

Current performance as an indicator of the foreign students' KROK-2 license examination results

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ABSTRACT

Aim: The aim of the work is to comprehensively assess the impact of indicators of current success of foreign students on the results of passing the licensing exam KROK-2 and its component - the subtest "Hygiene, Public Health".

Materials and Methods: A single-center retrospective quantitative study was conducted, during which a dataset of foreign students (n=70) with depersonalized records of current performance for the 3rd and 6th years, ECTS scales, traditional grades, the final result of KROK-2 and the subtest "Hygiene, Public Health" (2025) was analyzed. Data processing and modeling were carried out in the Python.

Results: Current success in the 6th year is statistically related to the result of KROK-2, but explains a limited proportion of the variation in the result ($R^2 \approx 0.13$-0.21). Indicators of the 3rd year provide moderate incremental value; the most informative is PC_3% (independent association in the extended model). ECTS (6th year) acts as a suitable risk stratifier: categories D/E are associated with a decrease in the expected result from STEP-2 by approximately 11 percentage points compared to the reference C. Traditional assessments have a clear linear gradient: in the 6th year ≈+8.9 p.p./point, in the 3rd year – ≈+7.3 p.p./point.

Conclusions: The Hygiene, Public health subtest is poorly predicted by overall grades in the 6th year of study, highlighting the need for subject-specific interventions. Multicollinearity between components of the 6th year current control is high; the use of robust and regularized approaches (HC3, PCA/PC1, Ridge, residualization) confirmed the robustness of key findings under alternative specifications.

KEY WORDS: KROK-2, targeted training, hygienic disease prevention

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INTRODUCTION

In the context of European integration and globalization of medical education, Ukraine occupies a prominent place in the educational market and consistently attracts foreign students to study in domestic medical higher education institutions (HEIs) [9]. At the same time, the full-scale war and the consequences of the pandemic have posed unprecedented challenges to the continuity and quality of training, the organization of the practical component, and the adaptation of international applicants to the changed educational environment [2,5,6,8,11-13,16]. Under these conditions, standardized quality indicators, primarily the licensed integrated exams KROK, which are mandatory elements of state certification and tools for external control of educational achievements, acquire special importance [14,15].

International and local studies emphasize the role of formative assessment, systematic educational work, and feedback as factors that increase students' readiness for final exams [1,3,4]. Current academic performance (weekly/module assessments, semester summaries), its aggregated representations (traditional grades, ECTS scale), and disciplinary results can serve as early risk markers and practical guidelines for mentoring interventions even before the KROK-2 is compiled. For international students who simultaneously overcome language, cultural, and organizational barriers, these markers acquire additional weight as indicators of successful academic adaptation [6,10].

The disciplines "Hygiene and Ecology" and "Hygienic Prevention of Diseases" play a key role in the formation of preventive thinking of a future doctor, which is especially relevant given the significant proportion of diseases associated with behavioral and environmental factors [7]. Along with the transition to mixed formats and distance learning technologies, there is a need to empirically verify the extent to which current learning indicators (for the 3rd and 6th years), ECTS scales and traditional assessments are associated with the results of the "Hygiene, Public Health" subtest and the result of KROK-2 in real wartime conditions [8,11–13,16]. That is why the analysis of departmental data on foreign students, combining descriptive statistics, correlations and regression modeling, is timely and practically significant for improving intra-course monitoring, targeted support and planning of preparation for the licensing exam [14,15].

AIM

The purpose of the work is to comprehensively assess the impact of current performance indicators of foreign students on the results of the KROK-2 licensing exam and its component - the "Hygiene, Public Health" subtest, and on this basis to offer practical guidelines for early risk identification and targeted training.

