Establishing Emergency Sections on Land Roads in Order to Improve the Quality of Transport Services, Creating Comfortable Conditions for International and Local Traffic

Jurijus Zaranka[1], Jonas Matijošius[1], Urtė Radvilaitė[2], Jacek Caban[3], Agnieszka Dudziak[4]

[1] Department of Automobile Engineering, Faculty of Transport Engineering, Vilnius Gediminas Technical University, J. Basanavičiaus Str. 28, LT-03224 Vilnius, Lithuania

[2] Faculty of Fundamental Sciences, Vilnius Gediminas Technical University, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania

[3] Department of Automation, Faculty of Mechanical Engineering, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland

[4] Department of Power Engineering and Transportation, Faculty of Production Engineering, University of Life Sciences in Lublin, Głęboka 28, 20-612 Lublin, Poland

* Corresponding author's e-mail: j.caban@pollub.pl

ABSTRACT

The rapid increase in the number of cars in Lithuania and abroad every year (Statistics of traffic accidents in Lithuania), ensuring road safety is becoming an increasingly important and relevant aspect for road users and other responsible institutions. In the statistics of traffic accidents in Lithuania, no information is provided according to the nature of the vehicle collision, nor is there any information on the damage caused by the vehicle to the victim according to the type of collision. The work analyzes the security situation and emergency factors based on statistics. Factors determining the occurrence of traffic accidents are analyzed. A visual analysis of "black spots" was performed to determine the main factors of higher accidents. Statistical data and comparative analysis methods are used for the research. Calculated traffic incidents and the amount of damage caused by them are analyzed according to the type of collision.

Keywords: creditable traffic accidents, accident factors, traffic safety, black spot, road.

INTRODUCTION

The occurrence of a traffic accident is largely determined by the human factor, namely the conscious actions of the driver can cause an emergency, while the traffic environment and the car are in the background [1]. Violation of traffic rules is the driver's factor that causes an accident. The mentality and lack of responsibility of road users, psychological aspects can be the cause of a traffic accident [2].

When there was not much attention paid to traffic safety, education of traffic participants and control of drivers, it can be concluded that most of the traffic accidents occurred due to speeding of the vehicle [3]. It can be concluded that not choosing a safe speed is the main factor for the occurrence of the incident. A significant part includes other aspects where the speed may have been not exceeded, but due to the nature of the event itself, such as a head-on collision or running over a pedestrian, the consequences of the event are undesirable [4]. Pedestrians also play an important role, they, like vehicle drivers, must be alert and follow the traffic rules. A person feels like a more agile and mobile participant in a traffic accident, which is why a pedestrian can often be seen violating road traffic rules [5, 6, 7]. Neither the driver nor the pedestrian is used to managing an emergency on the road, so violations of traffic rules not only by drivers but also by pedestrians are investigated [8].

Road infrastructure, road condition and its characteristics can thus be the cause of a traffic accident [9, 10, 11]. In the case of urbanized areas, an additional problem is the organization and coordination of public transport [12, 13, 14, 15].

Comparing the traffic accident statistics provided by the Lithuanian Road Police Service in which people were injured since 2017. Until 2020, it can be concluded that the main reasons for the rise in traffic accidents do not fundamentally change. This is not to say that no steps have been taken to remove the carpet from the event in the past 20 years. According to the data of the ETSC (European Transport Safety Council) report "4th Road Safey Pin Report" (2021), Lithuania was in 22nd place out of 27 countries of the European Union in terms of the number of fatalities per 1 million people [16]. Population in 2009 Also, the number of qualifying events in Lithuania in 2008 decreased by even 26% compared to 2007, and in 2009 the number of qualifying events in Lithuania decreased by another 5.3% [17]. The goal of the European Transport Safety Council was to halve the number of road deaths by 2010. The set goal was not achieved, although the number of deaths among EU countries decreased by 42% in total, which amounted to almost 35 thousand road traffic deaths, which is much more than the expected number of 27 thousand deaths if the theoretical goal was achieved. In addition to 35 thousand dead people, more than 1.7 million people are recorded in the EU police [17]. Population as injured, including 300 thousand injured, in which the injuries were treated as serious. It is important to note that not all incidents are recorded and the definition of serious injuries may vary from country to country. In the program of the European Transport Safety Council from 2011 to 2020, the goal is to reduce not only the number of fatalities, but also the number of seriously injured people [18]. In the Figure 1 shows the relative change in road fatalities between 2010 and 2020 in EU countries.

Based on the conclusions presented by the European Transport Safety Council in a 2010 article, it is safe to say that drivers who exceed the speed limit, do not wear seat belts or are drunk significantly increase the likelihood of being injured in an accident or injuring other participants in a traffic accident [19]. If a drunk driver increases the probability of an accident, it does not mean that a driver who is not wearing a seat belt is also a participant of increased risk, but active safety measures during an accident protect passengers from more serious injuries [20]. Sober or not, the driver can also not notice the pedestrian, exceed the speed and perform other actions on the road, but it depends on his condition whether he does it consciously or simply does not orient himself in the environment, if he is under the influence of chemicals [21].

