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Andrii BORYSENKO,
Anna ANTONENKO,
Mykola KONDRATIUK,
Vasyl BARDOV,
Oksana PARFIONOVA

The role of current academic performance of medical students in preparation for the final exam: experience in teaching the discipline "Hygiene and Ecology"

ANDRII BORYSENKO, ANNA ANTONENKO, MYKOLA
KONDRATIUK, VASYL BARDOV, OKSANA PARFIONOVA.
The role of current academic performance of medical students
in preparation for the final exam: experience in teaching the
discipline "Hygiene and Ecology". *Current academic performance
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academic achievements during studies are significant predictors of success in the licensing KROK-2 exam, which assesses professional competencies. However, the war in Ukraine has introduced substantial challenges to the educational environment, particularly in medical education, disrupting teaching and learning processes.

***The aim** of this study was to analyze the success of foreign medical students in the KROK-2 exam as a means of improving the effectiveness of the educational process in universities.*

***Materials and Methods.** The study analyzed the academic performance of 6th-year foreign medical students specializing in "Medicine" during the 2023 and 2024 academic years. The subtest results for "Hygiene and Health Care Organization" in KROK-2 were compared with academic marks in the discipline "Hygiene and Ecology."*

***Results and Discussion.** The analysis revealed significant changes in the distribution of grades between 2023 and 2024. The proportion of students achieving higher grades ("B" and "C") increased, while those with lower grades ("D" and "E") decreased. In 2024, a greater number of students took the KROK-2 exam (252 compared to 112 in 2023). Despite this, the average scores in 2024 were generally lower than in 2023, indicating potential challenges in adapting to wartime conditions. Statistical analysis showed a positive correlation between KROK-2 results and both discipline scores and everyday control assessments. The correlation strength was higher in 2024, suggesting that current academic performance and regular assessment more effectively predicted exam success compared to 2023.*

***Conclusions.** There is a positive trend in student performance, with an increase in higher ECTS grades ("A," "B," and "C") and a decrease in lower grades ("D" and "E") in 2024. While the number of students taking the KROK-2 exam increased in 2024, the average scores decreased, indicating a need for further investigation into influencing factors. Efforts should focus on enhancing the preparation of students with lower grades ("C," "D," and "E") to improve overall educational outcomes.*

***Keywords:** medical education, foreign students, education optimization, Learning strategies, student motivation.*

1. Introduction

Current academic performance of medical students plays an important role in their preparation for final exams. High academic performance during studies is an important predictor of success in the final exam. Many authors confirm this finding, noting that students with higher academic performance are usually better prepared for exams [1, 2]. Scientists from around the world analyze different strategies for preparing for exams, pointing out the importance of regular study and current academic performance, emphasizing that students with high academic performance have a higher chance of success in final exams [1, 3]. Rebecca Morris with co-authors point out the importance of systematic study throughout the course to achieve high results in final exams [4].

Over the past decade, Ukraine has confidently established itself as a leading center for obtaining medical education by foreign students. The constant increase in the number of foreign applicants to higher medical education institutions (HMEI) testified to a high level of trust in the Ukrainian educational system and its competitiveness in the international market of educational services [5].

However, the military aggression by the Russian Federation, which began in 2022, has caused significant challenges for the Ukrainian educational environment, particularly in the field of medical education.

In the conditions of war, the Ukrainian HMEI was faced with the task not only of maintaining the education level for foreign students, but also of ensuring its competitiveness in the future. The satisfaction of the customer countries with the results of their citizens' education is one of the key factors in the attractiveness of Ukrainian HMEI [6]. Of particular importance is the level of graduates' mastery of professional competencies that are crucial for their further activities. The discipline "Hygiene and Ecology" plays an important role in this, which forms in future doctors the knowledge and skills necessary to confirm their high professionalism. It is important for future doctors to understand that preventing diseases is much more effective and economically feasible than treating them. According to the World Health Organization, a significant percentage of diseases are associated with non-compliance with the rules of personal and social prevention, as well as the influence of environmental factors [7].

The transition to remote studying has also created difficulties in providing practical training, which is critically important for medical students [8, 13]. In particular, this applies to preparation for the integrated licensing exam KROK-2, which assesses the professional competence of graduates and is a mandatory component of state certification [9, 14, 15].

