



NEW METHOD OF PREDICTING THE OCCURRENCE OF ROAD ACCIDENTS IN UKRAINE

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Abstract

Insufficient road safety level remains a serious problem in Ukraine. The number of people killed in road accidents in 2018 per 100 thousand of population is 9,11, while in the countries of the European Union, on average, this indicator is 5-6 deaths per 100 thousand of population. The growing number of vehicles and road users increases the likelihood of road accidents and, accordingly, the number of the suffered people increases. This regularity can be noted not only in our country, but also in the countries over the world. Method of prospective extrapolation is proposed for the prevention of road accidents which makes it possible to transfer the trends and links connected with the occurrence of road accidents in the past to the current period and for the future. To apply this method, it is necessary to have a qualitative statistical analysis of the road accident data. This provides an opportunity to foresee the occurrence of a particular type of accident, its location and the causes affecting its occurrence. By using the prospective extrapolation method, it is possible to reduce the number of road accidents and the severity of their consequences, including reducing the number of fatal accidents to a minimum.

Keywords: road safety, road accidents, road conditions

1 Introduction

Over the past decades, the world has witnessed a rapid increase in the number of vehicles and an increase in traffic which leads to an increase in traffic accidents and the severity of their consequences [1]. The UN General Assembly resolution 58/289 of 14.04.2004 «Improving the global road safety» [2] approved the concept: «It is impossible to achieve mobility at the expense of health and life of people». According to the World Health Organization's estimates in 2030, road traffic accidents may be one of the five main causes of mortality in the world [3].

The Constitution of Ukraine recognized the life, health and human security as the highest social value in Ukraine of «[4]. In Ukraine, a number of legislative and legal acts which provide for increased responsibility of the national Ministries and Agencies, institutions and organizations for the implementation of measures to protect life and health» were adopted. The basic ones related to the road sector are the «Law of Ukraine on Road Traffic» [5]; «Presidential Decree on Additional Measures to Prevent Traffic Accidents» [6]. Based on the above list, it can be stated that human safety in Ukraine is a state policy.

According to the First International Congress on the Reform of the Road Traffic Safety Management System [7], the mortality rate on the roads of Ukraine is extremely high, and road traffic injuries are in the eighth place among the main causes of mortality and are the main cause of mortality among young people aged 15- 29 years old.

The conducted studies on the level of accidents on Ukrainian highways show that, as compared with European countries, the state of road safety in Ukraine is extremely unsatisfactory. The number of deaths in Ukraine is 7-10 times higher than in the economically developed countries of the European Union [2, 8].

Ways of solving the problems of reducing the accident rate on highways are proposed in the works of many Ukrainian scientists. Polishchuk V.P., Yerezov V.I., Lanovyi O.T., Kunitskaya O.M., Dzyuba O.P., in their works, analyzed and advised on reducing the accident rate and the severity of the consequences of an accident [1, 9, 10].

In the paper [11], a thorough analysis of the circumstances of the road traffic accident on public roads in Ukraine was conducted. The presented analysis showed that in many traffic accidents there was an influence of the disadvantages of road traffic conditions which, in turn, led to the driver's errors and the complications in driving. It is proved that the most frequent accidents occur in places where drivers must suddenly change the modes of movement due to the sudden complication of road conditions. Other causes were also analyzed, leading to an accident, and the measures were presented to reduce the number of accidents and the severity of their consequences [1, 11]. In the above-mentioned works it is stated that in order to achieve the reduction of the accident rate, it is expedient to develop the programs for the development of public highways on the basis of the methodology of road safety management in the region of Ukraine.

The Belarussian scientist Kapsky D.V. in his works describes the theoretical basis for predicting the accident rate and the dependence of the accident occurrence on various factors, and proposes methods for solving this problem [12]. The occurrence of accidents is considered by the author as a jump-free transition from the normal process of driving to an emergency one due to the emergence of a conflict situation when the driver makes the wrong decision and changes the parameters of driving.

The analysis of statistics of road traffic accidents in Europe convincingly proves that on the motorways allowing only motor vehicles traffic and prohibiting the traffic of all other types of vehicles, as well as pedestrians, the number of accidents per million kilometers of the vehicle mileage is 2-3 times lower than on ordinary roads open to all road users.

Overseas statistics states that only the lack of road markings can increase the number of accidents by 25 %.

It is driving skills during the critical assessment of real road conditions and the choice of safe driving techniques can help to improve road safety.