MATERIALS AND METHODS

A single-center retrospective quantitative study was conducted, during which a dataset of foreign students (n=70, only those students who studied continuously and were in the 3rd year in 2021/2022 academic year and in the 6th year in 2024/2025 academic year) with depersonalized records of current performance for the 3rd and 6th years, ECTS scales, traditional grades, the final result of KROK-2 and the subtest "Hygiene, Public Health" (2025) was analyzed. The results of KROK-2 (KROK_2) and the subtest "Hygiene, Public Health " (H_PH) are presented in percentages; current performance assessments (0-80) (CPA_3 and CPA_6), final control (0-120) (FC_3 and FC_6), overall result for disciplines (0-200) (D_3 and D_6) were in points; the ECTS scale was reflected by categorical variables in the form of letter designations "A", "B", "C", "D", "E", "F" and "FX"; interpretation of traditional assessment (T_O_3 and T_O_6) - in a five-point scale.

To unify the scales, the point scores were converted into percentages: scores for current study / 80×100 (CPA_3_% and CPA _6_%); scores for final control / 120×100 (FC_3_% and FC_6_%); score for discipline / 200×100 (D_3_% and D_6_%). ECTS were coded as dummy variables (reference – "C") and additionally as an ordinal variable (A=5 … E=1) for ranked tests. Traditional scores were considered as a numerical variable for a linear trend.

To control the quality of manually entered data, identify omissions, and check the robustness of conclusions to possible errors, we conducted a sensitivity analysis of the consistency of the integral assessment of the discipline. First, the consistency of the assessments in each course $\Delta = D - (CPA + FC)$ was checked, and then the results of the models were compared in three specifications: (1) Original – using the original value of D, (2) Recomputed – replacing D with the arithmetic sum of CPA + FC, (3) Drop(|Δ|>1) – excluding records where the absolute deviation exceeded 1 point (the threshold value was chosen taking into account the typical "graininess" of the assessment and possible rounding). Comparison of the β coefficients, their HC3-robust errors, R^2, and p-values between these three approaches allowed us to assess whether the key associations (in particular D_% → KROK_2) persist regardless of the source of potential data inconsistency. The stability of estimates across all scenarios is interpreted as the robustness of the results to inconsistencies in the construction of the variable D.

The primary characterization of continuous variables was carried out using descriptive statistics methods with the presentation of the mean, standard deviation and 95% confidence intervals calculated by the t-method. Linear relationships between indicators were assessed using Pearson correlation, and rank or potentially insensitive to deviations from normality - Spearman correlations. The associations of the STEP_2 result with the current indicators of the 6th and 3rd years, as well as with the results of the H_PH, were analyzed separately, which allowed comparing the general and subject-specific success profiles.

To quantify the contribution of predictors to the variation in KROK_2, ordinary least squares (OLS) models were used using HC3-robust standard errors, which ensures the correctness of inference under conditions of potential heteroscedasticity and deviations from normality of residuals. The report provided unbiased estimates of coefficients (β), p-values, as well as coefficients of determination R^2 and adjusted R^2, which characterize the explanatory power of the models taking into account their complexity.

1) Basic model (A):
2) Aggregated model (B):
3) Advanced (Basic model + CPA_3 та FC_3):

The added value of the 3rd year was assessed by an F-test comparing nested models (Extended vs Basic) on the same subsample.

4) Basic model "3rd year only":

To assess the role of ECTS (3rd and 6th years), we combined three approaches that reflect different aspects of the relationship. First, the ordinal (monotonic) relationship was determined by the Spearman coefficient, having previously coded the categories as A=5 … E=1. Second, to test for between-group differences without assuming normality, the Kruskal-Wallis test was used. Third, for quantitative interpretation, OLS models were created with dam-predictors for levels A, B, D, E (reference – C), where the coefficient estimates are interpreted as absolute differences in the mean KROK-2 (in percentage points) relative to category C. All linear models were reported with HC3-robust standard errors, which increases the correctness of the inference in the presence of potential heteroscedasticity; additionally, 95% CI (confidence interval) and two-sided p-values (α=0.05) were given. Particular emphasis is placed on practically significant thresholds – primarily categories D/E as indicators of reduced expected results.