It is also worth noting that students' motivation to learn is a decisive factor that affects the quality of knowledge acquisition and the formation of necessary skills. It determines the student's ability to overcome difficulties and effectively use their own resources to achieve educational goals [10]. It has been proven that motivation to learn can change under the influence of various factors, including learning conditions, the organization of the educational process and the characteristics of teaching [11, 12, 17]. Understanding these factors allows teachers to influence them to form positive motivation, especially among foreign students who face additional difficulties in adapting to a new educational environment.

Analysis of current student performance is an important tool for assessing the effectiveness of training and preparation for the KROK-2 exam. This is especially relevant in the context of teaching disciplines that form basic professional competencies, such as "Hygiene and Ecology". In modern conditions, research on student performance allows us to identify factors that affect the quality of education and develop recommendations for optimizing the educational process.

This article is aimed at analyzing the current performance of medical students as a key element of their preparation for the final exam using the example of the discipline "Hygiene and Ecology", which is especially important in the context of a changed educational environment due to the war.

The purpose of the study was to analyze the success of taking the KROK-2 exam by foreign students as a tool for improving the studying efficiency at universities.

2. Materials and Methods

The results of the 6th-year foreign students' "Medicine" specialty testing (Hygiene & Health Care Organization subtest scores), conducted on 6 June 2023 and 21 May 2024, along with their academic marks in the discipline Hygiene and Ecology, were analyzed.

Statistical analysis of the obtained results was performed using licensed software MedStat v.5.2 (Copyright © 2003-2019) and Microsoft® Excel® for Microsoft 365 MSO (Version 2305 Build 12.0.6425.1000, 2007) (License Identifier: CWW_0071e48a-250c-4bdb-9013-b8daf357b5e9_b5685e92-c95d-4399-9b83-449d76a26fb6_79f3b2da2f9adcda29). Additionally, the interactive programming environment Jupyter Notebook was utilized for executing Python code and visualizing results. For data processing and analysis, the following Python libraries were employed: Pandas, NumPy, SciPy, Scikit-learn, Matplotlib, and Seaborn.

The normality of the distribution in the study groups was assessed using the D'Agostino-Pearson test (for group sizes $n > 30$) and the Shapiro-Wilk test (for group sizes $n < 30$). In most cases, a normal distribution was established ($p > 0.05$). Since the results obtained over two years were compared, paired comparisons were utilized. Groups with a normal distribution were analyzed using a parametric test (Student's t-test), while groups with a distribution differing from normal were analyzed using a non-parametric test (Wilcoxon's W-criterion (Mann-Whitney U test)).

During the study, the following statistical analyses were performed: calculation of the mean (median), standard deviation, standard error of the mean (median), 95% confidence interval, proportion, and assessment of group independence (χ^2 test). Statistical force was set at 80% with a significant level of 0.05.

3. Results and Discussion

The students were divided into five groups based on their grades in the discipline "Hygiene and Ecology" according to the ECTS scale (Table 1). It was established that academic performance in 2024 was significantly different from that of the 2023 cohort (χ^2 test = 41.82; $p < 0.001$).

A significant decrease is observed in the "E" grade category, dropping from 38.4% in 2023 to 12.7% in 2024. This indicates a reduction in the number of students just barely meeting the minimum requirements. The percentage of students receiving a "D" grade decreased from 26.8% in 2023 to 21.0% in 2024, which might suggest a shift towards higher performance levels. The "C" grade category saw a substantial increase from 22.3% in 2023 to 37.3% in 2024, indicating that more students are performing at a satisfactory level. There was a significant increase in the percentage of students scoring a "B" grade, jumping from 7.1% in 2023 to 22.6% in 2024. This suggests a notable improvement in the number of students achieving above-average results. The percentage of students achieving an "A" grade slightly increased from 5.4% in 2023 to 6.3% in 2024, indicating a minor improvement in top performance.

The change in grade distribution suggests an improvement in students' academic performance in 2024. This is evidenced by several facts, including a significant decrease in the proportion of students with lower grades ("E") and a notable increase in the proportion of students with higher grades ("B" and "C").

These changes may be attributed to improved learning conditions (adaptation to wartime circumstances, shorter power outages, and

Table 1. Distribution of Students by ECTS Grades in the Discipline “Hygiene and Ecology” for 2023 and 2024 (%).

