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A Regression and Path Analysis of the Influence of Entrance Exams and Academic Performance on Medical Students

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Abstract

Introduction: Entrance examinations to medical school are fundamental instruments because they objectively identify applicants with the highest probability of academic success during the first year, by assessing disciplinary knowledge, cognitive skills, and critical reasoning necessary to face the complexity of biomedical sciences.

Objective: To evaluate the predictive capacity of the entrance exam, high school grade point average, and preparatory course on first-year academic performance in medical students.

Methodology: Observational retrospective cohort study with 321 students from the 2022 and 2025 cohorts. Hierarchical regression and path analysis using structural equation modeling were applied.

Results: The model explained 19.4% of the performance variance. EXANI II Ceneval (β=.242), Histology (β=.239), and high school (β=.181) showed significant direct effects. High school exerted an indirect effect through Histology (β=.041).

Conclusions: The entrance exam and the preparatory course are the most robust predictors of initial academic success in medicine.

Introduction

The fundamental purpose of higher education institutions is to train qualified professionals, a process in which university success derives from complex interactions such as study habits and academic performance.[1] In this context, universities select the best students through entrance exams that serve as tools to identify candidates based on their admission profile.[2] Getting these selection processes right is imperative to ensure educational quality, which must result from the analysis of different dimensions and fundamental axes within the school system. For this reason, educational research has focused on finding admission procedures that not only assess general intelligence but also verbal, numerical, and analytical skills. The selection of students should be based on criteria that ensure graduates' greater ability to perform tasks related to their profession optimally and efficiently.[3] The optimization of admission systems is therefore crucial to ensuring the excellence and relevance of medical training.

The first year of a medical degree often determines a student's academic progress and their continued enrollment in the university system.[4] Several international studies indicate that the average grade obtained in secondary education is a relevant predictor of future academic performance.[5] However, in other contexts, the general knowledge exam is the only significant predictor of the overall average.[6] There is a positive and considerable correlation between high school academic performance and the average achieved in the initial semesters.[7] Even so, the predictive validity of these indicators may vary depending on the heterogeneity of the high schools of origin.[6] Identifying variables for success from the moment of admission allows for the implementation of effective institutional support strategies.

Another dimension evaluated is mathematical ability, which stands out as applied knowledge used to solve real-life problems through logical and quantitative reasoning.[8,9] However, it has been observed that many new students have a low level in this area, which is often the responsibility of the instruction received in high school.[10] On the other hand, proficiency in English is an essential and priority skill for accessing better opportunities and scientific literature in a globalized world.[11] Likewise, the results of institutional diagnostic exams show a direct relationship with performance in biomedical subjects such as Anatomy and Biochemistry.[4] It has been documented that admission tests tend to predict academic success more accurately in the basic cycle.[7] However, these assessments must be reviewed periodically to adjust their weightings according to actual observed performance.[5] Analysis of these variables allows for the scientific modeling of the ideal admission profile.

Non-academic factors, such as personality traits and vocational interviews, tend to show little or no predictive power.[12] In contrast, results obtained in preparatory courses prior to formal admission show a higher correlation with academic performance.[13] It is essential to consider that the academic index achieved in upper secondary education is one of the most reliable indicators for predicting university performance and success in a medical career.[14,15] Various studies maintain that standardized aptitude tests and state exam results accurately measure the effectiveness of previous school preparation, explaining a significant proportion of the variation in future academic performance.[16,17] Therefore, the academic performance of medical students is considered a predictable outcome when previous educational grades and admission scores are correctly analyzed.[18] On the other hand, mental health and the presence of psychopathology can selectively affect performance in high-demand subjects.[6] Discarding instruments with low predictive validity is essential to improve terminal efficiency.

Academic performance is a vital indicator for measuring the quality and relevance of work in educational institutions. Success in training surgeon's results from complex interactions that include study habits and comprehensive prior knowledge.[19] This article aims to evaluate the predictive capacity of various variables in the entrance exam for medical school.[7] It seeks to determine whether the current criteria are able to identify the students most likely to pass their first-year courses.[4] Understanding these relationships is key to reducing dropout rates and optimizing the management of university resources.[12] This study provides the empirical data needed to refine evidence-based admission mechanisms.

The evaluation of academic performance in medicine is a priority analysis to ensure the quality of professional training and the efficiency of educational institutions. A longitudinal study was conducted at Jorge Basadre Grohmann National University in Peru, which reported, using Spearman's correlation, that verbal reasoning and language are consistent predictors of academic performance,[20] concluding that standardized tests are effective tools for predicting university persistence.

