CLINICAL PREDICTION METHODS AS A LEARNING TOOL IN MEDICAL EDUCATION

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Abstract

The relevance of the study is determined by the need to develop the ability of medical students to make clinical prediction as a key component of professional thinking. The aim is to develop and evaluate the effectiveness of a training module on methods for predicting treatment outcomes in the training of future doctors. Research methods: modified Objective Structured Clinical Examination (OSCE), Clinical Reasoning Test, analytical test Medical Logic, self-assessment questionnaire, semi-structured group interview. As a result, the experimental group (EG) students (n=50) demonstrated significantly higher indicators on all criteria compared to the control group (CG) (n=50): Clinical Reasoning Test – 7.8 versus 5.1 points; OSCE – 8.3 versus 5.5; analytical thinking – 26.1 versus 19.2 points; improved self-esteem – up to +2.2 points. The training module turned out to be effective for the development of clinical reasoning, decision logic, and professional confidence. The academic novelty of the study is the first-ever approved integration of clinical prediction scales (CHA_2DS_2-VASc, SHFM, APACHE II, etc.) as a didactic tool in the Clinical Reasoning course. The prospects for future research is scaling up the module for interdisciplinary training, as well as in studying its impact on real clinical decisions of interns.

Keywords: Medical education; Treatment prediction; Analytical testing; Self-assessment; Clinical scales.

MÉTODOS DE PREVISÃO CLÍNICA COMO FERRAMENTA DE APRENDIZAGEM NO ENSINO MÉDICO

Resumo

A relevância do estudo é determinada pela necessidade de desenvolver a capacidade de previsão clínica dos estudantes de medicina como uma componente fundamental do pensamento profissional. O objetivo é desenvolver e avaliar a eficácia de um módulo de formação sobre métodos de previsão de

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resultados de tratamentos na formação de futuros médicos. Métodos de investigação: Exame Clínico Estruturado Objetivo (OSCE) modificado, Teste de Raciocínio Clínico, teste analítico Lógica Médica, questionário de autoavaliação, entrevista de grupo semi-estruturada. Como resultado, os estudantes do grupo experimental (GE) (n=50) demonstraram indicadores significativamente mais elevados em todos os critérios em comparação com o grupo de controlo (GC) (n=50): Teste de Raciocínio Clínico - 7,8 versus 5,1 pontos; OSCE - 8,3 versus 5,5; pensamento analítico - 26,1 versus 19,2 pontos; melhoria da autoestima - até +2,2 pontos. O módulo de formação revelou-se eficaz para o desenvolvimento do raciocínio clínico, da lógica de decisão e da confiança profissional. A novidade académica do estudo é a primeira integração aprovada de escalas de previsão clínica (CHA_2DS_2-VASc, SHFM, APACHE II, etc.) como ferramenta didática no curso de Raciocínio Clínico. As perspectivas de investigação futura consistem em ampliar o módulo para formação interdisciplinar, bem como em estudar o seu impacto nas decisões clínicas reais dos internos.

Palavras-chave: Educação médica; Previsão de tratamento; Testes analíticos; Autoavaliação; Escalas clínicas.

MÉTODOS DE PREDICCIÓN CLÍNICA COMO HERRAMIENTA DE APRENDIZAJE EN LA ENSEÑANZA DE LA MEDICINA

Resumen

La relevancia del estudio viene determinada por la necesidad de desarrollar la capacidad de los estudiantes de medicina para realizar predicciones clínicas como componente clave del pensamiento profesional. El objetivo es desarrollar y evaluar la eficacia de un módulo de formación sobre métodos de predicción de resultados terapéuticos en la formación de futuros médicos. Métodos de investigación: examen clínico objetivo estructurado (OSCE) modificado, prueba de razonamiento clínico, prueba analítica de lógica médica, cuestionario de autoevaluación, entrevista de grupo semiestructurada. Como resultado, los estudiantes del grupo experimental (EG) (n=50) demostraron indicadores significativamente superiores en todos los criterios en comparación con el grupo de control (CG) (n=50): Prueba de razonamiento clínico - 7,8 frente a 5,1 puntos; OSCE - 8,3 frente a 5,5; pensamiento analítico - 26,1 frente a 19,2 puntos; mejora de la autoestima - hasta +2,2 puntos. El módulo de formación resultó eficaz para el desarrollo del razonamiento clínico, la lógica de decisión y la confianza profesional. La novedad académica del estudio es la integración por primera vez aprobada de escalas de predicción clínica (CHA_2DS_2-VASc, SHFM, APACHE II, etc.) como herramienta didáctica en el curso de Razonamiento Clínico. Las perspectivas de investigación futura es la ampliación del módulo para la formación interdisciplinar, así como en el estudio de su impacto en las decisiones clínicas reales de los internos.

Palabras clave: Educación médica; Predicción de tratamiento; Pruebas analíticas; Autoevaluación; Escalas clínicas.

1. Introduction

The importance of developing clinical reasoning, the ability to make informed decisions and act under uncertainty is growing in medical education. A promising direction is the introduction of clinical prediction technologies that model the course of diseases and stimulate students' analytical and critical thinking (Binuya et al., 2022).

In evidence-based medicine (EBM), prediction tools-clinical scales, digital risk calculators, and algorithmic models-have become standard instruments for evaluating patient trajectories. However, their pedagogical potential remains underutilized, as noted by Morid et al. (2022). Previous studies indicate that the use of simulation tasks with prediction of treatment outcomes can increase the level of clinical logic, analytical flexibility and confidence in decision-making. However, the Ukrainian educational environment lacks empirical data on the effectiveness of such modules in training future doctors.

The central research problem addressed in this study is the lack of empirically validated pedagogical models that integrate clinical prediction tools (prognostic scales and digital calculators) into the development of clinical reasoning in medical students.

