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## CLINICAL CONSEQUENTIAL RISKS OF FATAL OUTCOMES IN CHILDREN INJURED IN ROAD TRAFFIC ACCIDENTS

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### Summary.

Road traffic injuries represent a leading cause of disability and mortality among the active, working-age population and constitute the primary cause of violent death in children worldwide.

**The aim of the study.** To determine and evaluate the clinical consequential risks of fatal outcomes in children injured in road traffic accidents, as a basis for developing and implementing clinical protocols and patient care pathways in the provision of medical assistance to victims.

**Research materials and methods.** This retrospective study analyzed 259 cases of road traffic injury (RTI) in children, forming the primary study cohort. The cohort was selected by irreversible randomization from a larger array of 1671 victims injured in road traffic accidents in rural and urban areas during 2022-2023, stratified by age. The study was conducted in accordance with evidence-based medicine principles and the requirements of the Declaration of Helsinki. The protocol was approved by the Bioethics Commission of the State Institution «Ukrainian Scientific and Practical Center of Emergency Medical Care and Disaster Medicine» of the Ministry of Health of Ukraine. To ensure the clinical relevance of the study, the influence of epidemiological and nosological characteristics on the risk of adverse outcomes in the course of the traumatic process in injured patients was examined. Parametric methods were employed for analysis; fractal analysis and the laws of formal logic served as statistical analytical methods. The analysis was performed using computer-based technologies within the Statistica software system. The study was conducted as part of the research projects «Development of Clinical and Organisational Principles of Functioning, Structure, and Human and Material Resources of the Emergency Medical Care System for Road Traffic Accidents» (applied research, state registration No. 0113U002107, January 2013 – December 2015) and «Development of Contemporary Evidence-Based Principles and Measures of Medical Rehabilitation of Patients Injured in Road Traffic Accidents» (applied research, state registration No. 0116U003044, January 2016 – December 2018).

**Research results.** The study demonstrated that the clinical consequential risk of an adverse outcome in the traumatic process is influenced by both clinical-epidemiological and clinical-nosological risk factors, albeit with varying degrees of impact. The most substantial effects were observed for the factors «severity of injury,» «damaged anatomical-functional area,» and «mode of participation in traffic.» The least influential factors included «number of damaged anatomical-functional areas,» «gender,» and «age of the victim.» Boys exhibited the highest risk of an adverse outcome (significant risk). Among modes of participation in traffic, pedestrians were at significant risk. Damage to two, three, or five anatomical-functional areas (AFA) was associated with insignificant risk. Among mode «damaged AFA damage to the pelvis and abdomen carried significant risk. On the New Injury Severity Score (NISS), values exceeding 35 points indicated significant risk, while values exceeding 45 points indicated catastrophic risk.

**Conclusions.** 1. The clinical consequential risk of an adverse outcome in the traumatic process among children with road traffic injuries is multifactorial, resulting from the combined influence of multiple risk factors, with an overall risk level that is generally low (0.15), although ranging from theoretically absent (0) to catastrophic (0.81). 2. Both clinical-epidemiological and clinical-nosological risk factors contribute to the formation of this risk, but with differing intensities. 3. Among clinical-epidemiological factors, mode of participation in traffic exerts the greatest influence; among clinical-nosological factors, injury severity is predominant. 4. The highest risk of an adverse outcome is observed in boys (significant risk), school-aged (insignificant risk) and pedestrians (significant risk).

**Keywords:** Road Traffic Accident; Road Traffic Injury; Children; Clinical Outcome Risks; Mortality.

### Introduction

Road traffic injuries are associated with high rates of disability and represent one of the leading causes of mortality among the active, working-age population [1-5]. In children, they constitute the primary cause of violent death worldwide [6-10]. The occurrence of an adverse outcome in the traumatic process among children injured in road traffic accidents is determined by both clinical-epidemiological and clinical-nosological risk factors.

