Pedestrian Road Accident Index for Municipalities: The Portuguese Case

IOP Conf. Series: Materials Science and Engineering **603** (2019) 042084 doi:10.1088/1757-899X/603/4/042084

Pedestrian Road Accident Index for Municipalities: The Portuguese Case

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Abstract. Portuguese road traffic accidents statistics show that the number of accidents with fatalities and serious injuries has in general decreased in recent years. However, the number of accidents involving pedestrians is still high when compared with those observed in other countries of the European Union. In order to assess this problem, an index of pedestrian road traffic accidents for municipalities that could be used in decision-making about pedestrian safety measures is proposed. The use of absolute values of accidents involving pedestrians (running over) does not allow itself a reliable comparison of pedestrian safety level between municipalities. In this sense, the approach proposed uses the information available in the Portuguese database PORDATA to calculate a municipal index that takes into account the degree of exposure of pedestrians to accident, based on national and municipal resident population annual growth rates and number of pedestrian's casualties. This index allows to identify the municipalities with unfavourable deviation to national numbers of road accidents involving pedestrians (per 10000 inhabitants), supporting the plan and allocation of human and economic resources for the diagnosis, definition and implementation of safety measures. The results obtained can be visualized in a GIS for a more comprehensive comparison between municipalities. The analyses performed for Portugal showed that, in general, municipalities with higher resident population annual growth rates, located mostly along the coastline and in more consolidated urban areas, tend to present better index values, which points to the need to intervene in less consolidated areas.

1. Introduction

Most of European cities face problems caused by transport and traffic. To minimize these problems, sustainable urban mobility policies have been promoting soft modes of transport, such as walking and cycling. Despite the advantages of walking to reduce traffic congestion and pollution, cities have not always evolved to accommodate the needs of pedestrians (road users more vulnerable to accidents), and walking has in many cases been neglected in the development of transport systems [1].

With regard to Portugal, despite the increased use of bicycles in major cities, walking remains the main mode of soft transport. The significant number of high-traffic national roads that cross urban areas,

leading to frequent conflicts between pedestrians and vehicles, is one of the main pedestrian safety concerns.

In 2016, the proportion of pedestrian fatalities in all European Union (EU) traffic fatalities was 21% (22% for Portugal). Pedestrian fatality rates per million population was 10.6 for all EU countries and 11.9 for Portugal. The lowest rate was verified in the Netherlands (2.6) and the highest in Romania (36.3). Inside European urban areas, 39% of the fatalities were pedestrians while outside urban areas it was 10% (2015). In Portugal, these figures are respectively 37% and 12% [2]. It is important to point out that in Greece, Italy and Portugal about 60% of all pedestrian fatalities were elderly [3].

The problem of road accidents involving pedestrians, as well as other road safety problems, can be studied through models and tools developed in GIS environment. In recent years, GIS have been used in road safety as a geographical database to store data, represent results of statistical studies and most important, to perform a wide range of spatial analysis with graphical representation of the results for subsequent interpretation. Several examples of the development of GIS models and tools to aid the decision-making process associated with road safety can be found in the literature. Applications to define priority in safety road interventions [4] [5], develop and interpret pedestrian safety indexes [6], analyse the influence of spatial [7] or specific factors (such as demographic and socioeconomic [8]), pedestrian environment and road design on the occurrence of pedestrian crashes [9] [10], are among the most common uses.

In order to assess pedestrian safety, an index of pedestrian road traffic accidents for municipalities that could be used in decision-making is proposed in this paper. The approach proposed uses the information available in the Portuguese database PORDATA [11] and a GIS environment to calculate, represent and interpret a municipal index that takes into account the degree of exposure of pedestrians to accident, based on national and municipal resident population annual growth rates and number of pedestrians casualties. This index allows to identify the municipalities with unfavorable deviation to the average national numbers of pedestrians casualties (per 10000 inhabitants), supporting the plan and allocation of human and economic resources for the diagnosis, definition and implementation of safety measures.

