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# STUDY OF THE INFLUENCE OF SUSTAINABLE TRANSPORT ON TRAFFIC INCIDENTS

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**Abstract.** *Purpose* – to determine whether changes in sustainable transport influence the difference in the number of road accidents.

*Research methodology* – synthesis and comparative scientific analysis of concepts and methods published in the literature, secondary data analysis, statistical processing, correlation-regression analysis, ARIMA method.

*Findings* – the number of traffic accidents will increase in the coming years. According to the result of the correlation regression analysis, the number of traffic accidents is influenced by the reduced level of work capacity, people and the average traffic intensity, car/day; the change in the number of electric cars was not identified as an influencing factor.

*Research limitations* – lack of data (incomplete statistics on sustainable vehicles) or difficult access to them.

*Practical implications* – the results can be used in preparing strategic city plans to predict the consequences of sustainable transport regarding traffic accidents.

*Originality/Value* – the article covers the development and changes in road traffic accidents in the big cities of Lithuania and predicts the possible reasons for this.

**Keywords:** sustainable transport, road traffic incidents, correlational regression analysis.

**JEL Classification:** M0.

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## Introduction

One of the main goals of municipal management is to ensure a healthy environment for residents. Unfortunately, pollution caused by urban transport accounts for about 40% of all $CO_2$ emissions and 70% of other pollutants emitted by road transport. To solve this situation in July 2020. The basis of the adopted documents is to restore the EU economy by transitioning to a green economy and sustainability. The principles of sustainable mobility are applied in cities when switching to various means of movement to reduce environmental pollution and ensure safety and security in the city. Therefore, the question arises about how changes in sustainable transport in the city affect the number of accidents in road traffic. Based on the definitions of different scientists, we conclude that the car is one of the biggest polluters on the road (Juodvalkis & Dargužis, 2021), a technical device designed to transport and transfer (Bogdevičius, 2012), which has a negative impact on the transport sector: congestion on the streets, impact on the environment (Pečiukėnas et al., 2017), noise maker (Bareikis & Vasiliauskas, 2016; Danilevičius, 2020; Vitkūnas et al., 2021), one of the causes of traffic accidents

(Zaranka, 2012). According to data from the Department of Statistics, the number of road vehicles increased by more than 20% in 2021 compared to 2017. Of which, new vehicles represented more than 2%. And that is more than 2%, more than in 2017. The number of dead people in 2020 compared to 2006 decreased more than four times, but in April 2023, compared to the year before, 15 more traffic accidents occurred.

In Lithuania, most traffic accidents are caused by the young age of drivers, their lack of driving experience, distraction, fatigue, drunk driving, speeding, poor road conditions, and disregard for traffic rules.

This study aims to determine whether and how changes in sustainable vehicles impact the number of accidents in road traffic. To achieve this goal, the following tasks are set:

1. To provide an overview of the theoretical aspects of sustainable transport, road traffic accidents, and the factors that determine them.
2. Create regression models after applying the correlational regression analysis.
3. Prepare a road traffic forecast using the ARIMA method.

## 1. Review of the literature

According to the population survey of the general plan of the Vilnius city territory (Vilniaus miesto savivaldybė, 2016), up to 41.9% of the respondents prefer to travel during the morning rush hour by car, on foot – 25.4; by city bus – 13.4%. 98.9% of conventional fuel-powered cargo vehicles are registered in the Vilnius city vehicle register (95.2% of the fuel type is diesel). However, in recent years, cities have been implementing the principles of sustainable development to reduce air pollution. According to the Vilnius City Municipality Sustainable Mobility Plan approved in 2018, the following will be aimed at by 2030: Develop a non-motorized transport infrastructure (infrastructure of a non-motorized transport network, bicycle storage infrastructure). To use public transport – to install public transport lanes in areas of vehicle congestion; increase the share of bicycle trips in the overall structure of trips (only 0.7% of trips are made by bicycle) – in the territories of the old town, city centre, and residential areas, reduce car speeds on the streets, reduce transit traffic flows, reduce the roadway of the roads to minimum parameters, at the expense of increasing the spaces for bicycles for transport; to increase trips on foot, because in the general structure of trips in 5 years about 6% decreased share of trips on foot/bicycles (29.4% in 2016, 35.9% in 2011) – by integrating sections of existing routes, installing a standard system of pedestrian routes, increasing their integrity for smooth daily pedestrian traffic, trips to schools, shopping, and health care institutions, by installing/renovating surfaces for convenient trips on rollerblades, skateboards, scooters, and other rolling devices, it should also be emphasized that a large percentage of traffic accidents with pedestrians (according to the average data of the last three years, 4.2% of this type of incident kills pedestrians).