According to the World Health Organization, the World organization "Life expectancy research" ranked the countries by road traffic deaths level (Table 1).

Ukraine has the indicators of the number of deaths in road accidents by 100 thousand people worse than in Europe. Only Albania, Lithuania, Belarus and Moldova are worse than Ukraine. Thus, it is extremely important to develop methods that will influence the reduction of traffic accidents and the severity of their consequences, namely: improving the behavior and discipline of road users; improvement of vehicle technical characteristics and improvement of road conditions.

Table 1 The number of deaths in traffic accidents per 100,000 of population in Europe in 2018

Country	Killed per 100 thousand people.	Country	Killed per 100 thousand people
Sweden	2,49	Serbia	6,38
Great Britain	2,58	Bulgaria	6,40
Netherlands	2,81	Belgium	6,61
Switzerland	2,82	Luxemburg	6,71
Denmark	2,89	Greece	7,00
Norway	2,93	Macedonia	7,02
Spain	2,94	Slovakia	7,30
Iceland	3,24	Romania	7,89
Germany	3,54	Poland	7,93
Finland	3,73	Croatia	8,22
Ireland	4,01	Turkey	8,85
Italy	4,72	Latvia	8,85
Australia	4,74	Montenegro	9,01
France	4,86	Ukraine	9,11
Slovenia	5,75	Moldova	9,90
Estonia	5,94	Belarus	11,16
Czech	5,97	Lithuania	11,34
Portugal	6,11	Albania	12,32
Hungary	6,22	Russia	15,85

2 The main part

To develop methods for identifying the causes of an accident, planning and implementing effective measures to eliminate them, the authors identified objective and subjective factors that affect road safety. Objective factors include road conditions, traffic flow, weather conditions. To the subjective factors, the state of drivers and pedestrians, violation of traffic rules by them can be referred to.

Every year, a large number of traffic accidents occur in Ukraine, people are killed and injured. Only in 2018, according to the departmental data base of the accidents analysis and recording (Road Safety Management (RSM) which is created and functioning at «DerzhdorNIDI» SE, the number of traffic accident victims on the roads of state importance of Ukraine increased by 2.9 % as compared with 2017 (Table 2).

The authors of this article noted that road safety is most of all affected by the following factors:

- meteorological factors (weather conditions);
- traffic flows (human factor, vehicle's reliability);
- road conditions (road conditions).

Table 2 Accident statistics on roads of state importance for 2011-2018.

Year	Traffic accidents total	Traffic accidents with injured	Killed (persons)	Injured (persons)
2011	18687	5982	1774	8037
2012	24755	7808	2579	10506
2013	23685	7498	2152	10277
2014	17280	5958	1848	8334
2015	14499	5417	1556	7508
2016	15371	5203	1453	7382
2017	16250	5104	1378	7722
2018	16231	4686	1418	7079

Meteorological factors are characterized by the state of atmospheric phenomena. These phenomena include temperature, pressure, humidity, wind, clouds, precipitation, fog, thunderstorms, snow cover height and others. These phenomena can be long-term and short-term. Long-term atmospheric phenomena include, for example, negative temperature and snow cover in winter; the short-term atmospheric phenomena include precipitation, fog, ice. All these phenomena adversely affect the road safety. After all, when the weather conditions are changing, the situation on the highways is also dramatically changing. This affects the condition of the surface of the roadway, by reducing the coefficient of tyre grip with the pavement surface which leads to a sharp decrease in the road safety level.

The next factor that affects the road safety is traffic. Traffic includes the human factor and the reliability of vehicles. The technical condition of vehicles and their equipment must meet the requirements of standards relating to road safety and environmental protection, as well as technical regulations and other normative and technical documents.

In most countries, public opinion and official statistics often attribute the causes of traffic accidents to the driver's mistakes. So, the World Health Organization believes that 9 out of 10 accidents are caused by the drivers and other cases to some extent depend on it [3]

Another important factor affecting the road safety is road conditions. The authors analyzed a number of major disadvantages in road conditions that affect the occurrence of certain types of road traffic accidents (Table 3).

The list of deficiencies was identified by the specialists of «DerzhdorNDI» SE by comparing the indicators of the operating condition of the road with the regulatory requirements. Identification of specific disadvantages allows predicting the probability of occurrence of certain types of accidents and estimating the probability of the absolute number of the accident level reduction provided that the road conditions are improved, that is, the elimination of these disadvantages.