This study attempts to fill this gap by assessing the impact of an experimental training module based on the prediction of treatment outcomes on the development of students' professional clinical competencies. The assessment was conducted using a comprehensive toolkit that included a clinical reasoning test, an analytical test Medical Logic, a modified OSCE, a self-assessment questionnaire, and a semi-structured interview.

The aim of the study is to assess the effectiveness of the implementation of a training module on clinical prediction in the development of clinical reasoning, analytical skills, and confidence in medical students.

Empirical objectives: a) Compare the level of clinical reasoning, analytical logic and practical skills between students who took the training module on prediction and those who studied according to the standard programme; b) Determine the dynamics of subjective confidence and readiness to use prognostic tools in students before and after completing the module; and c) Study students' perceptions of integrating prediction methods into learning and the impact of this experience on their clinical reasoning and motivation.

2. Literature review

Recent studies emphasize the importance of developing clinical reasoning as a key competency for future doctors. Locke et al. (2020) point out that clinical reasoning is not reduced to diagnostics, but is developed through interaction with a mentor and critical reflection. Leitão and Esteves (2023) focus on students' perceptions of clinical logic, showing that most of them identify it with "knowing more" rather than structured thinking, which indicates a methodological gap in teaching.

Hermasari et al. (2023) focus on online learning models during the pandemic: the authors demonstrate that even in a distance learning format, it is possible to activate clinical reasoning through interactive cases. However, other authors, Sayed et al. (2025) emphasize that the key to developing clinical reasoning is the experience of a real clinical environment, which many students lack. This contrast points to the dilemma between simulated and real learning contexts.

Ishizuka et al. (2025) showed the effectiveness of team-based learning (TBL) for the development of clinical reasoning, especially in complex diagnostic situations. This is consistent with the findings of Delavari et al. (2024), who in a large review emphasize that case-oriented, interactive and interdisciplinary approaches are of greatest importance for the training of clinical reasoning, but note the lack of systematic use of cognitive strategies in courses.

Radziievska (2022) draws attention to the effectiveness of various educational formats in the professional training of future doctors, emphasizing the importance of a systematic combination of theoretical and practical components. At the same time, the author recognizes that most domestic educational models retain a traditional reproductive teaching style, where students are rarely involved in active prediction or analysis. Michalik et al. (2024) provide a more global view, showing how new technologies, from virtual reality to medical simulators, are gradually becoming tools not only for training skills but also for shaping clinical reasoning. However, Chowdhury et al. (2024) emphasize that despite technological progress, teachers often fail to adapt their methods to the rapidly changing digital environment. The authors aptly summarize: "without rethinking pedagogy, technology itself is just a shiny shell."

A current approach to studying students' perception of technology is presented in a qualitative study by Alrashed et al. (2024). It was found that most students find new educational platforms useful, but experience a lack of navigational support: if a tool is difficult to use, it quickly loses its pedagogical value.

Grainger et al. (2023) focus on a philosophical perspecive, asking whether technologies are transforming the very essence of medical education into a set of digital templates, losing the humanistic dimension. Their concept of an "unconscious future" encourages a critical reflection on the goals of digitalization.

These considerations are particularly relevant in the context of resource-limited regions. Pebolo et al. (2024) emphasize that even the best technical solutions may remain ineffective without taking into account local conditions, cultural barriers and digital infrastructure. At the same time, Khalifa et al. (2024) emphasize that digitalization changes not only teaching methods, but also the very structure of curricula: a new logic of modules, emphasis on interdisciplinarity, and prediction of clinical risks appear.

Modern medical education is undergoing a transition from the classical model to flexible digital formats, but there are still some challenges of integrating innovations. Herasymenko et al. (2022) consider distance learning

as a forced, but potentially promising model of professional training. They point out the pros (accessibility, mobility) and cons (reduction of practical interaction), but do not analyze the effect on clinical reasoning. In the work of Yefremova et al. (2024), the focus is on the use of cloud technologies in the training of future doctors. The authors demonstrate that services such as MedCram or VisualDx can form students' skills of logical analysis and clinical forecasting. However, the technologies themselves are presented as a means of presenting material, and not as a tool for building thinking. Thus, both works confirm the importance of the digital environment, but do not answer the question: how these technologies affect the logic of clinical decision-making.

Medicine currently focuses on accurate prediction, which is increasingly based on model-based thinking. Chen (2020) provides a systematic review of classic clinical models (e.g., APACHE II, CHA_2DS_2-VASc), but acknowledges their static nature and limited adaptability to the individual patient. This view is developed by Riley et al. (2023), who show that models developed without considering a multiplicity of scenarios can have "unstable behaviour" in real-world practice – they call it a "medical multiverse".

In contrast, Meijerink et al. (2025) and Khalifa and Albadawy (2024) emphasize the adaptation of prediction using AI. Their review demonstrates the potential of deep learning to update models, but raises a new question: how understandable these systems are to students and practitioners. Moriarty et al. (2024) bring this discussion to a humanistic level: patients do not always perceive predictive models as "useful" if they are not explained in accessible language. Therefore, clinical prediction is not only a technical skill, but also a communicative skill. Other authors – Clift (2025), Riley and Collins (2023) – emphasize the gap between the development of models and their application in practice. As Arshi et al. (2023) confirms, only a small percentage of models find their way into real-world use, and therefore even fewer of them are included in educational programmes.

These sources outline predictive models as a promising tool, but do not consider them a didactic tool. So, our study attempts to fill the gap by integrating clinical prediction not only into practice, but also into the pedagogy of medical education – through cases, digital calculators, and OSCE interventions. Despite the rapid development of technologies, most researchers agree that no educational innovation will be fully integrated without meaningful pedagogical design, critical analysis of effectiveness and adaptation to students' needs. The persistent gap is the lack of models that link digital technologies to the development of clinical logic through predictive tools, which is the focus of our study.

