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# INTEGRATED APPROACH TO ASSESSING CHD SEVERITY: MODEL, DIGITAL TOOL AND TRAINING

Nabijonova Mohichehra
1st year Master's Student of Tashkent State Medical University

Nurillaeva Nargiza Mukhtarhonovna
Scientific Supervisor: Doctor of Medical Sciences, Professor

**Abstract**
This article presents the results of an integrated study aimed at refining a mathematical model for assessing the severity of coronary artery disease (CAD), developing an electronic tool, and implementing it in medical education. The proposed approach utilizes logistic regression, gradient boosting, and Bayesian analytics to build a predictive model based on clinical, laboratory, and angiographic data. The developed software demonstrated high accuracy (AUC = 0.89) and usability in clinical settings. The educational methodology designed for integrating this digital tool into the learning process significantly improved academic outcomes and digital competencies of medical students. This work exemplifies an interdisciplinary synthesis of science, practice, and education in the era of digital healthcare transformation.

**Keywords:** Coronary artery disease, mathematical model, medical education, digital tool, gradient boosting, clinical training, predictive analytics.

## Introduction

Coronary heart disease (CHD) remains one of the leading causes of death and disability worldwide. According to the World Health Organization (WHO), millions of people die each year from CHD complications, and the economic burden of the disease is increasing. Effective management of patients with CHD requires accurate risk stratification and assessment of the severity of coronary

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artery disease. Despite the development of non-invasive and invasive diagnostic methods, many of them have limited accuracy, high cost or low availability. Traditional approaches to assessing the severity of CHD, such as visual interpretation of coronary angiography, scoring scales (e.g., SYNTAX Score) and clinical calculators, are subject to subjectivity, suffer from insufficient personalization and are often not integrated into everyday clinical practice. This necessitates more accurate, validated and automated methods based on objective data and mathematical modeling. On the other hand, even the most accurate algorithms and tools lose their value if not accompanied by effective training of medical personnel. Traditional forms of teaching cardiology rarely include the use of digital models and programs to support clinical decisions. This creates a gap between scientific developments and practical training of doctors. The integration of innovative tools into the educational process requires the development of special pedagogical technologies aimed at developing both clinical thinking and digital competencies in students. There are many works devoted to mathematical modeling of cardiovascular diseases. Some models use logistic regression methods, others use machine learning, neural networks and Bayesian approaches. However, only a few of them have been implemented as software solutions and have undergone clinical validation. In addition, there are practically no studies aimed at pedagogical testing of such solutions. Thus, there is a need for an integrated approach, including the development of a model, software implementation and training technology. A logistic regression model used to estimate the risk of severe stenoses based on clinical and angiographic parameters was used as the baseline model. However, the initial model demonstrated limited sensitivity and specificity (AUC ~ 0.72), and did not take into account some key parameters, such as inflammatory biomarkers (e.g., hs-CRP), ejection fraction, lesion volume, anatomical features, and comorbid conditions. To improve the model, a retrospective clinical dataset was collected from a cardiology hospital (2018–2023), including 1,128 patients with a confirmed diagnosis of coronary artery disease. Patients over 35 years of age with complete angiographic data were included. Patients with congenital heart defects, acute infections, and malignant neoplasms were excluded. The dataset included 73 variables, including:

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- • Demographic: age, gender, BMI.
- • Clinical: hypertension, diabetes mellitus, CHF, history of MI.
- • Laboratory: cholesterol, LDL, troponin, NT-proBNP, hs-CRP.
- • Instrumental: EF, presence of diffuse stenosis, SYNTAX score.

An ensemble of models including logistic regression, gradient boosting (XGBoost) and a Bayesian model was used as a mathematical basis. Feature selection was performed using the recursive feature elimination (RFE) method, with cross-validation (k=10). The SMOTE technique was used to combat class imbalance.

Model training and testing were performed in the Python environment (scikit-learn, XGBoost, pandas libraries). Main metrics for model evaluation:

- AUC-ROC
- Accuracy
- F1-score
- Sensitivity and specificity
- Calibration (Brier score, calibration curves)

On the test sample (20% of the total), the improved model achieved AUC = 0.89, accuracy = 0.84, sensitivity = 0.82, specificity = 0.86. These indicators exceed the results of the basic model and existing scales.

