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IDENTIFICATION OF ANIMAL –VEHICLE COLLISION LOCATIONS ACCORDING TO EVALUATION OF DRIVER INJURIES AND VEHICLE DAMAGE IN THE KYIV REGION

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Abstract

Purpose: We *have implemented the evaluation of identification of animal –vehicle collision (AVC) in Kyiv region in 2007-2014, using the methodology of descriptive statistics for three pairs of variables, which depend on the location of AVC: 1) "AVC location" and "number road" 2.) "AVC location" and "injury of the driver" 3.) "AVC location" and "damage of the vehicle."* ***Methods:*** *For the study we used the tests for the normal distribution of variables, that include: 1.) Table "Test of Normality", that used test Kolmogorov-Smirnova and Shapiro-Wilk, with taking into account the appropriate number of times for evaluation; 2. Histogram, which has a distribution for the relevant type of data according to normal distribution curve for visual comparison and further evaluation; 3) one of the functions of Descriptive Statistics, entitled Table "Descriptives", and which in turn uses two types of characteristics: a.) Skewness and b.) Kurtosis.* ***Result:*** *For the analysis we used IBM SPSS Statistics program, which allows to assess the correspondence of AVC to the normal distribution by including tests of Kolmogorov-Smirnov and Shapiro-Wilk. After passing the tests for each variable has been getting the word «Yes» or word «No» from SPSS. If the variable passed tests and its distribution corresponds to the normal distribution, the variable got the word «Yes». If the variable is not passed tests and its distribution is not responsible normal distribution, the variable got the word «No».* ***Discussion:*** *The appropriate assessment of location data was collected in the summary tables which allow to analyse the animal – vehicle collision locations on the roads in Kyiv region. It was found, that theoretical calculations to test normality in the SPSS program for many variables of all three factors «Road», «Damage», «Injuries» corresponds to the variable locations, but there are also a lot of variables that do not comply with the law of the normal distribution, although they have enough number of animal –vehicle collisions.*

Keywords: animal-vehicle collisions; descriptive statistics; normal distribution.

1. Introduction

Animal – vehicle collision (AVC) in Ukraine creates additional risk for decrease of environmental safety level on the roads. As a result of AVC is the death or injury of the driver, the death of animals and damage of the vehicle that causes a costly expenditure for driver and his welfare. Such expenditures may lead to decrease of environmental safety level, the threat for animal and deterioration of human health. As an example of well-known data, a large number of animal's vehicle collisions (AVC) on roads were occurring in all countries. In the USA, the total number of annual AVC was estimated at more than 1 million in early 1990s [1]. These collisions were estimated more than 200 human fatalities, about 30000 human injuries, and more than $1 billion USD in property damage [1, 2]. In Canada, more than 30000 collisions with animals occur: 23 human fatalities, 1887 human injuries, and more than U.S. $60 million in property damage in 2000 [3] (Tardif & Associates Inc., 2003). In Europe the AVCs statistics is as follows: more 509.000 ungulates are killed, 300 human fatalities, 30.000 human injuries, and more than $1 billion dollars in material damage [4] (Bruinderink and Hazebroek, 1996). A lot of studies were focused on the trends and characteristics of AVC in the USA [5].These statistics data have shown that AVC can bring serious trouble and require studies to reduce their impact on the people, on the animal and on the nature while one of the important task is to identify AVC locations to hold a prevention measures. Relevant studies are conducted in Ukraine, where, according to the Interior Ministry of Ukraine, for example, in the Kyiv region in during period from 2017 to 2014 has occurred 1656 cases of AVC with injured 21 people and killed six people, damaged 1,355 vehicles. In this study the using methodology can find and assess the connection between the factors to identify the location of AVC [6, 7, 8]. The value for AVC location as kilometers is transformed

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into meters. It is important to note, that value for AVC location depends on following factors: a.) the number of the road, b). the number of deaths or injured drivers c.) the level of vehicle damage according to collected data of road accidents.

2. Research tasks and problem statement

There are many study proposed to use of nonlinear methods of analysis of AVC, but it also have restrictions that complicate for implemented them in practice. Analysis restrictions of nonlinear methods [15] leads to the idea that in some cases it is necessary to use linear methods and with evaluation of test the normal distribution.