3. Methods and materials

It is important to describe how the methodology is organized, in four topics, and list each one here. This section is organized into four thematic components: research design, research methods, sample and instruments. Each

of these topics is presented in a separate subsection to ensure clarity and methodological transparency.

3.1. Research design

The study was conducted over one year (September 2023 – September 2024) and consisted of several stages.

- Preparatory stage (September – October 2023): advancing a hypothesis, development of a training module, creation of assessment tools. A programme was drawn up for the implementation of the method of predicting treatment outcomes as an educational tool (Table 1). It included: introductory lesson, thematic cases, work with prediction calculators, modified OSCE, analytical test, and questionnaire survey.

Table 1. Methods of predicting treatment outcomes as a learning tool in medical education programme.

ITEM NO.	SECTION TITLE	TRAINING CONTENT	FORMS OF WORK	EXPECTED RESULTS
1	Theoretical foundations of clinical prediction	- Types of prognosis in medicine - The role of prediction in clinical decisions - Fundamentals of EBM and statistics	Lecture Interactive tests	Understanding the role of prognosis in the treatment process Preparation for practical modelling
2	Prediction tools	- Prognostic scales: APACHE II, SOFA, CHA_2DS_2-VASc, SHFM - Online calculators: MDCalc, QxMD - Sepsis mortality scales - Fundamentals of interpretation of results	Demonstration Master classes Pair work	Calculator skills Development of analytical clinical reasoning
3	Practical prediction	- Working with cases - Building prognosis in clinical situations - Group discussions of decisions	Practical activity OSCE stations Debate	Developing clinical analysis skills Ability to argue medical prognoses
4	Reflection and self-assessment	- Questionnaire survey before/after - Student portfolio	Observation Diary	Development of reflection

		- Assessment of confidence dynamics	Group Discussion	Awareness of one's own growth
5	Summary check	- Clinical Reasoning Test - Medical Logic analytical test - Practical task on prediction	Written Test OSCE Assessment	Determining of individual progress Assessment of academic performance

Source: Developed by the authors (2025).

- Main stage (November 2023 – June 2024): implementation of the module in the EG, collection of empirical data. EG students took classes using prognostic techniques in a clinical context. The CG students studied according to a typical programme without intervention.

- Final stage (July – September 2024): data analysis, results processing, statistical comparison, group interviews, drawing conclusions and providing recommendations.

3.2. Research methods

- Quantitative method: clinical reasoning testing, Medical Logic analytical test, modified OSCE, and self-assessment questionnaire were applied. The results are presented in the form of means, standard deviations, and a t-test was calculated to check the statistical significance of differences between groups.

- Qualitative method: a semi-structured group interview with the EG participants was applied to identify the features of perception of the prediction method, its effectiveness, and difficulties. The interview was analysed using thematic coding.

- Experimental method: a training module was developed and tested on the EG. Comparison of the EG and CG results gave grounds to assess the effectiveness of the educational intervention.

- Statistical method: calculation of means, standard deviations, Cohen's d and Student's t-test for independent samples. Analysis was performed using Excel and SPSS.

3.3. Sample

The study involved 100 5th year medical students (50 in the CG and 50 in the EG). There was a total of 143 students on the course. Of these, 100 were randomly selected. Stratification was based on GPA and gender to ensure equality of groups. The EG and CG did not have statistically significant differences in baseline characteristics (success, motivation, previous experience).

3.4 Instruments

- Clinical Reasoning Test: situational tasks (vignettes) with a brief description of the clinical situation, laboratory parameters, and dynamics. The task consisted of choosing a possible prognosis (e.g., risk of complications, probability of remission, response to therapy), and logically justifying the choice. Maximum score – 10. Assessment was carried out before and after the intervention.

- Modified OSCE: 3–5 stations with virtual or simulated clinical scenarios. The student built a prognosis using a prognosis form and a reflection form. Assessment: accuracy of prognosis, logical thinking, and communication skills.

- Medical Logic analytical test: task to establish cause-and-effect relationships and logical correspondences between clinical parameters and treatment outcomes. For example: "decreased glomerular filtration rate (GFR) → risk of nephropathy".

- Self-assessment questionnaire: Likert-type questionnaire (1–5 points) to measure confidence, understanding of prediction mechanisms, and willingness to apply these methods in future practice.

- Semi-structured interview: questions aimed at qualitatively assessing the effectiveness of the intervention, with a focus on changing thinking, the usefulness of the tools, and practical value for clinical practice.

