, a simple description of those particular traffic movements could alert us for the importance of the Lisbon downtown area in the subject of vehicle and pedestrian accessibility. The available information concerning the pedestrian movements in that selected area must also be related to the high accidents rates in the last five years. It is possible to distinguish two different epidemiological victim patterns, in Infante D. Henrique Avenue the pedestrian accidents seemed to be related to the leisure activities (according the time and victim analysis), however, in 24 de Julho Avenue we found a mix pattern, i.e. pedestrian accidents related to leisure activities and also accessibility problems in what concerns the users of the public transport in the afternoon south exit from Lisbon.

The existence of those two patterns in that selected area seems therefore to be related not only to the availability of leisure activities (the use of space), but also with the structural differences found in the studied avenues (road design).
If the last one could be easily manageable with the help of engineers, the first one seems to be a little more difficult to handle, given the scarcity of studies on that subject. The first step of this preliminary investigation has allowed us to relate the high pedestrian accidents with the leisure habits of adolescents and young adults, namely alcohol and drug abuse. We aim, in the next step, to describe and map all the pedestrian movements, pedestrian accidents, location of leisure establishments, and, above all, the alcohol and drug consumption and abuse habits among the young. For this purpose there is a strong determination from the research team and all the intervening partners in achieving our proposed objectives and hence adding some possibly useful knowledge to this matter.

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