The methodology of test for compliance with the normal distribution has specific and very clear conditions [22, 23], which allow to remove more non-normal data. It reduces the quality of analysis and requires approaching theoretical knowledge to practical measurement. In this case, it is needed to evaluate of data using tests to check for normality limits the amount of data that can be predicted of animal-vehicle collisions.

3. Analysis of the latest research and publications

In studies often used as regressions dependent location of AVC from various parameters and characteristics of the road and the vehicle in the studies use linear regression [12] or nonlinear regression model, such as generalized linear mixed model, gamma regression model Poisson [14] and regression models [15]. It should determine that nonlinear methods have their limitations, which narrows their trend of use, and for linear techniques it is necessary to conduct a preliminary analysis by the methods of descriptive statistics, after which it can be held, such as regression analysis, which can help find location and relationship between various factors of AVC to prevent them in the future.

4. Methodology

4.1. Data

Data on traffic accidents with animals were obtained from the Department of Internal Affairs of Ukraine. These data include: 1) the date of the AVC; 2) the number (designation) of roads; 3.) indication of accident location on the highway; 4.) notation of the injury or death of the driver; 5.) indication of the number of damaged car parts. Collection of such data of the accidents on the road may be used for monitoring tasks of roadmap in Kiev region (Fig. 1).

Also these data of traffic accidents with animals allow identifying hotspots for further improvement the modeling results. The actual data of spatial clustering is the preferred method of hotspots identification and predictive models of presence / absence date should be constructed if the intention is to extrapolate to additional areas [9].

The evaluation of relationships between the traffic and abundance of wildlife on the probabilities of AVCs used the total number of reported AVCs [10]. The analysis relation between animal road-crossings and AVC data from police has highlighted different spatiotemporal risk zones [11].

For evaluation of AVC's location identification we are proposing to use methodology [16, 17]. As the tool the software IBM SPSS Statistics (the further - as SPSS) is used, which allows processing the data: filtering, sorting, grouping and evaluation of data, particularly on compliance with the normal distribution.

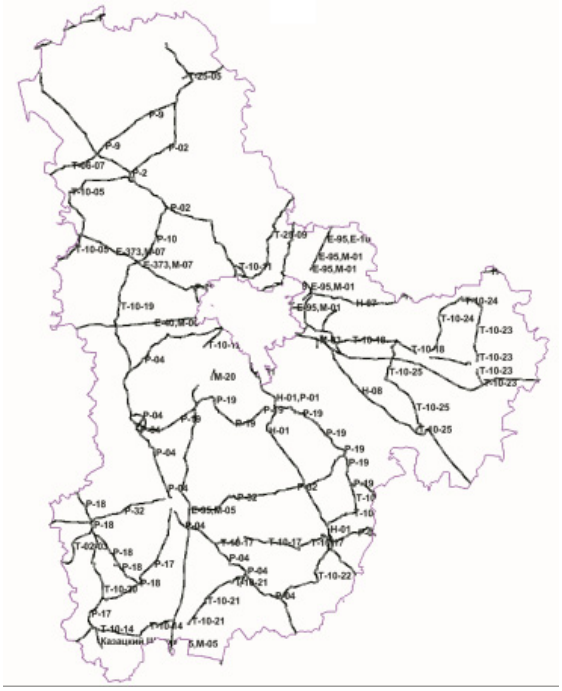

Fig. 1. Map of roads in Kyiv oblast

4.2. Instrument

The program the IBM SPSS Statistics was used for experimental and analytical investigations. Examples of using the program SPSS in research are given in study [18] that demonstrate the implementation of next operations: calculating processes of the regression, linear and non-linear regression, analysis of dependent and independent parameters, collecting and sorting of data, descriptive statistics in SPSS and methods for further analysis [19]. Analysis of descriptive statistics has highlighted, that «the object of

descriptive statistics, from sample data, is to describe the most important characteristics, by which we refer to those amounts that provide information on the topic of interest which we are studying"[20].

Furthermore, the statistical terminology and methods are used to explain the descriptive statistics, including levels of measurement, measures of central tendency (average), and dispersion (spread) and the concept of the normal distribution [21]. Based on mentioned methodology, the authors suggested to exercise SPSS program for the research by using one of the functional of descriptive statistics.