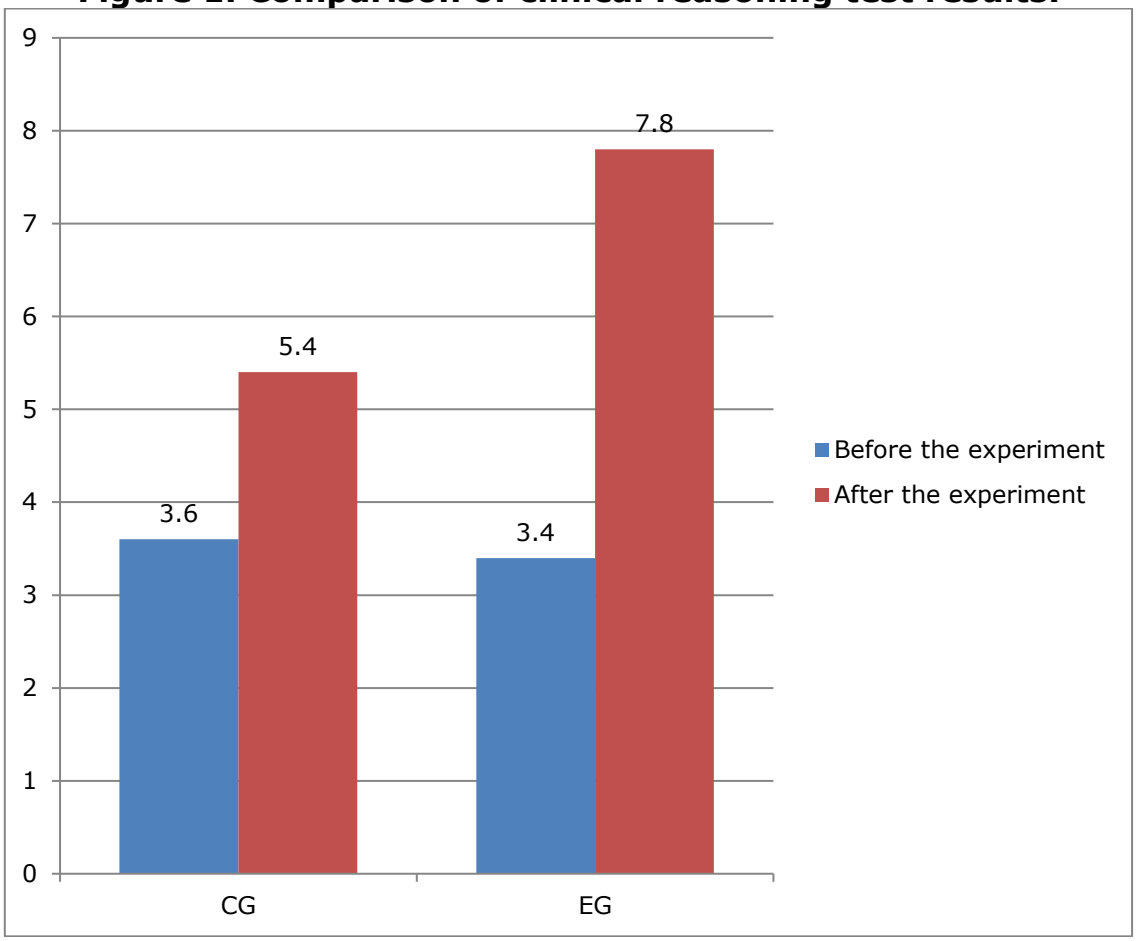
- Software tools: Microsoft Excel for data collection and pre-processing, SPSS and SEM for statistical analysis; clinical calculators and scales were also used: CHA_2DS_2-VASc, SHFM, sepsis mortality scale, APACHE II, SOFA, MDCalc, QxMD.

4. Results and discussion

The students were asked to take a clinical reasoning test in order to assess the effectiveness of the training module on predicting treatment outcomes. It consisted of clinical tasks that required not only the correct prediction of the prognosis (for example, the risk of complications or the probability of remission), but also to justify their choice. The assessment was carried out on a 10-point scale, taking into account the accuracy and logic of the answer.

Figure 1 shows a comparison of the average EG results of the, which completed the training module, and the CG, which studied according to the standard programme before and after the experiment. The graph shows that the EG students demonstrated significantly higher results in the clinical reasoning test after the programme implementation.

Figure 1. Comparison of clinical reasoning test results.



Source: Developed by the authors (2025).

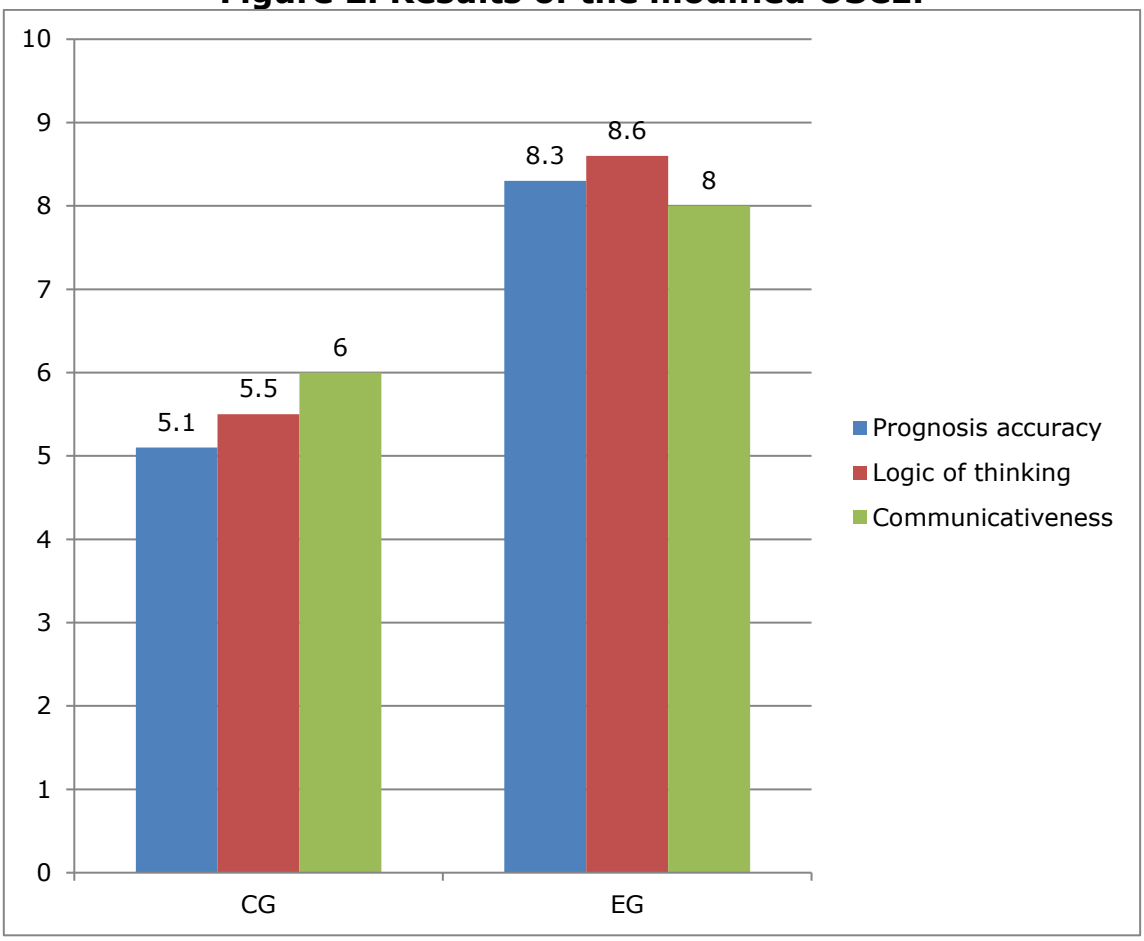
The test results indicate a higher level of clinical reasoning and analytical skills of the EG students after the experiment (7.8 points versus 5.4 points in the CG). At the same time, the variability of the results remained approximately the same: the standard deviation was 1.3 in the EG and 1.2 in the CG, which indicates the stability of the acquired level of knowledge among students who underwent the intervention.

