EFFECTS OF TRAFFIC VOLUMES ON ACCIDENTS: THE CASE OF ROMANIA'S NATIONAL ROADS

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ABSTRACT:
Every road accident is important. Investigating the road accidents and their causes is the main action to be conducted in the prevention and the prediction stages. The main aim of the paper is to investigate the state-of-the-art regarding road accidents research in Romania, one of the top country in the EU Road Death Statistics. It came out that there is an inconsistent research conducted in the country, with very few studies which were spread across different fields, along with a major lack in accident prediction methods. The study provides a starting point for the accident prediction by validating an international model which could be employed in Romania. The specific goal of the paper is to investigate the impact of the traffic volumes on the accidents occurrence. The traffic data were provided by the National Road Infrastructure Management Company (CNAIR). The road accident data were provided by the Traffic Department of the General Inspectorate of Romanian Police (GIRPTD) and it consisted in the information collected in the field during 2015 on the main national roads in Romania. The database was simplified in accordance to the aim of the paper to include only the relevant details regarding the accident, the vehicles, and the participants. The preliminary analyses were performed using Geographic Information System (GIS) software. The outcome was employed further in the research to highlight the correlation between accidents and the traffic volumes, by means of power regression. The results have proved the major impact of traffic volumes in accident occurrence up to a certain level of congestion. The importance of the study reaches beyond the stated goals and it shows the necessity of a research strategy at the national level regarding the road safety. In order to overcome the lack of scientific practice in the field, it is mandatory to improve the data, to adopt and develop methods and knowledge according to the local conditions for a future with safer roads in Romania.

Key-words: *Road safety, Traffic accidents, Traffic volumes, GIS, Romania.*

1. INTRODUCTION

Road safety is an essential component of a modern transportation system. According to the World Health Organization (WHO, 2015), Romania ranks first in the European Union in terms of number of road fatalities and the second in Europe after the Russian Federation. On the streets of Romania, a person dies every four hours. Under these circumstances, road safety is a subject of major importance but as it can be seen further, very few research has been conducted in this direction, not to mention the lack of work undertaken in practice. Although it is acknowledged that the number of lives that perish on the Romanian roads every year is considerable, very little has been done to prevent the fatalities.

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According to the Romanian Road Safety Strategy RRSS (2016), there is not any research strategy regarding the safety on the national roads in Romania or any systematic research on the relevant impact factors in the field at the moment. In order to investigate the road accidents and their causes, a scientific literature review was conducted over all available papers that were connected to the subject or to the case study. It has revealed that there have been only a few practical pilot programs carried out at the national scale and they were mostly focused on the road safety education of children and adults.

The scientific literature review has also revealed that there is no clear record of the road safety research conducted over the last years in Romania; hence the paper presents the studies that have been identified in different areas. **Table 1** summarizes the results of these studies, indicating that there are four main research areas that have dealt with road safety issues over the past years.

Table 1

Road accidents studies in Romania

Author and publication year	**Subject area**	**Highlight**
Cioca & Ivașcu (2017)	Engineering	Risk Indicators and Road Accident Analysis for the Period 2012–2016
Brătucu Gabriel et al (2016)	Social Sciences	Road Safety Education in the Context of the Susta inable Development of Society
Benedek, Ciobanu & Man (2016)	Engineering and Social Sciences	Hotspots and social background of urban traffic crashes
Rus Ma, Diana et al (2015)	Medicine	Epidemiology of Road Traffic Injuries Treated in a Large Romanian Emergency Department
Ciobanu & Benedek (2015)	Engineering	Spatial Characteristics and Public Health Consequences of Road Traffic Injuries
Costescu et al (2016)	Engineering	Accident prediction functions for urban road intersections
Ivan et al (2015)	Engineering and Social Sciences	Identification of traffic accident risk-prone areas under low-light conditions
Doroga & Aldea-Capotescu (2015)	Psychology	An Analytical Approach to Preventing Work-related Road Accidents for Romanian Employees
Danciu et al (2012)	Psychology and Social Sciences	Psychological Risk Factors for Road Safety
Ivan & Haidu (2012)	Engineering and Social Sciences	The spatio-temporal distribution of road accidents in Cluj-Napoca
Călinoiu et al (2009); Călinoiu et al (2011)	Medicine	The lack of road safety research in order to understand the causes, the social and economic impact of traffic accidents

