International periodic scientific journal

ONLINE

www.sworldjournal.com

D.A.Tsenov Academy of Economics - Svishtov (Bulgaria)

Indexed in
INDEXCOPERNICUS
(ICV: 73)
GOOGLESCHOLAR

SWorld Journal

Issue №39
Part 1
September 2026

Published by:
SWorld & D.A. Tsenov Academy of Economics, Svishtov,Bulgaria

ISSN 2663-5712
DOI: 10.30888/2663-5712

Editor: Shibaev Alexander Grigoryevich, *Doctor of Technical Sciences, Professor, Academician*
Scientific Secretary: Kupriienko Sergiy, *PhD in Technical Sciences*

Editorial board: More than 400 doctors of science. Full list on page:
https://www.sworldjournal.com/index.php/swj/about/editorialTeam

Expert-Peer Review Board of the journal: Full list on page:
https://www.sworldjournal.com/index.php/swj/expertteam

The International Scientific Periodical Journal "SWorldJournal" has gained considerable recognition among domestic and foreign researchers and scholars. Today, the journal publishes authors from from different countries.

Journal Established in 2018. **P**eriodicity of publication: 6 times a year

The journal activity is driven by the following objectives:

- Broadcasting young researchers and scholars outcomes to wide scientific audience
- Fostering knowledge exchange in scientific community
- Promotion of the unification in scientific approach
- Creation of basis for innovation and new scientific approaches as well as discoveries in unknown domains

The journal purposefully acquaints the reader with the original research of authors in various fields of science, the best examples of scientific journalism.

Publications of the journal are intended for a wide readership - all those who love science. The materials published in the journal reflect current problems and affect the interests of the entire public.

Each article in the journal includes general information in English.

The journal is registered in the INDEXCOPERNICUS, GoogleScholar.

DOI: 10.30888/2663-5712.2026-39-01

Published by:
SWorld &
D.A. Tsenov Academy of Economics
Svishtov, Bulgaria
e-mail: editor@sworldjournal.com

Copyright
© Authors, scientific texts 2026

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-021
DOI: 10.30888/2663-5712.2026-39-01-021

UDC: 004.94:681.5:616-001

ANALYTICAL REVIEW OF METHODS AND MEANS OF DETERMINING THE RISK OF ADVERSE OUTCOME IN COMBINED INJURIES WITH LOWER LIMB FRACTURES

Rysovana L. / Рисована Л.М.
c.t.s., as.prof. / к.т.н., доц.
ORCID: 0000-0001-7937-4176
Kharkiv National Medical University, Kharkiv, Nauky Avenue, 4, 61022
Харківський національний медичний університет, Харків, просп.Науки, 4, 61022
Vysotska O. / Висоцька О.В.
d.t.s., prof. / d.т.н., проф.
ORCID: 0000-0003-3723-9771
National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Vadym Manko St., 17, 61070
Національний аерокосмічний університет «Харківський авіаційний інститут, м.Харків, вул. Вадима Манька, 17, 61070
Hryhoruk V. / Григорук В.В.
c.m.s., as.prof. / к.м.н., доц.
ORCID: 0000-0002-8937-7802
Kharkiv National Medical University, Kharkiv, Nauky Avenue, 4, 61022
Харківський національний медичний університет, Харків, просп.Науки, 4, 61022
Lytvynenko M. / Литвиненко М.І.
c.m.s., as.prof. / к.м.н., доц.
ORCID: 0000-0003-1308-5034
Kharkiv National Medical University, Kharkiv, Nauky Avenue, 4, 61022
Харківський національний медичний університет, Харків, просп.Науки, 4, 61022
Alekseienko R. / Алексеєнко Р.В.
c.m.s., as.prof. / к.м.н., доц.
ORCID: 0000-0002-0926-7903
Kharkiv National Medical University, Kharkiv, Nauky Avenue, 4, 61022
Харківський національний медичний університет, Харків, просп.Науки, 4, 61022

Abstract. *The article presents an analytical review of methods and tools for assessing the risk of unfavorable outcome in patients with combined lower-limb injuries under the changing structure of modern trauma, driven by the growing share of high-energy gunshot and mine-blast injuries. The evolution of prognostic approaches is examined - from classical anatomical and physiological scales through Bayesian and neural-network models to contemporary explainable machine-learning methods focused on predicting specific complications. The biomedical engineering direction is analyzed separately, including the influence of the biomechanical stiffness of the "fixator-bone" system and local tissue perfusion on the quality of osteoreparation. It is established that the clinical-statistical and biomedical-engineering research traditions develop in parallel, without integration into a unified mathematical framework, and that predicting hospitalization length of stay as an independent target variable for this patient category has practically not been studied. Based on the identified gap, the concept of a two-stage integrated model built on multivariate logistic regression is substantiated, combining clinical-laboratory, anatomical, biomechanical, and perfusion predictors to forecast the risk of unfavorable outcome and the length of inpatient treatment, which is particularly relevant for the healthcare system under wartime conditions.*