This difference was reflected not only in quantitative indicators, but also in the qualitative characteristics of the responses: the EG students demonstrated the ability to reasonably use clinical scales (e.g., CHA_2DS_2-VASc, GOLD, SHFM), build logically coherent forecasts based on medical data, and present realistic clinical scenarios taking into account risks. In contrast, the CG students were mostly limited to descriptive formulations without clear interpretation or justification.

The increased average score in the EG while maintaining a moderate dispersion of results indicates not only the effectiveness of the educational module, but also its ability to ensure relatively uniform assimilation of the material among the majority of students. Such an effect is an important criterion for the pedagogical appropriateness of introducing innovative educational practices into the training programmes of future doctors.

The progress of practical skills of students' clinical forecasting was checked through a modified OSCE (Figure 2). During the exam, students analysed clinical scenarios and formed forecasts regarding the course of the disease, possible complications, and response to treatment. The assessment was carried out according to three criteria: accuracy of the forecast, logic of thinking, and communicativeness (if the answer contained an oral explanation).

Figure 2. Results of the modified OSCE.



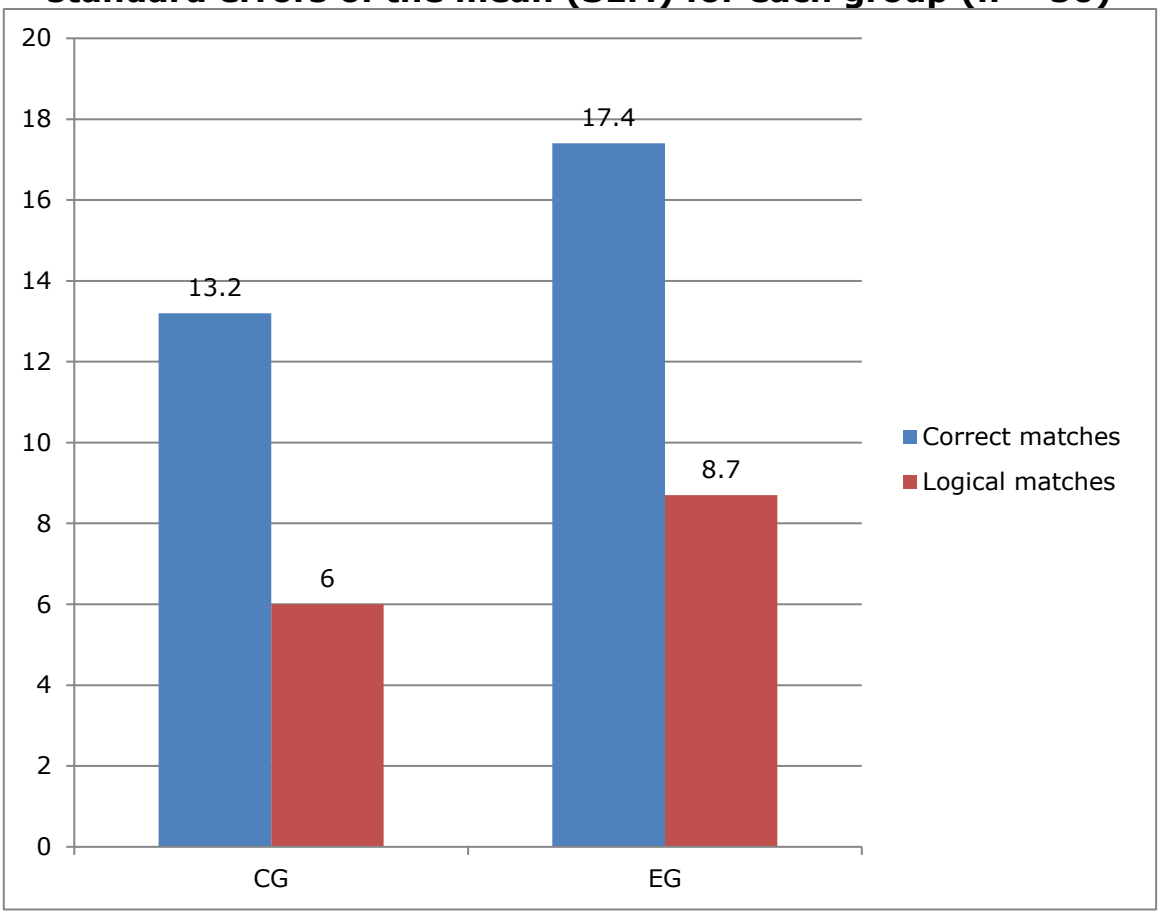
Source: Developed by the authors (2025).