A previous study (Cioca & Ivașcu, 2017) has shown that the number of road accidents is influenced by the combination of vehicles and personal factors. In numbers, more than 60% of serious accidents occurred on national roads and streets, which resulted in a high number of serious injuries and deaths, namely three quarters of the total. The study also proposes a framework for improving the road safety.

From the driver behaviour perspective, Brătucu et al (2016) carried out a study on a representative sample for the Romanian adult population, in order to quantify one of the main traits, the seatbelt wearing. It has been revealed, inter alia, that the percentage of women always wearing seatbelts (76.4%) is higher than the percentage of men (69.9%). This article is the first comprehensive quantitative study conducted in Romania on this topic.

At the same time, some studies (Doroga & Aldea-Capotescu, 2015; Danciu et al, 2012) have advocated the implementation of the RRSS and the importance of the relationship between the driving behaviour and psychological factors. The conclusions of the study conducted by Rus Ma et al (2015) suggest that people in the 18-29 age group are more exposed to road crashes, judging by the high number of road accidents involving people in this age group recorded at the Emergency Department in Tirgu Mures between 2009 and 2010, which might be a consequence of the high number of drivers in this age group who do not wear the seatbelt.

Some older medical studies conducted in Romania, such as Călinoiu et al (2009) and Călinoiu et al (2011) have concluded that road safety research is required in order to understand the causes and the social and economic impact of traffic accidents and to define the national targets of the RRSS.

On the other hand, in the recent years, the combination between GIS (Geographic Information System) and statistical analysis has been increasingly used by researchers in Romania in road accident assessment (Benedek et al, 2016; Ciobanu & Benedek 2015; Ivan & Haidu, 2009; Ivan et al, 2015). GIS technique, employed in these studies, provides a spatial distribution of the traffic accidents with all their characteristics across the whole country or across narrower areas, which is a very important step in the analysis of accident occurrence. Furthermore, Ivan et al (2015) have analyzed the effect that one of the non-behavioural factors, the low-light, has on the road accident occurrence. They have established a strong linear correlation between them, so that the low-light conditions have a significant impact on the traffic accidents occurrence in the urban environment.

This research overview has shown the level of interest over the road safety in Romania in the recent years and it was practically the starting point of the paper. The state-of-the-art highlights that there is no prior evidence regarding the influence that traffic volumes have on road accident occurrence on the Romanian national roads. In this respect, the article aims firstly to update the data from the existing studies which were carried out so far in Romania with additional information by extending the time horizon from 2014 to 2015, which gives the possibility to connect the road accidents data with the traffic data from the census undertaken in 2015. After preparing the data, the relationship between the accidents rate and AADT is going to be established by means of power regression. The paper does not intend to develop a new methodology or model for assessing the impact of traffic volumes on accident rates.

Moreover, the research covered by this paper presents The Highway Safety Manual (HSM, 2010) method of prediction of the road accidents and validates it with the aim of introduce it for further use in Romania.

The results of the study may be used by decision-makers in implementing the RRSS and in improving the relevant road safety legislation. Furthermore, the results are comparable with the studies from other countries (Oguchi T, 2016; Ayati & Abbasi, 2011).

2. DATABASE

The study area of this research is represented by the main national roads in Romania. The spatial distribution of the traffic accidents has been analysed on seven national roads across the country: DN1, DN2, DN3, DN4, DN5, DN6 and DN7. The length of these roads according to the data provided by the National Road Infrastructure Management Company - CNAIR (2017) is shown in (**Table 2**). The roads in study share a common feature: they are all two-lane roads.