Score in points	Score on a national scale	ECTS scale	2024 (%)	2023 (%)
170-200	Perfectly	A	6.3	5.4
155-169	Fine	B	22.6	7.1
140-155		C	37.3	22.3
125-139	Satisfactorily	D	21	26.8
111-124		E	12.7	38.4
60-110	Unsatisfactorily	FX	-	-
1-59		F	-	-

periodic stabilization of the energy system), which allowed students to better prepare for practical classes. It should also be noted that the number of students taking the KROK-2 exam increased significantly – 252 out of 390 in 2024 compared to 112 out of 440 in 2023 (χ^2 test = 64.57; $p < 0.001$).

The results of the KROK-2 subtest “Hygiene & Health Care Organization” were analyzed, including their mean values (medians), confidence intervals, and comparisons within groups for a single academic year and across groups of the same ECTS cohort between years (Table 2).

Table 2. Comparison of KROK-2 Results for the Discipline “Hygiene and Ecology” in 2023 and 2024 by ECTS Grades.

Discipline ECTS grade	"A"	"B"	"C"	"D"	"E"*	ALL*
2024						
Number of students:	16	57	94	53	32	252
Mean±standard error of the mean	71.5±3.1	66.5±1.3	62.2±1.3	56.5±1.7	51.6±3.1	61.1±0.9
95% confidence interval	64.9-78.2	63.9-69.1	59.7-64.8	53-60	45.2-57.9	59.2-62.3
2023						
Number of students:	6	8	25	30	43	112
Mean±standard error of the mean	74.1±2.3	79.2±3.4	73.1±2.1	75.4±2.5	67.4±1.9	72.0±1.2
95% confidence interval	68.1-80.1	71.1-87.3	68.8-77.4	70.3-80.5	63.5-71.4	69.7-74.4

Note: «*» – distribution differing from normal for «E»(2023) median ± standard error of the median =66.7±2.7 (95% CI 66.7-72.2); «ALL» (2023) = 72.2±1.5 (95% CI 66.7-77.8); «E»(2024) =50.0±4.0 (95% CI 44,4-61,1); «ALL» (2024) = 61.1±1.1 (95% CI 55.6-66.7)

Table shows that the total number of students increased from 112 in 2023 to 252 in 2024. The overall mean score decreased from 72.0 in 2023 to 61.1 in 2024. However, the 95% confidence interval narrowed slightly, indicating a slight improvement in overall consistency of performance across all grades. This comprehensive analysis highlights both the changes in student numbers and performance between 2023 and 2024, showing a general trend of increased participation but lower average scores with varying levels of consistency across different grades.

The number of students achieving a grade “A” increased from 6 in 2023 to 16 in 2024. However, the mean score slightly decreased from 74.1 in 2023 to 71.5 in 2024. There was a significant increase in the number of students receiving a grade “B”, rising from 8 in 2023 to 57 in 2024. Despite this increase, the mean score for this group decreased significantly from 79.2 in 2023 to 66.5 in 2024. The number of students achieving a grade “C” rose from 25 in 2023 to 94 in 2024. The mean score for this grade decreased from 73.1 in 2023 to 62.2 in 2024. The 95% confidence intervals for all above mentioned grades are narrowed, indicating improved consistency in scores. For grade “D”, the number of students decreased from 30 in 2023 to 53 in 2024. The mean score dropped from 75.4 in 2023 to 56.5 in 2024. The number of students achieving a grade “E” decreased from 43 in 2023 to 32 in 2024. The mean score also fell from 67.4 in 2023 to 51.6 in 2024. The 95% confidence interval widened, suggesting greater variability in scores for this grade.

In 2023, no statistically significant differences were observed between most groups ($p = 0.130$ – 0.760), except for the “B” & “E” and “D” & “E” groups ($p = 0.016$ and 0.023 , respectively). In contrast, in 2024, statistically significant differences were observed between most groups ($p < 0.001$ – 0.035), except for “A” & “B” and “D” & “E” groups ($p = 0.120$ and 0.230 , respectively). Overall, in 2024, a decline in the overall KROK-2 results compared to 2023 was observed ($p < 0.001$) (Table 3). The largest decline was noted in the “B”, “C”, and “D” groups. The “E” group also experienced a decrease in mean scores, which may be explained by the influence of external factors (such as learning under wartime conditions and the long-term effects of the pandemic) that negatively affected student outcomes.

For the next academic year, efforts should focus on improving the preparation of students in the “C”, “D”, and “E” ECTS groups for KROK-2. The results of students with an “A” grade remained stable between 2023 and 2024 ($p = 0.523$). This stability may indicate that high-performing students remain equally prepared regardless of external factors, likely due to their strong personal motivation and preparation, which mitigate the effects of changes in learning conditions.