It has been reported that selection tests as predictors of academic performance in medical students can identify the degree of prediction of student academic performance using the admission instruments employed by the institution. In correlational studies, the independent variables included high school GPA,

the College Board test, the EXANI-II CENEVAL test, and the results of the preparatory course, analyzing the intake cohorts for 2012 and 2013. Academic performance was defined as the average grade obtained in the first semester. The results showed that the preparatory course is the variable with the highest predictive validity in the study. This test achieved a correlation of r = 0.603 and 0.629, explaining about 40% of the variance in academic success. In contrast, high school GPA showed lower predictive capacity than the entrance exams. Selection mechanisms were significantly related to initial performance, with the preparatory course being the most robust predictor for medical students. It has been suggested that the implementation of this course should be improved and that the validity of instruments such as the EXANI-II CENEVAL should be reevaluated.[13]

According to the studies presented, the objective of this research was to test an explanatory model of the academic performance of medical students in their first year, based on entrance exams and high school grade point average.

Materials and methods

Study design

A retrospective observational cohort study of a census nature was conducted. Cohort, analytical, and retrospective longitudinal designs are collectively recognized as observational studies. In particular, cohort studies allow for the examination of incidence, causes, and prognosis. By recording events in chronological order, they offer the possibility of establishing the relationship between cause and effect more clearly.[21]

Participants

Participants in the study were applicants registered for the admission process of the Faculty of Medicine in the years 2022 and 2025 with: a) Complete data records for the variable Sex (Female/Male), b) Records with final numerical grade recorded in the database of the Preparatory Course and c) Records with numerical average recorded for the First Academic Period of the Medicine career.

Procedure description

The information was collected using two databases provided by the School Control area of the Faculty, corresponding to the 2022 and 2025 cohorts; both will incorporate sociodemographic data of applicants, grades of the Preparatory Course and Academic Performance of the First Period

Statistical analysis

Descriptive statistics

First, a descriptive analysis was performed to determine the means and standard deviations, the recommended first step for understanding the data distribution.[22] Assessing normality, both univariate (using the Anderson-Darling test) and multivariate (using the Mardia test), is important for selecting subsequent parametric statistical techniques. The Anderson-Darling test is particularly sensitive to deviations in the tails of the distribution,[23] while the Mardia test is one of the most widely used for assessing multivariate normality.[24] Identifying multivariate outliers using Mahalanobis distance (with a conservative cutoff point of $p < .001$) is common practice to ensure that these extreme observations do not distort the results of the analysis.[25]

Hierarchical Regression

Subsequently, the hierarchical regression model was used, entering variables according to their correlation with the criterion, which allowed for the evaluation of the unique contribution of each block of predictors.[26] Rigorous verification of the assumptions is fundamental for the validity of the inferences. Homoscedasticity: White's test is a general test for detecting heteroscedasticity in regression models.[27] Linearity and Independence: Evaluating linearity using residuals and using the Durbin-Watson statistic for the independence of errors are standard procedures.[26] No Multicollinearity: The use of the Variance Inflation Factor (VIF) and Tolerance is the most recommended method for diagnosing multicollinearity, with VIF values > 5–10 considered problematic (a threshold of < 2 is very conservative).[28]

Path Analysis and Structural Equation Modeling (SEM)

Finally, path analysis was performed using SEM with the maximum likelihood method, the appropriate technique for testing theoretical models with direct and indirect relationships between variables.[29] Evaluating model fit using a combination of absolute (χ^2, RMSEA, GFI), incremental (CFI, TLI), and parsimony (CMIN/DF) indices is an established practice to avoid relying on a single indicator.[30] The bootstrapping procedure with 5000 samples provides a robust method, free from normality assumptions, for testing the significance of indirect effects.[31] Finally, multigroup invariance analysis (unconstrained vs. constrained model) is the correct method for comparing the stability of the model structure across different cohorts or groups.[32]

Results

Table 1 presents the characteristics of the total sample (n = 321) of medical students, comprised of two cohorts (2022, n = 167; 2025, n = 154). The gender distribution shows a higher proportion of women (n = 191, 59.5%) than men (n = 130, 40.5%). Regarding their academic profile upon entry, the students had a high high school GPA (M = 92.00, SD = 6.73) and a score on the Ceneval entrance exam above the expected average (M = 1121.72, SD = 63.66). During the preparatory course, performance in Histology (M = 73.58, SD = 13.46) was significantly higher than in Anatomy (M = 58.61, SD = 14.57), suggesting greater difficulty or a different evaluation standard in the latter subject. This pattern is reflected in the

overall average for the first term (M = 77.79, SD = 13.13), which falls between the two preparatory averages.