The obtained results indicate the effectiveness of the training module focused on the application of clinical prediction tools in simulated practice. High EG indicators for all three criteria give grounds to conclude about the comprehensive improvement of professional competencies, covering not only knowledge, but also analytics, decision-making, and clinical communication.

The students' ability to establish cause-and-effect relationships between clinical parameters and the prognosis of treatment outcomes was determined by using the Medical Logic analytical test. The test consisted of two parts: establishing correspondences between clinical indicators (e.g., troponin, GFR, Body Mass Index (BMI)) and possible complications or prognosis, and building logical sequences of the clinical course of events.

Each task was aimed not only at checking factual knowledge, but also at assessing the level of clinical logical thinking and flexibility in modelling situations. Figure 3 presents the comparative results of this test by the CG and EG students.

Figure 3. Results of the Medical Logic analytical test with added standard errors of the mean (SEM) for each group (n = 50)



Source: Developed by the authors (2025).

The results of the Medical Logic analytical test indicate a higher level of logical and prognostic skills in the EG students: the average overall score was 26.1 versus 19.2 in CG. The EG also showed better results in performing both parts of the test: correct correspondences of clinical parameters – 17.4 versus 13.2, logical sequences – 8.7 versus 6.0, respectively.

These data indicate that the inclusion of forecasting methods in the educational process contributes not only to deepening knowledge, but also to activating analytical thinking, developing cognitive connectivity, and the ability of clinical modelling.

The effectiveness of the training module on methods for predicting treatment outcomes was verified through a statistical comparison of the CG and EG results according to key indicators of educational performance. The analysis

included: the results of the clinical resoning test, the Medical Logic analytical test, and the modified OSCE (Table 2).

Table 2. The t-test results for comparing student performance

INDICATOR	AVERAGE CG	AVERAGE EG	ST. DEVIATION CG	ST. DEVIATION EG	T-VALUE	P-VALUE	COHEN'S D
Clinical Reasoning Test	5.13	7.82	1.12	1.14	-11.934	< 0.05	2.37
Analytical Test – Correct Matches	13.16	17.50	1.12	1.07	-19.836	< 0.05	3.99
Analytical Test – Logical Matches	6.15	8.68	1.09	1.19	-11.064	< 0.05	2.25
OSCE – Prognosis Accuracy	5.14	8.54	0.93	1.28	-15.193	< 0.05	3.04
OSCE – Logic of thinking	5.45	8.52	1.18	1.28	-12.506	< 0.05	2.50
OSCE – Communicative skills	5.74	8.03	0.90	0.93	-12.469	< 0.05	2.56

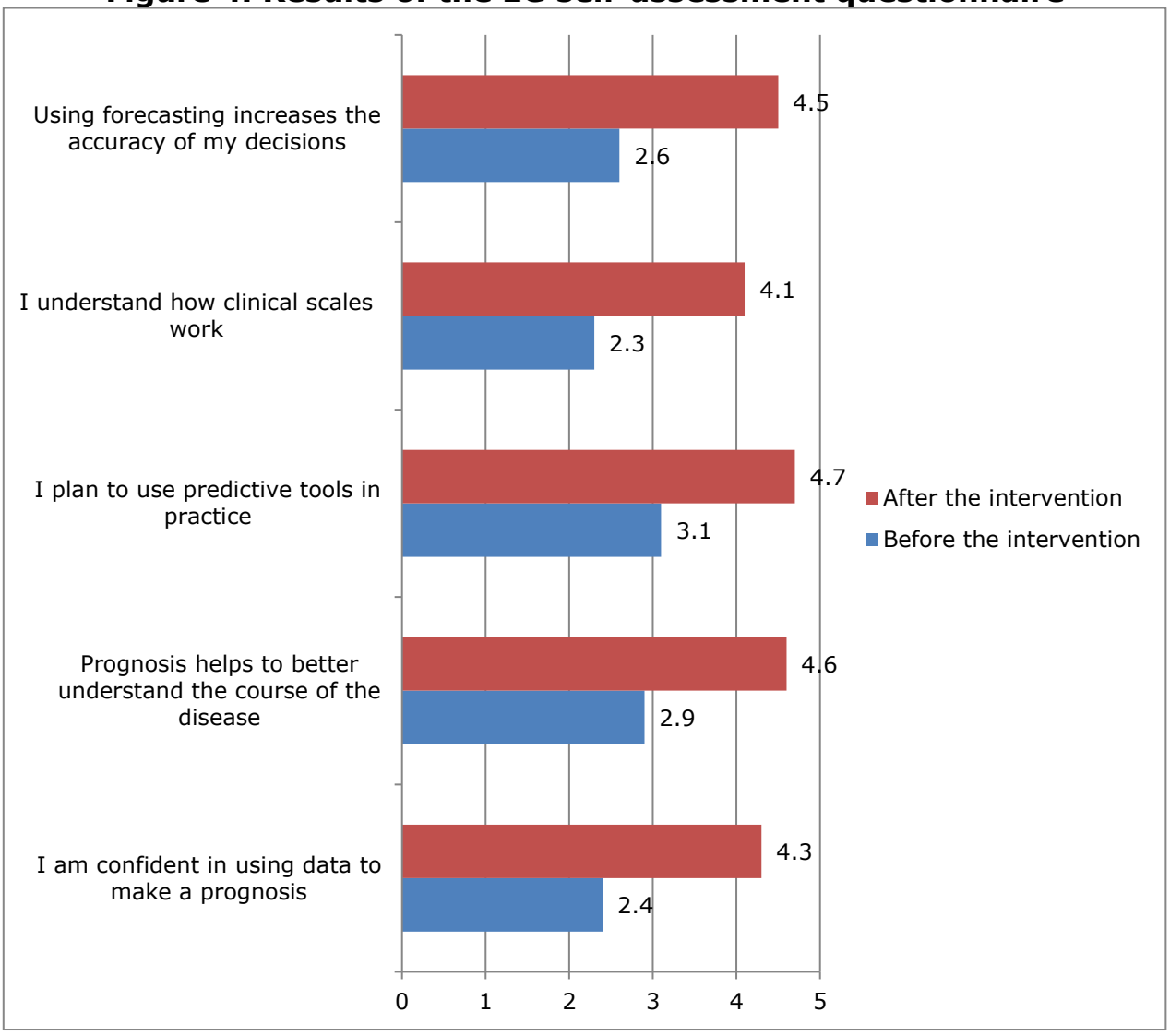
Source: Developed by the authors (2025).

