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Spatio-temporal patterns of hazards and their use in risk assessment and mitigation. Case study of road accidents in Romania

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Road accidents are among the leading causes of death in many world countries, partly as an inherent consequence of the increasing mobility of today society. The World Health Organization estimates that 1.3 million people died in road accidents in 2011, which means 186 deaths per million. The tragic picture is completed by millions of peoples experiencing different physical injuries or by the enormous social and economic costs that these events imply. Romania has one of the most unsafe road networks within the European Union, with annual averages of 9400 accidents, 8300 injuries and almost 2680 fatalities (2007-2012). An average of 141 death per million is more than twice the average fatality rate in European Union (about 60 death per million). Other specific indicators (accidents or fatalities reported to the road length, vehicle fleet size, driving license owners or adult population etc.) are even worst in the same European context.
Road accidents are caused by a complex series of factors, some of them being a relatively constant premise, while others act as catalyzing factors or triggering agent: road features and quality, vehicle technical state, weather conditions, human related factors etc. All these lead to a complex equation with too many unknown variables, making almost impossible a probabilistic approach. However, the high concentration of accidents in a region or in some road sectors is caused by the existence of a specific context, created by factors with permanent or repetitive character, and leads to the idea of a spatial autocorrelation between locations of different adjoining accident. In the same way, the increasing frequency of road accidents and of their causes repeatability in different periods of the year would allow to identify those black timeframes with higher incidence of road accidents. Identifying and analyzing the road blackspots (hotspots) and black zones would help to improve road safety by acting against the common causes that create the spatial or temporal clustering of crash accidents.
Since the 1990's, Geographical Informational Systems (GIS) became a very important tool for traffic and road safety management, allowing not only the spatial and multifactorial analysis, but also graphical and non-graphical outputs.
The current paper presents an accessible GIS methodology to study the spatio-temporal pattern of injury related road accidents, to identify the high density accidents zones, to make a cluster analysis, to create multicriterial typologies, to identify spatial and temporal similarities and to explain them.
In this purpose, a Geographical Information System was created, allowing a complex analysis that involves not only the events, but also a large set of interrelated and spatially linked attributes. The GIS includes the accidents as georeferenced point elements with a spatially linked attribute database: identification information (date, location details); accident type; main, secondary and aggravating causes; data about driver; vehicle information; consequences (damages, injured peoples and fatalities). Each attribute has its own number code that allows both the statistical analysis and the spatial interrogation. The database includes those road accidents that led to physical injuries and loss of human lives between 2007 and 2012 and the spatial analysis was realized using TNTmips 7.3 software facilities. Data aggregation and processing allowed creating the spatial pattern of injury related road accidents through Kernel density estimation at three different levels (national – Romania; county level – Iasi County; local level – Iasi town). Spider graphs were used to create the temporal pattern or road accidents at three levels (daily, weekly and monthly) directly related to their causes. Moreover the spatial and temporal database relates the natural hazards (glazed frost, fog, and blizzard) with the human made ones, giving the opportunity to evaluate the nature of uncertainties in risk assessment. At the end, this paper provides a clustering methodology based on several environmental indicators intended to classify the spatial and temporal hotspots of road traffic insecurity. The results are a useful guide for planners and decision makers in developing effective road safety strategies and measures.