

## БІОЛОГІЧНІ ТА МЕДИЧНІ ПРИЛАДИ І СИСТЕМИ

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## IMPACT OF GEOMAGNETIC STORMS, LUNAR CYCLES AND DAYS OF THE WEEK ON CAR ACCIDENTS INJURING PEOPLE IN TERMS OF THEIR POTENTIAL IMPACT ON ROAD USERS IN VINNYTSIA AND THE REGION, UKRAINE

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**Анотація.** У дослідженні аналізується вплив геомагнітних бур, місячних циклів і днів тижня на автомобільні аварії з травмами людей з точки зору їх потенційного впливу на учасників дорожнього руху. Дослідження проводилося на основі даних з 2015 по 2020 рік у м. Вінниця та області, Україна. Вплив геомагнітних бур оцінювався за значеннями індексу Kr і був слабким на рівні менше 0,05. Аналіз за місячними циклами відбувався за чотирма місячними фазами. Збільшення кількості аварій спостерігалось лише в період молодика – першу чверть циклу. У четвер та п'ятницю кількість аварій зросла по відношенню до днів тижня, а з понеділка по вівторок за останні два роки спостереження – зменшилась.

**Ключові слова:** автомобільні аварії, геомагнітні бурі, місячні цикли, дні тижня.

**Abstract.** The study analyzes the impact of geomagnetic storms, lunar cycles and days of the week on car accidents with injuries to people in terms of their potential impact on road users. The study was conducted on the basis of data from 2015 to 2020 in the city of Vinnytsia and region, Ukraine. The effect of geomagnetic storms was estimated according to the values of the Kr index and was weak at a level less than 0.05. The analysis by lunar cycles took place in four lunar phases. An increase in the number of accidents was observed only in the period of the new moon - the first quarter of the cycle. The number of accidents increased on Thursday and Friday relative to the days of the week, and the number of accidents decreased from Monday to Tuesday during the last two years of observation.

**Key words:** car accidents, geomagnetic storms, lunar cycles, days of the week.

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### Introduction

Man is an important component of the road transport system. Along with transport factors, traffic factors, the external environment, the human factor is a priority. It was found that human error was a definite or probable cause in more than 90% of the accidents studied [1, 2]. Thus, most accidents and related injuries and deaths are the result of dangerous driving due to human factors [2, 3].

On the other hand, man, as a biological system, is under the influence of various rhythms of the external, in particular, the natural environment, which affects its physiological parameters [4, 5, 6]. An increase in blood pressure with an increase in the level of geomagnetic activity was estimated, and systolic and diastolic bp increased significantly on the first day of the geomagnetic storm [4, 6]. These effects were present regardless of gender and medication [4, 6, 7]. The average increase in systolic and diastolic blood pressure in the study group reached 9% [7, 11]. The percentage of people who reported subjective psychophysiological complaints was also significantly increased with increasing geomagnetic activity and the highest sensitivity was found in women with hypertension [7, 11]. Sensitivity to magnetic storms increases in patients with hypertension and increases significantly from moderate to severe hypertension [7, 8, 11]. The state of human habitat is dependent on solar activity due to variations in the parameters of the lower ionosphere, changing its resonant frequencies that correlate with brain rhythms: alpha, beta, gamma, delta and theta [8, 9]. The electrical conductivity of the human body reflects the biophysical state of man, and this can be used as an indicator of human response to perturbations of various origins. A strong relationship between conductivity, geomagnetic perturbations and atmospheric characteristics was found [9, 10]. Biochemical studies reveal inhibition of melatonin secreted by the pineal gland, possibly due to desynchronized biological rhythms, which links geomagnetic activity and human health [10, 11]. There are indications that calcium ions in cells may play a role in one or more mechanisms [10, 11].