The analysis of statistical data performed by the specialists of «DerzhdorNDI» SE shows that the most common types of accidents include collisions and riding on the obstacles (Figure 1).

Table 3 Disadvantages in road conditions that contribute to the occurrence of certain types of road traffic accidents

Type of traffic accident	Disadvantages in road conditions that contribute to the occurrence of this type of road accident
Collision	Nonconformance of the width of the carriageway; Nonconformance of the radius of the curve in the plan; Nonconformance of the visibility with the regulatory requirements for the roads of this category; the level of the road loading exceeds the optimal; the absence of a centre mall or the safety barrier on a centre mall depending on the category of the road; nonconformance of the intersection type and the junction to the traffic volume; the absence of speed change lanes at the approaches and ramps of road interchanges.
Roll over	Absence or nonconformance of the transverse superelevation gradient of the curve in the plan with the normative designing requirements; the radius of the curve in the plan and the expansion of the carriageway do not meet the regulatory requirements for the roads of this category; lack of safety barriers in the right places; unsatisfactory state/the absence of the hard shoulders; lack of hard pavement at the ramps.
Riding on the obstacle	Close proximity of the trees to the carriageway edge; lack of fencing of the electric lighting supports and other obstacles; Unsatisfactory state of the roadside.
Riding on the vehicle that is standing	Insufficient width of the sidewalk; insufficient width of the stopping area; nonconformance of the visibility distance with the regulatory requirements for the roads of this category; lack of parking lots near the service objects.
Riding on the pedestrian	Lack of equipped pedestrian crossings in the required places; absence or unsatisfactory condition of sidewalks and pedestrian paths in the settlements; nonconformance of the visibility distance with the regulatory requirements for the roads of this category; absence of bus stops in the right places; lack of lighting in the settlements; unsatisfactory state of the roadside.

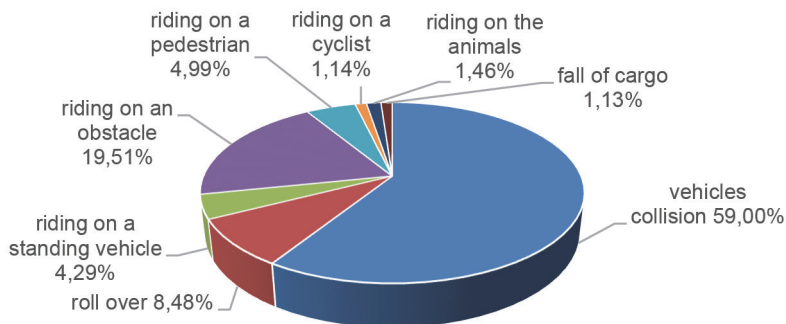


Figure 1 Distribution of traffic accidents by types of accidents on the roads of state importance for 2018

3 Prospective extrapolation method

The authors propose an extrapolation method based on analytical indicators of dynamics series to prevent the occurrence of road accidents. The method of extrapolation is a method of statistical analysis which allows transferring the trends that are associated with the occurrence of road traffic accidents from the past to the current period and for the future. Dynamic series (the dynamic row) is called a sequence of indicators characterizing the change of the phenomenon (process, object) in time. Separate observations of a dynamic series are called the levels. By time displayed in dynamic series, they are divided into moment and interval. In the series, the dynamics of the level express the magnitude of the phenomenon to the corresponding date, for example, the number of accidents on the first day of each month or the number of accidents at the beginning, end of the year, etc. In interval series the levels express the quantity of events over a period of time, for example, the number of accidents per month, quarter, year. When constructing the dynamic series, the focus should be on the comparability of the levels of the series. This means that all the levels must be expressed in the same units of measure, calculated according to a single methodology, and include a single circle of objects.

The quality of forecasting can only be judged after the event has taken place. To assess the reliability of the method used, the so-called «ex post forecast» method is used. Its essence is as follows.

The initial data are divided into 2 parts (two periods). According to the first part, conditionally adopted for the «prehistory», an equation (model) is constructed on the basis of which the forecast for the second part (second period) is made, the results of which are then compared with the actual data. This approach is also applicable to other quantitative methods of forecasting. The disadvantage of this method is that when calculating only the extreme levels of the dynamic series are used. Intermediate values, in fact, are not involved in the calculations.

