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ABSTRACT

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CIRCUMSTANCES OF INJURY AND CHARACTERISTICS OF DAMAGE IN CHILDREN INJURED DURING ELECTRIC VEHICLE DRIVING

Introduction. Trauma as a result of road accidents is the leading cause of death among children and young people aged 5–29. In recent years, a new type of road accident involving children driving light personal and low-speed electric vehicles has emerged, with its own specific traumagenesis and type of injury.

Objective: To improve the effectiveness of emergency medical care for children who were injured as a result of driving light personal and low-speed electric vehicles by determining the cause of injury, studying the structure and characteristics of injuries.

Materials and Methods. The total study population consisted of 57 injured children. The epidemiological and nosological characteristics of the patients were studied. The causes and circumstances of road traffic accidents were studied to determine risk factors. The condition of the injured children was assessed using the generally accepted injury scales PTS (Pediatric Trauma Score), ISS (Injury severity score) and SIPA (Shock Index, Pediatric Age-Adjusted). Statistical analysis was performed using nonparametric statistics in accordance with the principles and criteria of evidence-based medicine.

Results: The main causes of the accident were violations of road safety rules by children driving the vehicle and violations of vehicle operation rules. The clinical and epidemiological characteristics of the patients indicate that males are at increased risk of injury, mainly in the age groups of 4–6 years and 12–14 years. The dominant mechanism of injury was a fall. The majority of patients sustained mild or moderate injuries. In the nosological structure of injuries, head injuries, bruises and abrasions of the extremities were the most common.

Conclusions: In recent years, a new type of road accident involving children driving light personal and low-speed electric

vehicles has emerged, with a specific type of traumatogenesis and type of injury. Undoubtedly, the problem requires further careful study.

Key words: children, road accidents, electric vehicles, circumstances of injury, damage characteristics.

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ОБСТАВИНИ ТРАВМУВАННЯ ТА ХАРАКТЕРИСТИКИ УШКОДЖЕНЬ ПОСТРАЖДАЛИХ ДИТЯЧОГО ВІКУ ПІД ЧАС КЕРУВАННЯ ЕЛЕКТРИЧНИМИ ТРАНСПОРТНИМИ ЗАСОБАМИ

Вступ. Травматизм унаслідок дорожньо-транспортних пригод – це головна причина смерті дітей та молодих людей віком 5–29 років. За останні роки з'явився новий вид дорожніх пригод за участю дітей, які керували легкими персональними та низькошвидкісними електротранспортними засобами, з притаманним специфічним травмогенезом, різновидом ушкоджень.

Мета дослідження: підвищити ефективність екстреної медичної допомоги постраждалим дитячого віку, травмованих під час керування легким персональним та низькошвидкісним електротранспортом шляхом верифікації причинних факторів травмування, вивчення структури та характеристик ушкоджень.

Матеріали та методи дослідження. Загальний масив дослідження складався з 57 постраждалих дитячого віку. Досліджувались клініко-епідеміологічні та клініко-нозологічні характеристики постраждалих. Вивчались причини і обставини дорожньо-транспортних пригод з верифікацією ризикстворюючих факторів. Оцінку стану травмованих дітей проводили, використовуючи загальноприйнятні шкали травм PTS (Pediatric Trauma Score), ISS (Injury severity score) та SIPA (Shock Index, Pediatric Age-Adjusted). Статистичний аналіз проводили методом непараметричної статистики відповідно до принципів і критеріїв доказової медицини.

Результати дослідження. Основними причинами виникнення дорожньої пригоди були порушення правил безпеки дорожнього руху кермувальником та порушення правил експлуатації транспортного засобу. Клініко-епідеміологічна характеристика постраждалих вказує, що підвищений ризик травмування мають особи чоловічої статі, переважно у вікових групах 4–6 років та 12–14 років. Домінуючим механізмом отримання ушкодження було падіння. Переважна кількість постраждалих отримала травми легкого або середнього ступеня тяжкості. В нозологічній структурі ушкоджень найчастіше траплялися травми голови, забої та садна кінцівок.

Висновок. За останні роки з'явився новий вид дорожніх пригод за участю дітей, які керували легкими персональними та низькошвидкісними електротранспортними засобами, з

притаманним специфічним травмогенезом, різновидом ушкоджень. Безумовно проблема потребує подальшого ретельного вивчення.

Ключові слова: діти, дорожньо-транспортна пригода, електричний транспортний засіб, обставини травмування, характеристики пошкоджень.