Keywords: *multivariate logistic regression, clinical decision support system, biomechanical fixation stiffness, perfusion monitoring, length-of-stay prediction, heterogeneous data fusion*

Introduction

In recent years, fundamental changes have occurred in the structure and etiopathogenetic nature of trauma, which is especially clearly observed in modern Ukrainian realities. If previously the main factors of severe damage to the musculoskeletal system were road traffic accidents, domestic injuries and man-made accidents, now this spectrum has expanded critically due to high-energy military trauma [1]. Modern combat operations cause the formation of multifactorial lesions: gunshot and mine-explosive injuries are characterized by the synergistic effect of excessive shock wave pressure, thermal energy, acubarotrauma, as well as primary and secondary wounding shells, which causes massive fragmentation of bone structures and devascularization of the periosteum [2]. According to military medical statistics, more than 60–65% of all appeals at the stages of medical evacuation are due to gunshot and mine-explosive injuries of the extremities, with about 70% of them being fractures of long tubular bones - the femur and tibia [1]. Along with this, road accidents and man-made emergencies remain the key causes of disability of the working-age population: in the structure of polytraumas due to road accidents, severe injuries of the lower extremities are diagnosed in almost 50% of victims [3, 4].

Combined injuries (polytraumas) are particularly complex, when a patient simultaneously has high-energy injuries to several anatomical and functional segments. Such a condition cannot be considered as an additive sum of isolated injuries - its development is based on an avalanche-like cascade of pathophysiological reactions, known as the syndrome of mutual burden, when each component of the injury multiplicatively increases the overall severity of the process, suppressing the compensatory and adaptive mechanisms of the body [5].

Destruction of large musculoskeletal masses is accompanied by massive internal blood loss, which often remains latent at the initial examination: the volume of hidden hemorrhage in fractures of the hip or pelvic ring can reach 1.5–2.5 l. The combination of acute hypovolemia with an intense pain impulse provokes the “triad of death” - hypothermia, metabolic acidosis and coagulopathy - which leads to generalized tissue hypoxia and endothelial dysfunction against the background of a systemic

inflammatory response (SIRS). As a result of intramedullary hyperpressure, bone marrow microdroplets are released with the subsequent development of fat embolism of the small vessels and the brain, and large-scale rhabdomyolysis causes hypermyoglobinemia with the risk of acute renal failure. These processes are potentiated by deep phlebothrombosis due to prolonged immobilization [6, 7].

It should be emphasized that the pathogenetic peculiarity of mine-explosive and gunshot injuries lies in the combination of several independent destructive factors at one point of application: the shock wave causes acubarotrauma of parenchymal organs at a distance from the visible wound, high-speed fragments form a temporary pulsating cavity with a much larger zone of secondary necrosis than is seen during primary surgical treatment, and the thermal component of the explosion adds burn damage to the skin and subcutaneous tissue. This fundamentally distinguishes such injuries from blunt trauma due to a road accident, where the energy is dissipated mainly along the axis of the limb, and causes a higher frequency of multi-fragmented, contaminated, multi-segmented fractures, which a priori have a worse prognosis for osteoreparation even with technically flawless osteosynthesis.

The category of “unfavorable course” in the context of combined lower limb trauma is an integral clinical and pathophysiological criterion that determines the deviation of treatment and rehabilitation from the physiological norm due to critical complications. The pathological process is transformed from reparative-regenerative to destructive-cascade: in the first days, the critical danger is fat embolism with the risk of acute respiratory distress syndrome (ARDS) and damage to cerebral microcirculation; the likelihood of deep vein thrombosis and pulmonary embolism increases; subfascial hyperpressor syndrome (compartment syndrome) is threatening, in which ischemia and subsequent reperfusion are accompanied by massive rhabdomyolysis [8].

In the long term, an unfavorable course destroys the processes of osteoreparation: with open injuries, the risk of osteomyelitis increases - a chronic purulent-necrotic process resistant to pharmacotherapy due to impaired regional microcirculation. The imbalance between the stability of the "fixator-bone" system and the perfusion of the

surrounding tissues inhibits osteointegration, leading to the formation of pseudoarthrosis. The final result of such a cascade is persistent disability of the patient - contractures, shortening or deformation of the limb, chronic pain syndrome, muscle hypotrophy, which transforms the medical problem into a deep socio-economic maladaptation [9].

The urgency of the problem is due to the need to develop high-tech biomedical tools to overcome this socio-medical crisis. The radical transformation of the trauma structure - a shift from isolated low-energy injuries to high-energy destruction as a result of hostilities - puts the problem in the category of critical challenges for national security and the health care system. In conditions of martial law, accompanied by an overload of the medical infrastructure and a shortage of beds, minimizing the duration of inpatient treatment and accelerating the restoration of locomotor function becomes strategic: prolonged hospitalization not only creates a financial burden, but also increases the risks of hypodynamic complications and nosocomial infections. The use of advanced engineering and medical approaches allows you to translate the subjective caution of doctors regarding early mobilization into a mathematically justified, safe process.