Table 2

Summary of Road Analysis in Romania

Roads	Length (km)	Length reviewed in census (km)	Route
DN1	642,065	550,000	București - Ploiești - Câmpina - Comarnic - Sinaia - Predeal - Brașov - Făgăraș - Sibiu - Sebeș - Alba Iulia - Teiuș - Aiud - Turda – Cluj-Napoca - Huedin - Aleșd - Oradea – Borș -> Hungary
DN2	431,400	422,000	Bucureşti - Voluntari - Urziceni - Buzău - Râmnicu Sărat - Focșani - Mărășești - Adjud - Bacău - Roman - Fălticeni - Suceava - Siret
DN3	256,000	243,000	Pantelimon - Fundulea - Lehliu Gară - Călărași - Băneasa - Murfatlar
DN4	60,350	47,000	București - Oltenița
DN5	64,884	50,000	București - Giurgiu -> Bulgaria
DN6	639,250	602,000	București - Alexandria - Craiova - Drobeta Turnu Severin - Lugoj - Timișoara - Cenad -> Hungary
DN7	596,630	498,000	București - Găești - Pitești - Râmnicu Vâlcea - Sibiu - Deva - Arad - Nădlac -> Hungary

Two databases were used for this study. The data on traffic accidents in Romania for the year 2015 were obtained from the General Inspectorate of the Romanian Police - Traffic Department (GIRPTD). The data on traffic volume in Romania for the year 2015, including the Annual Average Daily Traffic (AADT), were obtained from the National Road Infrastructure Management Company (CNAIR), from the Centre for Road Engineering and Computer Science (CESTRIN, 2015). The traffic volumes on the different road corridors considered in this study vary from 3252 to 15018 vehicles per day.

Moreover, the statistical data were extracted from the relevant reports of the National Institute of Statistics - NIS (2017) in order to analyse traffic accident evolution in Romania versus the length of roads over a period of two decades. As it can be observed in **Fig. 1**, the number of accidents and the length of the roads do not vary directly proportional.

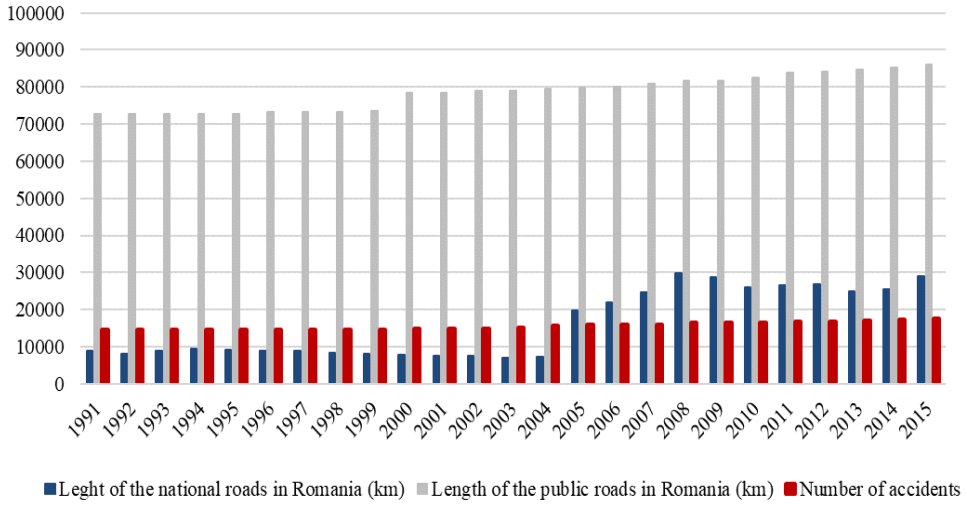

Fig. 1 The number of accidents versus the length of the roads in Romania, 1991-2015.

3. METHODOLOGY

Regression is the mathematical expression used to estimate the dependent variable - accidents rate – and the independent variable function – the Annual Average Daily Traffic (AADT). Regression helps to determine the relationship between these two variables and is mainly used in prediction studies.

