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Hotspots and social background of urban traffic crashes: A case study in Cluj-Napoca (Romania)

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ABSTRACT

Mobility practices have changed dramatically in Romanian towns over the last 25 years, following the collapse of socialist mobility restrictions. Urban areas like Cluj-Napoca are facing both increasing immigration and car mobility, and therefore increasing levels of road traffic crashes.

The analysis of traffic crashes is one of the most important elements for improving the road safety policy. This paper is divided in two parts. In the first one, the authors focus on identifying the traffic crash hotspots along the street network, while in the second part they discuss the social background of road traffic crash occurrence.

The first step in analyzing traffic crashes is to determine crash hotspots. A four-year record (2010–2013) provided by the Traffic Department of the General Inspectorate of Romanian Police (GIRPTD) was used. As a method of hotspot determination, the Kernel Density Estimation tool was employed, in the frame of the spatial analysis along network (SANET). The outcome was the hotspot map of traffic crashes in Cluj-Napoca. The results have revealed 4 categories of street segments: *not-dangerous*, *low-dangerous*, *medium-dangerous* and *high-dangerous*. Based on this classification, at least 4 dangerous areas were identified, located at the city entrances-exits (in the West, North-West and East) and the city center (the most dangerous zone).

The second part of the paper focuses on social groups involved in car crashes. The following are considered: age, gender and blood alcohol concentration of the person (driver or pedestrian) found guilty for every individual crash.

1. Introduction

The issue of traffic crashes is of major interest at national and international level since these lead to loss of human lives, causing significant material damages and potential environmental degradation. Traffic crashes analysis one of the most important elements to improve traffic safety policies.

It is very important to know where and when do crashes occur and which are the vulnerable social groups in order to help the enforcement authorities take effective measures to reduce their number.

According to the *General Inspectorate of the Romanian Police, Traffic Department* (GIRPTD), no less than 3792 road crashes were recorded in Cluj County between January 1st, 2010 and December 31st, 2013. These totaled 4129 casualties of which 2767 slightly injured, 1120 seriously injured and 242 deaths. According to European Commission reports (2015), most of the traffic crashes in Romania are recorded in urban areas. Because of the low level of infrastructure improvement and strong increase of traffic, Romania is the "leading" EU country in traffic crashes statistics (European Commission, 2015).

In this paper, the authors intend to answer the questions "where do traffic crashes occur?" and "which are the social groups vulnerable to the occurrence of traffic crashes?" in the Cluj-Napoca municipality, the economic core area of Cluj county, one of the leading areas of Romania in traffic crashes statistics. Thus, the paper is structured into two distinct parts. The first part deals with identification of traffic crash hotspots using GIS (Geographic Information System) techniques, while the second part is dedicated to delineation of social groups vulnerable to crash occurrence.

GIS played an important role in traffic crashes analysis and prevention in recent years, as it constantly expanded, providing researchers with more and more diverse opportunities for analysis

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every year. Therefore, some authors used GIS for simple linear analyses and development of maps combining various parameters such as the number of crashes, number of deaths and injuries or material damage (Gundogdu, 2010; Truong and Somenahalli, 2011; Pulugurtha et al., 2007; Qin et al., 2013). Others used it for spatial analyses and identification of risk areas (Ivan et al., 2015; Erdogan, 2009; Aguero-Valverde and Jovanis, 2006; Vandenbulcke et al., 2014), while others employed it for spatio-temporal analyses (Ivan and Haidu, 2012; Plug et al., 2011; Prasannakumara et al., 2011).

Traffic crashes often form clusters known as *hotspots* (Xie and Yan, 2008). Hotspots identification leads to the discovery and removal of common causes of crashes, thus improving traffic safety (Steenberghen et al., 2010). Several methods for determining the traffic crashes hotspots have been analyzed and implemented in literature over the last decades (Li et al., 2007; Erdogan et al., 2008; Montella, 2010; Okabe et al., 2009; Okabe and Sugihara, 2012; Xie and Yan, 2013; Yu et al., 2014). One of the most frequently used methods to determine traffic crash hotspots is the Kernel Density Estimation (Anderson, 2009; Thakali et al., 2015; Bíl et al., 2013; Flahaut et al., 2003). This is known in literature in two forms: Planar Kernel Density Estimation (PKDE) and Network Kernel Density Estimation (NKDE). The PKDE method is more rarely used in the study of traffic crashes because it calculates the density within a homogeneous 2D space using the Euclidean distance between the crashes, thereby altering the result. It is a well-known fact that crashes occur along a network, also known in the literature as "network space" (Yamada and Thill, 2004). Hence, the NKDE method was developed, which calculates the density of events strictly along the network (Xie and Yan, 2008). This method was included in a toolbox (Okabe et al., 2009), called SANET (spatial analysis along network).