Lunar rhythms have become one of the most studied issues in modern chronobiology. A number of obvious lunar influences on the animal world have been proven, but there is no solid evidence that human biology is regulated in any way by the moon [12, 13]. The belief that stars and planets can affect human health and behavior is not only seen in ordinary people [18], but a high proportion of health professionals continue to hold this belief: a survey of 325 people in New Orleans found that 140 individuals (43%) believe that the lunar phases affect the behavior of the individual [14]. In a study [15], the number of patients with injuries did not increase during the full month compared to other days of the menstrual cycle. Also, the relationship between the attack and the suicide attempt was not observed on the days of the full moon [15]. The full menstrual cycle phase did not cause a higher number of patients in a psychiatric hospital and was only 0.007% of the deviation [20], but there was a significant grouping of seizures during the full moon [21]. Another analysis showed that in non-epileptic seizures there was an increase in their number in the full moon, and in epileptic seizures – an increase

in the last quarter [16]. There was an increase in the number of patients during the full month of hospitalization for gastrointestinal bleeding, although the authors express the feasibility of further research [17]. The dependence of the state of the cardiovascular system on the four phases of the moon in men has been noted [19].

The influence of weekly rhythms is reflected in the change in human mood, which amounted to 40% of the variance in the sample of 74 students [22]. One subject rated his mood daily for 1,500 consecutive days. A series of mood swings demonstrated a clear and dominant 7-day period [23].

The aim of this study was to assess the human impact of geomagnetic storms, phases of the moon and days of the week on car accidents with injuries in Vinnytsia and the region, Ukraine.

## **Methods**

### **Study design and setting**

The study was conducted in the city of Vinnitsia and Vinnitsia region, Ukraine for the period 2015-2020. The data were obtained from the municipal administration "TMO Vinnytsia Regional Center for Emergency Medical Aid and Disaster Medicine". The original data structure, reflecting the date of the emergency call, diagnosis, situation, hospitalization, was transformed into a table with two columns: date and number of accidents. For the study, all days of the period February 2015 - December 2020 were taken into account.

### **Study population**

Accidents involving drivers and passengers of cars, cyclists and pedestrians were selected for the study. Given that an ambulance was called before each accident, there were injuries ranging from mild to severe, as well as fatalities.

### **Ethical considerations**

The study did not use data concerning personal information about the victims of the accident: name, surname, date of birth, place of residence and more.

### **Statistical analysis**

Statistical analysis was performed separately for the effects of days of the week, solar storms and phases of the moon. STATISTICA (Dell, USA) and MS Excel were used to automate the processing. The normality of the distribution of the original data was checked and not confirmed [24].

For the days of the week for each of the studied years, the number of accidents was determined separately for each of the days of the week. Given that the number of Mondays, Tuesdays, etc. in a year can be various, calculated average value of road accident on days of week. Next, we calculated the differences between the average values of accidents for each day of the week and determined the dynamics accordingly.

Regarding magnetic storms for each day of the studied years from open sources, the value of the  $Kp$  index was obtained [25, 26]. Scattering diagrams are constructed in order to visually determine the data distribution. Given the non-normal distribution of the input data, the Spearman correlation coefficient is calculated to determine the correlation.

From the full lunar cycle, 4 of its phases were chosen for consideration - observation points: new moon, first quarter, full moon and third quarter. Similarly to the research on the days of the week, the number of accidents for each phase of the lunar cycle was determined and averaged over the years. The duration of menstrual cycles, and, accordingly, its quarters vary within +1 day, so they were also averaged. The final result of the dependence of the number of accidents on the phases of the moon was obtained by averaging data for 6 years from 2015 to 2020.

## **Results**

### **Influence of days of the week on the number of accidents**

Table 1 presents the average number of accidents in the city of Vinnytsia and Vinnytsia region, Ukraine for 6 years of observation (2015-2020). The need for averaging, as mentioned above, is due to the different number of days of the week, such as Mondays, within a year. The average number of accidents in 2015 is lower than in other years, due to the availability of data obtained not from the beginning of the year, but from February. Graphs Figure 1 for better analysis are spaced by years, and for the latter, they are averaged. As you can see, the data does not have anomalous values, which allows us to speak about their adequacy.

### **Influence of magnetic storms on the number of accidents**

The values of the studied parameters (the number of accidents and  $Kp$ ) are quantitative values, so we can calculate the correlation coefficient. But first you need to do a visual analysis of the data, building scatter charts over the years. As can be seen from Fig. 2 points on the graphs are evenly distributed without separate accumulations or emissions.