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INTRODUCTION / ВСТУП

Road traffic injuries are the eighth leading cause of death among all age groups and the leading cause of death among children and young people aged 5 to 29 years [1, 2, 3]. The 2018 Global Road Safety Report, presented by the WHO in December 2018, reports that the number of annual deaths due to road traffic accidents reached 1.35 million [4]. However, the mortality rate in relation to the total world population remains almost constant [5, 6].

Pedestrians, cyclists and motorcyclists are the most vulnerable road users, accounting for more than half of all road deaths worldwide. Pedestrians and cyclists account for 26% of all fatalities, while road users using motorized two- and three-wheelers account for 28%. Car occupants account for 29% of all deaths, and the remaining 17% are unidentified road users [7, 8].

Road traffic injuries in Ukraine are an extremely urgent problem, the scale and consequences of which should be considered as one of the national security risk factors. In recent years, the situation has worsened due to the rapid growth in the number of private vehicles with an extremely unsatisfactory state of road infrastructure [9].

Over the past decade, a new category of road users has emerged on the roads at a fairly rapid pace – drivers of electric vehicles.

Electric scooters, electric scooters, electric bicycles, gyroscopes and gyroboards, electric unicycles, gyro rollers, electric skateboards – this is an incomplete list of the most popular models in various categories of electric vehicles.

According to a report by the U.S. Consumer Product Safety Commission (CPSC), injuries related to these so-called micromobility products increased dramatically by 70% between 2017 and 2020. Between 2017 and 2020, injuries related to personal electric vehicles resulted in more than 190.000 visits to U.S. emergency departments [10].

Electric scooters accounted for most of the surge: 7.700 emergency room visits in 2017; 14.500 in

2018; 27.700 in 2019; and 25.400 in 2020. The Commission said it was aware of 71 deaths related to micromobility products during the study period, but noted that reporting was incomplete [11].

Most European countries and the United States have introduced a system of fairly strict restrictions and fines for violating the rules for using electric scooters. For example, in Germany, driving on the sidewalk is prohibited, and only those electric vehicles that have been certified (ABE – Allgemeine Betriebserlaubnis) and received a permit are allowed on the street. To obtain a permit, an electric scooter must be equipped with lights and brakes that meet German requirements; the maximum speed of travel is 20 km/h; it must have a signaling device and 500 watts of maximum power. A driver's license is not required, but the driver of such vehicles must be at least 14 years old. You can only ride on bicycle lanes, and if they are not available, then on the roadway.

The demand for electric vehicles in Ukraine has tripled. The number of road accidents involving electric scooters is also growing proportionally.

In February 2023, the Verkhovna Rada of Ukraine adopted document No. 8172 (supported by 259 parliamentarians). The President signed it at the end of March, and on April 4, 2023, the “Law on Certain Issues of the Use of Vehicles Equipped with Electric Engines and Amendments to Certain Legislative Acts of Ukraine on Overcoming Fuel Dependence and Development of Electric Charging Infrastructure and Electric Vehicles” came into force.

The law, among other things, stipulates that electric scooters, gyroscopes, and other similar equipment (it is important to note that it is electric) are officially recognized as vehicles.

They are divided into two categories:

- light personal vehicle – a wheeled vehicle driven exclusively by electric traction motors with a power in the range of up to 1000 watts. The maximum speed is up to 25 km/h. They

do not require a driver's license, registration, or license plate.

- low-speed – driven exclusively by electric traction motors. The maximum speed is up to 50 km/h. The curb weight is no more than 600 kilograms. They can be driven from the age of 16, having received a driver's license, wearing a protective helmet. It is allowed to drive in the lane for cars and motorcycles. Drivers of low-speed electric vehicles will be held liable for violating traffic rules.

The emergence of a new category of road users raises a number of questions for the medical community: risk factors, causes and circumstances of road accidents, clinical and nosological characteristics of injuries are virtually unexplored. There are virtually no publications on this topic in the Ukrainian medical literature.

Solving these issues will increase the effectiveness of treatment of pediatric victims injured while driving light personal and low-speed electric vehicles by developing and implementing diagnostic and treatment algorithms and optimizing treatment methods.

All of the above determined the relevance of the study and became the basis for its conduct.

Objective: to improve the effectiveness of emergency medical care for children injured while driving light personal and low-speed electric vehicles by verifying the causative factors of injury, studying the structure and characteristics of injuries.

Materials and Methods. The reporting documentation of the Sumy Regional Center for Emergency Medical Care and Disaster Medicine, the Main Department of Statistics in Sumy Region, was analyzed [12].

The total study population consisted of 57 pediatric victims. The inclusion criteria for the study were: the age of the victims was under 18 years, cases of injuries while driving light personal and low-speed electric vehicles in the period 2019–2023.