Different authors distinguish the intended definition of a traffic accident. Most authors emphasize the consequences, that is, health problems (various injuries, even death) (Goniewicz et al., 2016). For this reason, it is necessary to accelerate the implementation of road safety prevention measures (Solanki, 2016). The extraordinary impact on public health in developing countries was emphasized (Mohtasham-Amiri, 2016). The authors of Utanaka

and Widyastuti (2019) state that a traffic accident is one of the leading causes of death, even one of the ten leading causes of death in the world, next to medical factors (such as heart disease, stroke, diabetes, etc.). A traffic accident is defined as a global tragedy, the trends of which are growing and endless (Deme, 2019). A traffic accident is considered the most undesirable situation and one of the most important causes of death and injury worldwide (Shaik & Hossein, 2020). A traffic accident can be identified as a threat to human safety, which has a multifaceted effect on the economy of households and countries, negatively affects food security, as it affects the availability of essential food products; for health safety, which can cause mortality, illness, and disability; for the physical safety of individuals (Micheale, 2017). In addition, road traffic accidents are a significant source of human and financial disasters, a global, social, and economic problem, and killing millions yearly (Khan et al., 2020).

In summary, it can be said that scientists describe a traffic accident in various ways, but they usually emphasize the threat to human safety, health, or even life. Every day, thousands of traffic accidents occur throughout the world, during which people are killed or seriously injured. Several factors cause a traffic accident (see Table 1), which can be extraneous, direct, or indirect and simultaneously affect the driver and the vehicle.

**Table 1.** Factors influencing traffic accidents

| Factors | Michalaki et al. (2015) | Slavinskienė and Žardeckaitė-Matulaitienė (2017) | Karkee and Lee (2016) | Potoglou et al. (2020) | Rolison et al. (2018) | Bucsuházy et al. (2020) | Khan et al. (2020) | Mansurovna and Eshquvvaovich (2021) |
|---|---|---|---|---|---|---|---|---|
| Insufficient driving skills | + | + | | | + | + | + | + |
| Alcohol and drug use | | | | | + | + | | |
| Risky driving | + | + | | + | + | + | + | |
| Driver's emotional state | | | + | | + | | + | + |
| Health and its disorders | + | | | | + | + | | + |
| Fatigue | + | | | | + | + | | + |
| Driver's age | | | + | + | + | | + | |
| Driver's gender | | | + | + | | | + | |
| Car speed | + | + | | | + | + | + | |
| Carelessness | + | | | | + | + | + | + |
| Weather conditions | + | | + | | + | | + | + |
| Road characteristics | | | + | + | + | | + | + |
| Traffic intensity | + | | + | + | + | + | + | + |

Inexperienced drivers are more likely to cause an accident. Markšaitytė et al. (2017) conducted a review of the links between the motives of risky driving and the style of dangerous driving and the negative consequences of such driving. They claim that such drivers more often violate road rules (KET) and receive fines for it, cause traffic accidents more often, and are caught more often by police officers due to violations of KET (Markšaitytė et al., 2017).

The use of alcohol and drugs has a strong effect on the driver and his ability to drive. After consuming alcohol, some functions of the human body are disrupted and slowed down, such as a person no longer can drive a vehicle properly (Bucsuházy et al., 2020). Therefore, a traffic accident occurs. Rolison et al. (2018), in a study of factors that cause traffic accidents, found that alcohol or drugs were most often associated with traffic accidents caused by drivers.

Risky driving, according to Khan et al. (2020), who conducted a study to assess the factors that cause driver distraction and cause traffic accidents, is the most researched phenomenon, and this confirms that such driving causes traffic accidents. Risky driving can be attributed to unsafe changes in the lane on the road. Dangerous lane change is also one of the identified causes of traffic accidents when wrongly changing into another lane without making sure that another vehicle is not obstructing, or passing a vehicle without making sure that it is not approaching, and without even having time to look around, car crashes. He can no longer concentrate on driving the car when he is angry, sad, confused, or happy. Khan et al. (2020) found that 2.8–11.2% of traffic accidents occurred due to the driver's emotional state.