Table 1 – The average number of accidents

Years	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2015	2.3	2.7	2.0	2.3	2.7	2.6	2.9
2016	2.8	3.0	3.1	3.1	3.6	3.2	2.9
2017	3.3	2.9	3.4	3.5	4.0	3.0	3.9
2018	3.1	3.1	2.8	3.3	3.7	3.2	2.9
2019	3.9	2.7	3.1	3.7	3.8	4.3	4.0
2020	3.1	2.9	3.2	3.4	3.9	38	3.0

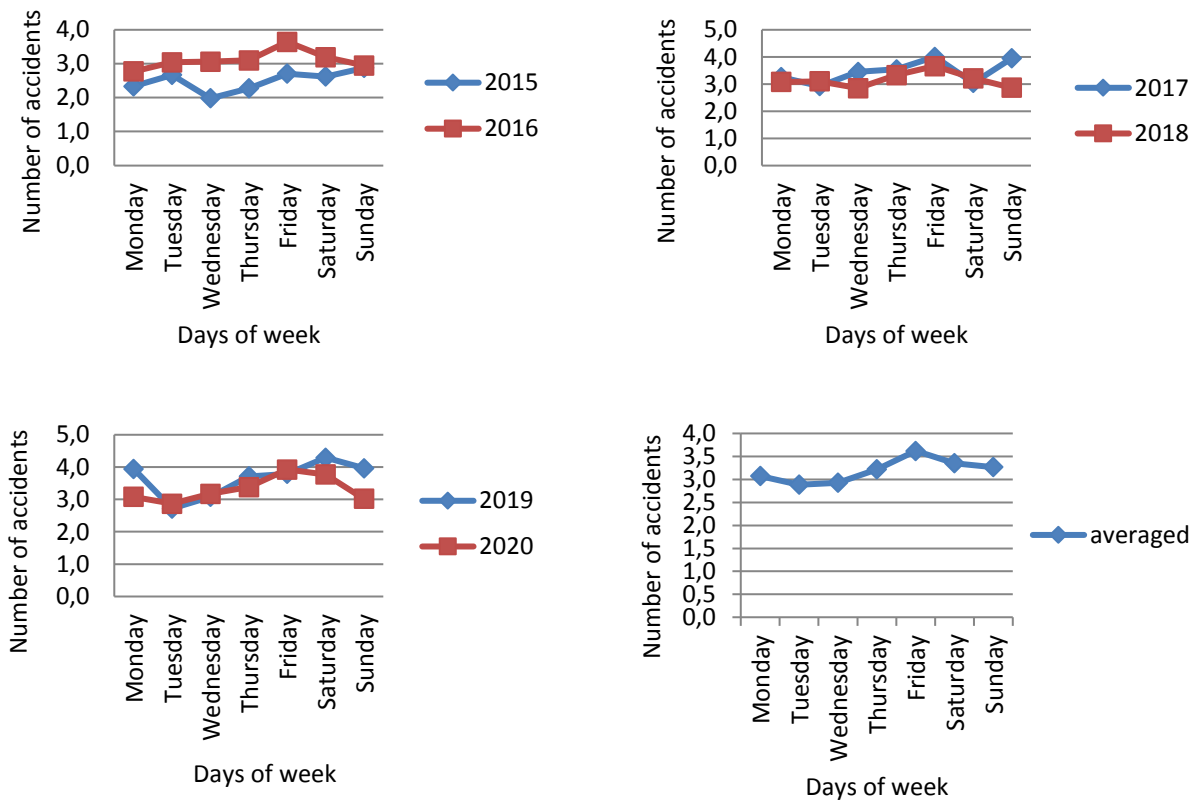


Figure 1 – Dependence of the average number of accidents on the days of the week in the context of 2015 – 2020

Table 2 – The value of the Spearman correlation coefficient

Years	r	p	Communication type
2015	0.031	<0.05	direct
2016	0.025	<0.05	direct
2017	0.076	<0.05	direct
2018	0.014	<0.05	direct
2019	-0.042	<0.05	inverse
2020	-0.086	<0.05	inverse

To calculate the correlation coefficient, it was taken into account that the data distribution is not normal. Spearman's correlation coefficient (Table 2) at a level statistical significance less than 0.05 showed that the relationship is, but weak. In addition, its type in the last two years (2019, 2020) becomes inverse.