Hughes et al. al. [22] analyzed various traffic safety strategies, what they focus on, in which area the most investments are made, and which area they consider the most important for improving engineering traffic safety. The study
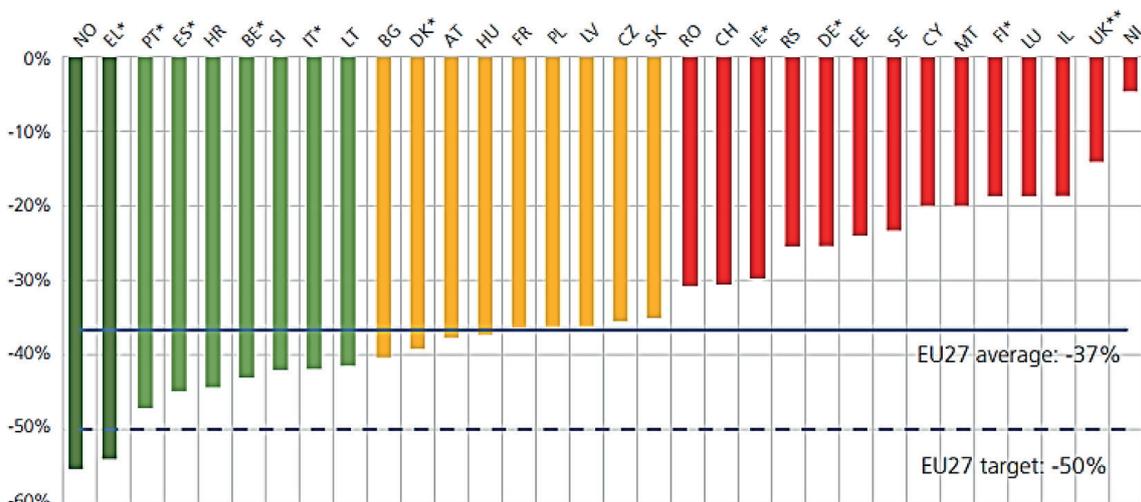
Figure 1. Relative change in road fatalities between 2010 and 2020 [16]

showed that about 90% of all road safety strategies focus on improving road infrastructure, vehicles and safety [23].

In conclusion, it could be said that the human factor is the main factor that determines the occurrence of a traffic accident, but the question remains, why traffic accidents are observed more often on some sections of the road than on others [24, 25]. For this reason, other causes of the traffic accident, such as the technical condition of the car [26, 27, 28] and the road infrastructure, are also being examined [29, 30, 31]. Some researchers see the improvement of safety in the technology of autonomous vehicles [32, 33, 34], but this is still a distant prospect.

According to the data of the Lithuanian Road Police Service in September 2019, improperly selected driving speed causes at least one fifth of all accidents on the country's roads and determines the consequences of every third traffic accident [35]. Statistics show that 2 out of 3 drivers in the country exceed the speed limit in urban areas. More than 10 km/h exceeds the speed limit on highways by 17.6%. Drivers, on district roads – 19.2%, and on regional roads – 31.6%. Between January and August of last year, police officers detected 101,905 speeding cases, during the same period last year, 156,790 such cases were detected on the roads [18]. Similar figures were also obtained in 2002, during the research it was found that from 61 to 75 percent of drivers in Lithuania exceeded the speed by up to 20 km/h [17].

At higher driving speeds, one of the human factors, such as reaction time, should not decrease, but the vehicle travels a greater distance in the same time. It is an interesting fact that the driver's perception of the environment differs at different driving speeds [36]. Sight distance defined as the length of the roadway that the driver can see [37]. The better the driver can see the environment, the better he assesses the situation. If the field of vision is limited or insufficient, it is obvious that more traffic accidents happen in such places.

Thus, in cities and on highways, the driver perceives the environment differently due to different speeds. In the city, it is easier to notice road elements, pedestrians, signs and traffic lights. On highways, at higher driving speeds, the field of vision is narrower, which makes it more difficult to assess the situation or avoid a collision with a large animal that ran onto the road. On highways, due to higher speeds, it is possible not to notice another vehicle approaching, or if it is noticed,

the stopping distance will be too long considering the reaction time [38].

The surroundings of the road and objects that distract the driver from driving are also important. This aspect of road transport safety was presented in the works [39, 40]. According to the manners of driving a car, the personality of the driver, his respect for other road users, responsibility, discipline, vigilance and deliberate caution can be accurately determined [41]. If the driver drives the car in an orderly manner and deliberately avoids speeding, such a driver is less likely to get into a traffic accident [42]. For other road users with less experience, awareness and discipline, and especially when driving on unfamiliar roads, it is necessary to follow road markings, warning signs, do not try to be smarter than others and do not exceed the speed limit. Road signs are one of the main means of information and traffic regulation. The contractual prohibited symbols indicate the directions and order of movement, drivers are informed about the road and traffic conditions. Road signs on the streets are installed in such places that they are visible to the participants of the traffic accident. City streets are lit, and country roads have signs covered with reflective film [43, 44].

Therefore, the purpose of this research is to analyze the factors determining creditable traffic accidents based on the data of the insurance company's database, and to investigate which types of collisions are the most dangerous based on the amount of damage paid out for each type of collision.

MATERIALS AND METHODS

Since the goal of the national road maintenance and development program of the Republic of Lithuania is zero fatalities in road transport by 2050 [36], we need to create a research model examining extremely dangerous sections, which are marked as "black spots". The road section has many parameters for the origin of the traffic accident, but it is closely related to the participants in the traffic accident, so it is difficult to assess all the causes of the occurrence of the accident, but the influence of the human factor can be reduced. Figure 1 a model for the study of "black spots" is presented.