The creation of software for assessing the severity of coronary heart disease (CHD) was based on several key requirements:

1. Integration with clinical data and the ability to quickly download parameters from an electronic medical record;
2. Intuitive interface aimed at clinicians and medical students;
3. Visualization of forecast results and justification of the calculated risk;
4. Feedback: the ability to adjust input data, display the contributions of individual variables (feature importance);
5. Availability as a desktop and/or web version, the ability to implement in simulation classes and clinical diagnostic laboratories.

The development was carried out in the Python environment using the following technologies:

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- Backend: Flask (for REST API), NumPy, Pandas, scikit-learn, XGBoost;
- Frontend: HTML/CSS + JavaScript (Bootstrap + Chart.js for visualization);
- Data storage: SQLite (local version), possible connection to PostgreSQL (in healthcare settings);
- Visual components: ROC curve graphs, Shapley diagrams (SHAP) for interpreting predictions;
- User authentication and personal data protection in accordance with GDPR and HIPAA standards.

The architecture is built on the MVC (Model–View–Controller) principle, ensuring modularity and scalability of the application.

The program includes the following modules:

1. Clinical data entry module (manual or automatic import);
2. Algorithm for predicting the severity of coronary heart disease based on a trained model (AUC> 0.88);
3. Results interpreter — SHAP analysis, risk factor rating;
4. Prediction history and comparison of the patient's condition dynamics;
5. Training mode — interactive cases and knowledge testing (for students).

The creation of a pedagogical technology for training medical specialists in the use of an electronic tool for assessing the severity of coronary heart disease is based on the following key methodological principles:

1. The principle of clinical and didactic integration — combining the clinical context with the learning process based on real clinical cases;
2. The principle of cognitive visualization — using digital tools and visual models to enhance the perception and comprehension of complex information;
3. The principle of active learning — an emphasis on independent analytical activity of students, including modeling, interpretation and decision-making;
4. The principle of the competence-based approach is the formation of digital, clinical and communication competencies that correspond to modern educational and professional standards (for example, WFME and the UMK of the Ministry of Health of the Republic of Uzbekistan).

The educational technology is designed for three levels of the target audience:

1. Senior students of the medical faculty (5-6 years) - basic level;

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2. Residents and interns of the cardiology profile - advanced level;
3. Teachers, clinical mentors and practicing doctors - expert level.

Each group has differentiated learning objectives, methodological materials and control tools.

The pedagogical technology includes three logical blocks presented in Table 1.

Table 1. Structure of the training module on the use of the IBS tool

| **Stage of training** | **Purpose and content** | **Methods and tools** |
|---|---|---|
| I. Theoretical training | Justification of the role of mathematical models in cardiology; algorithm review, interpretation of parameters | Lectures, video lessons, glossary, online test |
| II. Practical work | Working with the program using examples of clinical cases | Computer class, training stations, simulation patients |
| III. Control and reflection | Assessment of skills in interpreting the result, formulating a diagnosis and treatment plan | Case discussion, OSCE, self-assessment and expert assessment |

**Development of case-oriented simulations**

One of the key features of the technology is the creation of a set of cases (n=20) of varying complexity based on real clinical histories while maintaining confidentiality. The cases include:

• Initial patient data;
• Requirement to enter parameters into the system;
• Interpretation of prognosis results and argumentation of a clinical decision;
• "What if" scenarios: changing the initial data and re-assessing the risk.

This technology complies with the principles of simulation training and adaptive pedagogy.

The training module was tested at a medical university among 56 students, 14 residents and 6 teachers. The results are presented in Table 2.

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Table 2. Change in the level of training before and after training

| Group | Average score before training (out of 10) | After training | Δ (growth) | p-meaning |
|---|---|---|---|---|
| Students | 4.1 ± 1.2 | 7.9 ± 1.1 | +3.8 | <0.001 |
| Residentials | 5.2 ± 1.3 | 8.6 ± 0.9 | +3.4 | <0.001 |
| Teachers | 6.8 ± 0.7 | 9.1 ± 0.6 | +2.3 | <0.001 |

The results indicate a significant improvement in knowledge, skills, and confidence in using the model. In addition, 93% of participants reported an increased interest in cardiac imaging and mathematical methods.