The Highway Safety Manual (HSM, 2010) Predictive Method can be used to predict the number of accidents on a roadway based on the cross-sectional analysis of the specific geometrics and traffic volumes.

Correlation is the mathematical expression used to express the strength of the relationship or the intensity of the relationship between the dependant variant – i.e. predicted accidents – and the independent variable function – i.e. observed accidents.

The Geographic Information System (GIS) was used to visualize, interrogate, analyze and interpret road traffic accidents data in Romania in order to understand the causes, relationships, patterns and the trends. The analyses conducted in this study are based on preliminary information achieved with the aid of GIS. For instance, in **Fig. 2** are presented the causes of the accidents for all the main national roads.

4. RESULTS AND DISCUSSION

Many independent variables affect accident frequency. One of these indicators – the traffic volume (AADT) expressed in vehicles/day) – was used in this study to describe the degree of association with the accident rate, expressed as number of accidents per kilometres of road (column 3 in **Table 2**). A total of 2188 accidents were recorded in 2015 on the seven national roads considered in this study, of which 583 on DN1, 467 on DN2, 151 on DN3, 52 on DN4, 56 on DN5, 436 on DN6 and 443 on DN7.

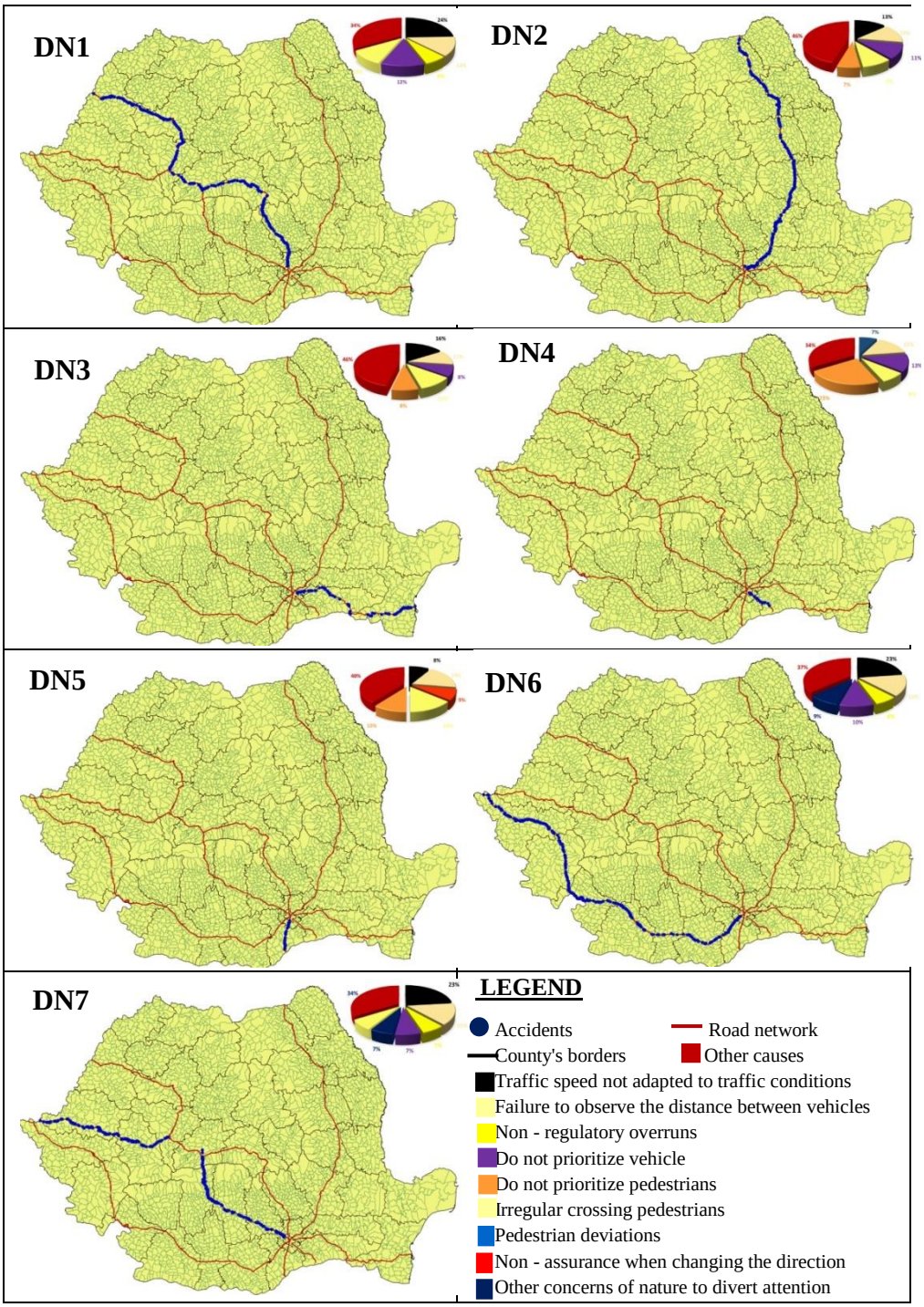

Fig. 2 The main national roads and the causes of accidents.

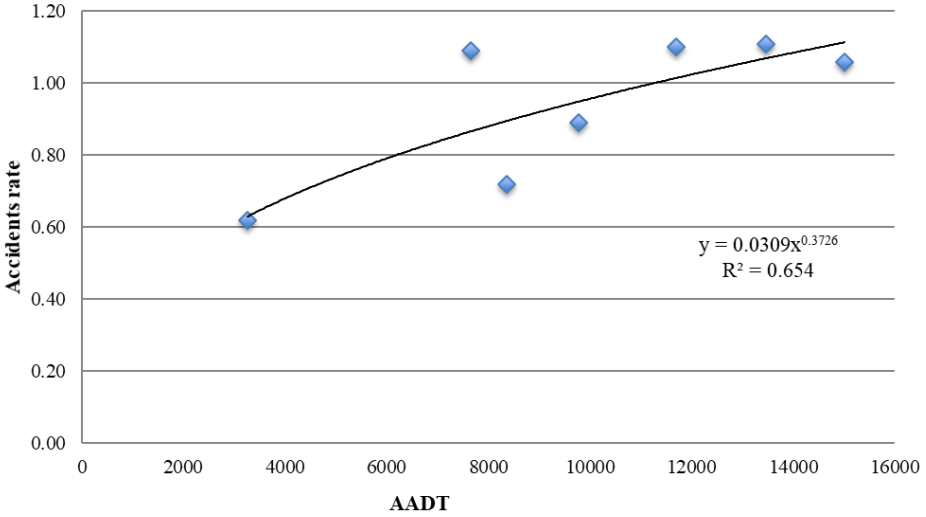

Fig. 3 The model of the dependency of the accident rate on AADT.

The shape of the dispersion diagram suggests that the power regression model would be more suitable for describing the functional dependence of the variables analysed, in other words, a formula of the type: Y = a Xb. This model indicates that the total number of accidents per kilometre during the year and on the roads analyzed increased with the increase in AADT, as it can be seen in **Fig. 3**.

Also, the number of predicted accidents on the seven roads were determined using the Crash Prediction Models (CPMs) from HSM. The values obtained are: 529 on DN1, 418 on DN2, 108 on DN3, 50 on DN4, 54 on DN5, 370 on DN6 and 387 on DN7.