Clinical, epidemiological and nosological characteristics of the victims were studied. The causes and circumstances of road accidents were studied with the verification of risk factors. The condition of injured children was assessed using the generally accepted injury scales PTS (Pediatric Trauma Score), ISS (Injury severity score) and SIPA (Shock Index, Pediatric Age-Adjusted) [13, 14, 15].

Statistical analysis was performed using nonparametric statistics in accordance with the

principles and criteria of evidence-based medicine. The data obtained were processed on a personal computer using the statistical program IBM SPSS Statistics subscription trial for Microsoft Windows 64-bit from 03.01.2024. The nature of the distribution of the obtained characteristics was assessed by the Kolmogorov-Smirnov criterion. To analyze the results of the study, mean values with standard deviations, percentages, and medians with ranges were calculated. The statistical significance of the quantitative results was assessed using the Whitney-Mann test and Kruskal-Wallis test. Differences were considered statistically significant at $p < 0.05$.

The study was conducted with the depersonalization of patients' personal information and in compliance with moral and ethical standards in accordance with the principles of the Helsinki Declaration and the laws of Ukraine.

Results. In order to determine the impact of gender and age on the outcome of the trauma process, we analyzed the distribution of victims by gender and age. The distribution of victims by age revealed that 77.2% of victims were male, 22.8% were female. The average age of the total study population is 10.8 years.

In the course of further research, we categorized road accidents according to the causes and circumstances of their occurrence. The results of the analysis are shown in Table 1.

The data in Table 1 shows that the main causes of road accidents were violations of road safety rules by the driver (26.3%) and violations of vehicle operation rules (19.3%). We found that more than half of the victims were not wearing protective equipment (helmet, elbow pads, knee pads, etc.).

The most common mechanism of injury was falling from a height of their own (35.1%). The second most common was hitting an obstacle (24.6%). Particular attention is drawn to road accidents caused by collisions with motor vehicles, with 5 cases recorded (8.8%).

The results of the study and systematization of the nosological structure of transport trauma are presented in Table 2.

The data in the table shows that in 91.2% of cases, the victims sustained isolated injuries. The most common injuries were head injuries (47.4%), including bruises, contusions of the forehead and chin, traumatic tooth extraction, and nasal fractures. The second place was occupied by bruises and abrasions of the extremities (40.3%).

Table 1 – Distribution of road traffic accidents by gender and age, as well as by causes and circumstances of their occurrence

Indicator		Number of cases n (%)
Total number of victims		57
Gender:		
boys		44 (77.2)
girls		13 (22.8)
Average age ($M \pm \sigma$)		10,8 \pm 0.42
Causes of the road accident	Violation of traffic safety rules by the driver	15 (26.3)
	Violation of vehicle operation rules	11 (19.3)
	Poor condition of the road surface	3 (5.3)
	Excessive speed	7 (12.3)
	Dangerous maneuvering	9 (15.8)
	Sudden braking	4 (7.0)
	Coincidence of circumstances	8 (14.0)
	Total	57 (100)
Circumstances of the road accident	Collision of electric vehicles	4 (7.0)
	Collision with a pedestrian	9 (15.8)
	Collision with a motor vehicle	5 (8.8)
	Running into an obstacle	14 (24.6)
	Falling down	20 (35.1)
	Under unknown circumstances	5 (8.8)
	Total	57 (100)

Table 2 – Distribution of victims by clinical and nosological characteristics of injuries

Type of damage	Number of victims		
	abs.	percentage	R*
Isolated trauma, including those involving	52	91.2	
• head	27	47.4	1
• upper extremities	8	14.0	3
• trunk	2	3.5	4
• lower extremities	15	26.3	2
Multiple and combined injuries	5	8.8	
Total	57	100	–

Note: *R – rank

Multiple and combined injuries occurred in 8.8% of cases.

To determine the severity of traumatic injuries sustained in road accidents, we used the generally accepted injury scales PTS (Pediatric Trauma Score), ISS (Injury severity score) and SIPA (Shock Index, Pediatric Age-Adjusted). The results are shown in the diagrams in Figures 1, 2, 3.

The distribution of victims depending on the severity of their condition according to the PTS (Pediatric Trauma Score) scale is shown in Figure 1. Light injuries and moderate injuries without a risk to life were observed in 53 (93%) of the victims, and a potentially life-threatening condition was identified in 4 (7%) children ($p < 0.05$). There were no victims with a score of less than 6 points.