SPSS has a database of accidents in the Kiev region, with the following variables: 1) date of AVC; 2) the number (designation) of road; 3) indication of accident location on the highway; 4) notation of the injury or death of the driver; 5) indication of the number of damaged car parts. For this case the functionality "Descriptive Statistics" will be used, which has the option "Descriptive Statistics" - "Explore", which in turn uses data such as “Depends list" and «Factor list».

AVC location data will be evaluated in accordance with the normal distribution. In this study the number of AVC identification is defined by following variables: 1) the road, where the accident is occurred; 2) the variable, which characterizes the injury or death; 3) variable, which characterizes the damage to the vehicle. The above-mentioned data are as factors, which together with another pair of "dependent" variables - location of the accident, allow to estimate the probability distribution of the data and to compare them with the normal distribution by using descriptive function of software SPSS.

4.3. Method

The study is implemented according to [22,23] on the basis of the tests for the normal distribution of variables, that include: 1) Table "Test of Normality", that used test Kolmogorov-Smirnova and Shapiro-Wilk, with taking into account the appropriate number of times for evaluation; 2) Histogram, which has a distribution for the relevant type of data from a normal distribution curve for visual comparison and further evaluation; 3) one of the functions of Descriptive Statistics, entitled Table "Descriptives", and which in turn uses two types of characteristics: a) Skewness and b) Kurtosis. After passing three tests for each variable has been getting the word «Yes» or word «No» from SPSS. If the variable passed tests and its distribution corresponds to the normal distribution, the variable got the word «Yes». If the variable is not passed tests and its distribution is not responsible normal distribution, the variable got the word «No». One of the principle used for identification of AVC locations is of evaluation of the deviation between of location of the animal-vehicle collisions in the road [17].

For this aim the type of roads and damage of the vehicle are used, which approved by order of the Interior Ministry of Ukraine [13]. The software SPSS is used descriptive statistics for three pairs of variables: 1) the dependent variable «Location» and other variable «Road», which is a factor for the «Location»; 2) The dependent variable «Location» and other variable «Injuries», which is a factor for the «Location»; 3) dependent variable «Location» and other variable «Damage», which is a factor for the «Location».

It had been calculated following two tables and Histogram for each of the three factors that are necessary for research and evaluation in the future: 1) Table Descriptive table for evaluation of dependent variable (Table 1); 2) Histogram, which is separated for each variable for each of the three factors. (Fig.2); 3) Test of normally for dependent variable "Test of normally" (Table 2). For each factor a definitional number of variables was set: a) For «Road» - 40; b) for «Damage» - 52; c) For «Injuries» - 3.

After proceeding each pair of variables the program SPSS rejected the results, which have a small number of AVC and have no significant impact in the calculations and brought as a result of handling SPSS in following table (Table 1 and Table 2) and Histogram (Fig. 2).

Table 1. Descriptive table for evaluation of dependent variable "Location" and “Damage”

Descriptive	1,7		1,9	
Damage	Statistic	Std. Error	Statistic	Std. Error
Mean	48219,67	17877,54	62517,14	16236,24
Interquartile Range	81460		81280	
Skewness	0,626	0,845	0,526	0,794
Kurtosis	-8,00E-01	1,741	-7,44E-01	1,587

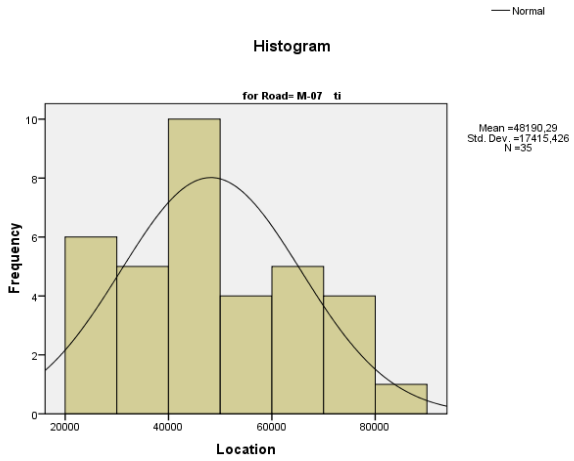

Fig 2. Histogram with normal curve plotted (SPSS result) for evaluation of dependent variable "Location" and parameter "Road"

Table 2. Test of normally for dependent variable "Location" and "Road"