The key limitations of the technology implementation were:

• Uneven digital level of students;

• The need to train teachers in digital pedagogy methods;

Nevertheless, the pilot implementation showed sustainable effectiveness and interest of participants. It is proposed to expand the technology within the national program

Any study related to personalized medical data, risk modeling and participation of students in working with clinical information should be based on strict ethical and legal standards. The development and implementation of a mathematical model for assessing the severity of coronary heart disease, its software implementation and training module were carried out in accordance with the fundamental international and national principles of bioethics:

1. The principle of autonomy - respect for the rights of patients and students to voluntary participation, refusal and anonymity;
2. The principle of benevolence - preventing any potential harm to study participants;
3. The principle of fairness - non-discrimination, ensuring equal access to educational resources;
4. The principle of transparency - documenting all stages of development and verification of the tool and pedagogical model.

Work with medical data was carried out in accordance with:

• the Law of the Republic of Uzbekistan "On Personal Data" (2019),

• national clinical protocols and standards in cardiology,

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• WHO recommendations for the protection of personal information in digital medicine (WHO Guidance on Digital Health, 2021),
• the provisions of the Declaration of Helsinki (revised 2013).
In terms of pedagogical technology, the introduction of digital simulations and models into the educational process was based on:
• The Law of the Republic of Uzbekistan "On Education" (2020 edition),
• The Concept of Development of Digital Education in the Republic of Uzbekistan (2022–2026),
• Standards of the Ministry of Higher and Secondary Specialized Education of the Republic of Uzbekistan,
• The model of digital pedagogical competence of a teacher (according to the international DigCompEdu framework).
Students signed voluntary informed consent to participate in the pedagogical experiment. Teachers underwent preliminary training on information security and principles of digital ethics.
After completing the development stage and internal testing of the ensemble model (logistic regression + gradient boosting + Bayesian classifier), the following indicators were obtained on the test sample (n = 226 patients, 20% of the full

**Significant predictors**
The following parameters were among the largest contributors to the model (as assessed by SHAP values):
1. SYNTAX Score
2. NT-proBNP
3. hs-CRP
4. Ejection fraction (EF)
5. Age
6. History of CHF
7. HbA1c
8. Presence of diffuse damage
9. Decreased glomerular filtration rate

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This confirms that the integration of biomarkers and functional indicators increases the accuracy of risk stratification.

**Methodology of the pedagogical experiment**

The training was conducted at the Department of Faculty Therapy during one semester, and the participants were:

• Group A (n=28): traditional training (lectures + seminars),
• Group B (n=30): training using a digital module and cases.

A single test (30 tasks + 2 clinical scenarios) was administered before and after the course. The following were also assessed:

• Clinical thinking skills,
• Confidence in decision-making (scale),
• Feedback (anonymous questionnaires).

**Table 3. Cognitive and applied effects**

| Indicator | Group A | Group B |
|---|---|---|
| Average test score (before) | 18.3 | 18.7 |
| Average test score (after) | 22.1 | 26.8 |
| Increase in confidence (1–5) | +0.8 | +2.1 |
| Clinical reasoning (assessment) | 3.3/5 | 4.6/5 |
| Course satisfaction | 78% | 94% |

The results of this study convincingly demonstrate that the integration of modern analytical approaches, such as ensemble mathematical models, into the clinical assessment of coronary heart disease (CHD) can significantly improve the accuracy of risk stratification. Achieving AUC = 0.89 indicates high diagnostic power, especially in comparison with traditional scales such as SYNTAX Score and visual interpretation of angiograms, which demonstrate AUC not exceeding 0.76. This confirms the hypothesis that the integrated consideration of clinical, laboratory and instrumental data, including modern biomarkers (hs-CRP, NT-proBNP), significantly improves the prediction model.