From an engineering and systems point of view, the relevance of the topic is determined by the lack of integrated methodologies capable of performing multiparametric synthesis of heterogeneous biomedical data - clinical and laboratory markers, biomechanical parameters of osteosynthesis stiffness and characteristics of local monitoring of tissue blood flow - into a single mathematical prediction model. The development of such a method will create a scientific and technical basis for clinical decision support systems (DSS), which will allow identifying patients with a high risk of adverse outcomes at the early stages of hospitalization, adjusting the stiffness of fixation systems and reasonably reducing the duration of inpatient treatment due to early controlled rehabilitation, which is especially valuable in wartime.

Modern concepts of osteosynthesis are based on optimizing the synergy between mechanical stabilization of fragments and biological stimulation of reparative processes. The geometry of the fracture, the size of the interfragmentary gap, the nature of the dynamic load and the stress-strain state of the structure directly determine the

speed and quality of reparative osteogenesis [10]. However, the existing scientific and methodological apparatus for assessing such patients is based mainly on static anatomical scales that do not take into account the dynamics of pathophysiological processes in the acute period and do not integrate individual biomechanical and perfusion parameters in real time. This creates a scientific and practical contradiction between the need for predictive determination of the risk of an adverse course and the lack of unified mathematical models for the integrated processing of such heterogeneous data.

The purpose of the article is to conduct an analytical review and systematization of existing mathematical, statistical, biomechanical, and technical-informational methods and tools for assessing the condition of patients with combined lower limb injuries to substantiate the concept and structure of a new integral method for determining the risk of adverse outcomes.

Presentation of the Main Material

In [11], the authors demonstrate a Bayesian approach to predicting survival probability based on Grand National Bank of the United States trauma data, starting from the classic TRISS model, which uses physiological indicators, anatomical injury severity (ISS) and age. It is shown that TRISS has significant limitations: instability of predictions in multiple injuries, incorrect estimates in intermediate risk zones and weak uncertainty characterization. The proposed Bayesian model considers the parameters and the survival probability itself as random variables, giving not a “point” estimate, but a full posterior distribution for each patient, which allowed to demonstrate a statistically significant increase in the accuracy of the prediction, especially in groups with multiple injuries, and the concept of a web-based calculator for practical healthcare.

At the same time, this approach has significant drawbacks in terms of implementation. The Bayesian model is computationally complex: constructing the posterior distribution requires specialized numerical algorithms and qualified software, which makes the method inaccessible to the average hospitalist. The model is sensitive to the choice of prior distributions and the structure given by the researcher, which

reduces the transparency and trust of the clinician. The complexity of the model limits its interpretability - it is difficult for a doctor to obtain simple coefficients and odds ratios for individual risk factors, unlike logistic regression. Finally, the model is built on specific American data, and without a local base and retraining, its transfer to the Ukrainian population is problematic. It is these limitations that justify the choice of logistic regression as a more transparent and reproducible method of integral prediction.

The authors in [12] proposed a mortality prediction model based on empirical estimates of the severity of each injury according to the abbreviated trauma scale (AIS) with aggregation into a numerical index - Trauma Mortality Prediction Model (TMPM). The classic ISS is a rough, consensus (not data-based) constructed function of AIS scores, so TMPM tries to give a "data-driven" estimate of the severity of each code. The authors show that TMPM has a higher discriminatory power (ROC) and better calibration (Hosmer–Lemeshov test) than the ISS, especially after adding age, sex and mechanism of injury.

However, as a mathematical tool, TMPM has three levels of shortcomings. First, it remains a purely anatomical model that does not include dynamic physiological or laboratory parameters, so its prognostic function is systematically biased: it approximates mortality through the "damage structure", while for the unfavorable course of polytrauma, functional and temporal factors are decisive - shock, stabilization speed, blood loss, organ dysfunction. Second, the empirical weights of AIS codes depend on the specific population and care system: when changing the standards of intensive care or osteosynthesis tactics, these weights cease to reflect real mortality, and therefore TMPM requires complete remodeling on local data. Third, a large number of AIS predictors and their combinations creates a high dimensionality of the parameter space and the risk of overtraining the model on artifacts of a specific database. In addition, the two-stage construction "AIS→index→logistic mortality function" complicates the interpretation of a single factor and does not provide a simple way to add new predictors - in contrast to multivariate logistic regression, where each variable is included in a linear model with a clear coefficient, and expanding the model with new predictors is a

formally and numerically simple procedure that does not require recalculation of the entire index. It is significant that the calibration and discrimination characteristics of TMPM on the training and validation samples may look convincing, while the ability of the model to generalize beyond this sample remains unknown without separate external testing - a typical pitfall for any high-dimensional regression design built on empirical, rather than mechanistic, scales. It is these limitations - the narrow anatomical space of features, the dependence on specific treatment data and the complex two-stage structure - that give grounds for choosing multivariate logistic regression as a more effective method for building an integral forecast.