Contemporary research in this field is predominantly based on a risk-stratified approach, with particular attention given to the assessment of clinical consequential risks. The most severe clinical outcome in injured individuals is fatal outcome [11-18]. Considerable attention is devoted worldwide to pediatric mortality and to the identification of factors influencing the occurrence of adverse outcomes in the traumatic process. A primary focus is placed on mechanisms for reducing mortality in children. One such

mechanism is the risk-based approach, which aligns with the principles of clinical risk management [19-26].

These considerations determine the relevance, scope, and direction of the present study.

**Purpose and objectives of the study.** To determine and evaluate the clinical consequential risks of fatal outcomes in children injured in road traffic accidents, thereby providing a foundation for the development and implementation of clinical protocols and patient care pathways during the provision of medical care to victims.

### Materials and research methods

The study is based on a retrospective analysis of 259 cases of road traffic injury (RTI) in children, forming the primary study cohort. The cohort was selected by irreversible randomization from a larger array of 1671 victims injured in road traffic accidents in rural and urban areas during 2022-2023, stratified by age. Randomization was performed across the age range of 0-18 years, resulting in children comprising 15.50% of the total array of road traffic accident victims. The sample size exceeds the minimum required threshold as determined by the law of large numbers.

The analysis included the main clinical-epidemiological risk factors (gender, age, mode of participation in traffic) and clinical-nosological risk factors (number of damaged anatomical-functional areas [AFA], injury severity, and specific damaged AFA) that contribute to the formation of clinical outcome risk.

Age was categorized as follows: 0-3 years (early preschool period), 3-6 years (preschool period), and 6-18 years (school period). This classification corresponds to social developmental stages and was selected as optimal for the purposes of the study.

Injury severity was assessed using the standardized New Injury Severity Score (NISS).

To ensure the clinical relevance of the study, the influence of epidemiological and nosological characteristics on the risk of adverse outcomes in the course of the traumatic process in injured patients was examined.

Parametric methods were employed for analysis; fractal analysis and the laws of formal logic served as statistical analytical methods. The analysis was performed using computer-based technologies within the Statistica software system.

The study was conducted as part of the research projects «Development of Clinical and Organisational Principles of Functioning, Structure, and Human and Material Resources of the Emergency Medical Care System for Road Traffic Accidents» (applied research, state registration No. 0113U002107, January 2013 – December 2015) and «Development of Contemporary Evidence-Based Principles and Measures of Medical Rehabilitation of Patients Injured in Road Traffic Accidents» (applied research, state registration No. 0116U003044, January 2016 – December 2018).

### Research results and their discussion

The most severe consequence of road traffic injury is the risk of an adverse outcome in the traumatic process, namely fatal outcome in the victim.

In the overall study cohort, the clinical consequential risk of death among children injured in road traffic accidents was 0.15 in quantitative terms, corresponding qualitatively to an insignificant risk.

The outcome of the traumatic process is determined by a combination of risk factors, primarily clinical-epidemiological and clinical-nosological.

One of the key clinical-epidemiological risk factors influencing fatal outcome in children after road traffic accidents is gender. The results of the analysis according to the risk factor «gender» are presented in Table 1.

Table 1

**Analysis of clinical consequential risks of fatal according to the risk factor «gender»**

Risk factor «gender»	Quantitative characterization of risk	Qualitative characterization of risk	Rank
Boys	0.25	significant	1
Girls	0.05	minimal	2

Analysis of the data in Table 1 revealed that the clinical consequential risk of fatal outcome in the traumatic process is five times higher in boys than in girls. Furthermore, the risks differ in both quantitative and qualitative characteristics between boys and girls. This distribution is primarily attributable to physiological and behavioral

differences, with boys tending to engage in more active lifestyles.