Using the research model, it is necessary to first assess whether it is a new, old or changed

black spot. The maps of the previous year are compared and black spots are searched for. Traffic intensity is an important factor for road sections, so regardless of the type of road it is important to take traffic intensity into account. Next, it is taken into account what kind of road section it is: straight or intersection. A straight road can be single or multi-lane. Theoretically, there can be no traffic accidents on a one-lane road, but due to the geometrical parameters: the slope of the road section, the turning radius and unequipped roadsides, the vehicle may slip. If it is a road with two or more lanes, the number of collision points also increases.

At intersections, it is important to consider the type of intersection, 3 types of intersections are already known. The intersection can be regulated, at such intersections the order of passage prevails. Unregulated intersections increase the human factor error, so it is important to ensure an understandable perception of the environment, good visibility, road marking and placement of signs [45].

After theoretically analyzing the factors that determine traffic accidents, it was concluded that three factors that determine traffic accidents are the most important:
- human factor;
- environmental factor and its perception;
- infrastructure factor.

It was also noticed that all investigated traffic incidents are classified and they are sorted according to the type of collision, but not the type of vehicle collision. The damage caused to the participants of the traffic accident depends on the type of vehicle collision. The type of collision also shows which factor is the main determinant of the traffic accident.

RESULTS AND DISCUSSION

After analyzing the scientific literature and research conducted by various scientists, it is possible to come to the conclusion that the human factor is one of the most important causes of traffic accidents. Another important factor is the density of vehicles. Lithuanian fleet of vehicles in 2018, compared to 2017, increased by 7.10% – 118,838 vehicles. Accordingly, the number of vehicles per 1000 inhabitants increased from 596 to 642 units [18].

Based on the available statistical data, the comparative analysis method was used to evaluate the consequences of creditable traffic accidents according to the amount of compensation due to health injury. When reading people's posts, factors such as:
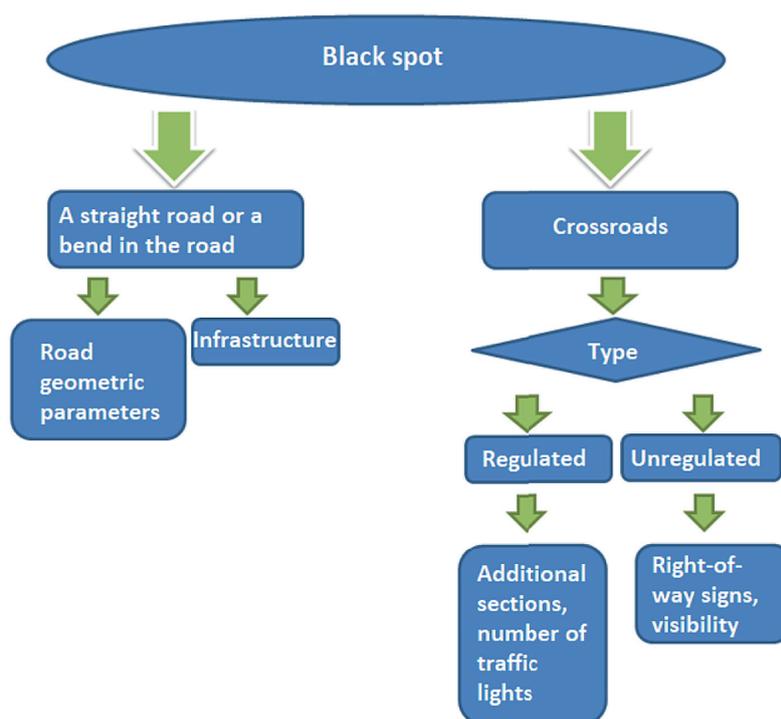- missed/unobserved vehicles driving straight while the culprit turns left;

Figure 2. Black spot evaluation model

- missed/unobserved vehicles driving on the main road;
- exit to the opposite direction traffic lane;
- hit the rear of the vehicle;
- running over a pedestrian;
- driving through a red traffic light;
- driving off the road.

In order to analyze these factors investigated for each factor, a 10-year period (2010–2019) will be evaluated, and the entire period consists of 636 creditable traffic accidents where people were injured. In order to find out the influence of the listed events' determining factors on the amount of damage, each factor will be evaluated separately. The determining factors of the traffic accident are studied by comparative analysis.

Based on the data on black spots provided by the Motor Road Directorate of the Republic of Lithuania, it is noticeable that most black spots are formed on regional roads, a smaller number is noticeable on main roads, and there are even fewer on district roads. Since the main concentration of black spots is on main roads and country roads, where there are no pedestrians, we will pay more attention to the events according to the nature of the collision, and we will examine events such as running into a pedestrian only in order to assess the totality of the listed events and the extent of their danger to pedestrians [35].

"Black spots" may disappear, remain, migrate, or appear in new places with or without the implementation of road safety improvement measures. Disappearing black spots seem to confirm that traffic safety measures were properly chosen in those places, which no longer allow road users to behave ambiguously and recklessly, while reducing the occurrence of traffic accidents. Old or re-appearing black spots indicate that no security enhancements have been implemented in those areas or that they were not selected properly. Creditable traffic incidents are recorded not only on dangerous road sections, but also on all roads.