The Sacco Triage Method (STM) [17] is an optimization model aimed at maximizing the expected number of survivors in conditions of critical resource shortage, with an assessment of the probability of survival using a simplified RPM scale (respiratory rate, pulse, motor response). The high predictive power of the scale was proven by logistic regression on data from 7274 patients with penetrating injuries, and the combination with linear programming algorithms allowed to provide a higher level of saved lives compared to traditional protocols during simulations of mass influx of victims. However, a key defect is the subjectivity of the initial data on the rate of degradation of the physiological state, calculated by the expert Delphi method, rather than instrumental monitoring. From the point of view of biomedical engineering, a significant drawback is operating exclusively with physiological parameters without taking into account the biomechanics of injuries, soft tissue perfusion and microcirculation, which deprives the model of adaptability in the case of the rapid development of fat embolism or compartment syndrome; the focus of the sample only on penetrating injuries also limits the transfer of the results to high-energy polytrauma of the extremities.

The authors of [13] proposed to replace TRISS with an artificial neural network (ANN) approach, justified by the similarity of the output function of the network to the survival probability function in TRISS and the flexibility of integrating additional prognostic variables. ANN was shown to outperform TRISS on both training and test samples, which allows for more effective detection of cases that significantly deviate

from expected ones and optimize the quality control of trauma care. At the same time, neural networks are less interpretable than logistic regression: the internal structure of ANN makes it difficult to explain the influence of input variables, which reduces the confidence of clinicians. Performance depends significantly on the representativeness of the training data, the study did not take into account the duration of hospitalization, and the model of one center for a limited period has the risk of insufficient generalizability without external validation.

The authors in [14] developed a multilayer perceptron for predicting survival/mortality and length of hospital and ICU stay on the input of TRISS components, vital signs (GCS, pressure, respiratory rate, saturation), laboratory data (hemoglobin, glucose, electrolytes, creatinine) and mechanism of injury. This work is of particular interest because it is the first among the analyzed sources to directly predict the length of hospitalization, and not just mortality. However, the sample of only 125 patients (30 test cases, 3 fatal cases) is insufficient for reliable training of a nonlinear model, and data from a single center reduces generalizability; in addition, the internal logic of the ANN remains a “black box”.

In [15], ANN was used to predict the outcome of treatment of patients with chronic subdural hematoma on eight predictors (age, gender, structural displacement, etc.), compared with logistic regression. Patients with combined lower limb fractures were not included in the sample, the duration of hospitalization was not taken into account, and the model remains less interpretable than the regression model.

A systematic review [16] summarized 36 studies (2000–2020) on the use of machine learning to support decisions in the management of severely injured patients - predicting bleeding, transfusion requirements, ICU length of stay and mortality. The most commonly used ANNs, Bayesian networks, random forest, support vector machines and ensemble approaches were used with mostly positive validation results. However, most of the studies had a retrospective design with the risk of systematic bias and overfitting, and significant heterogeneity of input variables and metrics makes it difficult to compare approaches; the review did not conduct a separate analysis of the length of hospitalization.

A review of classical approaches would be incomplete without an analysis of studies from 2025–2026 that apply ensemble methods not for a generalized survival prediction, but for specific complications specifically in lower limb fractures - this is the closest fit to the architecture of the future integral model.

In the study [18], a model for predicting the risk of postoperative pneumonia in patients with lower limb fractures was built using a combination of classical algorithms and transformative architectures; it was shown that even such an "extraskeletal" complication significantly prolongs hospitalization and is associated with age, smoking, duration of surgery, comorbidity, and markers of inflammation - that is, it should be taken into account in an integrated economic cost model. The study [19] determined the optimal time of surgical intervention in patients with combined traumatic brain injury and fractures of the limbs and pelvis to minimize the risk of infection using seven machine learning algorithms; the results confirm that the time and sequence of interventions in the mutual encumbrance syndrome is an independent, quantitatively measured risk factor, although the sample of 218 patients from a single center limits external validity.

In [20], eight models (logistic regression, XGBoost, random forest, decision tree, naive Bayesian classifier, k-nearest neighbors) predicted the risk of postoperative constipation in over a thousand patients with lower limb fractures, and key factors were identified using the SHAP method - an explanation of the contribution of each variable for a specific patient based on cooperative game theory. This is methodologically valuable: SHAP allows us to overcome the "black box" problem of ensemble methods while maintaining their accuracy, and seems promising for our own integral model. A study [21] combined logistic regression with machine learning to predict deep vein thrombosis after pelvic fracture surgery (AUC $\approx$ 0.88), confirming that a hybrid approach that combines the transparency of regression with the predictive power of ML is practically the most feasible compromise for implementation where the end user is a traumatologist rather than a data engineer.