Table 3. Statistical Analysis of KROK-2 Results for 2023 and 2024 by ECTS Grades.

Discipline ECTS grade		All	"A "	"B"	"C"	"D"	"E"
STEP-2 results		STEP-2 (2024)					
"E"	STEP-2 (2023)						<0.0011*
"D"						<0.0012*	
"C"					<0.0012*		
"B"				<0.0012*			
"A "			0.5232				
All		<0.0011*					
Statistical significance (<i>p</i> -value)							

Notes: "1" – comparison conducted using Student's t-test; "2" – comparison conducted using Wilcoxon's W-criterion; "*" – indicates a statistically significant difference.

To prevent unsatisfactory results among students in the KROK-2 licensing exam, an analysis was conducted to identify correlations between KROK-2 results and discipline scores as well as everyday current control scores. In both 2023 and 2024, a positive correlation was established between these variables and KROK-2 performance (Table 4, Figures 1–4).

Table 4. Correlation Between KROK-2 Results and Discipline Scores as Well as Everyday Current Control Scores in 2023 and 2024.

		Parameter	Correlation (<i>R</i>)	<i>p</i> -value	Coefficient of determination
2024	KROK-2	discipline score	0.423	<0.001	0.179
		everyday current control score	0.472	<0.001	0.223
2023		discipline score	0.252	0.007	0.064
		everyday current control score	0.325	<0.001	0.106

There is a moderate positive correlation ($R = 0.423$) between KROK-2 results and discipline scores in 2024. The *p*-value indicates that this correlation is statistically significant ($p < 0.001$). The coefficient of determination (R^2) of 0.179 suggests that approximately 17.9% of the variance in KROK-2 results can be explained by discipline scores.

There is a moderate to strong positive correlation ($R = 0.472$) between KROK-2 results and everyday current control scores in 2024. The p-value shows this correlation is statistically significant ($p < 0.001$). The R^2 of 0.223 indicates that about 22.3% of the variance in KROK-2 results can be explained by everyday current control scores.

In 2023, the correlation between KROK-2 results and discipline scores is weak ($R = 0.252$) but also statistically significant ($p = 0.007$). The R^2 of 0.064 suggests that only 6.4% of the variance in KROK-2 results can be explained by discipline scores. The correlation between KROK-2 results and everyday current control scores is weak ($R = 0.325$) but statistically significant ($p < 0.001$). The R^2 of 0.106 indicates that about 10.6% of the variance in KROK-2 results can be explained by everyday current control scores.

These findings suggest that, in 2024, everyday current control scores better explained the variations in KROK-2 results.

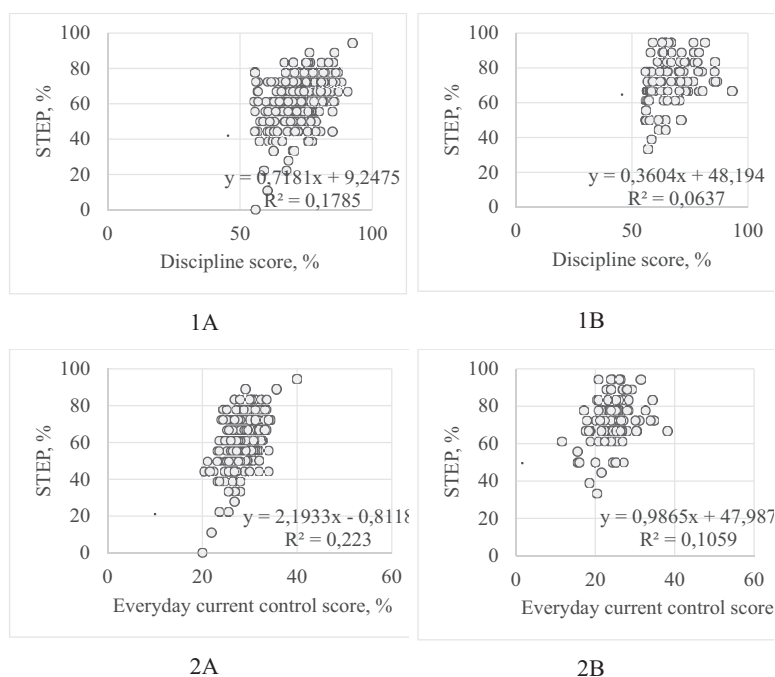


Figure 1. Correlation between discipline scores and STEP-2 results in 2024 (1A) and in 2023 (1B) and correlation between everyday current control scores and STEP-2 results in 2024 (2A) and in 2023 (2B).