Type of road	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	**Sig.**
C	,241	70	,000	,727	70	,000
H-01	,180	55	,000	,890	55	,000
H-07	,166	22	,120	,898	22	,027
H-08	,191	28	,010	,900	28	,011
M-01	,078	108	,111	,948	108	,000
M-03	,192	125	,000	,876	125	,000
M-05	,119	95	,002	,912	95	,000
M-06	,123	78	,005	,916	78	,000
M-07	,095	35	,200*	,945	35	,079
P-01	,395	7	,001	,722	7	,006
P-02	,082	52	,200*	,952	52	,035
P-03	,328	15	,000	,703	15	,000
P-04	,284	21	,000	,764	21	,000
P-17	,260	2	.			
P-19	,281	4	.	,858	4	,253
P-27	,299	3	.	,914	3	,431
P-32	,260	2	.			
P-69	,349	3	.	,831	3	,192
O	,282	18	,001	,805	18	,002
T	,225	9	,200*	,869	9	,119
T-10-01	,174	8	,200*	,951	8	,725
T-10-08	,219	3	.	,987	3	,780
T-10-11	,260	2	.			
T-10-12	,260	2	.			
T-10-22	,260	2	.			
T-10-29	,260	2	.			

Based on obtained SPSS output processing, each value of the variable for each factor was assessed using words «Yes» or «No» was spaced to each cell, that is the intersection of the corresponding variable lines and the corresponding column, which meets one of the three types of tests.

If the tested variable is in compliance with the normal distribution, then the cell is marking by «Yes», if the test is not passed - then put a mark «No».

5. Research results

Results of proceeding variables in SPSS program are represented in the following table:

Table 3. Evaluation results of data by factor «Road» in accordance with the normal distribution

Type of road	Number of cases	Tests of Normality	Histogram	Descriptives
C	70	Yes	Yes	No
H-01	55	Yes	Yes	Yes
H-07	22	No	Yes	Yes
H-08	28	Yes	Yes	Yes
M-01	108	No	Yes	No
M-03	125	Yes	3,1%	No
M-05	95	Yes	1,0%	No
M-06	78	Yes	2,5%	Yes
M-07	35	No	,0%	Yes
P-01	7	Yes	No	No
P-02	52	No	Yes	Yes
P-03	15	Yes	No	No
P-04	21	Yes	No	Yes
P-09	1	No	No	No
P-17	2	No	No	No
P-19	4	No	No	Yes
P-27	3	No	No	No
P-28	1	No	No	No
P-32	2	No	No	No
P-56	1	No	No	No
P-69	3	No	No	No
O	18	Yes	No	No
T	9	No	No	Yes
T-10-01	8	No	No	Yes
T-10-02	1	No	No	No
T-10-08	3	No	No	No
T-10-11	2	No	No	No
T-10-12	2	No	No	No
T-10-14	1	No	No	No
T-10-16	1	No	No	No
T-10-17	1	No	No	No
T-10-19	1	No	No	No
T-10-21	1	No	No	No
T-10-22	2	No	No	No
T-10-27	1	No	No	No
T-10-29	2	No	No	No
T-10-32	1	No	No	No
T-10-33	1	No	No	No
T-20-12	1	No	No	No

Note:

1. Yes- test of normal is good;
2. No – test of normal is not good.
3. Type of road - own number of roads [24]

Number of cases – amount of animal-vehicle collision's cases

Table 4. Evaluation results of data by factor «Damage» in accordance with the normal distribution