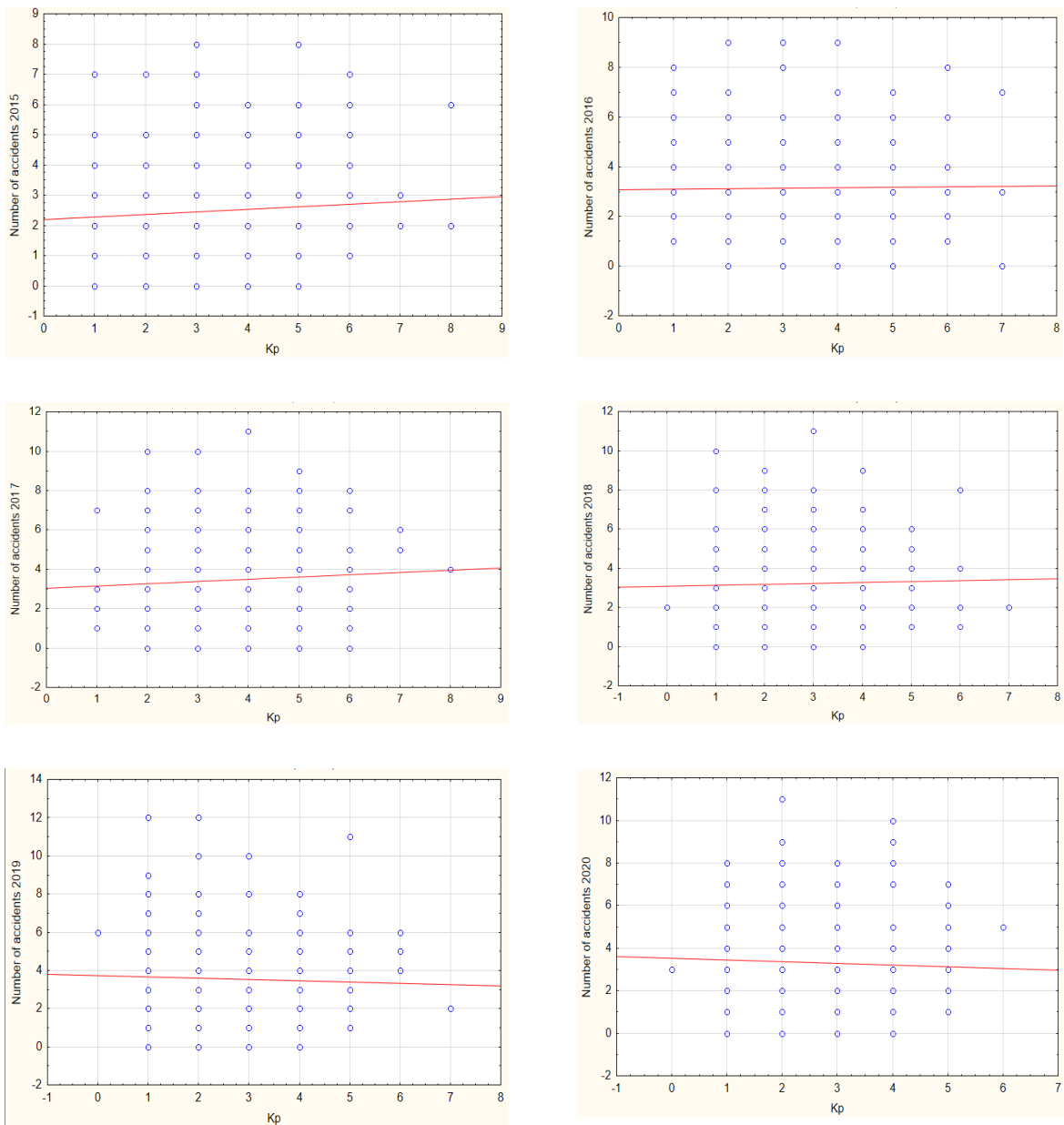
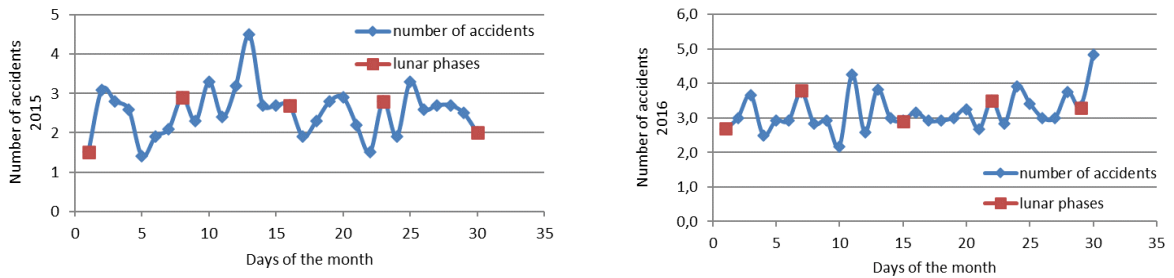