The impact of traditional grades (5-point scale; 3rd and 6th years) was analyzed in two complementary planes. The main quantitative assessment was provided using an OLS model with a linear trend, where the slope (β) is interpreted as a change in KROK_2 in percentage points for each +1 point of the traditional grade; robustness was provided by HC3-SE, 95% CI and p were reported. Spearman correlation (rank relationship) and Kruskal-Wallis test (comparison of distributions between discrete levels of 2–5 points) were used as a non-functional check of the linearity assumption and to confirm monotonicity. This combination allows to identify both a general trend (linear effect) and non-linear deviations or asymmetries between individual assessment categories.

The correctness of the inference in the regression models was checked using a standard battery of diagnostics. The normality of the distribution of the residuals of each OLS model was assessed using the Shapiro–Wilk test with accompanying visualization on QQ plots; for the basic variables, the Shapiro–Wilk and D'Agostino–Pearson tests were additionally used. Homoscedasticity was checked using the Broisch–Pagan test; in case of deviations or doubts about the fulfillment of the assumptions, further inference was performed based on HC3-robust standard errors (with presentation of β-coefficients, 95% CI and p-values).

Multicollinearity between predictors was assessed comprehensively: by VIF (interpreting values >10 as high), pairwise correlations and condition number of the design matrix. Given the significant correlation between the components of the current success of the 6th year (CPA_6%, FC_6%), a number of robust checks were performed: (I) construction of the PCA composite PC1 as a "general index of current success" to avoid instability of estimates in multidimensional space; (II) use of RidgeCV on standardized predictors as a sensitivity analysis to strong collinearity (with selection of the socialization parameter by cross-validation). Additionally, to separate the unique contribution of indicators, residualization was used (the effect of FC_6% on CPA_6%) and the results were interpreted together with partial R^2 indicators and standardized β-scores. The combination of these procedures ensured the consistency of conclusions under different model specifications and increased their methodological robustness.

All statistical tests were performed two-sided at a significance level of $\alpha = 0.05$. Given the identified non-normality of the distribution of residuals and potential heterogeneity of variances in key models, inference was performed based on HC3-robust standard errors, which ensures the correctness of the estimation of p-values and confidence intervals for deviations from classical OLS assumptions.

Data processing and modeling were performed in Python (Google Colab / locally) using pandas, numpy, scipy, statsmodels (OLS, HC3, diagnostic tests), scikit-learn (PCA, RidgeCV) and matplotlib for visualization. For reproducibility, all summary tables (descriptive statistics, correlation matrices, coefficient estimates, VIF, sensitivity analysis and diagnostic results).

RESULTS

The analysis included 70 6th-year foreign students. The generalized characteristics (%, 95% CI) showed the following average values: CPA_6% – 72.39 (70.61-74.17), FC_6% – 72.45 (70.77-74.13), D_6% – 72.41 (70.68-74.13), H_PH – 78.01 (75.00-81.02), KROK_2 – 80.28 (77.10-83.46). The obtained confidence intervals indicate moderate variability of indicators and relative homogeneity of the sample in terms of success results. Checking the internal consistency of the variable D with its components (CPA+FC) revealed only single deviations (maximum $|\Delta|$=3-4 points), which were not systemic. To control for the possible impact of these biases on the association estimates, the results were further tested within a sensitivity analysis with alternative specifications.

Complex correlation analysis showed that the closest relationship with the result of KROK_2 has the subject-specific indicator H_PH (Pearson $r = 0.809$; Spearman $r = 0.789$), which is consistent with the concept of convergent validity between the integrated result and the profile subtest. Among the indicators of success of the 6th year, moderate linear associations with KROK_2 were found: for CPA_6% $r = 0.367$, D_6% $r = 0.358$ and FC_6% $r = 0.334$. For the 3rd year, a moderate relationship was established between D_3% and KROK_2 ($r = 0.334$), which indicates the informativeness of early indicators for indicative screening. At the same time, the internal correlations between the components of the current success of the 6th year were extremely high (r(CPA_6%, FC_6%)≈0.98), which indicates significant multicollinearity and necessitates careful interpretation of multifactor models and the use of robust/collinearity-resistant approaches in further analysis.