Another important risk factor influencing both the occurrence of road traffic injury and the outcome of the traumatic process is the age of the injured child. The results of this analysis are presented in Table 2

Table 2

**Analysis of clinical consequential risks of fatal outcome according to the risk factor «age»**

Risk factor «age»	Quantitative characterization of risk	Qualitative characterization of risk	Rank
0-3 (early preschool)	0	theoretically impossible	3
3-6 (preschool)	0.14	insignificant	2
6-18 (school age)	0.15	insignificant	1

Analysis of the data in Table 2 demonstrated that in children of preschool and school age, the risk of an adverse outcome in the traumatic process is insignificant in qualitative terms, with quantitative values being closely comparable. In children aged 0-3 years, the risk is theoretically absent. The ratio of maximum to minimum risk is 1.07, indicating low variability in distribution. This

suggests that the occurrence of an adverse outcome is predominantly influenced by other risk factors, primarily the level and quality of medical care. As demonstrated in previous publications [6,7], the factor «mode of participation in traffic» exerts a significant influence on the outcome of the traumatic process in road traffic accident victims. The results of this analysis are presented in Table 3

**Table 3**

**Analysis of clinical consequential risks of fatal outcome according to the risk factor «Participation in traffic»**

Risk factor «Participation in traffic»	Quantitative characterization of risk	Qualitative characterization of risk	Rank
Drivers and passengers of two-wheeled vehicles	0.08	minimal	3
Passengers of four-wheeled vehicles	0.11	insignificant	2
Pedestrians	0.23	significant	1

The data in Table 3 indicate that pedestrians have the highest risk of fatal outcome following road traffic injury, ranking first and qualifying as significant risk, consistent with patterns observed in adults. Passengers of four-wheeled vehicles rank second (0.11), corresponding to insignificant risk in qualitative terms. The ratio of maximum to minimum risk is 2.88, indicating moderate variability in distribution and suggesting that the risk factor «mode of participation in traffic» exerts a notable influence on the occurrence of an adverse outcome in the traumatic process.

Clinical-nosological risk factors, including extent of injury and specific damaged anatomical-functional areas, also exert substantial influence on the occurrence of an adverse outcome in the traumatic process, with injury severity playing a decisive role.

The results of the analysis of the risk factor «number of damaged anatomical-functional areas (extent of damage)» are presented in Table 4.

Analysis of the data in Table 4 revealed the following: no clear linear increase in the clinical consequential risk of an adverse outcome occurs with increasing number of damaged areas, indicating the influence of additional risk factors, primarily the quality and level of medical care. In qualitative terms, the risks are minimal or insignificant; in quantitative terms, they range from 0.08 to 0.18. The highest risk (rank 1) is associated with damage to 3 anatomical-functional areas. The lowest risks are associated with damage to 1 and 4 areas (0.08 and 0.09, respectively). The ratio of maximum to minimum risk is 2.25, indicating moderate variability in distribution and confirming the influence of other risk factors on clinical outcome risk.

**Table 4**

**Analysis of clinical consequential risks of fatal outcome according to the risk factor «Number of damaged anatomical and functional areas (extent of damage)»**

Risk factor «Extent of lesion»	Quantitative characterization of risk	Qualitative characterization of risk	Rank
1	0.08	minimal	5
2	0.17	insignificant	2
3	0.18	insignificant	1
4	0.09	minimal	4
5	0.15	insignificant	3

One of the clinical-nosological risk factors exerting a pronounced influence on the clinical consequential risk of an adverse outcome in the traumatic process among

road traffic accident victims is the risk factor «damaged anatomical-functional area» (AFA). The data are presented in Table 5.

**Table 5**

**Analysis of clinical consequential risks of fatal outcome according to the risk factor «damaged AFA»**

Risk factor «Damaged AFA»	Quantitative characterization of risk	Qualitative characterization of risk	Rank
Head and neck	0.20	significant	3
Spine	0.08	minimal	4
Chest	0.24	insignificant	2
Abdomen	0.33	significant	1
Pelvis	0.33	significant	1
Limbs	0.04	minimal	5

Analysis of the data in Table 5 revealed that the clinical consequential risk of an adverse outcome in the traumatic process ranges from minimal to significant in qualitative terms. Damage to the pelvis and abdomen is associated with the highest quantitative risk (0.33, rank 1) and qualifies as significant risk. This elevated risk is primarily attributable to uncontrolled bleeding and the quality and timeliness of medical care rather than the injury itself. Insignificant risk is observed with damage to the chest (0.24) and head and neck (0.20), likely due to respiratory failure in chest trauma and impairment of vital functions in head injury. The lowest (minimal) risk is recorded for spinal and limb injuries (0.08 and 0.04, respectively). The ratio of minimum to maximum

risk is 8.25, indicating high variability in distribution and confirming the substantial influence of the risk factor «damaged AFA» on the formation of clinical consequential risk of an adverse outcome in children injured in road traffic accidents.