Table 1
Academic variables by gender of the 2022 and 2025 cohorts

Variable	**n**	**m DE (±)**
Cohort Year		
2022	167	-
2025	154	-
Gender		
Female	191	-
Male	130	-
Average Anatomy (Propaedeutic Course)		58.61(14.57)
Average Histology (Propaedeutic Course)		73.58(13.46)
Ceneval Score		1121.72(63.66)
High School GPA		92.00(6.73)
Overall GPA (1st Semester)		77.79(13.13)

Note: Descriptive statistics are presented for the total sample (N = 321) comprised of the 2022 and 2025 cohorts. Values for categorical variables (Cohort Year and Gender) are reported as frequencies (n). For continuous academic variables, the mean (m) with its standard deviation (SD±) is reported in parentheses. EXANI II Ceneval = National Examination for Higher Education Entrance; General Average 1st Period = Cumulative average of the first academic cycle of the medical degree.

Correlational Analysis

The initial correlation analysis shown in Table 2 revealed significant associations (p = 0.001) between the overall first-year average and the variables of Ceneval (r = 0.306), high school average (r = 0.293), and histology from the preparatory course (r = 0.281). Conversely, the subjects of anatomy and biochemistry did not show significant correlations with final academic success.

Table 2
Correlation analysis

Variables	Average
Anatomy (Propaedeutic Course)	.049
Histology (Propaedeutic Course)	.281***
EXANI II CENEVAL	.306***
High School GPA	.293***
Anatomy (Semester 1)	.048
Biochemistry (Semester 1)	− .004
Notes: *** p = .001. Source: Own elaboration.	

Hierarchical Regression Model

A model was obtained with the three variables, reflecting a significant association (F = 25.51, df = 317, p = 0.001). The three predictor variables maintained significant standardized coefficients: EXANI II CENEVAL (β = 0.241, p = 0.001), histology (β = 0.238, p = 0.001), and high school GPA (β = 0.181, p = 0.001). These results indicate that the national exam and performance in the preparatory course are robust indicators of initial university performance (Table 3).

Table 3
Hierarchical regression model

Model and variables	Coefficients				95% Confidence interval	
	r^2	B	S.D.	β	p	Lower	Upper
	.194					
Constant		-27.84	13.24		.036	-53.91	-1.77
EXANI II CENEVAL		.049	.010	.241	.001	.028	.071
High School GPA		.353	.104	.181	.001	.148	.558
Histology		.232	.049	.238	.001	.134	.330

Table 4 presents the zero-order, partial, and semi-partial correlations for the three predictor variables in the final hierarchical regression model:

Zero-Order Correlations

These represent the bivariate and direct relationship between each predictor and the criterion variable, without controlling for the influence of the other variables in the model. All are positive and of moderate

and similar magnitude, with the correlation for the CENEVAL EXANI II (r = .306) being slightly the strongest. This indicates that, considered in isolation, the three variables are significantly associated with better performance.

Partial Correlations

These measure the unique relationship between each predictor and the criterion, after eliminating the influence of the other two predictor variables for both the criterion and the predictor in question. It is the correlation between the residuals of both variables. Histology (pr = .253) shows the highest partial correlation, followed very closely by the CENEVAL EXANI II (pr = .249). This suggests that, once the variance shared with the other variables is isolated, performance in Histology and on the CENEVAL EXANI II exam maintains the strongest and most unique association with final performance. The High School GPA (pr = .187), while still significant, presents a smaller unique contribution in comparison, indicating that a substantial part of its relationship with the criterion overlaps with that explained by the CENEVAL EXANI II and/or Histology.