The results of t-tests showed a statistically significant advantage of the EG over the CG in all indicators (all $p < 0.05$). In particular, the largest differences were found in analytical thinking (logical correspondences: $t = -11.064$) and accuracy of predictions in simulated conditions (OSCE: $t = -15.193$). All indicators have Cohen's d values > 2.0, which indicates a very strong effect of the educational intervention. This confirms the significant impact of the prediction module on the development of students' clinical reasoning, analytical skills, and communicative skills.

The impact of the educational module on the formation of students' confidence in using methods for predicting treatment outcomes was assessed by using a questionnaire survey conducted among the EG participants before and after the intervention.

The respondents rated each statement on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). Figure 4 shows a comparison of the mean scores before and after completing the educational module.

Figure 4. Results of the EG self-assessment questionnaire



Source: Developed by the authors (2025).

The results of the survey demonstrate a significant increase in the level of students' confidence, awareness, and willingness to apply methods of predicting treatment outcomes in clinical practice. After completing the training module, the average scores on all items of the questionnaire increased by 1.8–2.2 points. The greatest increase was observed in the statements "I understand how clinical prognosis scales work" (from 2.3 to 4.1) and "I am confident in using data to make a prognosis" (from 2.4 to 4.3), which indicates the formation of specific applied skills, and not just a general positive attitude.

The next stage of the study involved an interview conducted in the format of an open group discussion in the EG. The focus was on how students perceived methods of predicting treatment outcomes, how they influenced their thinking style, motivation, assimilation of the material, and a sense of professional readiness. The audio recording of the discussion was transcribed and analysed using thematic coding (Table 3).

Table 3. Results of the open interview.

TOPIC	CODE (SEMANTIC UNIT)	TYPICAL STUDENT STATEMENTS
Changing the style of clinical reasoning	transition from diagnosis to prognosis	"I used to perceive the task as: find the correct diagnosis. And now — how to predict what will happen to the patient. It's a completely different way of thinking."
Understanding the structure of prognosis	numbers turn into prognosis	"When I first entered the patient's data into the calculator, I first really understood how numbers turn into a prognosis. It's not magic — it's a structure."
Prognosis tools	application of clinical calculators	"I especially liked working with CHA_2DS_2-VASc, SHFM, sepsis mortality assessment scales."
Tools as a stimulus for deeper understanding	relationship of scales with pathophysiology	"The prognosis makes you understand the pathophysiology more deeply. Otherwise, you won't fill out the scale correctly. It motivates you not just to read a lecture, but to understand the logic of the process."
Difficulties at the initial stage	too much data, difficult to structure	"When you start — it seems that there is too much data, and it's unclear which ones are the most important. But after a few cases — you have an intuition that what to look at first."
Working with complex models	difficulties with survival in heart failure	"It was difficult with the survival model for heart failure — there are many variables. But over time, you understand their meaning — and the prognosis becomes clear."
Motivation for learning	awareness of the value of knowledge	"When you see that it really affects the decision, you want to know more. Because you understand: knowledge is not just an answer on a test, but the patient's life."
Professional identity	willingness to act as a doctor	"This is not just learning — it's already part of the profession. If I can predict, I'm no longer just a student, but almost a doctor."

Source: Developed by the authors (2025).

So, the interview revealed a clear transformation of students' thinking: from memorization to analytics, from reactive to proactive approach. Prediction

methods were perceived not as an abstract theory, but as a particular tool that increases clinical confidence, decision logic, and a sense of professional subjectivity. This gives grounds to conclude about the high level of acceptance and effectiveness of integrating forecasting into medical education.

Our study tested a training module that integrates the use of clinical prognostic scales into the pedagogical process. After working with the CHA_2DS_2-VASc, SHFM, APACHE II, SOFA, and sepsis mortality scales, the EG students demonstrated: significantly higher accuracy of predictions (8.54 vs. 5.14), better logic of thinking (8.52 vs. 5.45), and a deeper analytical understanding of pathophysiology, which is reflected in the results of the Medical Logic test (26.1 points vs. 19.2).

Li et al. (2025) showed that SOFA and APACHE II are reliable predictors of mortality risk in patients with sepsis. The authors emphasize the accuracy of the models, but focus only on clinical application. Our study complements this model, showing that the use of SOFA and APACHE II in the educational process not only provides knowledge, but also develops students' critical thinking. Wu et al. (2022) in a large review systematized prognostic sepsis scales, including SOFA, qSOFA, APACHE II. They noted that the effectiveness of the scales depends on the context, but the issue of the pedagogical potential of these scales was not addressed. We filled this gap by proving that the scales are not only tools for the physician, but also thought-formers for the student.