An equally important risk-creating factor that has a decisive influence on the formation of the clinical effective risk of a negative outcome of the traumatic process is «severity of injury». The results of such an analysis are given in Table 6.

An equally important risk factor with decisive influence on the formation of clinical consequential risk of an adverse outcome is severity of injury. The results of this analysis are presented in Table 6.

Table 6

#### Analysis of clinical consequential risks of fatal outcome according to the risk factor «severity of injury»

Risk factor «severity of injury» (according to NISS)	Quantitative characterization of risk	Qualitative characterization of risk	Rank
Up to 16 points	0	theoretically impossible	5
16-24 points	0.01	minimal	4
25-34 points	0.19	insignificant	3
35-44 points	0.37	significant	2
45-75 points	0.81	disastrous	1

Analysis of the data in Table 6 revealed a clear linear trend: the quantitative indicator of the clinical consequential risk of an adverse outcome in the traumatic process increases with increasing injury severity as assessed by the standardized New Injury Severity Score (NISS). In qualitative terms, the risk ranges from theoretically impossible (NISS  $\leq$  16 points) to catastrophic (NISS 45-75 points). The ratio of maximum to minimum risk is 81, indicating very high variability in distribution and confirming the strong dependence of clinical consequential risk of an adverse outcome on injury severity.

The data demonstrate that clinical-epidemiological and clinical-nosological risk factors exert varying degrees of influence on the formation of clinical consequential risk of an adverse outcome in the traumatic process among children injured in road traffic accidents. The most substantial effects are observed for severity of the injury, specific damaged anatomical-functional areas, and mode of participation in traffic.

#### Conclusions

1. The clinical consequential risk of an adverse outcome in the traumatic process among children with road traffic injuries is multifactorial, resulting from the combined influence of multiple risk factors, with an overall risk level that is generally low (0.15), although ranging from theoretically absent (0) to catastrophic (0.81).

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2. Both clinical-epidemiological and clinical-nosological risk factors contribute to the formation of this risk, but with differing intensities.

3. Among clinical-epidemiological factors, mode of participation in traffic exerts the greatest influence; among clinical-nosological factors, injury severity is predominant.

4. The highest risk of an adverse outcome is observed in boys (significant risk), school-aged (insignificant risk) and pedestrians (significant risk).

**Prospects for further research.** Based on the present findings and previous studies, future work will focus on the development of a risk-stratified model for road traffic injuries in children.

**Contribution of co-authors to the preparation of materials for the scientific article:** S. Guriev – concept and design of the study; V. Kushnir – data analysis, text writing; N. Iskra – processing of materials; V. Grebenyuk – data collection, information analysis; O. Solovyov – collection and processing of research materials.

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## КЛІНІЧНІ РЕЗУЛЬТАТИВНІ РИЗИКИ ВИНИКНЕННЯ ЛЕТАЛЬНОГО РЕЗУЛЬТАТУ В ДІТЕЙ УНАСЛІДОК ДОРОЖНЬО-ТРАНСПОРТНИХ ПРИГОД

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### Резюме.

Травмування населення внаслідок дорожньо-транспортних пригод призводять до високої інвалідизації та є однією з основних причин смертності серед найбільш активного, працездатного населення, а у дітей – провідною причиною насильницької смерті в усьому світі.

**Мета дослідження.** Визначити та оцінити клінічні результативні ризики виникнення летального результату в дітей, які отримали пошкодження в результаті дорожньо-транспортної пригоди, як фундаментальної підстави розробки та формування клінічних протоколів та клінічних маршрутів пацієнта в процесі надання медичної допомоги постраждалим.