The paper is organized as follows: Section 2 presents the methodological assumptions that support the definition and interpretation of the proposed index. Section 3 presents the formulation adopted and the necessary input data. A proof of concept was achieved in Section 4 with the application of the proposed approach to the Portuguese case. Section 5 concludes the paper highlighting some reflections of the authors on the methodology and results obtained for Portuguese municipalities.

2. Methodological assumptions

Portuguese road traffic accident statistics show that the number of accidents with fatalities and serious injuries has in general decreased in recent years. However, the number of accidents involving pedestrians is still high when compared with those observed in other countries of the European Union. Consequently, with the aim of improving Portugal's position within the European Union, a municipal accident index is proposed.

The use of absolute values of accidents involving pedestrians (running over) does not allow itself a reliable comparison of pedestrian safety level between municipalities. It is necessary to find a valid comparison approach that takes into account the degree of exposure of pedestrians to accidents.

In view of this, the approach presented is based on population and safety data available in the Portuguese database PORDATA. PORDATA is the Database of Contemporary Portugal organized and developed by the Francisco Manuel dos Santos Foundation. This public database provides official and

certified statistics on multiple areas of society for Portugal and its municipalities, and for the European countries. The reported statistics derive from official and certified sources with data production skills in the respective areas.

To find a comparable pedestrian accident index between municipalities and with the national average scenario (base scenario), it was decided to associate the number of pedestrian's casualties and the resident population data (number and annual growth rates).

To assess the index robustness and consistency, all the information was introduced, treated and represented in a geographic information system, which allowed the spatial analysis of the results.

3. Pedestrian Road Accident Index for Municipalities

The index calculation for each municipality is based on the combination of two conditions, one related to municipal and national population annual growth rate, and the other related to municipal and national number of pedestrian's casualties by 10000 inhabitants (Table 1).

Two PORDATA statistical information are needed to determine the Pedestrian Road Accident Index for Municipalities:

- National and municipal resident population and annual growth rates.
- Number of pedestrians casualties (running over road accidents).

Table 1. Classification and conditions proposed for the index calculation.

Classification			**Conditions**		
1	Very Bad	If	Municipal: population annual growth rate	<=	National: population annual growth rate
			Municipal: N.º of pedestrian casualties (running over) / 10000 inhabitants	>=	National: N.º of pedestrian casualties (running over) / 10000 inhabitants
2	Bad	If	Municipal: population annual growth rate	>	National: population annual growth rate
			Municipal: N.º of pedestrian casualties (running over) / 10000 inhabitants	>	National: N.º of pedestrian casualties (running over) / 10000 inhabitants
3	Good	If	Municipal: population annual growth rate	<	National: population annual growth rate
			Municipal: N.º of pedestrian casualties (running over) / 10000 inhabitants	<	National: N.º of pedestrian casualties (running over) / 10000 inhabitants
4	Very Good	If	Municipal: population annual growth rate	>=	National: population annual growth rate
			Municipal: N.º of pedestrian casualties (running over) / 10000 inhabitants	<=	National: N.º of pedestrian casualties (running over) / 10000 inhabitants

The index calculation can be easily programmed in an Excel® spreadsheet or script. The calculation is performed for each municipality by comparing the pedestrian casualties and population values with a national base scenario, adopting one of 4 values: 1 (Very Bad), 2 (Bad), 3 (Good) or 4 (Very Good).

The pedestrian road accident index can be defined as the model that allows prioritize and identify municipalities with deviations from the average national pedestrian casualties trend. It allows to prioritize and intervene proactively in the municipalities most likely to present pedestrian safety problems. Lower index values (1 and 2) indicate a higher pedestrian safety assessment priority.