During the research, the Microsoft Excel software package is used for the processing of statistical data on traffic accidents. The study analyzes creditable traffic incidents since 2010. until 2020 selected insurance companies, traffic intensity data of the Road Directorate of the Republic of Lithuania on national roads, statistics of traffic accidents in Lithuania [18].

In 2019 17 black spots have been identified on roads of national importance in Lithuania, of which 8 black spots on main roads, 8 black spots on regional roads, and 1 black spot on regional roads. In 2019, compared to 2018, 5 new black spots were identified on Lithuanian national roads, 9 black spots disappeared and 12 black spots remained. There were 94 creditable traffic accidents during the years 2015–2018, during which 18 people were killed and 126 were injured in the designated black spots of national roads. Figure 3 variation of black spots is shown.

Examining the statistics of traffic accidents in Lithuania, it can be noticed that since 2011, the number of accidents has been fluctuating (Figure 4). Considering that the number of vehicles is growing, and the number of registered traffic accidents is not directly proportional to the increase in vehicles, it can be said that the almost stable number of registered accidents is positive,
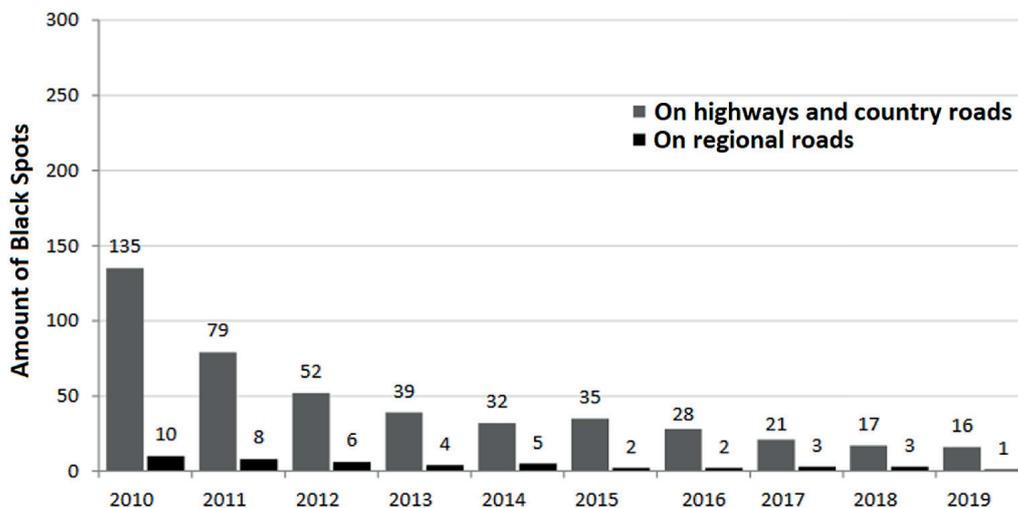

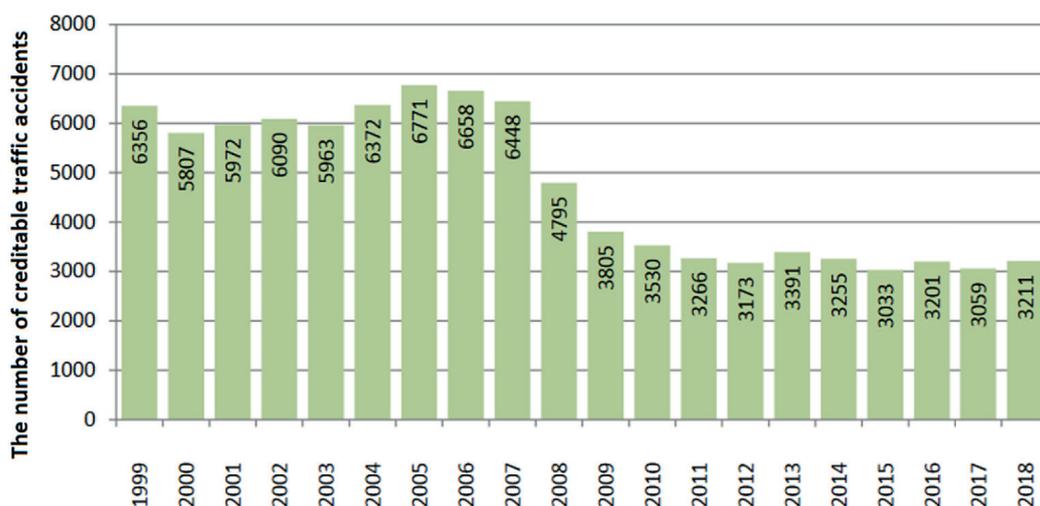**Figure 3.** Change of black spots in Lithuania in 2010–2019

Figure 4. The number of creditable traffic accidents in Lithuania in 2010–2018

although undesirable. The same is reflected in the decrease in the number of black spots.

One of the more interesting facts is that the World Health Organization assumes that the number of technical traffic accidents in 2030 may be the same as in 2010 due to the increase in the number of vehicles, but the number of creditable accidents is expected to be lower.