**Матеріали і методи дослідження.** Дослідження ґрунтується на ретроспективному вивченні та аналізі 259 випадків дорожньо-транспортної травми (ДТТ) у дітей, що сформувало загальний масив вивчення. Масив вивчення формувався методом беззворотної рандомізації з масиву 1671 постраждалих, які отримали травми унаслідок ДТП в сільській та міській місцевості у 2022-2023 роках, за ознакою віку. Дане дослідження проведено відповідно до вимог та критеріїв доказової медицини з дотриманням вимог Гельсінської декларації, схвалено комісією з біоетики ДЗ «Український науково-практичний центр екстреної медичної допомоги та медицини катастроф» МОЗ України. Для забезпечення клінічної спрямованості дослідження було вивчено вплив епідеміологічних та нозологічних ознак на ризик виникнення негативного результату перебігу травматичного процесу в постраждалих. Методами аналізу були параметричні, методами статистичного аналізу – фрактальний аналіз, закони формальної логіки. Аналіз проводився за допомогою комп'ютерних технологій у системі Statistica. Дослідження проведено у межах виконання науково-дослідної роботи «Розробити клініко-організаційні принципи функціонування, структуру та кадрово-матеріальний ресурс системи надання екстреної медичної допомоги при дорожньо-транспортних пригодах» (прикладне дослідження, № ДР: 0113U002107, термін виконання січень 2013 рік – грудень 2015 рік) та науково-дослідної роботи «Розробити сучасні науково-обґрунтовані принципи та заходи медичної реабілітації постраждалих внаслідок дорожньо-транспортних пригод» (прикладне дослідження, № ДР: 0116U003044, термін виконання січень 2016 рік – грудень 2018 рік).

**Результати.** В результаті даного дослідження встановлено, що на клінічний результативний ризик виникнення негативного результату перебігу травматичного процесу мають вплив як клініко-епідеміологічні, так і клініко-нозологічні ризикстворюючі фактори, але даний вплив має різну інтенсивність. Найбільш виражений вплив мають такі ризикстворюючі фактори, як «тяжкість пошкодження», «пошкоджена анатомо-функціональна ділянка», «ознака участі в русі». Менш виражений вплив мають такі ризикстворюючі фактори, як «кількість пошкоджених анатомо-функціональних ділянок», «стать постраждалого», «вік постраждалого». Найбільший ризик виникнення негативного результату перебігу травматичного процесу мають хлопчики (ризик суттєвий). За ознакою участі в русі «пішоходи» – ризик суттєвий; за ризикстворюючим фактором «кількість пошкоджених анатомо-функціональних ділянок» при пошкодженні двох, трьох та п'яти АФД (ризик несуттєвий); за ознакою «пошкодженої АФД» таз та живіт (ризик суттєвий); за шкалою NISS більше 35 балів ризик суттєвий, а при більше 45 балів катастрофічний.

**Висновки:** 1. Клінічний результативний ризик виникнення негативного результату перебігу травматичного процесу в постраждалих дітей з дорожньо-транспортною травмою є багатокомпонентним, що виникає під впливом низки ризикстворюючих факторів та в цілому є несуттєвим 0,15, хоча коливається від теоретично неможливого (0) до катастрофічного (0,81). 2. На формування клінічного результативного ризику виникнення негативного результату перебігу травматичного процесу в постраждалих дітей унаслідок дорожньо-транспортної травми мають вплив як клініко-епідеміологічні, так і клініко-нозологічні ризикстворюючі фактори, але в різному ступені. 3. Серед клініко-епідеміологічних ризикстворюючих факторів найбільший вплив має ознака участі в русі, а серед клініко-нозологічних – тяжкість пошкодження. 4. Найбільший ризик виникнення негативного результату перебігу травматичного процесу за гендерною ознакою мають хлопчики (ризик суттєвий), за ознакою віку – у шкільному віці (ризик несуттєвий), а за ознакою участі у русі «пішохід» (ризик суттєвий).

**Ключові слова:** дорожньо-транспортна пригода; дорожньо-транспортна травма; діти; клінічні результативні ризики; летальність.

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