4. The Portuguese case

The proof of concept was made through the application of the approach proposed to the municipalities of mainland Portugal (278 municipalities) for the biennium 2016-2017. Table 2 presents data on total pedestrian accidents and casualties and the distribution of casualties inside and outside urban areas. Data disaggregated by municipality was obtained from PORDATA database, being organized for calculation and visualization of results in a GIS.

Table 2. Annual pedestrian safety data (running over accidents) in mainland Portugal [12]

Pedestrian safety data (running over)	**2016**	**2017**
N.º of running over pedestrian accidents with casualties	4671	4753
N.º of pedestrian casualties	5087	5113
Inside urban areas	98%	97%
Outside urban areas	2%	3%
N.º of pedestrian fatalities*	109	115
Inside urban areas	80%	79%
Outside urban areas	20%	21%
Accident severity index**	2.3	2.4

* 30 day road crash fatality
** Number of fatalities per 100 accidents with casualties

According to PORDATA figures, average population density in mainland Portugal for the biennium 2016-2017 was 110.2 inhabitants per km^2, annual average population growth rate -0.2% and the average annual number of pedestrian's casualties was equal to 6 casualties for every 10000 inhabitants.

Figures 1 and 2 show the average annual distribution of pedestrian casualties and fatalities per 10000 inhabitants by municipality for 2016-2017 biennium. The population density and annual growth rates by municipality are presented in Figure 3 and 4.

The analysis carried out to obtain the pedestrian accident index is presented in Figure 5.

5. Main results, discussions and conclusions

Spatial analysis revealed four concentrations of municipalities with more than 6 pedestrian's casualties per 10000 inhabitants. These concentrations are located in the north and south of the territory and in the metropolitan areas of Lisbon and Oporto. There is a significant correlation with the municipalities presenting highest values of population density and growth rates (Figures 1, 3 and 4).

This correlation does not occur in the spatial analysis of the municipalities with highest values of pedestrian fatalities per 10000 inhabitants (Figure 2).

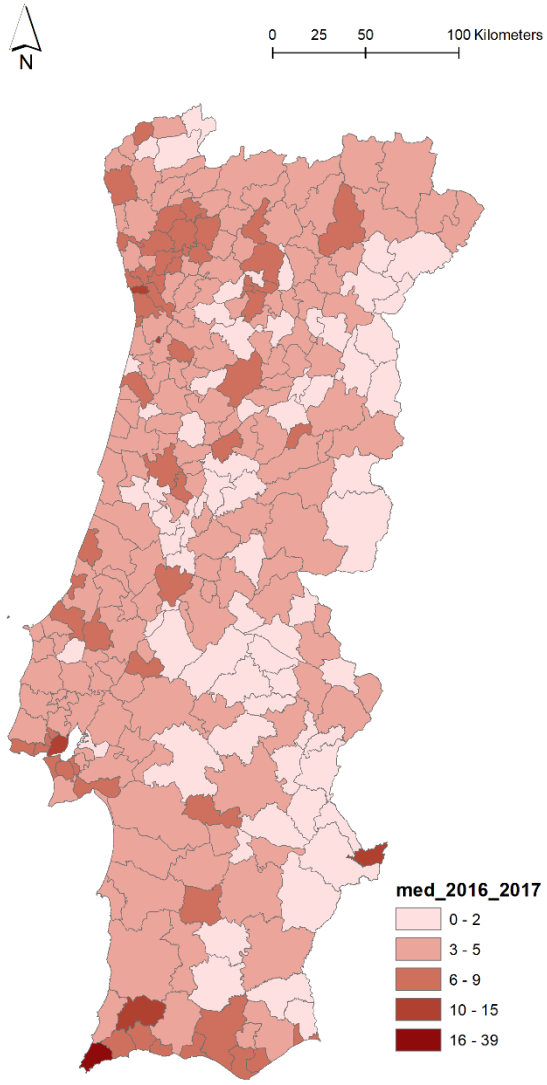

Figure 1. N.º of pedestrian casualties (running over) / 10000 inhabitants by municipality