Semi-Partial Correlations

These showed the unique and proportional contribution of each predictor to the total variance (R^2) of the criterion. It is calculated as the correlation between the criterion and the portion of the predictor that is not correlated with the other predictors. The pattern holds: Histology (sr = .250) and the CENEVAL EXANI II (sr = .238) contribute a unique and almost identical portion of variance to the total R^2 of the model (.194 or 19.4%). The High School GPA (sr = .176) contributes a single, smaller portion. To quantify its exact contribution to the R^2, each sr value is squared: EXANI II CENEVAL: $(0.238)^2 = .057$ → Contributes only ~ 5.7% to the performance variance. High School GPA: $(0.176)^2 = .031$ → Contributes only ~ 3.1%. Histology: $(0.250)^2 = .063$ → Contributes only ~ 6.3%. The sum of these single contributions (.057 + .031 + .063 = .151) does not equal the total R^2 (.194) due to shared or overlapping variance among the predictors, which represents approximately 4.3% of the explained variance.

Table 4
Correlations of the fitted regression model

Independent Variables	**Zero-order correlations r**	**Partial correlations Pr**	**Semi-partial correlations sr**
EXANI II CENEVAL	.306	.249	.238
High School GPA	.293	.187	.176
Histology	.281	.253	.250

Assumptions of the Hierarchical Regression Model

To verify the assumptions of the regression models, White's test was performed, yielding a non-significant result (4.73, p = .093), indicating homoscedasticity. Regarding linearity, a mean of standardized residuals of 0 (SD = 11.78) was obtained, suggesting that the model variables follow a

linear trend. Furthermore, the independence of cases was confirmed by obtaining a Durbin-Watson parameter of 2.15, as well as the absence of multicollinearity, as the VIF values ranged from 1.02 to 1.12.

These results provide greater certainty that the regression model performed adequately.

Path Analysis

Table 5 presents the results of an SEM path analysis model, where the direct and indirect relationships between the predictor variables EXANI II CENEVAL, High School Average and Histology and the criterion variable General Average of the first period are evaluated.

Table 5
Table of coefficients

Direct effects	
Variables	**β coefficients (95% CI)**
EXANI-II CENEVAL score → Overall GPA	.242 (CI 95% = .145, .338, *p* = .001)
High school GPA → Overall GPA	.181 (CI 95% = .044, .319, *p* = .016)
Histology grade → Overall GPA	.239 (CI 95% = .116, .362, *p* = .001)
High school GPA → Histology grade	.170 (CI 95% = .058, .281, *p* = .003)
Indirect effects	
High school GPA → Histology grade → Overall GPA	.041 (CI 95% = .006, .075, *p* = .016)
Correlations	
EXANI-II CENEVAL score and High school GPA	*r* = .294, CI 95% = .176, .412, *p* = .001
Total effects	
Variables	Coefficients
High school GPA → Histology → Overall GPA	.222 (CI 95% = .087, .357, *p* = .003)
	.464 (CI 95% = .332, .596, *p* = .001)

Regarding direct effects, these standardized coefficients show the influence of one variable on another. For example, the EXANI II CENEVAL score – overall average (β = .242, p = .001) shows that for every standard deviation increase in the EXANI II CENEVAL score, the overall average increases by 0.242 standard deviations, holding the high school average and Histology grade constant. Similarly, the high school average – overall average (β = .181, p = .016) effect shows that a one standard deviation increases in the high school average leads to a 0.181 standard deviation increase in the overall average. This is a significant effect, but smaller than the direct effects of the EXANI II CENEVAL score and Histology grade on the overall average. The following controlled effect, considering EXANI II CENEVAL and high school GPA, Histology - Overall GPA (β = .239, p = .001), shows that better performance in

Histology directly predicts a 0.239 standard deviation increase in Overall GPA. Its effect is virtually identical in magnitude to that of EXANI II CENEVAL and highly significant. Similarly, in the case of High School GPA - Histology (β = .170, p = .003), this is a pathway within the model that explains part of the variance in Histology. It indicates that students with a higher high school GPA tend to obtain significantly higher grades in Histology (β = .170), regardless of their EXANI II CENEVAL score.

For indirect effects, the influence of certain variables on a third mediating variable, such as High School GPA - Histology - Overall GPA, is shown (β = .041, p = .016). High School GPA has a positive and significant effect on Overall GPA, which is explained by better performance in Histology. That is, a portion of the benefit of having a good high school GPA on university success is due to the fact that these students tend to perform better in Histology, which in turn improves their overall GPA.

Figure 1 shows the correlations between variables such as EXANI II CENEVAL and High School GPA (r = .294, p = .001). This indicates a moderate and significant positive correlation between the score on the EXANI II CENEVAL admission exam and high school grades.