Code of damage	Number of cases	Tests of Normality	Histogram	Descriptives
0	114	Yes	Yes	No
1	344	Yes	Yes	No
1,11	2	No	Yes	No
1,12	1	No	No	No
1,18	3	No	No	No
1,2	38	No	Yes	No
1,2,3	1	No	Yes	No
1,2,3,4	1	No	No	No
1,2,3,9	1	No	No	No
1,2,4	1	No	No	No
1,2,6	1	No	No	No
1,2,8	5	No	Yes	Yes
1,2,8,9	1	No	No	No
1,2,9	1	No	No	No
1,21	1	No	No	No
1,3	2	No	No	No
1,3,5,7	3	No	No	No
1,3,7	1	No	No	No
1,3,9	2	No	No	No
1,4,9	1	No	No	No
1,5	1	No	No	No
1,6	1	No	No	No
1,6,8	1	No	No	No
1,7	6	No	Yes	Yes
1,7,8	2	No	Yes	No
1,7,8,9	2	No	Yes	No
1,7,9	1	No	No	No
1,8	21	No	Yes	No
1,8,9	2	No	No	No
1,9	7	No	Yes	Yes
11	1	No	No	No
12	5	No	No	Yes
18	1	No	No	No
2	91	Yes	Yes	No
2,12	1	No	No	No
2,3	9	No	Yes	Yes
2,6,8	1	No	No	No
2,7,8	1	No	No	No
2,8	1	No	No	No
21	1	No	No	No
3	9	No	Yes	Yes
3,4,5,9	1	No	No	No
3,7,9	1	No	No	No
3,9,21	1	No	No	No
4,11,15	1	No	No	No
6	1	No	No	No
6,7,8	1	No	No	No
7	8	No	Yes	Yes
7,8	6	Yes	Yes	No
8	73	Yes	Yes	No
8,18	2	No	Yes	No
8,9	1	No	No	No

Note:

1. Yes- test of normal is good;
2. No – test of normal is not good.
3. Type of damage - own number of damage of vehicle [24]
4. Number of cases – amount of animal-vehicle collision's cases

Table 5. Summary of data for the evaluation factor «Injuries» in accordance with the normal distribution

Code of injuries	Number of cases	Tests of Normality	Histogram	Descriptives
0	1629	Yes	Yes	Yes
1	21	No	No	Yes
2	6	No	No	Yes

1. Yes - test of normal is good;
2. No – test of normal is not good.
3. Type of injuries - own number of injuries of driver: 1 – injuries, 2 – fatal, 0 – without of injuries and fatal [24]
4. Number of cases – amount of animal-vehicle collision's cases

The results of calculation of three factors: «Road», «Damage», «Injuries» that correspond to variable "Location" is realized on practical measurements for definition of hotspot - location of animal vehicle collisions with more expenditures and losses. Our study can help to definition of hotspot by used the Tables 3, 4, 5 that definition of most influential parameter of AVC and Fig. 3, 4, 5 which can determine the location for next parameters: 1. Code of road, which is occur of AVC. 2. Injured / Death of driver; 3. Damage of the vehicle.

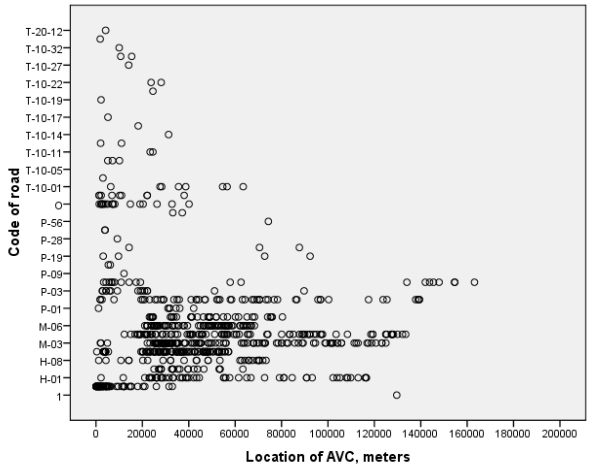

Fig. 3. Distribution of locations of animal vehicle as "Location of AVC" from road as "Code of road" in Kyiv oblast.

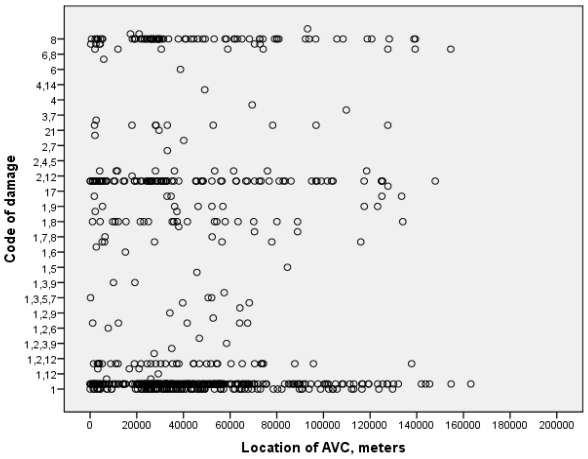

Fig. 4. Distribution of locations of animal vehicle collisions as "Location of AVC" from vehicle damage as "Code of damage" in Kyiv oblast.