Bucsuházy et al. (2020), conducting a study on the influence of human factors on traffic accidents, identified that health and mental disorders influence a traffic accident. When sick, it is more difficult for the driver to make safe decisions on the road, so the probability of a traffic accident increases several times. Rolison et al. (2018) agrees with this factor as well. He says that health problems, such as heart disease, stroke, or vision problems, are associated with an increased risk of traffic accidents. After conducting a study, it was revealed that 3.02% of traffic accidents occurred because the driver had health problems (Rolison et al., 2018).

Driver fatigue is among the most frequently cited factors leading to traffic accidents (Michalaki et al., 2015). Fatigue is not taken seriously enough because the relationship between various physiological and behavioral signals is underestimated.

The driver's age and gender also influence the traffic accident. Regarding driver age, the authors Potoglou et al. (2020), the results of a study on the factors influencing traffic accidents in the city showed that drivers aged 24 years and younger were more likely to be involved in a traffic accident than those drivers aged 45–54 years. This is because young drivers are more likely to choose risky driving. After conducting the study, the authors found that if the vehicle exceeds the allowed speed in the city (50 km/h), the probability of a traffic accident is equal to 1.6 times (Potoglou et al., 2018). Poor driving skills and risky driving, including excessive speeding and the use of drugs and alcohol, are associated with road accidents caused by young drivers. On the contrary, accidents among older drivers are associated with higher rates of visual and cognitive impairment and drug use. Additionally, the examined authors state that the gender of the driver influences the traffic accident; for example, men, especially young ones, are more likely to cause a traffic accident than young women because men are more likely to choose risky driving and driving under the influence (Rolison et al., 2018).

Exceeding the speed limit can also lead to a traffic accident. The higher the vehicle speed, the less time is left to react to the environment and the situation. When the car goes fast, it becomes significantly more challenging to stop, and when driving fast, it is not easy to see what is happening in front of the vehicle and around it. Speeding drivers often drive recklessly and disregard traffic rules (Khan et al., 2020).

The study by Bucsuházy et al. (2020) showed that the most common factor that led to a fall was inattention (irrespective of age or sex). Research by these authors showed that 40% of traffic accidents analyzed were caused by inattention by drivers.

Weather conditions also influence traffic accidents. Karkee and Lee (2016), analyzing traffic accidents in Seoul, writes that the most influential factor is weather conditions, such as rain, fog, snow, etc., i.e., elements related to rain, in particular, are an important cause of traffic accidents due to poor visibility and reduced friction resulting from slippery road surfaces (Karkee & Lee, 2016). Michalaki et al. (2015), who conducted a study of the factors influencing the severity of road accidents in England, found that weather conditions are significant for road accidents because visibility is reduced in poor conditions, such as fog and rain, snow reduces visibility, and road surfaces in the rain if the road becomes slippery during snowfall and the vehicle may become uncontrollable when driving on such a road, then a traffic accident may occur.

Mansurovna and Eshquvvatovich (2021), after conducting a study on how vehicle operation factors influence a traffic accident, named road characteristics as a factor in the occurrence of a traffic accident. Road characteristics can include layout, surface condition, type, etc. Potoglou et al. (2018) states that even 50.5% of traffic accidents occurred at intersections and 1.5% occurred in poor road surface conditions.

Summarizing the factors listed above, it can be said that traffic intensity, insufficient driving skills, and risky driving influence traffic accidents. Most of the authors examined mentioned these factors. However, according to the authors, factors such as driver's gender, health and disorders, and alcohol and drug use have the most negligible impact on traffic accidents.

## 2. Research methodology

The completed research will be presented in three stages. In the first stage, secondary data analysis is performed during which changes and trends are predicted.

In the second stage, a correlational regression analysis is performed. The purpose is to identify the relationships between factors and to create decision-making models. Correlation analysis is a statistical method that studies the relationships between random variables with a normal distribution in a general set (Zigmantavičiūtė & Miečinskienė, 2015). This analysis aims to determine whether a linear relationship exists between two variables (dependent and independent) and how strong it is. Regression analysis is a measurement method to evaluate the relationship between variables (one dependent and one or more independent) (Pabedinskaitė & Činčikaitė, 2016).