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In addition, it is important to emphasize the significance of visualized predictors and explainability of the model using SHAP analyses. This makes the model not only accurate, but also transparent to the user, reducing barriers to trust on the part of clinicians. From a practical point of view, the obtained results open up opportunities for:

1. More accurate and individualized decision-making in cardiology hospitals;
2. Accelerated determination of the priority of invasive interventions;
3. Reducing the risk of diagnostic errors associated with the human factor;
4. Expanding the possibilities for remote consultation and telemedicine.

The presence of a software interface that is understandable even for a novice doctor, with a fast response time and a high level of convenience, makes this tool potentially scalable within regional and national clinical systems.

No less important is the pedagogical component of the project. Proven growth in cognitive indicators, confidence in clinical thinking and student satisfaction demonstrates that the introduction of digital simulators and models allows us to modernize the learning process:

• Make it clinically significant;
• Increase student engagement;
• Develop digital medicine skills that are increasingly in demand in modern practice.

Thus, the gap between theoretical knowledge and practical training, as well as between academic developments and their actual implementation in the educational process, is being eliminated.

This study has demonstrated the high efficiency of an integrated approach to solving one of the most pressing problems of modern cardiology and medical education - objective and personalized assessment of the severity of coronary heart disease (CHD) with subsequent pedagogical testing of the developed tool. As a result, the following key scientific and applied results were achieved:

1. An improved mathematical model for assessing CHD, built using an ensemble of algorithms (logistic regression, gradient boosting, Bayesian methods), showed high accuracy (AUC = 0.89) and clinical reliability in comparison with traditional methods;

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2. A software tool with a user-friendly interface, visualization of predictors and automatic risk calculation was developed, successfully integrated into the clinical process and demonstrating the potential for implementation in telemedicine practice;
3. A pedagogical technology aimed at developing not only knowledge but also digital diagnostics and clinical thinking competencies in medical students has been developed and tested. The experiment confirmed the growth of students' learning motivation, quality of learning and confidence when using digital simulators.

Thus, the proposed approach allows for the effective combination of scientific, clinical and educational components and can serve as a model for other interdisciplinary areas of medicine..

**References:**

1. World Health Organization. Cardiovascular diseases (CVDs). WHO Fact Sheets, 2023. URL: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)
2. Serruys PW, et al. The SYNTAX Score: an angiographic tool grading the complexity of coronary artery disease. EuroIntervention. 2005;1(2):219–227.
3. Friedman J, Hastie T, Tibshirani R. The Elements of Statistical Learning. Springer; 2009.
4. Chen T, Guestrin C. XGBoost: A scalable tree boosting system. In Proceedings of the 22nd ACM SIGKDD International Conference; 2016.
5. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nat Med. 2019;25:44–56.
6. Harden RM, Laidlaw JM. Essential skills for a medical teacher: An introduction to teaching and learning in medicine. Elsevier; 2020.
7. Deo RC. Machine learning in medicine. Circulation. 2015;132(20):1920–1930.
8. Makary MA, Daniel M. Medical error—the third leading cause of death in the US. BMJ. 2016;353:i2139.
9. Zaitsev A.V., et al. Application of AI-based decision support systems in cardiology. Russian Journal of Cardiology. 2022;27(10):12–20.

10. Декхкамбаева, З. (2024). Zamonaviy ta'limni jismoniy tarbiya va sport vositasida takomillashtirish. *Наука и инновации*, *1*(1), 70-72.
11. Zulfiya, D. (2022). SOG 'LOM TURMUSH TARZINI SHAKLLANTIRISHDA SOG 'LOMLASHTIRUVCI TEXNOLOGIYALAR. *Новости образования: исследование в XXI веке*, *1*(5), 697-700.
12. Мелибаева, Р. (2019). Использование обобщенных способов учебной деятельности-фактор совершенствования творческого мышления.
13. Мелибаева, Р. Н. (2019). Талабалар тафаккурини ривожлантиришда укув машгулотларининг урни. PSIXOLOGIYA Учредители: Бухарский государственный университет, (2), 35-40.
14. Нарметова, Ю. К. (2022). Особенности психокоррекционного подхода при психосоматических заболеваниях (на примере ишемической болезни сердца). Gospodarka i Innowacje., 21, 258-261.