In 2019 5 black spots have been identified on roads of national importance in Lithuania, which were formed due to traffic accidents caused by drivers under the influence of alcohol or drivers who do not have the right to drive vehicles. This figure accounted for 29.41% of the total in 2019. black spots of national significance on the roads. 2 black spots were formed on main roads due to the fault of drivers who were intoxicated or who did not have the right to drive, on country roads – 3 black spots, on regional roads – 0. Compared to 2018, in 2019 the total number of black spots formed due to the fault of drivers who were intoxicated or who did not have the right to drive increased by 1 pc.

Analyzing the dependency of the insurance payment according to different factors, it is observed that the amount of the payment for the victim of the culprit of the drunk driver is the highest compared to other factors. It has also been observed that the amount of compensation due to drunken drivers is very variable, which can be explained by the unconscious actions of the driver, such as: worse control of the vehicle, higher speeds while intoxicated, inadequate awareness of the environment. Drivers who do not have the right to drive have smaller damages, and the smallest amount of compensation belongs to dutiful drivers.

Another important factor when looking at black spots further is the speed limit. It can be observed that in Lithuania the average speed on highways and country roads does not exceed the set speed limit, but in certain sections of the road, drivers significantly exceed the speed limit. Danish researchers found that approximately 85% of all traffic accidents in the country occur for one or more of the following reasons: speeding, alcohol consumption, cyclists, intersections. To this day, it cannot be said that the cause of the black spots on the main roads in Lithuania is speeding. On the country roads, it is noticeable that some black spots may have formed due to speeding by drivers, as the main factor in the occurrence of traffic accidents. Speeding has been recorded on certain sections of the road:

- 141 road 219 110 m. point, 217,244–217,958 m of black spots, respectively. Section, about 38% of drivers exceed the speed limit.

Examining the variation of recorded traffic accidents, it can be noticed that there are sections of the road where the automobiles' roads is higher than in other sections of the road, such places require more attention. Comparing 2007–2008 formed black spots with 2019 it can be concluded that the allocation of municipal funds for the road maintenance and development program gives a positive result, but there are such road sections where greater accidents are observed to this day:

- 141 county road in 2008. was one of the most dangerous roads in the country, although in 2014–2016 no black spots were found in it, but again in 2017. when identifying emergency road sections, black spots are recorded on

the 217,500–218,000 m section, in 2018 on the 213,691–213,991 m section and, respectively, in 2019 on the 217,244–217,958 m section. in the stretch. Based on the available information and statistics of previous recorded events, that the accident section is not a specific section of the road, we assume that it is a longer section of the road where the incidents occur.

- 160 edge road in the section 3997–4404 m, although in 2011–2015 this black spot was gone, since 2007 until 2011 the mentioned section of the road was recorded as a high emergency, and since 2016 until 2019 are again marked as black spots on the map. Although in the statistics of traffic accidents, most of the incidents are recorded in the presence of drunk drivers, it is difficult not to notice that the section of the road is constant and its problem has not been fully resolved.

- A9 trunk road 56,704–57,429 m road section cannot be overlooked either, because only in 2011. in the mentioned road section, the automobiles' roads was lower and the road section was not recorded as a black spot, in all other years from 2007 to 2019, the road section is of increased emergency. In the mentioned section of the road, creditable traffic incidents are recorded in the road section 55 253–55 520. It appears that the stretch of road is dangerous due to higher speeds, higher traffic volumes or poor road awareness.

Several sections of the road, where there is a greater emergency, have already been reviewed. Every stretch of road is different and there are also different types of traffic accidents. In this section, an analysis of the factors determining the damage of the insured traffic accidents of the selected insurance company is carried out according to the type of collision and it is estimated which type of collision is the most dangerous by comparing the amount of the payment due to the personal damage suffered, and not to the damaged property during the incident.

Examining the emergency sections, it is noticed that increased AC on roads of state significance can be in urban areas as well as outside urban areas, for this reason traffic incidents with pedestrians will also be examined, although it was assumed that there are fewer such traffic incidents on highways and rural roads.

During each of the listed events [18, 35], Lithuania suffers economic losses every year.

According to the data of the Automobile Road Directorate of the Republic Of Lithuania in 2018, the damage to the Lithuanian economy due to 1 person killed in a traffic accident was EUR 59,1538, due to a seriously injured person – EUR 84,686, and due to a lightly injured person – EUR 5,693. Since the division of injuries into serious and light credits in traffic accident statistics is not accurate and is not determined at all in more than 50% of cases, according to the "Methodology for the preparation of investment projects that aim to receive financing from the European Union's structural support and/or state budget funds", recommendations are presented in the methodology injuries were divided into 50%. As a result of all traffic accidents that occurred in 2018, the state of Lithuania suffered 271.51 million. EUR damage (Figure 5).

Every person must follow the rules of such behavior so as not to harm another person with their actions, traffic rules are no exception. Damage to a natural person can be pecuniary or non-pecuniary. The latter is compensated only in cases established by law. Non-pecuniary damage is compensated in all cases when it is caused due to a crime, to the health of a person or to the loss of a person's life, and in other cases established by law. It has been observed that the human factor is the main factor behind a traffic accident, so based on the personal injury statistics of the selected insurance company, the following statistics are presented by type of collision.