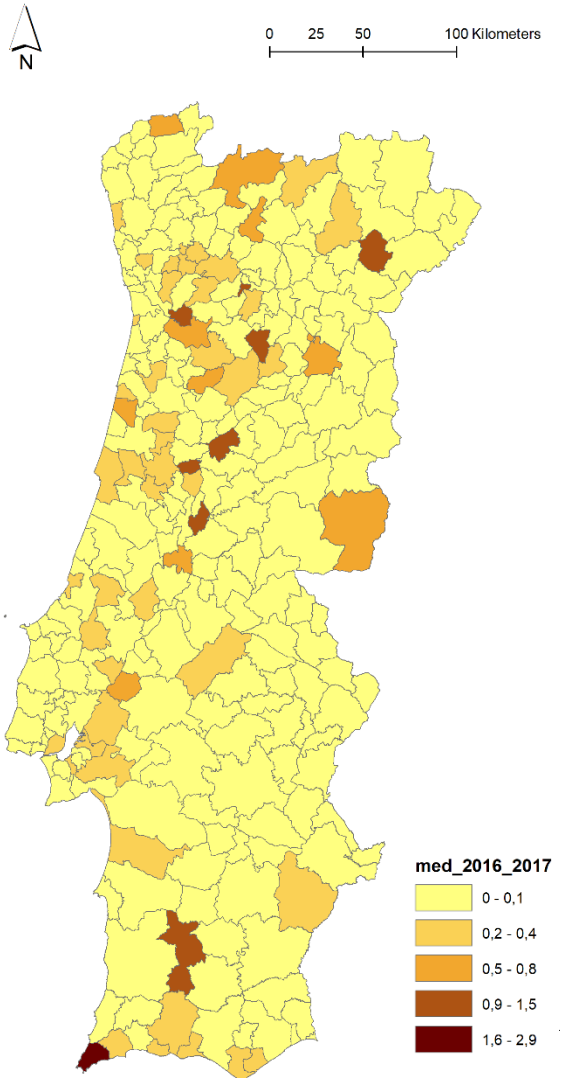

Figure 2. N.º of pedestrian fatalities (running over) / 10000 inhabitants by municipality

Municipalities with an index equal to 1 (Very Bad) present negative annual growth of the population (in average -0.7%) and similar number of pedestrian casualties (typically 6 to 8 running over pedestrians accidents per 10000 inhabitants). Two concentrations of municipalities with index equal to 1 and 2 (Very Bad and Bad) can be identified in the spatial analysis, one in the north and one in the south of the territory. It is also possible to identify a set of isolated municipalities on the central vertical axis of the territory.

This is the set of municipalities where it will be necessary to intervene in order to reduce the number of accidents involving pedestrians (11% of the territory area, 52 municipalities). The definition of these interventions will require a detailed analysis of the causes involved, including the location and nature of accidents.