Figure 2 – Scattering diagrams of the average number of accidents from the  $Kp$  index of magnetic storms in the context of 2015 – 2020

### Influence of lunar phases on the number of accidents

On the graphs of the number of accidents from the days of the month Figure 3 also shows the days of the lunar phases from left to right: new moon, first quarter, full moon and third quarter.



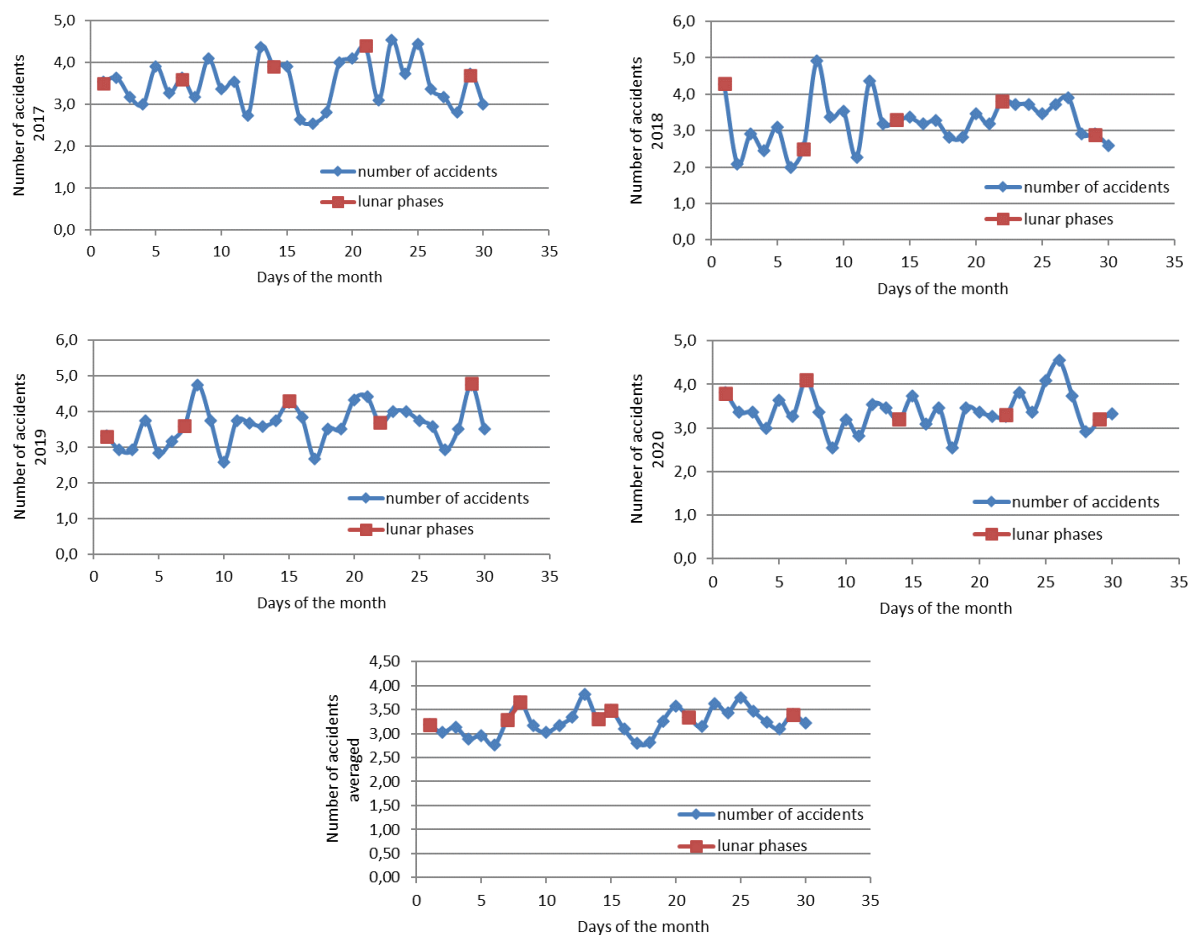


Figure 3 – Dependence of the average number of accidents on the lunar phases in the context of 2015 – 2020