Multigroup analysis

Finally, the multigroup analysis between the 2022 and 2025 admission cohorts showed significant differences (ΔX2 = 44.628, df = 8, p=.001). This variance was specifically attributed to the effect of high school grade point average on histology, which was significant in the 2022 cohort (β = .329, p=.001) but not in the 2025 cohort (β = .024, p=.781), suggesting a modulation of the model according to the year of application.

Discussion

The results of the hierarchical regression model and path analysis confirm that academic performance in the first year of medical school is a predictable phenomenon based on a set of cognitive variables and prior knowledge. In line with the findings of Rodríguez Castro and Gómez López,[7] the EXANI II CENEVAL entrance exam emerged as one of the most robust predictors (β = .242), validating its ability to predict success in the basic cycle. Likewise, the high school grade point average maintained a significant direct effect (β = .181), although of lesser magnitude, which coincides with the literature that points to it as a reliable indicator, but whose predictive power may be attenuated by the heterogeneity of the high schools of origin.[6] These findings reinforce the need to consider both indicators in a complementary manner in admission processes, as suggested by Bastías et al.,[18] who state that university performance is a predictable outcome when previous grades and admission scores are correctly analyzed.

A particularly relevant finding of this study is the mediating role of the preparatory course, specifically the Histology subject. The results showed that performance in this subject not only has a direct effect on the overall average (β = 0.239) but also acts as an intervening variable in the relationship between high school average and subsequent academic success (indirect effect β = 0.041, p = 0.016). This result supports the position of García Domínguez,[13] who identified the preparatory course as the predictor with

the highest predictive validity, explaining about 40% of the variance in school performance. The relevance of histology over other subjects, such as anatomy, suggests that certain preparatory subjects may be evaluating study and reasoning skills that are more transferable to the formal medical curriculum, which opens the door to what Muñoz Comonfort and Fortoul[4] pointed out about the direct relationship between institutional diagnoses and performance in biomedical sciences.

The multigroup analysis revealed significant variability in the model structure between the 2022 and 2025 cohorts, specifically attributable to the loss of predictive power of the high school average on Histology in the most recent cohort. This instability could be explained by changes in students' prior education or by variations in the rigor of upper secondary school curricula, a phenomenon already noted by Vergara-Díaz and Peredo-López[5] when they pointed out the need to periodically review the weightings of admission instruments. In line with the proposal by Castaño Castrillón,[12] discarding instruments with low predictive validity and adjusting models to the changing realities of cohorts is essential to optimize terminal efficiency. This study provides empirical evidence that underscores the importance of a dynamic, data-driven admission system, where entrance exams and preparatory courses are consolidated as fundamental tools for ensuring the quality and relevance of medical training.[19]

Conclusions

This study successfully tested an explanatory model of first-year medical students' academic performance, confirming that entrance exam scores and high school grade point averages have significant predictive power. The findings show that the combination of the EXANI II CENEVAL exam score, the high school GPA, and performance in the preparatory course in histology together explains about 20% of the variance in initial academic success. This evidence supports the relevance of maintaining and refining the current admission mechanisms, as it empirically validates that standardized instruments and previous academic records are legitimate tools for identifying candidates most likely to succeed in medical training.

The predominant role of the EXANI II CENEVAL entrance exam as the most consistent individual predictor of performance in the first academic period stands out, closely followed by performance in the Histology subject within the preparatory course. This last finding is particularly important, as it positions the preparatory course not only as a leveling mechanism but also as a filter with high predictive validity that could be strengthened to optimize the selection of applicants. Likewise, the identification of the indirect effect of the high school grade point average through Histology suggests that the knowledge and study habits consolidated in upper secondary education are manifested differentially in specific subjects of the preparatory course, which function as mediators of future success.

Finally, the variability found between the 2022 and 2025 cohorts highlights the dynamic nature of the educational process and the need for higher education institutions to implement systems for continuously monitoring the predictive validity of their admission instruments. The differences observed in the effect of high school grade point average on Histology warn of possible changes in the quality and

heterogeneity of prior education, which requires periodic adjustments to selection models. Consequently, it is recommended that institutional authorities maintain an evidence-based admission policy that considers not only standardized scores but also performance in specific preparatory courses, with the ultimate goal of ensuring academic excellence and reducing dropout rates in medical school.