In a study [22] on complications in adolescents with tibial fractures, an explanatory model based on coagulation and clinical parameters confirmed a

significantly higher incidence of complications in open fractures compared to closed ones, which is consistent with the above-described concept of the destructive potential of high-energy trauma; however, pediatric osteogenesis physiology limits the transfer of coefficients to adult victims. Summarizing this block, we can state the trend: machine learning in traumatology is moving from generalized survival prediction to highly specialized, explanatory prediction of specific complications - this is the direction that seems productive, but none of the models yet takes into account biomechanical and perfusion variables.

A comparative analysis of the sources [18–22] allows us to highlight a common methodological pattern: they are all based on retrospective samples of one or more centers with a volume of from two to over a thousand patients, use a similar set of algorithms (logistic regression as a baseline comparison, ensemble methods such as XGBoost and random forest as the main tool, neural network architectures - less often), and almost unanimously record the advantage of ensemble methods over classical regression in terms of the area under the ROC curve by 0.03–0.15 points. However, this increase in accuracy is almost always achieved at the cost of a decrease in interpretability, which is tried to be compensated for by methods of explanatory artificial intelligence (SHAP, permutation importance), which in themselves are an additional computational and methodological burden on the researcher. For a clinical decision support system that must function in a hospital overloaded with war trauma, where there are no dedicated data analysis specialists, this ratio of "accuracy - interpretability - computational complexity" becomes not a secondary technical issue, but a determining criterion for choosing a mathematical apparatus - in favor of transparent methods, which, however, can include nonlinear and interacting effects of predictors.

The review allows us to establish a clear evolution of methods for assessing the risk of adverse outcomes: from anatomical and physiological scales (ISS, TRISS, RPM as part of STM) through Bayesian and neural network generalizations to modern explainable machine learning models focused on predicting specific complications. In parallel, a significant amount of knowledge has been accumulated in biomedical

engineering about the quantitative impact of osteosynthesis stiffness and tissue perfusion on the speed and quality of reparative osteogenesis.

A key methodological gap is that these two research traditions - clinical-statistical and biomedical-engineering - have developed practically in parallel, without systematic integration into a single mathematical apparatus.

The concept of a new integral model is aimed at overcoming this gap. It is proposed to base it on multivariate logistic regression, a method whose advantages over more complex alternatives (Bayesian models [11], TMPM [12], ANN [13–15]) have been substantiated in detail above: transparency, reproducibility, clinically interpreted odds ratios, and low computational resource requirements, which are critically important in the conditions of a hospital overloaded with war trauma.

From an engineering point of view, the architecture of the model is assumed to be two-stage. At the first stage, when the patient is hospitalized, the initial risk of an adverse outcome is calculated based on clinical, laboratory and anatomical predictors available in the first hours after the injury, by analogy with how it is implemented in the models [11, 12, 17], but with a logistic, rather than Bayesian or anatomical-index form. At the second stage, after osteosynthesis and installation of the fixation device, the model is dynamically supplemented with biomechanical parameters of the stiffness of the structure and perfusion monitoring data, which allows daily recalculation of the updated prognosis of the duration of treatment as new data appear - a principle close to the logic of dynamic recalculation, tested for the duration of stay in the ICU in studies [14]. This two-stage approach allows combining the advantages of early risk stratification with the possibility of adaptive correction of the prognosis as objective biomechanical and perfusion information accumulates, which is not provided by any of the analyzed static models.

Conclusions

The analytical review allowed to systematize the existing mathematical, statistical, biomechanical and technical-informational methods of assessing the risk of adverse outcome in combined injuries with fractures of the lower extremities. It was established that the evolution of clinical-statistical models has gone from deterministic

anatomical scales (ISS, TRISS) through Bayesian generalizations and artificial neural networks to modern explained ensemble machine learning models focused on predicting specific clinical complications.

At the same time, it is shown that none of the analyzed approaches simultaneously integrates clinical and laboratory data with biomechanical parameters of osteosynthesis stiffness and indicators of local tissue perfusion, despite the proven quantitative influence of both of these classes of parameters on the speed and quality of reparative osteogenesis, and therefore on the duration of inpatient treatment.

It is substantiated that multivariate logistic regression is the optimal mathematical apparatus for constructing a new integral model - in terms of transparency, clinical interpretability and feasibility in wartime conditions compared to computationally complex Bayesian models and neural networks. A conceptual structure of the model is proposed, combining clinical-laboratory, anatomical, biomechanical and perfusion-rehabilitation predictors with the ultimate target in the form of the duration of inpatient treatment.

The practical implementation of this concept in the form of a clinical decision support system will allow, at the early stages of hospitalization, to identify patients with a high risk of adverse outcomes, adaptively adjust the rigidity of fixation systems, and reasonably reduce the duration of inpatient treatment through early controlled locomotor rehabilitation, which is especially relevant in conditions of critical load on the Ukrainian healthcare system during the war period.