The curves are quite variable, so the averaging of data over the years (the last graph in Figure 3) allowed to smooth out fluctuations and determine changes in the number of accidents relative to the lunar phases.

### Discussion

The paper examines the impact of geomagnetic storms, phases of the moon and days of the week on car accidents with injuries in Vinnytsia and the region, Ukraine due to the human factor. The choice of these impacts is due to the lack of their direct effect on the technical condition of vehicles and road infrastructure.

As for the effect of days of the week on the number of accidents, the average graph (Figure 1) illustrates the increase in the number of accidents on Thursday and Friday. This nature of the curves can be explained by the desire to complete the work by the weekend, which leads to an increase in traffic. Moreover, this trend is observed in almost all years of observation. Over the last two years of observation, there has been a slight decrease in the number of accidents from Monday to Tuesday. This can be explained by the increase in traffic on Monday due to the rest of the weekend. The nature of the dependence of the number of accidents on the days of the week, of course, can not be explained by purely weekly mood swings [22,23]. There are also weekly rhythms associated with work and rest, which in turn affect mood.

Geomagnetic storms affect human physiological parameters, for example, by increasing blood pressure [4-8], especially in women with hypertension [5, 7]. Such parameters as brain rhythms [8, 9], electrical conductivity of the human body [9, 10], desynchronization of biological rhythms [10, 11] also undergo changes due to geomagnetic activity. It was logical to expect the impact of magnetic storms on the number of accidents. As a result of research, the depth of connection was weak (Table 2). This nature of the connection can be explained by the fact that drivers, as road users, are mostly middle-aged people who are weakly affected by magnetic storms. The change in the type of communication in the last two years (2019, 2020) requires additional research.

The question of the influence of lunar rhythms on human biology is quite controversial and is studied both at the level of faith of ordinary people and health professionals, and in applied research. There are studies that confirm the influence of the lunar phases on certain, including mental, diseases and cause their exacerbation. In our observation there is an increase in the number of accidents from the new moon to the first quarter of the lunar phase (the last graph in Figure 3). Although this dependence could have been more pronounced without

2018, in which the curve in this interval is inverse. Further from the first quarter to the third quarter inclusive, the dependence is not observed.

### Conclusion

In this study, based on data from 2015 to 2020, the role of geomagnetic storms, lunar cycles and days of the week in car accidents with injuries to people in terms of their potential impact on road users was studied. The influence of these factors was proved. The impact of geomagnetic storms has been weak and even inverse in the last two years of the study. The lunar cycle was influential only in the period from the new moon to the first quarter of its phase. The days of the week had a negative effect on car accidents with injuries on Thursday and Friday, and the number of accidents decreased from Monday to Tuesday during the last two years of observation. The results of research can be used when planning road and walking trips to reduce the risk of injury as a result of an accident. Although the research was conducted on the basis of 6-year data, the reasons for the inversion of the effects of geomagnetic storms, as well as the reduction in the number of accidents from Monday to Tuesday in the last two years, should be further studied. Given that the analysis of impact factors was conducted within the city of Vinnytsia and Vinnytsia region, additional research is needed in other regions of Ukraine to determine the validity of the above results throughout the country.

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## ВПЛИВ ГЕОМАГНІТНИХ БУР, МІСЯЧНИХ ЦИКЛІВ ТА ДНІВ ТИЖНЯ НА АВТОМОБІЛЬНІ АВАРІЇ З ТРАВМУВАННЯМ ЛЮДЕЙ ЩОДО ЇХ ПОТЕНЦІЙНОГО ВПЛИВУ НА УЧАСНИКІВ ДОРОЖНЬОГО РУХУ У МІСТІ ВІННИЦІ ТА ОБЛАСТІ, УКРАЇНА

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