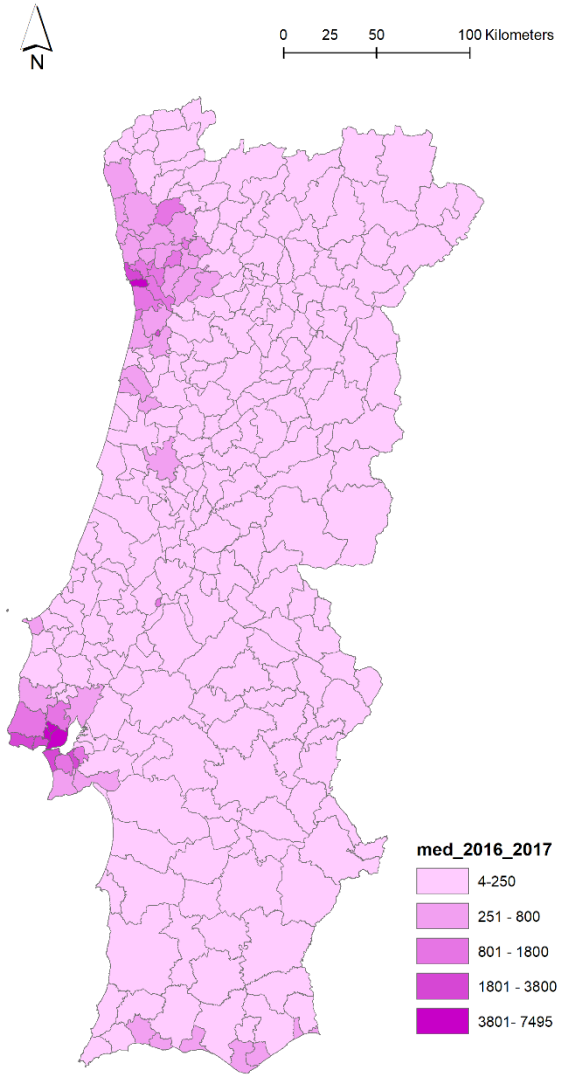

Figure 3. Municipality Population Density (inhabitants per km^2)

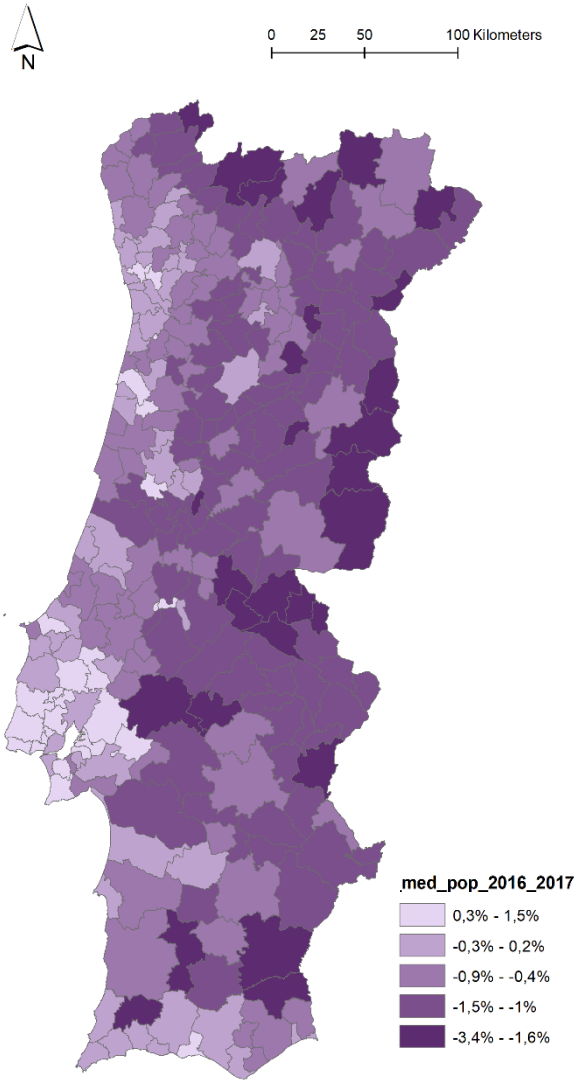

Figure 4. Municipality population annual growth rate (%)

The results show that municipalities with positive or slightly negative resident population growth rate (mainly on the coast and in metropolitan areas - Lisbon and Oporto) tend to present higher values of the index (green municipalities in Figure 5). However, cities with the highest pedestrian concentration are excluded from this situation and it is also believed that those with higher motorization rates (the motorization rate was not included in this analysis).

About 81% of the territory area, corresponding to 189 municipalities, has an index equal to 3 (Good), i.e. with a number of pedestrian's casualties per 10000 inhabitants below the national average.