A separate practical consequence of the review is that none of the analyzed foreign tools - neither TRISS, nor TMPM, nor any of the considered machine learning models - was developed or validated on a sample of patients with mine-explosive and gunshot injuries of the lower extremities, which constitutes the bulk of the modern Ukrainian trauma contingent. This means that even the most accurate foreign model will require significant readjustment of coefficients on local data before it can be reliably applied in domestic clinical practice - and this further emphasizes the need to develop our own integrated model adapted to the realities of Ukrainian war trauma, rather than directly borrowing existing foreign tools.

Further research by the author team is aimed at collecting their own clinical database, which will include prospective monitoring of clinical and laboratory, biomechanical, and perfusion parameters in patients with combined lower limb trauma, statistical verification of the proposed multifactorial model on this real contingent of victims, and development of appropriate software to implement the results into the practice of trauma hospitals.

References:

1. World Health Organization (WHO) (n.d.) *The top 10 causes of death*. Available at: https://www.who.int

2. Boiko, V.V. and Rysovana, T.P. (2024) 'Emergency Medicine', in *Entsyklopediia Suchasnoi Ukrainy*. Kyiv: Instytut entsyklopedychnykh doslidzhen NAN Ukrainy. doi:10.5281/zenodo.19751072.

3. Costa, A.S., Alencar, R.P., Fagundes, A.P.F.S., Araújo, C.M. and Pereira, D.S.O. (2023) 'Epidemiological profile of patients who were victims of thoracic trauma', *Revista Científica da Escola Estadual de Saúde Pública de Goiás "Cândido Santiago"*, 9(9c0), pp. 1–13. doi:10.22491/2447-3405.2023.V9.9c0.

4. Hryhoruk, V.V., Rysovana, L.M., Lytvynenko, M.I. and Nevmerzhytska, S.S. (2025) ‘Vyhotovlennya indyvidual′nykh orteziv postrazhdalym z vybukhovymy poshkodzhennyamy nyzhnikh kintsivok z dotrymannyam vymoh bezpeky’, in: *Zdobutky ta dosyahnennya prykladnykh ta fundamental'nykh nauk XXI stolittya*. Proceedings of the X International Scientific Conference, Dnipro, pp. 530–536. doi:10.62731/mcnd-07.11.2025.005.

5. Bustillo, R.A., Setien, F.J.A., Mate, C.O.M., Gomez, M.S., Ros, M.J.D. and Costa, C.L. (2020) 'Predictive capability of the injury severity score versus the new injury severity score', *European Journal of Trauma and Emergency Surgery*, 46, pp. 903–911. doi:10.1007/s00068-018-1057-x.

6. Warmerdam, E., Orth, M., Pohlemann, T. and Ganse, B. (2023) 'Gait analysis to monitor fracture healing of the lower leg', *Bioengineering*, 10, p. 255. doi:10.3390/bioengineering10020255.

7. Windolf, M., Varjas, V., Gehweiler, D., Schwyn, R., Arens, D. and Constant, C. (2022) 'Continuous implant load monitoring to assess bone healing status', *Medicina*, 58, p. 858. doi:10.3390/medicina58070858.

8. Sadoughi, F., Behmanesh, A., Najd Mazhar, F., Joghataei, M.T., Yazdani, S., Shams, R. et al. (2022) 'Bone healing monitoring in bone lengthening using bioimpedance', *Journal of Healthcare Engineering*, 2022, p. 3226440. doi:10.1155/2022/3226440.

9. Koch, L., Orth, M., Fink, T., Meiser, A., Volk, T., Menger, M.D. et al. (2023) 'Lower oxygen saturation with higher rates of norepinephrine in bone fractures of polytrauma patients', *Critical Care*, 27, p. 367. doi:10.1186/s13054-023-04657-6.

10. Kononenko, S.V. and Pelipenko, O.V. (n.d.) 'Biomechanical features of comminuted fractures of the humerus diaphysis', *Aktualni Problemy Suchasnoi Medytsyny*, 21(1(73)), pp. 26–29. doi:10.31718/2077-1096.21.1.26.

11. Schetinin, V., Jakaite, L., Jakaitis, J. and Krzanowski, W. (2013) 'Bayesian decision trees for predicting survival of patients: a study on the US National Trauma Data Bank', *Computer Methods and Programs in Biomedicine*, 111(3), pp. 602–612. doi:10.1016/j.cmpb.2013.05.015.

12. Osler, T., Glance, L., Buzas, J.S., Mukamel, D., Wagner, J. and Dick, A. (2008) 'A trauma mortality prediction model based on the anatomic injury scale', *Annals of Surgery*, 247(6), pp. 1041–1048. doi:10.1097/SLA.0b013e31816ffb3f.

13. Fuller, J.J., Emmett, M., Kessel, J.W., Price, P.D. and Forsythe, J.H. (2005) 'A comparison of neural networks for computing predicted probability of survival for trauma victims', *West Virginia Medical Journal*, 101(3), pp. 120–125.

14. Gholipour, C., Rahim, F., Fakhree, A. and Ziapour, B. (2015) 'Using an artificial neural networks (ANNs) model for prediction of ICU outcome and length of stay in traumatic patients', *Journal of Clinical and Diagnostic Research*, 9(4), pp. OC19–OC23. doi:10.7860/JCDR/2015/9467.5828.