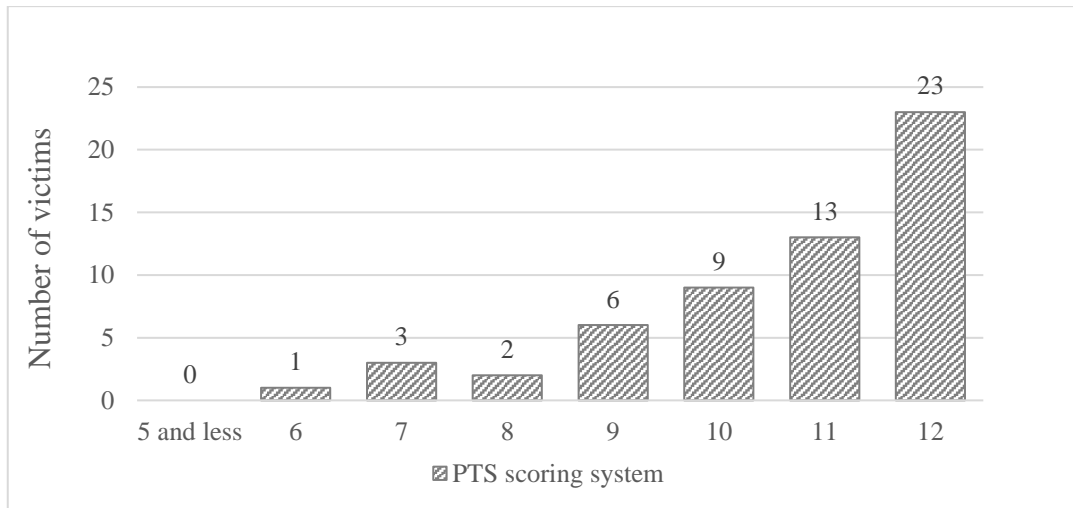


Figure 1 – Distribution of victims depending on the severity of the condition according to the PTS (Pediatric Trauma Score) scale

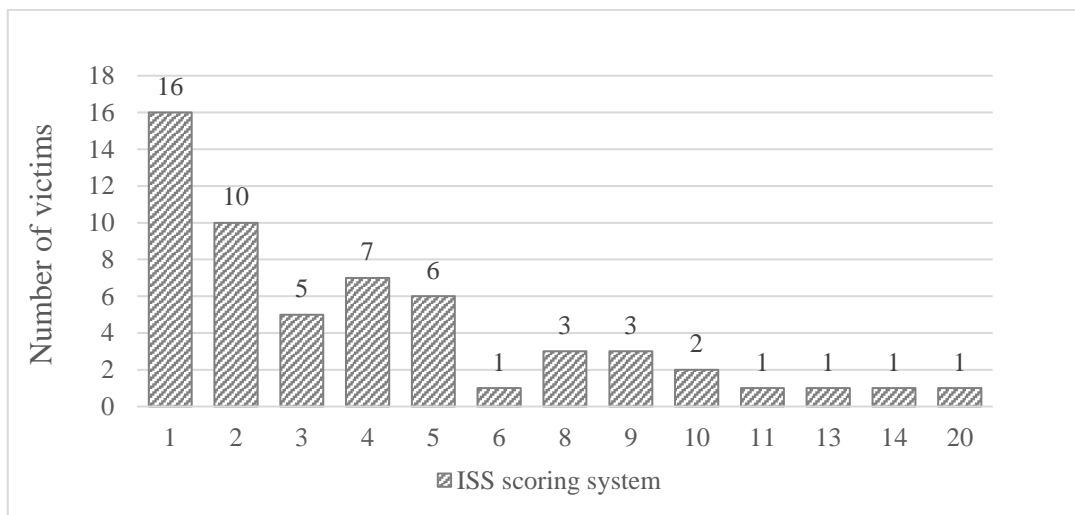


Figure 2 – Distribution of victims depending on the ISS score (Injury Severity Score)

