AN ADVANCED COMPUTATIONAL MODEL FOR EARLY SEVERITY STRATIFICATION OF COVID-19 PATIENTS IN EMERGENCY CARE SETTINGS

Iskhakov N.B.

Republican Research Centre Of Emergency Medicine, Tashkent, Uzbekistan.

Abstract: This thesis examines the development and clinical implementation of a mathematical model designed to predict the severity of COVID-19 using demographic, clinical, and laboratory parameters. The study analyzes 1,145 hospitalized patients and compares traditional physician-based stratification with an automated program that assigns a probabilistic severity index. The system significantly reduced stratification errors across all severity categories and improved patient routing, enabling earlier initiation of intensive therapy for high-risk individuals. The expanded text further explores the integration of machine-learning methods, temporal data analysis, and cross-pathology application. The findings highlight the clinical value of computational tools in standardizing triage and enhancing decision-making efficiency during pandemics.

Keywords: COVID-19; Severity Prediction; Mathematical Modeling; Machine Learning; Clinical Decision Support; Triage Optimization.

The COVID-19 pandemic demonstrated the urgent need for a rapid and objective tool to assess patient condition at the early stage of hospitalization. Traditional clinical scales and physician-based assessment, despite their value, are vulnerable to subjective influence. Under conditions of high system burden, this often resulted in errors in determining disease severity and subsequent delays in the provision of specialized care.

The use of mathematical models and computer algorithms opens new opportunities for standardizing risk assessment and accurately predicting the clinical course of COVID-19. The development of such a model at the Republican Research Centre of Emergency Medicine (RRCEM) made it possible to adapt existing machine-analysis methods to real clinical practice and create a practical tool for clinicians.

The aim of the study was to evaluate the accuracy and practical significance of a computer-based program for predicting COVID-19 severity, developed through mathematical modeling of clinical and laboratory parameters.

Materials and Methods.

The study included 1,145 patients with confirmed COVID-19 who were treated at RRCEM between March and December 2020. The control group (n=177) was stratified by receiving physicians based on clinical symptoms and the “Clinical Guidelines for the Management of COVID-19” (version 6, 2020). The main group (n=968) was assessed using the computer prediction program.

The model incorporated multilevel data analysis, including demographic indicators (age, sex), hemodynamic parameters (systolic and diastolic blood pressure, heart rate), anthropometry (height, weight, BMI), comorbidities (hypertension, diabetes mellitus, coronary artery disease, pulmonary pathology, obesity), and complications arising during COVID-19 (pneumonia, respiratory failure, cardiovascular failure, intoxication syndrome). A key advantage of the system was automated parameter analysis with generation of a probabilistic severity index for each patient.

Results.

The program significantly reduced errors in determining COVID-19 severity. Among patients with mild disease, errors were 77.8% in the control group versus 23% in the main group; for moderate severity—65.2% vs. 22%; and for severe cases—40.9% vs. 10%. Thus, the risk of incorrect stratification decreased by 2.9 to 4.1 times.

In addition to quantitative improvements, patient routing was optimized: individuals with a high risk of severe progression received priority hospitalization to specialized units and earlier initiation of intensive therapy. This reduced treatment delays and decreased workload on emergency department physicians.

Conclusion.

The mathematical model for predicting COVID-19 severity demonstrated high clinical effectiveness and practical usability. Its application at the admission–diagnostic stage enabled standardized triage, reduced subjective errors, and improved decision-making speed. This experience confirms that integrating computational technologies into clinical medicine is a promising direction for managing patient flow not only in infectious diseases but also across other healthcare domains.

Further development of the model highlights the potential of integrating advanced machine learning techniques, including neural-network-based classifiers and gradient-boosting algorithms, which can refine probability scoring and adapt to evolving clinical scenarios. Incorporating temporal data analysis would allow dynamic updates of patient risk as new information becomes available, thereby improving accuracy in predicting deterioration, respiratory failure, or the need for ICU admission.

Expanding dataset size and diversity remains a critical next step. Including additional laboratory biomarkers such as inflammatory indices, coagulation markers, and biochemical parameters could enhance model precision. Integration with electronic health records and automated data pipelines may further streamline triage processes and reduce dependency on manual data entry.

Moreover, the model demonstrates strong potential for implementation beyond COVID-19, particularly in other acute conditions requiring rapid triage, such as sepsis, acute cardiac syndromes, and respiratory emergencies. Such cross-pathology adaptation would significantly strengthen emergency department efficiency and resource allocation.

References

1. Knight SR, Ho A, Pius R, et al. Risk stratification of patients admitted to hospital with COVID-19 using the ISARIC WHO Clinical Characterisation Protocol: development and validation of the 4C Mortality Score. BMJ. 2020;370:m3339.

2. Wynants L, Van Calster B, Collins GS, et al. Prediction models for diagnosis and prognosis of COVID-19: systematic review. BMJ. 2020;369:m1328.

3. Yan L, Zhang HT, Xiao Y, et al. Prediction of criticality in COVID-19 patients using machine learning. Nat Mach Intell. 2020;2(5):283–288.

4. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395(10223):497–506.

5. Liang W, Liang H, Ou L, et al. Development and validation of a clinical risk score to predict the occurrence of critical illness in hospitalized patients with COVID-19. JAMA Intern Med. 2020;180(8):1081–1089.