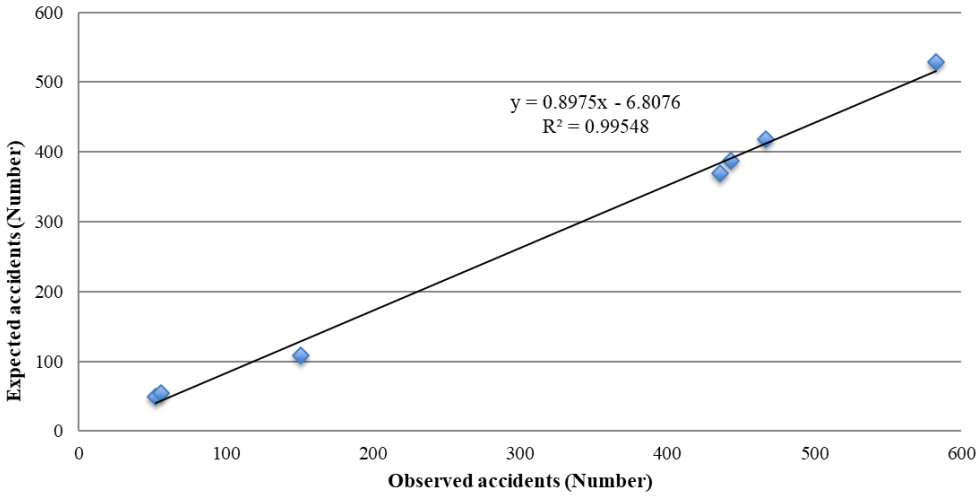

Fig. 4 Accidents expected versus accidents recorder.

The results are shown in **Fig. 4** above. A very good correlation was established between the two quantitative variables, one of which is a calculated variable – predicted accidents – and the other one is a recorded variable –observed accidents. Although at this stage no calibration for local conditions was carried, the results recommend the use of this method (CPMs) in the future as a useful tool for road engineers and planners in Romania.

5. VALIDATION OF RESULTS

By examining the correlation between x – AADT and y – accident rate, this study has determined that these variables are in a nonlinear relationship.

Numerous studies that have been conducted in the field have shown that the number of accidents increases with traffic growth expressed both as Annual Average Daily Traffic (AADT) and as Hourly Volume (HV). Caliendo et al (2007) has reviewed this literature and has shown that traffic is one of the major causes of accidents.

The vast literature on accidents prediction models considers traffic volume to be a significant variable. Accidents prediction models have evolved from Multiple Linear Regression to increasingly best fitted distributions: Poisson Distribution, Negative Binomial Distribution or Negative Multinomial Distribution. A comparison of all these results is quite challenging, firstly because results are based on a variety of methods and variables and, secondly, because geographic areas, data source, time periods and geometric characteristics of the road differ.

In Romania, the accident rate increases gradually with the increase in traffic volume up to about 11,000 - 13,000 vehicles/day on two-lane roads. When reaching those limits, traffic flow instability conditions are susceptible to occur, such as lower driving speed and rather limited freedom of manoeuvring, which leads to a lower risk of accidents. Wang et al (2009) study the impact of traffic congestion on the frequency of road accidents and they have reached to the same conclusion.

6. CONCLUSIONS

The general aim of the paper was achieved, the scientific literature review was conducted, and it has highlighted the lack of research in the field of road safety in Romania. There was found a small number of papers dealing with the subject but no major projects. Although very useful, only six studies were focused on engineering and most of them were assessing the number of road accidents and risk indicators. One article presented a method of road accident prediction, but it was focused on the specific case of urban road intersections. Starting from this it was clear that the authorities need to focus on all stages – investigation, prediction, prevention, in order to reduce the traffic accident epidemy in Romania.

The specific goal of the paper has been reached as well. It was argued that an increase in the AADT generates an increase in the total number of road accidents and the results have confirmed it. This is a heuristic deduction that has been proven by reasoning by previous research.

It should be noted that the relationship between the number of road accidents and traffic (AADT) is not strictly linear, but it takes an exponential shape in many of the reviewed cases (Glavić et al, 2016).

Moreover, as Karlaftis & Golias (2016) have demonstrated, AADT is the most important variable of the various road characteristics in terms of effects on road accidents. Therefore, AADT is an important cause, a major influencing factor in road accidents occurrence.

On the other hand, it has been shown that the HSM prediction method could be used in Romania as well, as a proper method for prediction in traffic safety engineering.

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