After grouping traffic incidents according to the type of accident, it can be concluded that road sections with unregulated intersections are more dangerous than regulated intersections. Although there are the most incidents of running into a pedestrian – 235, the total number of incidents where a vehicle was rear-ended and a vehicle driving on the main road was not missed is 228. These traffic incidents are characterized by one criterion, the human factor, when it was not noticed or reacted in time to another participant in the traffic accident that caused the incident. At regulated intersections without additional sections or unregulated intersections, 62 left-turning incidents were recorded without passing a straight-going vehicle; such collisions indicate a lack of driver attention or overconfidence of straight-going drivers at intersections. Fewer traffic accidents are observed when vehicles leave the road; many factors can be attributed to such incidents: tire-road adhesion coefficient, vehicle
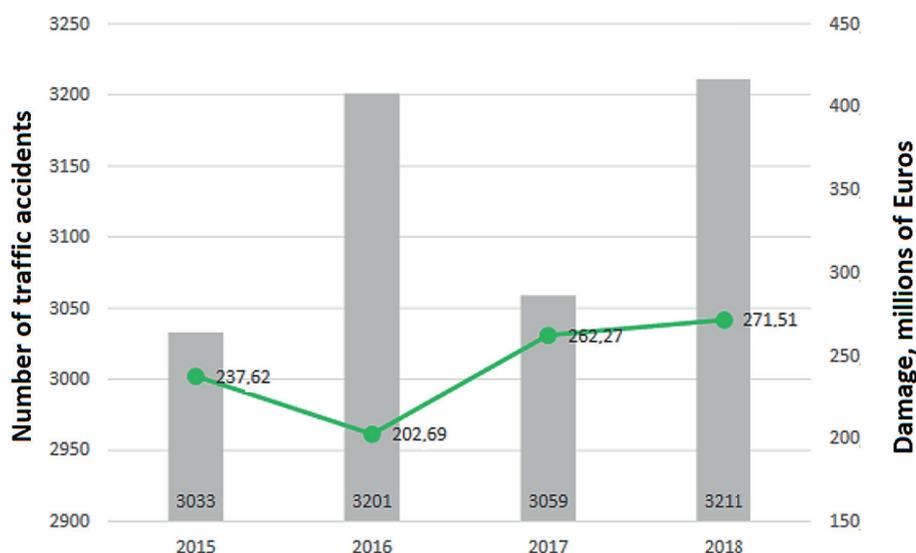
Figure 5. Countable traffic accidents for the Lithuanian economy in 2015–2018

speed, road slope, so it is difficult to assess the occurrence of such incidents, but it is possible to reduce their number by observing the set speed on the relevant road sections. Accordingly, there are more incidents when driving into the lane of the opposite direction, because sliding off the road can happen both to the left and to the right. When examining traffic incidents according to the nature of the collision, the incidents where the vehicle lost control and entered the opposite lane were treated as "crossing into the opposite direction lane". There are the fewest incidents of driving through a red light.

Each collision has different consequences and, accordingly, different payout amounts. According to the data of the Automobile Road Directorate of the Republic Of Lithuania, collisions and collisions with pedestrians cause the greatest losses to the Lithuanian economy every year. in 2018 collisions accounted for 34.23% (EUR 92.94 million), and collisions with pedestrians accounted for 28.10% (EUR 76.29 million) of all losses caused to the state due to creditable traffic accidents. According to the data of the selected insurance company, 1.557 million Euros was paid out in the last 10 years.

The total amount of the payment depends on the amount of damage caused and the number of events. Before that, we found that the majority of incidents occur when vehicles collide with pedestrians, and we also see that these collisions are the most damaging. It is hard not to notice that a significant part of the payouts is caused by collisions when driving into the opposite lane, also known as "head-on collisions".

When comparing the average amount of the payout, it can be seen that left-turn collisions when there is a vehicle traveling straight and the amount of payout when there is a vehicle traveling on the main road are similar, this can be explained by the fact that the nature of the collision is similar, because one participant in the event is standing still or moving slowly, while the other participant is driving straight and usually does not have time to react to the car that appears. The least damage is caused when entering from the rear, this is explained by the fact that the overall collision speed is lower, and also during the collision, the impact of the victim is evenly distributed and absorbed by the rear seat. Incidents involving driving through a red light can be classified as higher damages. The amount of damage is higher because both vehicles are moving, as they are believed to have the right of way. A fairly large average payout is also given to injured passengers when the vehicle is driven off the road, it seems that the vehicle could brake smoothly after driving, but in such events, the vehicle overturns or hits a stationary obstacle is quite often observed. The largest part of the payment is for events when driving into the lane of the opposite direction, the driving speeds of such events are added up and usually occur during overtaking before returning to the original traffic lane. During such events, the passengers of both vehicles are injured, when only pedestrians are injured when running into a pedestrian, as less protected participants in a traffic accident.

During the examination of the damage, there were also such incidents that were the fault of a drunk driver. Such events were recorded in as many as 12 out of all 636 examined, which is 1.88% of the

events. The amount of damages paid out by drunk drivers is 6.67% of all the damages paid out [18].

In the data of the selected insurance company, only property and health damage losses are presented. After suffering health injuries during the incident, the injured person has the full right to apply for compensation for moral damages. The latter is often greater than property damage.

CONCLUSIONS

The traffic safety situation on the roads of Lithuania is improving every year, but looking at the scale of the European Union, the situation does not meet the set goals.