15. Abouzari, M., Rashidi, A., Zandi-Toghani, M., Behzadi, M. and Asadollahi, M. (2009) 'Chronic subdural hematoma outcome prediction using logistic regression and an artificial neural network', *Neurosurgical Review*, 32(4), pp. 479–484.

doi:10.1007/s10143-009-0215-3.

16. Baur, D., Gehlen, T., Scherer, J., Back, D.A., Tsitsilonis, S., Kabir, K. and Osterhoff, G. (2022) 'Decision support by machine learning systems for acute management of severely injured patients: a systematic review', *Frontiers in Surgery*, 9, p. 924810. doi:10.3389/fsurg.2022.924810.

17. Sacco, W.J., Navin, D.M., Waddell, R.K., Fiedler, K.E., Long, W.B. and Buckman, R.F. (2007) 'A new resource-constrained triage method applied to victims of penetrating injury', *Journal of Trauma*, 63(2), pp. 316–325. doi:10.1097/TA.0b013e31806bf212.

18. 'Machine learning and transformer models for prediction of postoperative pneumonia risk in patients with lower limb fractures', (2025), *Scientific Reports*. Available at: https://www.nature.com/articles/s41598-025-04623-y

19. 'Interpretable machine learning for predicting optimal surgical timing in polytrauma patients with TBI and fractures to reduce postoperative infection risk', (2025) *Scientific Reports*. Available at: https://www.nature.com/articles/s41598-025-04003-6

20. 'Predicting the risk of postoperative constipation in middle-aged and elderly patients with lower limb fractures using machine learning algorithms'. (2025) Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12637909/

21. 'Machine learning model predicts new-onset lower extremity deep vein thrombosis after pelvic fracture surgery and targeted diagnosis', (2025), *medRxiv*.

22. 'Explainable machine learning-based prediction of early and mid-term postoperative complications in adolescent tibial fractures', (2026), *Frontiers in Surgery*. Available at: https://www.frontiersin.org/journals/surgery/articles/10.3389/fsurg.2025.1688702/full

Анотація. *Стаття присвячена аналітичному огляду методів та засобів оцінки ризику несприятливого перебігу в пацієнтів з поєднаними травмами нижніх кінцівок в умовах зміни структури сучасного травматизму, зумовленої зростанням частки високоенергетичної вогнепальної та мінно-вибухової травми. Розглянуто еволюцію прогностичних підходів - від класичних анатомо-фізіологічних шкал (ISS, TRISS, RPM) через байєсівські та нейромережеві моделі до сучасних пояснюваних методів машинного навчання, орієнтованих на прогнозування окремих ускладнень (пневмонії, тромбозу, компартмент-синдрому, жирової емболії). Окремо проаналізовано біомедично-інженерний напрям - вплив біомеханічної жорсткості системи*

«фіксатор-кістка» та локальної тканинної перфузії (NIRS-моніторинг) на якість остеорепарації. Встановлено, що клініко-статистична та біомедично-інженерна дослідницькі традиції розвиваються паралельно, без інтеграції в єдиний математичний апарат, а прогнозування тривалості госпіталізації як самостійної цільової змінної для цієї категорії пацієнтів практично не досліджено. На основі виявленої прогалини обґрунтовано концепцію двоетапної інтегральної моделі на базі багатофакторної логістичної регресії, яка об'єднує клініко-лабораторні, анатомічні, біомеханічні та перфузійні предиктори для прогнозування ризику несприятливого перебігу та тривалості стаціонарного лікування, що є актуальним для системи охорони здоров'я в умовах воєнного стану.

Ключові слова: *багатофакторна логістична регресія, система підтримки прийняття рішень, біомеханічна жорсткість фіксації, прогнозування тривалості лікування, біомедична інженерія, синтез гетерогенних даних*