In the third stage, the prediction of traffic accidents is carried out using the ARIMA method. A forecast is a prediction of the future based on data that helps decide the course of a future event. Forecasting itself is an activity consisting of many stages of research, the common goal of which is to obtain information about the future of the considered phenomenon, object, or process (Pabedinskaitė & Činčikaitė, 2016). One of the most popular time-series forecasting methods is the integrated autoregression moving average (ARIMA model) (Balabonienė et al., 2014). The better the forecasting model, the more accurate the forecast and the smaller the forecast error.

So, after all these tests have been performed and accurate results have been obtained, the linear regression equation can be constructed, and conclusions can be drawn about the linear regression model.

## 3. Results and discussion

The analysis of the statistical data shows that the number of individual cars increased in the period 2017–2021. In Taurage and Utena, this change is not as pronounced as when observing the Lithuanian data (see Figure 1).

Analyzing the change in traffic accidents in 2011–2021, we see that the number has decreased and no significant change has been observed in recent years (Figure 2).

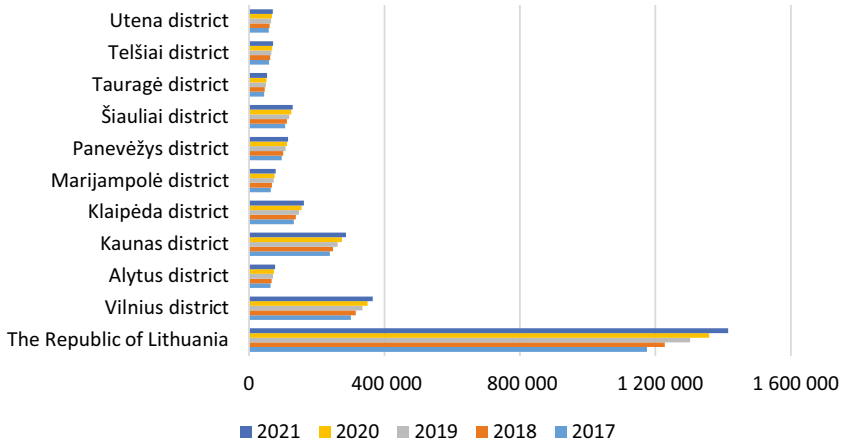


**Figure 1.** Number of individual cars in Lithuania 2017–2021 years (source: Lithuanian Department of Statistics, n.d.)

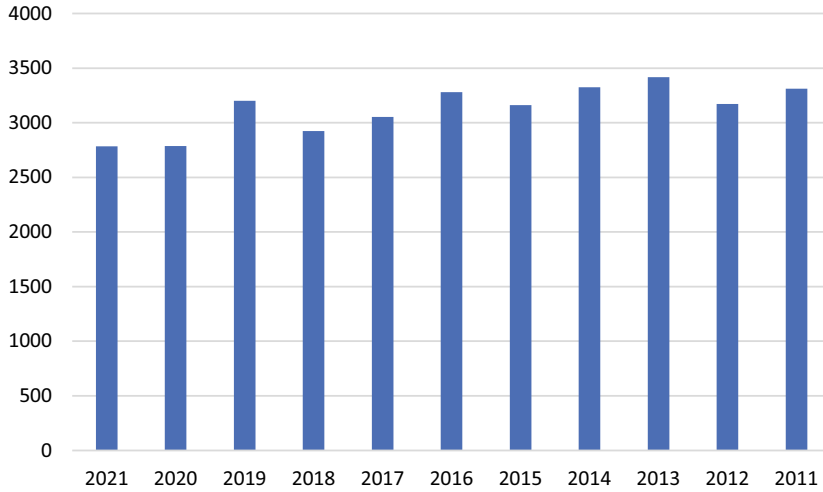


**Figure 2.** All traffic accidents in Lithuania (source: Lithuanian Department of Statistics, n.d.)

The improvement trend is also noticeable in the ranking of countries according to the number of road fatalities. "Road safety in the EU: fatalities in 2021 remain well below the prepandemic level" (https://transport.ec.europa.eu/news-events/news/preliminary-2021-eu-road-safety-statistics-2022-03-28_en) Lithuania ranked 52nd in 2021, and 67th in 2019. If we were to look at the neighbouring countries, Latvia took the 69th place in 2021, and Estonia – 39th.