It was established that "Black Spots" might disappear, remain, migrate, or appear in new places after the implementation or non-implementation of traffic safety improvement measures. In 2019, compared to 2018, 5 new black spots were identified on Lithuanian national roads, 9 black spots disappeared and 12 black spots remained.

Most of the black spots are formed on the country roads, a smaller number is noticeable on the trunk roads, and there are even fewer of them on the district roads. It can be said that the almost stable number of credit events is positive, although undesirable. The same is reflected in the decrease in the number of black spots.

After grouping traffic accidents by type, it can be concluded that road sections with unregulated intersections are more dangerous than regulated intersections. Although there are the most incidents of running into a pedestrian – 235, the total number of incidents where the rear of the vehicle was entered and the vehicle driving on the main road was not missed is 228. These traffic incidents are characterized by one criterion – the human factor.

Collisions and collisions with pedestrians cause the biggest losses to the Lithuanian economy every year. In 2018 collisions accounted for 34.23% (EUR 92.94 million), and collisions with pedestrians accounted for 28.10% (EUR 76.29 million) of all losses caused to the state due to creditable traffic accidents.

REFERENCES

1. Benzaman B., Ward N.J., Schell W.J. The Influence of Inferred Traffic Safety Culture on Traffic Safety Performance in U.S. States (1994–2014). Journal of Safety Research 2022; 80: 311–319.

2. Calvert S.C., van Aren B., Lappin J. Herd Immunity for Traffic Safety in Mixed Automated Traffic: What If Cars Could Not Crash!? Transportation Letters 2022.

3. Morimoto A., Wang A., Kitano N. A Conceptual Framework for Road Traffic Safety Considering Differences in Traffic Culture through International Comparison. IATSS Research 2022; 46: 3–13.

4. Raza S.A., Siddiqui A.W., Butt F.M., Elahi M.A., Minhas K.S. Saudi Arabian Road Accident Mortality and Traffic Safety Interventions Dataset (2010–2020). Data in Brief 2022; 44: 108502.

5. Czech P. Underage pedestrian road users in terms of road accidents. Advances in Intelligent Systems and Computing 2017; 505: 33–44.

6. Czech P. Physically Disabled Pedestrians—Road Users in Terms of Road Accidents. Lecture Notes in Networks and Systems 2017; 2: 157–165.

7. Zaranka J., Pečeliūnas R., Matijošius J. Analysis of the Influence of Fatigue on Passenger Transport Drivers' Performance Capacity. Transport 2012; 27: 351–356.

8. Borsche R., Meurer A. Microscopic and Macroscopic Models for Coupled Car Traffic and Pedestrian Flow. Journal of Computational and Applied Mathematics 2019; 348: 356–382.

9. Lizbetin J., Stopka O. Proposal of a Roundabout Solution within a Particular Traffic Operation. Open Engineering 2016; 6(1): 441–445.

10. Mishra K.R., Mohanty M., Dey P.P. Modelling Traffic Safety at Uncontrolled Median Openings: A Case Study in India. IATSS Research 2022.

11. Poliak M., Komackova L., Semanova S., Hernandez S., Jaskiewicz M. Defining the influence of the support of bus service on road safety. Communications – Scientific Letters of the University of Žilina 2016; 18(2): 83–87.

12. Boratto L., Manca M., Lugano G., Gogola M. Characterizing user behavior in journey planning. Computing 2020; 102: 1245–1258.

13. Hurtova I., Sejkorova M., Verner J., Kucera M. Preference and area coordination of public transport in modern city. In: Proc. of 17th International Scientific Conference: Engineering For Rural Development, Engineering for Rural Development 2018; 2085–2091.

14. Medvid P., Gogola M., Kubalak S. Occupancy of Public Transport Vehicles in Slovakia. Transportation Research Procedia 2020; 44: 153–159.

15. Brumercik F., Lukac M., Krzysiak Z., Krzywonos L. Model of integrated transportation system. Communications – Scientific Letters of the University of Zilina 2017; 19(2): 23–26.

16. ETSC – 15th Annual Road Safety Performance Index (PIN) Report, June 2021 – NRSO Avail-

able online: https://www.nrso.ntua.gr/etsc-15th-annual-road-safety-performance-index-pin-report-june-2021/ (accessed on 17 October 2022).

17. Union, P.O. of the EU. EU Transport in Figures: Statistical Pocketbook 2018. Available online: https://op.europa.eu:443/en/publication-detail/-/publication/52f721ed-c6b8-11e8-9424-01aa75e-d71a1 (accessed on 29 October 2019).

18. Database of Indicators - Portal of Official Statistics of Lithuania (In Lithuanina) - Rodiklių duomenų bazė - Oficialiosios statistikos portalas Available online: https://osp.stat.gov.lt/statistiniu-rodikliu-analize#/ (accessed on 8 November 2020).

19. AEE. The European Environment: State and Outlook 2020: Knowledge for Transition to a Sustainable Europe. Publications Office: LU, 2019.

20. Kilikevičius A., Kilikevičienė K., Fursenko A., Matijošius J. The Analysis of Vibration Signals of Critical Points of the Bus Body Frame. Periodica Polytechnica Transportation Enginerring 2020; 48: 296–304.