Declarations

Ethics approval and consent to participate

This retrospective observational cohort study was reviewed and approved by the Research Ethics Committee of the School of Medicine of Tampico “Dr. Alberto Romo Caballero” at the Universidad Autónoma de Tamaulipas, under approval number 415-2025 during its regular session held on February 24, 2026. The study was conducted in accordance with the ethical principles for medical research involving human subjects outlined in the Declaration of Helsinki of the World Medical Association (WMA) (1964), including its subsequent amendments.

In accordance with the risk-minimization principle underlying the Declaration of Helsinki, and considering that: (1) the study involved only the secondary analysis of anonymized institutional databases provided by the Academic Control Office; (2) no intervention or contact with participants occurred; (3) the retrospective nature of the study (2022 and 2025 cohorts) made it impracticable to obtain informed consent from all participants; and (4) all data were handled with strict confidentiality, ensuring that no individual participant could be identified at any stage, the institutional ethics committee granted a waiver of informed consent for this study.

The primary ethical justification for waiving consent in retrospective studies using anonymized data rests on the principle that participants are not exposed to additional risks. As argued in the bioethics literature, retrospective research using anonymized data may be ethically permissible not only because scientific advancement is valuable, but also because the subjects involved are not placed at risk of harm.[33]

Availability of data and materials. The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests. Not applicable

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Authors' contributions.

MECS. Conceived the study, designed the methodology, participated in the study design, conducted data collection, analyzed and interpreted the data, and contributed to the drafting of the manuscript.

ERB. Contributed to the drafting of the manuscript, critical revision of its content, and literature search and review.

RMVO. Contributed to the drafting of the manuscript, critical revision of its content, and literature search and review.

JEGC. Contributed to the drafting of the manuscript, critical revision of the manuscript, and review of the scientific literature.

All authors read and approved the final manuscript.

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Figures

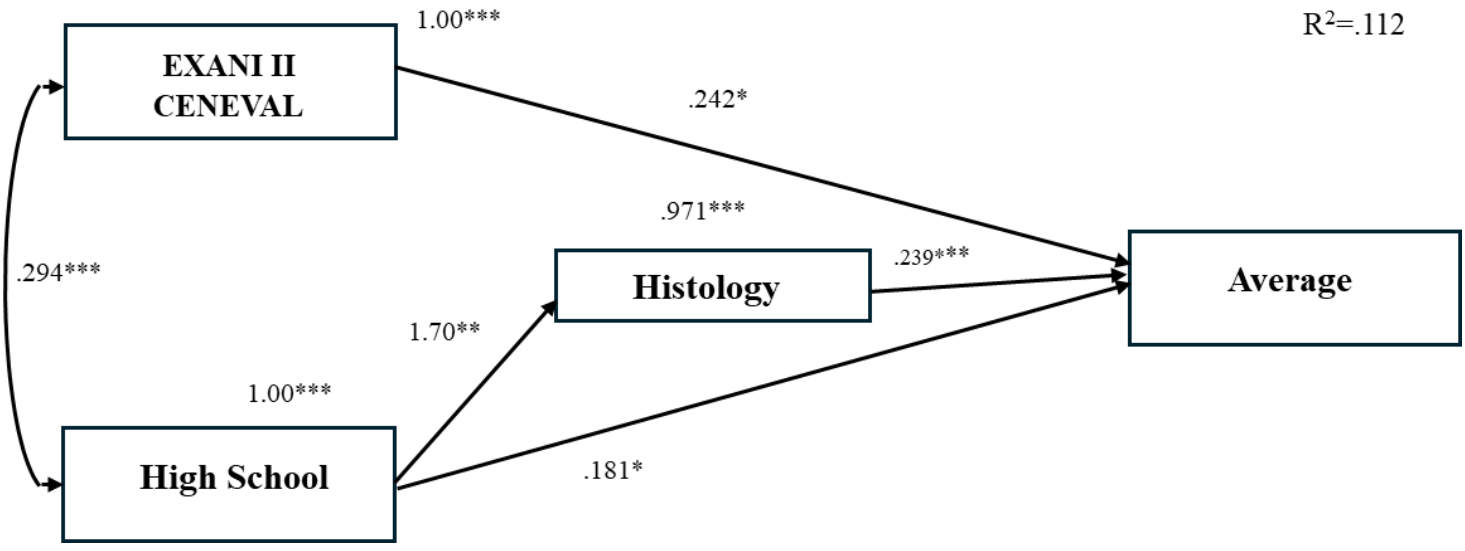


Figure 1

Analysis of the trajectory of academic performance prediction.