Identify of the most dangerous location – hotspot is made by determining the intersection of points between the value in one from three parameters: «Code of road», «Code of damage», «Injured/Death» on the ordinate and the value of the location as «Location of AVC» on the axis in the point where the occurred the most serious AVC – hotspot by through of Figures 3,4,5.

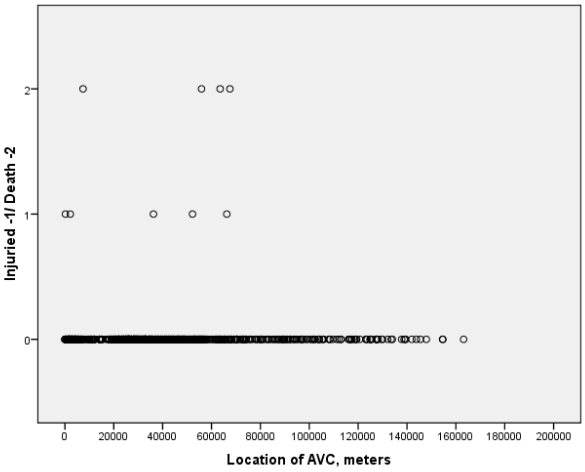

Fig. 5. Distribution of locations of animal vehicle collisions as "Location of AVC" from injured or death of driver as "Injured / Death" in Kyiv oblast.

5. Discussion

Using considered three types of tests to select data of normal distribution that can be used to AVC identification and their prevention. Analysis of accidents with animals is implemented by application of normal distribution law to estimate AVC location distribution. Such approach does not allow to reject those accidents that do not meet the

normal distribution and in this case situation does not become less safe compared with the change of location for the factors that are close to normal distribution.

There are next cases for our discursion 1.) the amount of variables has a sufficient number of accidents with animals and the results of tests of for them is positive; 2.) the amount of variables has not a sufficient number of accidents with animals and the results of tests of for them is negative; 3.) the amount of variables has a sufficient number of accidents with animals, but the results of tests of for them is negative; 4.) the amount of variables has not sufficient number of accidents with animals, but the results of tests of for them is positive.

The tests are based on clear numerical indicators that are recited and clearly provide the right set appropriate assessment "Yes" or "No". Accordingly, there is a limit on the errors number for normal distribution of data. Data analysis using SPSS descriptive analysis revealed some discrepancies in the data, as database includes indication of accidents in km, the value of which was far enough outside the area.

Second, the program SPSS simply and efficiently calculates data for descriptive parameters and detects the variables that should be not taken into account, because they decrease the accuracy of the analysis. The proposed evaluation of traffic accidents data allowing to use new methods to determine the location of accidents with animals. The authors suggest that prospective studies in the future, is estimation of accuracy locations of animal vehicle collisions, as example of the result that have been obtained in cases 3 and case 4.

7. Conclusion

The evaluation of locations of traffic animal-vehicle collision by using the tests for normal distribution has revealed discrepancies in their values. The errors can be occurred under entering of data location, or inaccuracy in the report or human factor (the person who submitted the data of incident).

Theoretical calculations to test normality in the SPSS program for many variables of all three factors «Road», «Damage», «Injuries» corresponds with the variable locations in the practical measurement, but there are many variables in all three factors distribution which does not comply with the law of normal distribution, although they have enough accidents with animals compared with variables which significantly fewer accidents with animals, but their distribution is close to normal distribution law.

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О.В. Кохан. Ідентифікація місцезнаходжень дорожньо-транспортних пригод з тваринами за оцінкою травмувань водіїв та пошкоджень автомобіля у Київській області