In the basic model (Model A) KROK_2 = 38.08 + 1.54·CPA_6% - 0.95·FC_6%, R^2=0.147 (adjusted 0.122) was obtained; according to HC3 errors, the model is generally significant (p=0.041), the contribution of CPA_6% has the character of a threshold trend (β=1.54; p=0.054), while FC_6% does not reach significance (p=0.211). Diagnostics indicate pronounced multicollinearity between predictors (VIF≈21 for both); the residuals deviate from normality (Shapiro–Wilk p<0.001), and the test for homoscedasticity is borderline (Broisch-Pagan test p≈0.08). Partial contributions confirm the dominance of CPA_6% (partial R^2=0.035) over FC_6% (0.012).

The aggregated model (Model B) KROK_2 = 32.49 + 0.66·D_6 % gives R^2=0.128 (adjusted 0.115), with a statistically significant coefficient for D_6% for HC3 (p=0.024), which supports the presence of a linear association of the integral success indicator with the exam result.

The extended model (6th+3rd years) KROK_2 = 14.84 + 1.46·CPA_6% - 0.91·FC_6% + 0.11·CPA_3% + 0.32F_3% improves the explanatory power to R^2=0.213 (adjusted 0.164); while FC_3% retains an independent and statistically significant association (β=0.32; p=0.001 by HC3), while the effects of the 6th year indicators decrease (for CPA_6% p=0.053; for FC_6% p=0.202). Comparison of nested models (Extended vs Basic) on the same subsample shows a trend towards incremental predictive value of the 3rd year indicators (F=2.709; p=0.074).

The "3rd year only" model KROK_2 = 40.57 + 0.29·CPA_3 % + 0.35·FC_3% demonstrates R^2=0.116 (adjusted 0.089); for HC3, FC_3% remains statistically significant (p<0.001), while CPA_3% is on the verge of significance (p≈0.057). Taken together, the results indicate that 6th year indicators are related to KROK_2, however, adding information for 3rd year (primarily FC_3%) provides a moderate increase in explainability against the background of high collinearity between the components of current 6th year success.

Analysis of ECTS scales showed a monotonic relationship with the KROK-2 score in the 6th year (Spearman r=0.270; p=0.024). In the linear model with dami-coding (reference – C), categories D and E were associated with significantly lower KROK-2 scores (β≈-10.87; p=0.009 and β≈-11.99; p=0.020, respectively), with a cumulative explanatory power of R^2≈0.157; however, A/B did not differ from C at a statistically significant level. For the 3rd year, the ordinal relationship was weaker (Spearman r=0.245; p=0.041) and corresponded to the low explanatory power in OLS (R^2≈0.071). Therefore, ECTS 6th year provides a practically useful risk stratification, where categories D/E can be considered as threshold indicators of reduced expected KROK-2 outcomes.

Traditional assessments demonstrated a clear linear trend: in the 6th year, each additional point corresponded to an increase of ≈+8.91 pp (percentage points) in the KROK-2 (p=0.0013; R^2=0.142), while in the 3rd year – ≈+7.32 pp/point (p=0.039; R^2=0.061). Nonparametric tests (Spearman, Kruskal-Wallis) confirmed the monotonicity and consistency of these findings. Taken together, this suggests that aggregated learning indicators (ECTS, 5-point scale) are convenient for interpretation and can serve as operational thresholds for early identification of students at risk before taking the STEP-2.