4. Conclusions

1. The overall trend from 2023 to 2024 indicates a positive shift in student performance, with increases in higher ECTS grades ("A", "B", and "C") and a decrease in lower grades ("D" and "E"). This improvement might be attributed to numerous factors such as changes in teaching methods, increased student engagement, or better preparation for the exams.

2. There has been a noticeable increase in the number of students in 2024 compared to 2023 (112) across all ECTS grades. However, the mean scores in 2024 (in general 61.1 ± 0.9) are generally lower than those in 2023 (in general 72.0 ± 1.2) for each grade, indicating a slight decline in average performance. The confidence intervals suggest that while the overall consistency in performance has improved slightly, there is more variability within certain grades (notably "D" and "E") in 2024. This could be due to a variety of factors, such as changes in exam difficulty, student preparedness, or other external factors affecting performance. Further analysis would be needed to identify the specific causes.

3. The statistical analysis highlights that while the performance at the highest grade ("A") remained consistent ($p = 0.5232$), there were significant changes in performance for grades "B", "C", "D" ($p < 0.0012$), and "E" ($p < 0.0011$). The overall student performance also saw significant differences between 2023 and 2024 ($p < 0.0011$). This could be indicative of various factors influencing student outcomes, such as changes in curriculum, teaching methods, or student engagement.

4. In both years, there are statistically significant correlations between KROK-2 results and both discipline scores ($p < 0.001$) and everyday current control scores. However, the strength of these correlations (R) is higher in 2024 (0.423-0.427) compared to 2023 (0.252-0.325). This suggests that in 2024, both discipline scores and everyday current control scores were better predictors of KROK-2 results compared to 2023.

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Authors

Andrii BORYSENKO

*DM, Bogomolets National Medical University,
Kyiv, Ukraine*

ORCID: <https://orcid.org/0000-0002-0211-607X>

E-mail: Andrey-b.07@ukr.net

Anna ANTONENKO

*DM, Bogomolets National Medical University,
Kyiv, Ukraine*

ORCID: <https://orcid.org/0000-0001-9665-0646>

E-mail: antonenko1985@ukr.net

Mykola KONDRATIUK

*PhD, Bogomolets National Medical University,
Kyiv, Ukraine*

ORCID: <https://orcid.org/0000-0001-5500-6352>

E-mail: kondratiuk.nikolas@gmail.com

Vasyl BARDOV

*DM, Bogomolets National Medical University,
Kyiv, Ukraine*

ORCID: <https://orcid.org/0000-0002-9846-318X>

E-mail: Andrey-b.07@ukr.net

Oksana PARFIONOVA

*PhD, Bogomolets National Medical University,
Kyiv, Ukraine*

E-mail: Andrey-b.07@ukr.net

Abstracts

АНДРІЙ БОРИСЕНКО, АННА АНТОНЕНКО, МИКОЛА КОНДРАТЮК, ВАСИЛЬ БАРДОВ, ОКСАНА ПАРФЬОНОВА. **Роль поточної академічної успішності студентів-медиків у підготовці до фінального іспиту: досвід викладання дисципліни "Гігієна та екологія".** Поточна академічна успішність відіграє важливу роль у підготовці студентів-медиків до фінальних іспитів. Високі досягнення під час навчання є важливим предиктором успіху на ліцензійному іспиті КРОК-2, який оцінює професійні компетенції. Проте війна в Україні створила значні виклики для освітнього середовища, зокрема у сфері медичної освіти, порушуючи процеси навчання та викладання.

Мета цього дослідження полягала в аналізі успішності складання іспиту КРОК-2 іноземними студентами-медиками як засобу підвищення ефективності освітнього процесу в університетах.

Матеріали та методи. У дослідженні проаналізовано академічну успішність студентів 6-го курсу спеціальності "Медицина" в 2023 і 2024 навчальних роках. Результати субтесту "Гігієна та організація охорони здоров'я" у складі КРОК-2 порівнювалися з оцінками з дисципліни "Гігієна та екологія".