CONTENTS

Innovative engineering, technology and industry

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-002 3
A MODEL FOR THE INTELLIGENT ANALYSIS OF CUSTOMER PURCHASING BEHAVIOR IN E-COMMERCE SYSTEMS
Brynza N. O., Koliesnik D. D.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-006 19
ARCHITECTURAL MODEL OF AN INFORMATION SYSTEM FOR THE AUTOMATED PROCESSING OF CUSTOMER INQUIRIES
Brynza N.O., Mazepa A. S., Zadrykin S. O.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-008 37
TECHNOLOGICAL DIFFERENCES AND EFFICIENCY CRITERIA OF SINGLE-STAGE AND TWO-STAGE PET CONTAINER MANUFACTURING: A PROCESS-ROUTE SELECTION FRAMEWORK
Morozov K.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-011 55
SUBSTITUTION OF THE DESIGN FEATURES OF LOW-ENERGY-CONSUMPTIVE DYNAMIC WORKING BODIES AND ATTACHMENTS OF EARTHQUAKE MACHINES
Gorbatyuk Ie.V., Borodynia V.V., Fedyshyn B.M., Sliusar V.S.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-018 61
IMPACT OF DRILLING TOOL VIBRATION PROCESSES ON STRUCTURAL ELEMENTS OF HORIZONTAL DIRECTIONAL DRILLING RIGS
Zakhara I. Y., Trukhanivskyi A.M.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-034 71
CALCULATION OF THE BUNKERING CYCLE FOR A VESSEL POWERED BY AN AMMONIA ENGINE
Kisietov J. V.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-038 79
MULTI-CRITERIA EVALUATION OF REPAIR MANUFACTURABILITY OF RESOURCE-LIMITING PARTS OF AXIAL-PISTON HYDRAULIC MACHINES BASED ON ENTROPY–AHP
Melyantsov P.T., Losikov O. M., Sidorenko V. K.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-040 106
IMPROVEMENT OF THE METHANE OXIDATIVE AMMONOLYSIS PROCESS IN HYDROGEN CYANIDE PRODUCTION
Avina S.I., Lomidze V.G.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-055 117
IMPROVEMENT OF VEGETARIAN DESSERT TECHNOLOGY FOR RESTAURANT ESTABLISHMENTS
Holovatiuk O.S., Mamchenko L.Y.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-057 127
ENERGY EFFICIENCY OF SECONDARY MINERAL RESOURCES IN CONCRETE AND MORTAR TECHNOLOGY
Dekhta T. M.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-063 137
THE ROLE OF OCCUPATIONAL SAFETY IN ENSURING SUSTAINABLE DEVELOPMENT OF AN ENTERPRISE
Zavytii O. P.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-068 148
ACCURACY CONTROL OF BEARING RING MACHINING
Halchuk T.N.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-070 157
EVALUATION OF THE EFFICIENCY OF QUANTIZED OPEN LLMS FOR THE ANALYSIS OF OPTICAL ACCESS NETWORK MONITORING DATA
Oreshkov V.I., Makarov I.V., Stelia D.O.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-077 166
EFFECT OF CALCIUM CARBONATE AND POLYOLEFIN ELASTOMER ON THE PROPERTIES OF MODIFIED POLYPROPYLENE COMPOSITES
Rymar T.E., Tsybulnyk M.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-081 178
MATERIALS FOR HEAT-EXCHANGE SURFACES OF BIOMASS-FIRED BOILERS: ANALYSIS OF OPERATIONAL PROPERTIES AND JUSTIFICATION OF MATERIAL SELECTION
Ivankova O.V., Huchenko S. O., Maksymenko O.O.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-086 191
GREEN TECHNOLOGY FOR PRODUCING ACOUSTIC PANELS FROM ANNUALLY RENEWABLE PLANT RAW MATERIALS
Trembus I. V., Skliarova A. M.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-087 202
EXPERIMENTAL DETERMINATION OF THE PHASE TRANSITION PARAMETERS OF ALTERNATIVE HEAT TRANSFER FLUIDS FOR SOLAR SYSTEMS
Yevtushenko E.O., Kutnyi B.A.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-092 212
METAPHYSICS OF WINE
Matyushenko R.V.

Computer science, cybernetics and automatics

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-001 235
USING BIG DATA FOR CRIME ANALYSIS AND PREDICTION
Lukianova V., Kobzev I., Zatkhei V.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-007 255
MODELLING OF PROCESSES OF HIGH-PRECISION MONITORING OF RADON-222
Sizova N.D., Solodovnikova L.M.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-017 266
NEURAL NETWORK-BASED MACHINE LEARNING IN CRISIS MANAGEMENT FOR INNOVATIVE BUSINESS PROJECT ACCELERATION UNDER GLOBAL ENVIRONMENT DYNAMICS AND TURBULENCE (SHIVA- AND WARMI- PARADIGMS)
Krasnyuk M.T., Kulazhenko V.V., Mozgalli O.P., Ustenko S.V., Savinkov N.D.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-021 285
ANALYTICAL REVIEW OF METHODS AND MEANS OF DETERMINING THE RISK OF ADVERSE OUTCOME IN COMBINED INJURIES WITH LOWER LIMB FRACTURES
Rysovana L., Vysotska O., Hryhoruk V., Lytvynenko M., Alekseienko R.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-024 301
AUTOMATION OF MANAGERIAL DECISION-MAKING IN TWO-LEVEL HIERARCHICAL SYSTEMS
Solodovnyk G.V.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-037 308
AUTOMATED VERIFICATION METHODS AND ALGORITHMS FOR ENGINEERING DRAWINGS COMPLIANCE IN THE LIBRECAD ENVIRONMENT
Tovstyk M., Burtseva O., Zub N.

https://www.sworldjournal.com/index.php/swj/article/view/swj39-01-047 323
RESOURCE EFFICIENCY OF WEB FRAMEWORKS: A COMPARATIVE ANALYSIS OF RESOURCE CONSUMPTION
Honcharenko I.S.