In models with HC3-robust errors, the basic specification H_PH ≈ CPA_6% + FC_6% demonstrated low predictive power (adjusted R^2≈0.03), and the predictor coefficients did not reach statistical significance. Adding ECTS_6 did not provide a noticeable increase in model quality, while including T_O_6 gave only a threshold effect (adjusted R^2≈0.06; p≈0.05 for traditional assessment). The full model with simultaneous consideration of ECTS_6 and T_O_6 retained a low level of predictive power (adjusted R^2≈0.058), which is consistent with the conclusion about the limited predictive power of generalized course metrics for this subtest. The results obtained indicate that H_PH is more sensitive to subject-specific training (targeted training in the hygienic direction, practicing test strategies, language component) and requires targeted educational interventions, and not just increasing general indicators of current success.

In order to check the robustness of the conclusions to possible errors in calculating the integral assessment of the discipline, three scenarios were compared: Original (initial D), Recomputed (replacing D with the arithmetic sum of CPA+FC) and Drop(|Δ|>1) (exclusion of records with absolute deviation |Δ|=|D-(CPA+FC)|>1). For the 6th year, the correlations with KROK _2 remained close: r≈0.358 (Original), 0.350 (Recomputed) and 0.278 (Drop|Δ|>1); for the 3rd year, r≈0.334/0.335/0.339, respectively. Thus, the qualitative conclusions did not change regardless of the method of constructing the variable, which indicates the robustness of the obtained associations; the moderate decrease in r in the 6th year dropout scenario is mainly due to a decrease in the sample size (n) rather than a systemic change in the relationship. In practice, this means that small differences in accounting for D do not distort the interpretation of the dependence on KROK_2.

Extremely high multicollinearity was recorded between the predictors of the current control of the 6th year: the pairwise correlation of CPA_6%-FC_6 % is r=0.976, and VIF ≈ 21 for both variables, which theoretically causes inflation of standard errors and instability of estimates in multivariate OLS models. The use of

PCA with the construction of the PC1 composite (as a "generalized index of current success") gave $R^2 \approx 0.125$; p=0.023 in the model KROK_2 ≈ FC1, confirming the presence of an integral relationship between total academic success and exam result. Additionally, RidgeCV on standardized predictors (optimal regularization parameter α≈178) stabilized the weights and retained positive coefficients for both components CPA_6, FC_6), which is consistent with the expected common direction of effects. Residualization analysis (projection of FC_6% onto CPA_6%) showed that the unique contribution of CPA_6% remains statistically significant (p=0.018), while the unique effect of FC_6% does not reach significance, a result that conceptually reproduces the findings of multivariate modeling with HC3 errors. Taken together, these approaches confirm that under conditions of strong collinearity, the interpretation of individual β-coefficients requires caution, and instead the use of aggregated indicators (such as D_6 % or PC1) and regularized/robust methods are justified for stable assessment of predictive relationships.

DISCUSSION

The results show that the indicators of the current control of the 6th year are statistically related to the result of the KROK-2, but explain a limited proportion of the variation of the result ($R^2 \approx 0.13–0.21$). The addition of indicators of the 3rd year, primarily FC_3%, provides a threshold/moderate incremental predictive value, which makes them relevant for early screening. The ECTS_6 scale provides a practically useful stratification: categories D/E are associated with a decrease in the expected KROK-2 by approximately 11 points, while traditional assessments give an interpreted linear gradient (≈+9 points for each point in the 6th year). At the same time, H_PH is poorly predicted by generalized assessments, which emphasizes the need for subject-oriented educational interventions. The high collinearity found between the components of current 6th year performance requires caution when interpreting individual coefficients; however, the use of robust approaches (HC3, PCA, Ridge, residualization) confirmed the stability of key findings under different specifications.

Our results confirm the hypothesis of the connection between current success and the result of the licensing exam, but at the same time indicate its limited scale. The explanatory power of the models based on the 6th year grades was low ($R^2 \approx 0.13–0.21$), which is consistent with the idea of the multifactorial nature of the KROK-2 results: in addition to academic scores, it is influenced by language competence, test strategies, interdisciplinary integration of knowledge and contextual factors of learning. High convergent validity with H_PH (r≈0.81) indicates that subject-specific indicators can better reflect readiness for individual components of the exam than aggregated indicators of success indicators.