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Мета: Проведено оцінку ідентифікації дорожньо-транспортних пригод з тваринами Київської області з 2007-2014 рр. за допомогою використання описових статистик для трьох пар змінних факторів, від яких може залежати місцезнаходження дорожньо-транспортних пригод з тваринами; 1) «місцезнаходження ДТП» та «номер автодороги»; 2) «місцезнаходження ДТП» та «травмування водія»; 3) «місцезнаходження ДТП» та «пошкодження автомобіля». **Метод:** Дослідження здійснюється з використанням оцінки нормального розподілу змінних, які включають в себе: 1) Таблицю "Тест нормальності", яка використовує критерій Колмогорова-Смирнова і Шапіро-Уілка, з урахуванням відповідної кількості оцінок; 2) Гістограму, яка має розподіл для відповідного типу даних відносно кривої нормального розподілу для візуального впорівняння і подальшої оцінки; 3) одну з функцій описової статистики, яка має назву описова таблиця, і яка, свою чергу використовує два типи характеристик: a) асиметрія і b) ексцес. **Результат:** Для аналізу була використана програма IBM SPSS Statistics, за допомогою якої проводилась оцінка змінних про дорожньо-транспортні пригоди на нормальне розподілення змінних, які включають в себе тести Колмогорова-Смірнова та Шапіро-Уілка. Отримані після

аналізу в програмі SPSS результати проходження тестів для кожної змінної, оцінюються за допомогою слова «Так», якщо змінна пройшла тести та її розподілення відповідає нормальному розподіленню, та оцінюються як «Ні», якщо змінна не пройшла тести та її розподілення не відповідає нормальному розподіленню. **Обговорення:** Відповідні оцінки внесені до зведених таблиць, на підставі яких був проведений аналіз місцезнаходжень дорожньо-транспортних пригод з тваринами на автодорогах Київської області. Було відмічено, що хоча теоретичні розрахунки для тестування нормальності в програмі SPSS для багатьох змінних всіх трьох факторів «Тип автодороги», «Тип пошкодження автомобіля», «Тип травмування водія» відповідають величинам змінних місцезнаходжень на практиці, але також є достатньо багато змінних ДТП з тваринами які не відповідають закону нормального розподілення, хоча вони мають достатню кількість дорожньо-транспортних пригод з тваринами.

Ключові слова: дорожньо-транспортні пригоди з тваринами; нормальне розподілення вірогідності; описова статистика.

О.В. Кохан. Идентификация местонахождений дорожньо-транспортними пригодами с животными по оценке травм водителей и повреждений автомобиля в Киевской области

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Цель: Проведена оценка идентификации дорожно-транспортных происшествий с животными Киевской области с 2007-2014 гг. с помощью использования описательных статистик для трех пар переменных факторов, от которых может зависеть местонахождение дорожно-транспортных происшествий с животными: 1) «местонахождение ДТП» и «номер автодороги»; 2) «местонахождение ДТП» и «травма водителя»; 3) «местонахождение ДТП» и «повреждение автомобиля». **Метод:** Исследование осуществляется с использованием оценки нормальным распределением переменных, которые включают в себя: 1) Таблица "Тест нормальности", которая использует критерий Колмогорова-Смирнова и Шапиро-Уилка, с учетом соответствующего количества оценок; 2) Гистограмму, которая имеет распределение для соответствующего типа данных относительно кривой нормального распределения для визуального сравнения и дальнейшей оценки; 3) одну из функций описательной статистики, которая имеем название описательная таблица, и которая в свою очередь, использует два типа характеристик: a) асимметрия и b) эксцесса. **Результат:** Для анализа была использована программа IBM SPSS Statistics, с помощью которой проводилась оценка переменных о дорожно-транспортные происшествия на нормальное распределение переменных, которые включают в себя тесты Колмогорова-Смирнова и Шапиро-Уилки. Полученные после анализа в программе SPSS результаты прохождения тестов для каждой переменной, оцениваются с помощью слова «Да», если переменная прошла тесты и ее распределение соответствует нормальному распределению, и оцениваются как «Нет», если переменная не прошла тесты и ее распределение не соответствует нормальному распределению.
Обсуждение: Соответствующие оценки внесены в сводные таблицы, на основании которых был проведен анализ местонахождений дорожно-транспортных происшествий с животными на автодорогах Киевской области. Было отмечено, что хотя теоретические расчеты для тестирования нормальности в программы SPSS для многих переменных всех трех факторов «Тип автодороги», «Тип повреждения автомобиля», «Тип травмирования водителя» соответствует величинам переменных местонахождений на практике, но также достаточно много переменных ДТП с животными не соответствующих закону нормального распределения, хотя они имеют достаточное количество дорожно-транспортных происшествий с животными.

Ключевые слова: дорожно-транспортные происшествия с животными; нормальное распределение вероятностей; описательная статистика.

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