In terms of the theoretical framework of vulnerability, we mention only one of the most influent theory developed by Watts and Bohle (1993), called the realistic theory of vulnerability. Thereby, vulnerability is determined by the interconditionings between institutions, power relations and historical framework. In this context, vulnerability is determined by distribution of commodities in time and space, by manner of occurrence and by property rights, which result in material deprivation of some classes to the benefit of others (Craddock, 2000).

Unlike physical vulnerability, social vulnerability is often ignored in the vulnerability studies (Flanagan et al., 2011; Siagian et al., 2014). Social vulnerability refers both to social groups (social vulnerability) and to territorial entities such as regions (regional vulnerability). Some authors (Watts and Bohle, 1993; Bohle, 2001; Oulahen et al., 2015) have even defined a vulnerability space consisting of the structure determined locally and historically by the interrelations between different social risk factors. However, in this paper the authors have adopted the perspective represented by Flanagan, who considered that social vulnerability referred to socioeconomic factors affecting the resilience of communities to hazards (Flanagan et al., 2011). In line with this perspective, the authors consider crash hotspots as being areas which require special emergency actions. They operate simultaneously as areas of high social vulnerability to car crashes. The authors have used hotspots in order to identify critical spaces (spaces of vulnerability).

2. The study area and the database

The study area of this research is the street network of Cluj-Napoca municipality. This is the capital of the Cluj County and it ranks second in the top cities in Romania, after Bucharest, in terms of number of residents, with 324,576 inhabitants according to the General Population Census in 2011 (National Institute of Statistics, 2012). An important aspect of this research is the fact that the metropolitan area of the city underwent a strong population growth over the last decade, as well as an increase in the level of motorization and urban mobility (Benedek et al., 2013). This represents the most important economic area of Romania, after the capital city Bucharest, which generates both a positive migration balance as important intra-urban "travel to work" type of mobility as well (Soaita, 2013). Contrasting with the dynamic economic and demographic development of the examined urban area, there was little improvement of urban transportation infrastructure; practically the road structure is the same (Benedek et al., 2013).

The findings and conclusions of this research are representative not only for Cluj-Napoca, but for all major cities of Romania because the main factor of increasing urban mobility is related to the 1989 system change. Moreover, the results are comparable to all other cities of the world where similar situations can be found: old and overcrowded transportation infrastructure, strong increase of urban mobility over a short period of time, increasing population, and reduced local administrative capacities.

2.1. Crash data

Statistically speaking, for such a study to have credible results, traffic crash records for a period of minimum 3 years are needed (Steenberghen et al., 2010). The traffic crash records in the city of Cluj-Napoca over a 4-year interval (2010–2013) were used in this study. These are the only official data made available by the General Inspectorate of Romanian Police, Traffic Department (GIRPTD). It should be noted that not all traffic crashes are recorded in the database, but only those of substantial gravity, which require the response of a traffic police squad.

Thus, the police go to the crash site only if there is at least one slightly injured person. Otherwise, the insurance companies manage the crash. Special cases are represented by collisions between 3 or more vehicles and the auto-pedestrian crashes, when the police go to the scene even if there are no casualties. The data collected by the insurance companies (minor traffic crashes – no casualties) could improve the impact of such a research. However, this data is unfortunately not available to the public.

The database contains detailed information about each particular crash, such as GPS coordinates, date and time of occurrence, the features of the street at the crash site (intersection, road turn, etc.), signaling means present in the vicinity of crash location, lighting conditions, main cause, manner of occurrence, number of vehicles involved, number of injured (slightly or severely), number of dead, age, gender and blood alcohol concentration of persons involved, etc. Unfortunately, the database contains no data about ethnicity, socio-economic status, area type or vehicles type.

It is worth mentioning that data collected by police at the crash site is updated for 90 days, depending on how the investigation progresses and depending on how the condition of victims evolves. For example, a slightly injured victim can become severely injured, a severely injured can die, a person declared guilty can become innocent and the other way around, etc.

The 5 municipalities and the town of Huedin in Cluj County have recorded a number of 2312 crashes over the 4 analyzed years (according to RDGIRP). The county capital, the city of Cluj-Napoca is clearly in the leading position, with a number of 1466 crashes.

This study considered both auto-auto crashes and auto-pedestrian crashes. During the survey period, 1466 crashes were reported, involving a total of 2510 participants (drivers, passengers, pedestrians), among which 1331 victims (934 slightly injured, 364 seriously injured and 33 dead). Of the 2510 participants, the police could determine the guilt for a number of 1159 persons.

The selection of variables for the model was restricted by the availability of data, which is highly reduced for the local level analysis in Romania. The authors of this study have considered only