Xie and Shi (2022) investigated the effectiveness of the combination of APACHE II, SOFA and CDSS in predicting survival in sepsis, with positive results. However, their work focuses on integration into decision support systems. Our intervention, in turn, adapts these tools to the educational environment, developing skills in their manual application and logical analysis without digital support – which is important during the learning phase.

Liu et al. (2022) indicated that the SOFA scale is convenient for monitoring the severity of the condition, especially in dynamics. Our study agrees with this opinion: students who practiced prediction based on SOFA learned to think in terms of clinical dynamics, and not only diagnosis, as confirmed by qualitative interview results. Mehta and Patil (2022) compared APACHE II and SOFA in the intensive care unit, noting the advantages of SOFA in operational assessment. In turn, we showed that the inclusion of these scales in the training case develop students' risk analysis skills, which is important even before entering clinical practice.

In our study, the EG students actively used MDCalc, QxMD and other digital calculators while working with cases. This significantly affected the results. In their systematic review of digital applications for cardiovascular risk assessment, Chavez-Ecos et al. (2024) confirm the high accuracy of calculators, but emphasize the risk of superficial use without a deep understanding of the algorithms. Our study shows how to overcome this problem: by teaching data interpretation, not just entering numbers. Wagner et al. (2025) concluded that the effectiveness of using digital tools depends on the level of students' digital literacy and belief in the value of EBM. Our results confirm that the combination

of practice with calculators and reflection (through portfolios and discussions) contributes not only to technical skills, but also to the formation of trust in digital sources of solutions. We moved digital calculators from the category of applications to a methodological component of the training module, which is proven by the increase in both students' results and subjective confidence.

Tenny and Varacallo (2024) define EBM as the combination of best evidence, clinical experience, and patient benefits. However, most EBM programmes do not teach practical prediction – they are more data analytics than proactive modelling of clinical outcomes. Reinhold and Bacon-Baguley (2021) attempt to change this by proposing to integrate EBM into the training of physician assistants through weekly clinical discussions. However, the authors acknowledge that students often feel disconnected from evidence-based theory and real-world practice. Our module bridges this gap. By working with specific risk scales (CHA_2DS_2-VASc, SHFM), clinical cases, and digital calculators, students do not just read about EBM – they live it in a simulated scenario. This results in an increase in clinical reasoning scores (from 5.13 to 7.82 points) and a deeper understanding of the logic of risk analysis.

Our results are also consistent with the study by Ang et al. (2024), which showed that preparatory programmes contribute to the development of students' psychological confidence during clinical practice. In our case, students' confidence in the use of predictive methods increased on average from 2.4 to 4.3 points. This indicates a similar dynamic, although in our study it was achieved mainly through practice with cases, rather than through emotional support. In the systemic review by Zainal et al. (2025), where critical thinking is recognized as a key factor for clinical decision-making, our results demonstrate its practical activation: after the intervention, students achieved 26.1 points in the analytical test, which is significantly higher than the CG score (19.2). In addition, unlike Meng et al. (2025), who focus on readiness for shared decision-making, we observed the development of professional subjectivity even at the training stage — all EG respondents noted in open-ended responses that they began to think like doctors, not just like students.

4.1. Limitations

The study was conducted at a single educational institution, which limits the generalizability of the results to a broader student population. Future studies should also address the applicability of this model in institutions with different pedagogical cultures and levels of digital infrastructure.

4.2. Recommendations

Further studies with larger samples in different medical education institutions and clinical practice settings are recommended. It is also recommended to develop an online version of the module for distance learning and postgraduate education.

5. Final considerations

The results of the study showed that the implementation of the training module on clinical prediction significantly increases students' professional competence. The EG demonstrated significantly better results compared to the CG: the average score for the clinical reasoning test was 7.8 versus 5.1, and for the modified OSCE – 8.3 versus 5.5. The difference in the accuracy of predictions (8.54 versus 5.14) and the logic of thinking (8.52 versus 5.45) was especially noticeable. The analytical test also revealed a significant advantage of the EG – 26.1 points versus 19.2 in the CG, which confirms deeper logical prognostic thinking.

Statistically significant differences ($p < 0.05$) between the groups in all indicators indicate the effectiveness of the module. The questionnaire showed an increase in students' self-esteem by 1.8–2.2 points after completing the course. The results of the group interview confirmed changes in the students' thinking style – from reproducible to analytical, increased motivation, and a sense of clinical confidence.

5.1. Academic novelty

In this study, a training module was developed and empirically tested for the first time in Ukrainian medical education based on the systematic use of digital clinical calculators and prognostic scales (in particular, CHA_2DS_2-VASc, SHFM, APACHE II, SOFA) as a means of developing clinical reasoning. The novelty of the approach is the comprehensive measurement of the effectiveness of the module, which combined quantitative analysis of results (modified OSCE, tests) with qualitative assessment through group interviews and thematic coding.

5.2. Practical value

The developed module can be integrated into a standard course on clinical reasoning in senior courses of medical higher education institutions. The module can also be used in postgraduate education of doctors as a tool for continuous professional development in the context of digital transformation of medicine.

5.3. Implications for curriculum developers

The study demonstrated the feasibility of introducing a clinical forecasting module into the programmes of senior medical schools. The module built on the use of digital tools (MDCalc, CHA_2DS_2-VASc, SHFM) is easily integrated into courses on clinical reasoning or EBM.

The developers should:

– include forecasting blocks to develop risk assessment and decision-making skills;

– use digital calculators as active learning tools;

– treat predictive thinking as a key clinical competency;

– apply the module in postgraduate medical training.

Such changes will contribute to the improvement of students' critical thinking and professional readiness.

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