Результати та обговорення. Аналіз виявив суттєві зміни у розподілі оцінок між 2023 і 2024 роками. Частка студентів з вищими оцінками ("B" і "C") зросла, тоді як кількість студентів із нижчими оцінками ("D" і "E") зменшилася. У 2024 році значно зросла кількість студентів, які склали КРОК-2 (252 проти 112 у 2023 році). Водночас середні бали у 2024 році були загалом нижчими, що свідчить про потенційні труднощі в адаптації до умов воєнного часу. Статистичний аналіз показав позитивну кореляцію між результатами КРОК-2, оцінками з дисципліни та поточними контрольними завданнями. У 2024 році сила кореляції була вищою, що свідчить про більшу ефективність поточної академічної успішності як предиктора успіху в іспиті.

Висновки. Спостерігається позитивна тенденція в успішності студентів із зростанням частки вищих оцінок ("A," "B," "C") та зменшенням частки нижчих ("D" і "E") у 2024 році. Незважаючи на збільшення кількості студентів, які склали КРОК-2, середній бал у 2024 році знизився, що вимагає додаткового аналізу впливових факторів. Сильна кореляція між результатами КРОК-2 та поточними оцінками підкреслює важливість регулярного навчання та контролю. Зусилля мають бути спрямовані на покращення підготовки студентів із нижчими оцінками ("C," "D," "E") для підвищення загальних результатів навчання.

Ключові слова: медична освіта, іноземні студенти, оптимізація освіти, стратегії навчання, мотивація студентів.

ANDRII BORYSENKO, ANNA ANTONENKO, MYKOLA KONDRATIUK, VASYL BARDOV, OKSANA PARFIONOVA. **Rola bieżących wyników akademickich studentów medycyny w przygotowaniach do egzaminu końcowego: doświadczenie w nauczaniu przedmiotu "Higiena i Ekologia".** Bieżące wyniki akademickie odgrywają istotną rolę w przygotowaniu studentów medycyny do egzaminów końcowych. Wysokie osiągnięcia w trakcie nauki są ważnym predyktorem sukcesu na egzaminie licencyjnym KROK-2, który ocenia kompetencje zawodowe. Jednak wojna w Ukrainie przyniosła znaczące wyzwania dla środowiska edukacyjnego, zwłaszcza w zakresie edukacji medycznej, zakłócając procesy nauczania i uczenia się.

Celem badania była analiza wyników egzaminu KROK-2 wśród studentów zagranicznych jako narzędzia do poprawy efektywności procesu edukacyjnego na uniwersytetach.

Materiały i metody. W badaniu przeanalizowano wyniki akademickie studentów 6. roku kierunku "Medycyna" w latach akademickich 2023-2024. Wyniki subtestu „Higiena i organizacja ochrony zdrowia” w egzaminie KROK-2 porównano z ocenami z przedmiotu „Higiena i ekologia”.

Wyniki i omówienie. Analiza wykazała istotne zmiany w rozkładzie ocen między rokiem 2023 a 2024. Wzrosła liczba studentów osiągających wyższe oceny („B” i „C”), podczas gdy liczba studentów z niższymi ocenami („D” i „E”) spadła. W 2024 roku znacznie wzrosła liczba studentów przystępujących do egzaminu KROK-2 (252 w porównaniu do 112 w 2023 roku). Jednocześnie średnie wyniki w 2024 roku były ogólnie niższe niż w 2023 roku, co wskazuje na potencjalne trudności w adaptacji do warunków wojennych. Analiza statystyczna wykazała pozytywną korelację między wynikami KROK-2, ocenami z przedmiotu oraz bieżącymi kontrolami wiedzy. W 2024 roku siła korelacji była wyższa, co sugeruje większą skuteczność bieżących wyników akademickich jako predyktora sukcesu na egzaminie.

Wnioski. Obserwuje się pozytywną tendencję w wynikach studentów ze wzrostem liczby wyższych ocen („A,” „B,” „C”) i spadkiem liczby niższych („D” i „E”) w 2024 roku. Pomimo wzrostu liczby studentów przystępujących do egzaminu KROK-2, średnia ocen w 2024 roku była niższa, co wymaga dalszej analizy czynników wpływających na ten wynik. Silna korelacja między wynikami KROK-2 a bieżącymi wynikami akademickimi podkreśla znaczenie regularnej nauki i kontroli. Należy skoncentrować działania na wsparciu przygotowania studentów z niższymi ocenami („C,” „D,” „E”) w celu poprawy ogólnych wyników kształcenia.

Słowa kluczowe: edukacja medyczna, studenci zagraniczni, optymalizacja edukacji, strategie nauki, motywacja studentów.