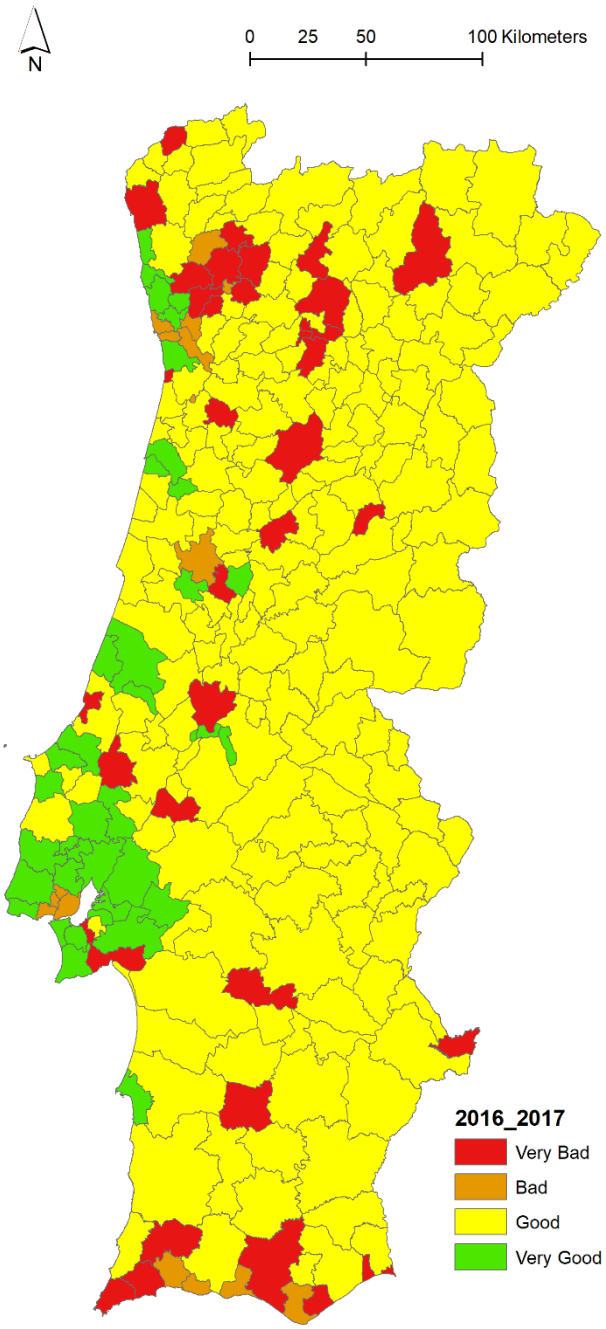

Figure 5. Municipal Pedestrian Road Accident Index (1-Very Bad, 2-Bad, 3-Good, 4-Very Good)

The proof of concept proved that the adoption of the number of pedestrians casualties per 10000 inhabitants and annual population growth rate at the municipality level and the comparison of these values with the national ones allowed to identify not only the municipalities with the highest exposure of pedestrians to accident (mainly associated to a higher population density, motorization rate and pedestrian environment quality), but also the municipalities that, despite a lower exposure of pedestrian to accident, present high values of pedestrian loss.

An adequate diagnosis of the pedestrian safety by municipality that takes into account the degree of exposure of pedestrians to accident and provide municipalities with a tool that allow them to assess the pedestrian safety of their territory against the national and other municipalities' scenarios, can be used to trigger actions to minimize this type of accident.

This diagnosis, which can be carried out through determination of the proposed Pedestrian Road Accident Index for Municipalities, supports the decision-making process by the prioritization of municipalities with more urgent needs for pedestrian safety intervention. The effectiveness of pedestrian safety measures, such as area-wide speed limits, proper street lighting and wearing reflective gear campaigns, can also be assessed by monitoring the index value over time.

Acknowledgment
The authors acknowledge University of Beira Interior, CERIS-CESUR- Civil Engineering Research and Innovation for Sustainability (ECI/04625) and Instituto Superior de Engenharia de Lisboa for supporting the performed study.

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