Road traffic accidents are now the eighth leading cause of death worldwide. They claim more than 1.35 million lives and cause up to 50 million yearly injuries. And the fact is that every one of those deaths and injuries is preventable.

To reduce environmental pollution and ensure safety in the city, cities apply the principles of sustainable mobility, i.e. transitions to different means of transportation (walking or walking, cycling, electric cars, hybrid electric cars, hydrogen cars, etc.) and applies/expand their infrastructure. In Lithuania, it is noticeable that in 2020–2023, the number of electric vehicles increased almost four times. Electric scooters can also be classified as sustainable transport. However, studies have shown that electric scooters are one of the vehicles that cause the most traffic accidents. Studies by the University of California, Los Angeles (UCLA) have shown that scooters cause more injuries than bicycles, cars, and motorcycles. It has been found that the number of injuries here is about 175–200 times higher than when driving a car. A total of 1 million electric scooter rides had 115 injuries compared to 8 injuries per 1 million car rides, 15 injuries per 1 million bicycle rides and 104 injuries per 1 million motorcycle rides. After evaluating the data analysis of cyclists injured in traffic accidents in Lithuania in 2022 carried out by the Transport Competence Agency, it was found that in cases where the consequences of cyclists involved in traffic accidents are known, up to 87% of cyclists were injured: 90% of them were lightly injured and 10% were seriously injured. In addition, the data obtained showed that cyclists accounted for 4% of all participants killed in traffic accidents and 9.5% of all injured participants. Although an increasingly positive trend is visible compared to 2021, the number of cyclists killed in traffic accidents decreased by more than half (55%). However, the analysis showed a 9-fold increase in injured electric bicycle drivers since 2019. It should also be noted that more than half (60%) of the cyclists killed in traffic accidents last year were middle-aged people aged 45–64 years.

It is important to remember that alcohol consumption affects not only when driving a car or other motor vehicle, but also concentration, stability, and safety when driving a bicycle or scooter.

Unfortunately, there are not enough data to assess the dependence of the number of traffic accidents on each sustainable mode of transport. Therefore, only the number of electric cars will be included in the study. Based on the results of the theoretical part, traffic accidents will be investigated based on the following factors (see Table 2): persons with a reduced level of working capacity; average traffic intensity, car/day; average annual population by age 20–24, persons; expenses for road maintenance works, EUR million; production of alcoholic beverages (beer), thousand deciliters; number of electric cars, units.

After conducting a correlation analysis (Table 3), the most substantial inverse relationship exists between the average annual population (20–24 years) and the number of electric cars.

**Table 2.** Factors influencing traffic accidents

| | Factors | Sources |
|---|---|---|
| X1 | Persons with a reduced level of working capacity | Lithuanian Department of Statistics (n.d.) |
| X2 | Average traffic intensity, car per day | |
| X3 | Average annual population by age 20–24, persons | |
| X4 | Expenses for road maintenance works, EUR million | |
| X5 | Production of alcoholic beverages (beer), thousand deciliters | |
| X6 | Number of electric cars, units | |

**Table 3.** Correlation analysis result

| | | X1 | X2 | X3 | X4 | X5 | X6 | Y |
|---|---|---|---|---|---|---|---|---|
| X1 | Pearson Correlation | 1 | –.522* | .826** | .167 | –.336 | –.627** | .782** |
| | Sig. (2-tailed) | | .018 | .000 | .482 | .147 | .003 | .000 |
| | N | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| X2 | Pearson Correlation | –.522* | 1 | –.761** | .450* | .725** | .759** | –.773** |
| | Sig. (2-tailed) | .018 | | .000 | .046 | .000 | .000 | .000 |
| | N | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| X3 | Pearson Correlation | .826** | –.761** | 1 | –.175 | –.392 | –.919** | .724** |
| | Sig. (2-tailed) | .000 | .000 | | .461 | .087 | .000 | .000 |
| | N | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| X4 | Pearson Correlation | .167 | .450* | –.175 | 1 | .580** | .272 | –.019 |
| | Sig. (2-tailed) | .482 | .046 | .461 | | .007 | .245 | .937 |
| | N | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| X5 | Pearson Correlation | –.336 | .725** | –.392 | .580** | 1 | .411 | –.544* |
| | Sig. (2-tailed) | .147 | .000 | .087 | .007 | | .072 | .013 |
| | N | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| X6 | Pearson Correlation | –.627** | .759** | –.919** | .272 | .411 | 1 | –.602** |
| | Sig. (2-tailed) | .003 | .000 | .000 | .245 | .072 | | .005 |
| | N | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Y | Pearson Correlation | .782** | –.773** | .724** | –.019 | –.544* | –.602** | 1 |
| | Sig. (2-tailed) | .000 | .000 | .000 | .937 | .013 | .005 | |
| | N | 20 | 20 | 20 | 20 | 20 | 20 | 20 |