An important practical conclusion is the role of ECTS and traditional grades as convenient "threshold" indicators. D/E categories in the 6th year were associated with a decrease in expected KROK-2 by approximately 11 points, and each additional point on the 5-point scale corresponded to an increase of ≈9 points. This creates operational guidelines for early identification of at-risk groups and targeting of mentoring interventions, which is consistent with the literature on the effectiveness of formative assessment and timely feedback. [1, 4].

Adding 3rd year data provided a threshold/moderate incremental benefit (primarily FC_3%), i.e. early academic performance already signals future performance, although it does not dominate 6th year metrics. This supports the use of screening in junior years for preventive support: systemic consultations, test strategy training, individual preparation plans.

At the same time, the models for H_PH showed low explainability even after adding ECTS and traditional grades. This reinforces the thesis that subject-oriented measures are needed to improve the subtest results: work with typical errors, training in hygiene disciplines, language support and regular short knowledge sections with detailed feedback.

A significant methodological challenge was multicollinearity between components of the current 6th year control (r≈0.98; VIF≈21). The use of HC3-robust errors, PCA-composite (PC1), regularization (RidgeCV) and residualization confirmed the robustness of the key findings, but reminded us to be cautious in interpreting individual β-coefficients. In such situations, it is advisable to focus on aggregated indicators (e.g., D or PC1) and on the consistency of results across multiple specifications, rather than on the target importance of individual predictors.

Sensitivity analysis of the consistency of D = CPA + FC showed the stability of the findings under different scenarios (Original / Recomputed / Drop|Δ|>1), and the decrease in correlation after dropout is explained by the reduction of the sample. This reduces the risk of systematic distortion due to small discrepancies in scoring.

Limitations of the study include a single-center retrospective design and a relatively small sample size (n=70), which limits generalizability. Diagnostics revealed deviations from normality of residuals and marginal homoscedasticity; we minimized their impact by HC3 estimation, but causal inferences remain limited.

Also, extraneous variables (English language proficiency, participation in additional preparatory courses, attendance/absence in classes, self-study time) that potentially explain some of the unaccounted variation were not taken into account.

Practical implications: (1) implement regular subject-specific training to improve H_PH results; (2) use ECTS D/E thresholds and the gradient of traditional grades to prioritize support; (3) monitor early indicators (especially FC_3%) as a trigger for mentoring activities; (4) favor aggregated or regularized models in reporting and internal monitoring.

Directions for further research: multicenter validation on larger cohorts; expansion of predictors (language level, attendance, time on the educational platform, practical OSCE metrics); analysis of tests to identify their complexity; comparison of alternative models (ordinal regression for ECTS, gradient boosting with cross-validation) with an emphasis on reproducibility and practical interpretability.

Overall, the results support the role of ongoing monitoring as a useful, but not exhaustive, indicator of success in KROK-2 and highlight the need to combine general academic metrics with targeted subject-specific interventions and a broader set of predictors of learning behavior. This opens the way for more personalized training trajectories and for systematic optimization of the educational process in the department.

CONCLUSIONS

Current performance in the 6th year is statistically related to the KROK-2 score, but explains a limited proportion of the variation in the result (R^2≈0.13-0.21).

The 3rd year indicators provide moderate incremental value; the most informative is the FC_3% (independent association in the extended model).

ECTS (6th year) acts as a suitable risk stratifier: categories D/E are associated with a decrease in the expected result from KROK-2 by approximately 11 percentage points compared to the reference C.

Traditional grades have a clear linear gradient: in the 6th year ≈+8.9 p.p./point, in the 3rd year – ≈+7.3 p.p./point.

The subtest "Hygiene, Public health" is weakly predicted by the overall grades in the 6th year of study, which emphasizes the need for subject-oriented interventions.

Multicollinearity between components of the 6th year current control is high; the use of robust and regularized approaches (HC3, PCA/PC1, Ridge, residualization) confirmed the robustness of key findings under alternative specifications.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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