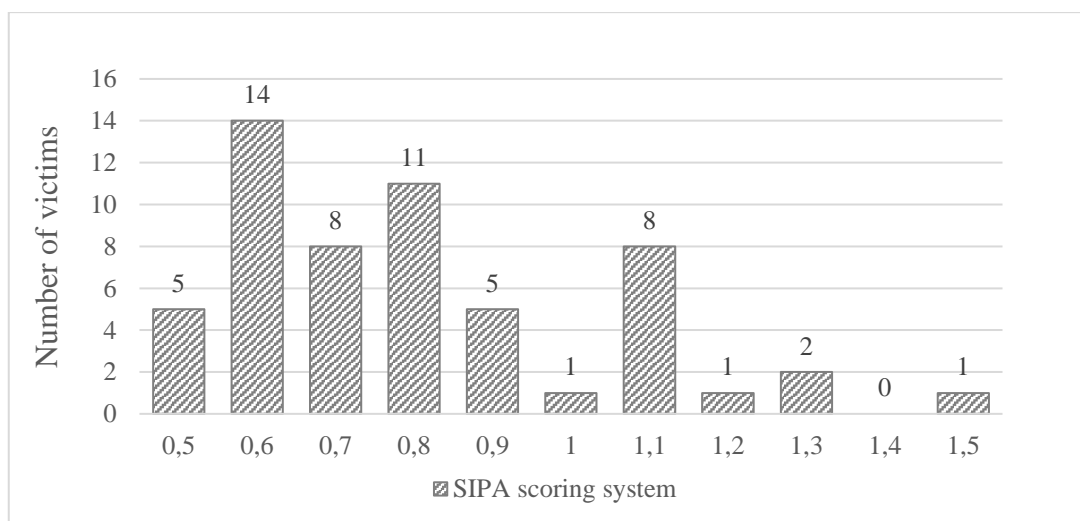


Figure 3 – Distribution of victims by SIPA score (Shock Index, Pediatric Age-Adjusted)

The distribution of victims depending on the severity of their injuries according to the ISS (Injury Severity Score) is shown in Figure 2. Based on the ISS score, all victims were divided into 4 groups. Mild injuries (ISS scores from 1 to 8) were identified in 48 (84.2%) of the injured children, moderate injuries (ISS scores from 9 to 15) were observed in 8 (14%) of the victims, and 1 child (1.8%) was classified as having severe injuries (ISS scores from 16 to 24). There were no victims with very severe injuries (more than 25 ISS points) in our study. There is a significant prevalence of mild injuries ($p < 0.05$).

When we analyzed the values of the Shock Index, Pediatric Age-Adjusted (SIPA), we found that in 43 (75.4%) of the injured children, the shock index was within the age range, and in 14 (24.6%) it was above the age range, which indirectly indicates an increased risk of blunt injury (Fig. 3).

Thus, the majority of those injured while driving light personal and low-speed electric vehicles sustained mild or moderate injuries.

Discussion. Low-speed electric transport is rapidly gaining popularity in Ukraine as a means of transportation and recreation. Children as drivers of this type of transport are at risk due to their less developed motor coordination skills, reduced sense of self-preservation, and lack of knowledge of traffic rules.

CONCLUSIONS / ВИСНОВКИ

1. In recent years, a new type of road accident involving children driving light personal and low-speed electric vehicles has emerged, characterized by specific traumatogenesis and types of injuries. Undoubtedly, the problem requires further careful study.

2. The main causes of road accidents were violations of road safety rules by the driver (26.3%)

The information obtained is somewhat limited due to the retrospective nature of the study, the small number of victims, and the time period of observation.

Based on the results of the study, we have formulated and summarized a list of rules for the use of light personal and low-speed electric vehicles:

- wear a helmet and other protective equipment (gloves, elbow pads, knee pads, etc.);
- when traveling at dusk, wear vests or other clothing with reflective elements;
- it is forbidden to ride with two people;
- it is forbidden to transport animals and any cargo;
- do not use a smartphone or headphones while driving;
- follow the traffic rules;
- use bicycle lanes and roads in the same direction as general traffic;
- ride as far to the right as possible on the roadway;
- pay attention to road signs and traffic lights;
- do not make dangerous maneuvers;
- do not exceed the speed limit;
- keep the distance and interval between other road users;
- do not use electric vehicles unless you are sure that they are in good working order.

and violations of vehicle operation rules (19.3%).

3. The clinical and epidemiological characteristics of the victims indicate that males are at increased risk of injury, mainly in the age groups of 4–6 years and 12–14 years. The dominant mechanism of injury was a fall. The majority of victims sustained mild or moderate injuries. The most common types of injuries were head injuries, bruises and abrasions of the extremities.

PROSPECTS FOR FUTURE RESEARCH / ПЕРСПЕКТИВИ ПОДАЛЬШИХ ДОСЛІДЖЕНЬ

It is planned to search for and study informative methods of blood loss assessment that can be used in prehospital emergency care.

CONFLICT OF INTEREST / КОНФЛІКТ ІНТЕРЕСІВ

The authors declare no conflict of interest.

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None.

AUTHOR CONTRIBUTIONS / ВКЛАД АВТОРІВ

All authors substantively contributed to the drafting of the initial and revised versions of this paper. They take full responsibility for the integrity of all aspects of the work.

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