However, after performing a linear regression analysis, a polynomial regression line model was created, including X1 – reduced working capacity, persons, and X2 – average traffic intensity, cars per day:

$$Y = 12923.85 + 0.225 \cdot X1\text{-}4.18 \cdot X2. \quad (1)$$

All other factors (see Table 1) were rejected as insignificant, that is, they did not meet the necessary conditions for the suitability of the linear regression model.

Thus, based on the regression analysis data, it can be stated that the number of electric cars does not affect traffic accidents. ARIMA results (see Table 4).

**Table 4.** ARIMA models

| Model | R2 | BIC | MAPE |
|---|---|---|---|
| (0,0,1) | 0.654 | 13.84 | 17.77 |
| (1,1,1) | 0.927 | 12.73 | 6.09 |
| (1,1,3) | 0.936 | 13.06 | 5.87 |
| (1,0,1) | 0.935 | 12.58 | 5.63 |

According to the suitability parameters of the model, the (1,0,1) model is the most suitable, based on the forecast for the coming periods (see Figure 3). For more details, see Table 5, which shows the lowest and highest possible forecast ranges.

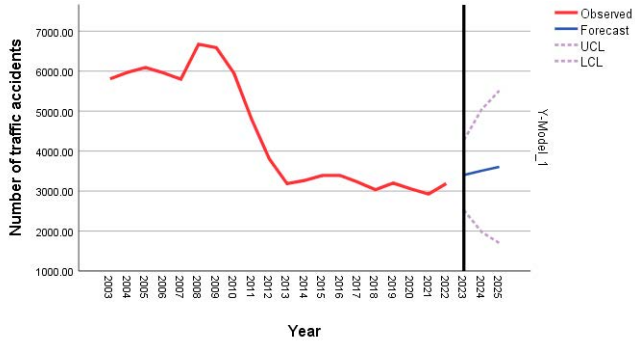


**Figure 3.** Forecast of traffic accidents

**Table 5.** Forecast of traffic accidents for 2023–2025

| Model | | 2023 | 2024 | 2025 |
|---|---|---|---|---|
| Y-Model_1 | Forecast | 3400.48 | 3508.36 | 3605.66 |
| | UCL | 4275.90 | 5040.71 | 5512.14 |
| | LCL | 2525.06 | 1976.01 | 1699.18 |

Based on the data in the table, we can say that the number of traffic accidents will increase, albeit slightly, in the next three years.

## Conclusions

After analyzing the concept of a traffic accident, it can be stated that traffic is the leading cause that threatens society, human life and health, and property, affects households and the economy of states, and traffic accidents are a source of human disasters. And the factors that affect traffic accidents the most are traffic intensity, insufficient driving skills, and risky driving. The driver's gender influences minor traffic accidents, the driver's health and disorders, and alcohol and drug use.

Summarizing the statistical data, we can see that the number of cars in Vilnius city is increasing the fastest, compared to Kaunas, Šiauliai, Alytus and Klaipėda counties. The change

in the number of vehicles is almost inevitable in big cities, where it isn't easy to do without one's car. This change process can depend on many individual factors, depending on the need.

After conducting a correlational analysis, significant independent factors were found: persons of working age who were diagnosed with a reduced level of working capacity for the first time; average annual daily traffic intensity on regional roads, vehicles/day; average annual population, people aged 20–24; production of alcoholic beverages (beer), thousand decalitres. In multinomial regression, traffic accidents are most influenced by the reduced level of work capacity and the least by the average annual number of the population, according to the age group 20–24. After forecasting road traffic accidents using the ARIMA method, it was observed that traffic accidents would increase slightly in the next three years.

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