21. Pravilonis T., Sokolovskij E., Kilikevičius A., Matijošius J., Kilikevičienė K. The Usage of Alternative Materials to Optimize Bus Frame Structure. Symmetry 2020; 12: 1010.

22. Hughes B.P., Anund A., Falkmer T. A Comprehensive Conceptual Framework for Road Safety Strategies. Accident Analysis & Prevention 2016; 90: 13–28.

23. Qi H., Yao Y., Zhao X., Guo J., Zhang Y., Bi C. Applying an Interpretable Machine Learning Framework to the Traffic Safety Order Analysis of Expressway Exits Based on Aggregate Driving Behavior Data. Physica A: Statistical Mechanics and its Applications 2022; 597: 127277.

24. Mamcarz P., Droździel P., Madleňáková L., Sieradzki A., Droździel P. Level of occupational stress, personality and traffic incidents: Comparative study of public and freight transport drivers. Transportation Research Procedia 2019; 40: 1453–1458.

25. Optimal Off-Ramp Terminal Locating Strategy Based on Traffic Safety and Efficiency. Transportation Letters 2022; 14: 174–185.

26. Drozdziel P., Krzywonos L., Madlenak R., Rybicka I. Selected aspects of analyses of failure rates of active safety systems in buses. Communications – Scientific Letters of the University of Žilina, 2014; 16(3): 114–119.

27. Mata-Carballeira Ó., del Campo I., Asua E. An eco-driving approach for ride comfort improvement. IET Intelligent Transport Systems 2022; 16(2): 186–205.

28. Sarkan B., Semanova S., Harantova V., Stopka O., Chovancova M., Szala M. Vehicle fuel consumption prediction based on the data record obtained from an engine control unit. MATEC Web of Conferences 2019; 252: 06009.

29. Arun A., Haque Md.M., Washington S., Mannering F. A Physics-Informed Road User Safety Field Theory for Traffic Safety Assessments Applying Artificial Intelligence-Based Video Analytics. Analytic Methods in Accident Research 2022; 100252.

30. Samociuk W., Krzysiak Z., Bukova B., Brumercikova E., Bąkowski H., Krzywonos L. Analiza międzynarodowego transportu produktów chemicznych w państwach Grupy Wyszehradzkiej. Przemysl Chemiczny 2018; 97(6): 829–833.

31. Skrucany T., Synak F., Semanova S., Ondrus J., Rievaj V. Detection of Road Vehicle's Centre of Gravity. In: Proc. of 11th International Scientific and Technical Conference on Automotive Safety, Casta Papiernicka, Slovakia, 2018.

32. Andrei L., Negulescu M.H., Luca O. Premises for the Future Deployment of Automated and Connected Transport in Romania Considering Citizens' Perceptions and Attitudes towards Automated Vehicles. Energies 2022; 15(5): 1698.

33. Kovačić M., Mutavdžija M., Buntak K. New Paradigm of Sustainable Urban Mobility: Electric and Autonomous Vehicles—A Review and Bibliometric Analysis. Sustainability 2022; 14(15): 9525.

34. Ren W., Yu B., Chen Y., Gao K. Divergent Effects of Factors on Crash Severity under Autonomous and Conventional Driving Modes Using a Hierarchical Bayesian Approach. International Journal of Environmental Research and Public Health 2022; 19(18): 11358.

35. Lithuanian Road Administration under the Ministry of Transport and Communications Available online: https://lakd.lrv.lt/en/ (accessed on 8 November 2018).

36. Kurakina E., Kravchenko P., Brylev I., Rajczyk J. Systemic Approach to Auditing Road Traffic Accident Black Spots. Transportation Research Procedia 2020; 50: 330–336.

37. Hall J.W. Stopping Sight Distance: Can We See Where We Now Stand? Transportation Research Record 1989; 10.

38. Fan Z., Liu C., Cai D., Yue S. Research on Black Spot Identification of Safety in Urban Traffic Accidents Based on Machine Learning Method. Safety Science 2019; 118: 607–616.

39. Hudak M., Madlenak R. The research of driver's gaze at the traffic signs. CBU International Conference Proceedings 2016: Innovations in Science and Education. Prague, Czech Republic, Proceedings of CBU 2016; 4: 896–899.

40. Madlenak R., Hostakova D., Madlenakova L., Drozdziel P., Torok A. The analysis of the traffic signs visibility during night driving. Advances in Science and Technology-Research Journal 2018; 12(2): 71–76.

41. Čižiūnienė K., Matijošius J., Čereška A., Petraška A. Algorithm for Reducing Truck Noise on Via Baltica Transport Corridors in Lithuania. Energies 2020; 13: 6475.

42. Tarkowski S., Rybicka I. Distraction of the Driver and Its Impact on Road Safety. Transportation Research Procedia 2020; 44: 196–203.

43. Maghrour Zefreh M., Torok A. Theoretical Comparison of the Effects of Different Traffic Conditions on Urban Road Traffic Noise. Journal of Advanced Transportation 2018; 1–11.

44. Maghrour Zefreh M., Torok A. Single Loop Detector Data Validation and Imputation of Missing Data. Measurement 2018; 116: 193–198.

45. Maghrour Zefreh M., Baranyai D., Torok A. Assessing the Possibility of Presenting a Semi-Stochastic Speed-Density Function. MATEC Web of Conferences 2016; 81: 04002.