To apply the method of extrapolation, we use a qualitative statistical analysis of data on accidents. In Ukraine, a study was conducted for which certain results were obtained. Statistical data for the full four years were used for the study. The main task of this scientific study is the analysis of the number of traffic accidents for the four-year period, which occurred on the territory of the Lviv region. The criterion of distribution is the severity of consequences (Figure 2).

As can be seen from Figure 8, the number of traffic accidents increases by more than 11 % on average in each subsequent year, which can be explained by the growth of traffic volume (in general in the region by 10-15 % annually in the in the considered periods), since the riding qualities of streets and roads and road conditions in general were almost unchanged during this period.

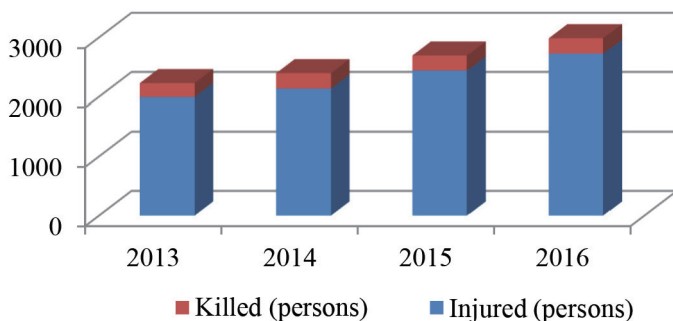


Figure 2 Number of traffic accidents in Lviv region in 2013 - 2016

It is important to note that the existence of a certain dependency between the number of traffic accidents and changes in the value of traffic volume allows making forecasts of changes in this relationship for future periods, using methods of direct extrapolation of the current state, which are usually applied for a short time period (up to 5 years and under condition that the territorial and road characteristics have not changed from the moment of the study). However, the total number of traffic accidents is not always a complete and sufficient indicator to make accurate conclusions. For this purpose the analysis of statistical data by types is also carried out: vehicles collision; rollovers; riding on a standing vehicle; riding on an obstacle; riding on a pedestrian; riding on a cyclist and the like. For considered period and territory, this distribution is shown in Figure 3.

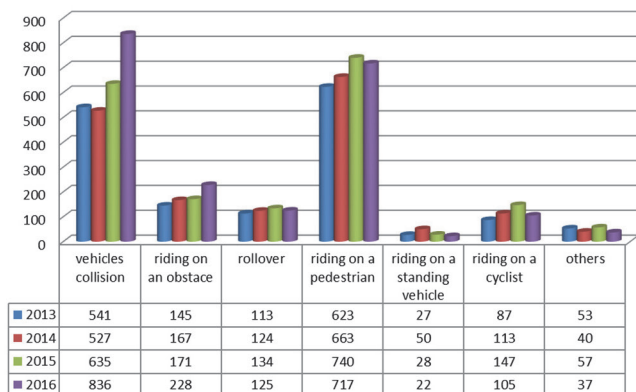


Figure 3 Distribution of traffic accidents by the type in the Lviv region for 2013-2016.

The largest number of traffic accidents during 2013-2016 are vehicles collisions and riding on a pedestrian. Very often the causes of these types of traffic accidents are exceeding the permitted speed limit, driving while intoxicated, lack of illumination or insufficient amount of illumination [17].

4 Conclusions

The number of traffic accidents with the victims on the roads of state importance of Ukraine from 2012 to 2018 has decreased but the number of deaths, on the contrary, has increased. The most common types of road accidents are collisions, riding on a vehicle, riding on a pedestrian, riding on an obstacle and rollover. The research of these types of accidents allows making the important conclusions and issuing the recommendations necessary for preventive work with the drivers, pedestrians, cyclists and all other road users. The analysis shows that the accidents occur under well-defined, constantly repeating circumstances. Moreover, each type of accident is characterized by the same emergency situations that need to be considered in detail in order to propose the methods that will promote preventing the occurrence of an accident. That is why, in order to prevent traffic accidents, an extrapolation method is proposed which will allow transferring the trends associated with the occurrence of road traffic accidents from the past to the current period and for the future. For the application of this method, a qualitative statistical analysis of the accident data should be performed. This allows predicting the occurrence of a particular type of road accident, the place and the causes that will affect their occurrence. From documentary studies it can be argued that a detailed analysis of the causes and consequences of accident rate and single traffic accidents will allow making predictions about the dynamics of changes in their number depending on changes in road conditions, riding qualities of carriageways and application of preventive measures to improve road traffic.

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