International Journal of Basic Sciences and Applied Computing (IJBSAC)
ISSN: 2394-367X (Online), Volume-3 Issue-6, November, 2021

Predictive Analysis of Higher-Education Graduation and Retention in Saudi Arabia using Multinomial Logistic Regression

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***Abstract*: *It is suggested that this study contributes by establishing a robust methodology for analyzing the longitudinal outcomes of higher education. The current research uses multinomial logistic regression. To the knowledge of the authors, this is the first logistic regression analysis performed at Saudi higher education institutions. The study can help decision-makers take action to improve the academic performance of at-risk students. The analyses are based on enrollment and completion data of 5,203 undergraduate students in the colleges of engineering and medicine. The observation period was extended for ten academic years from 2010 to 2020. Four outcomes were identified for students: (i) degree completion on time, (ii) degree completion with delay, (iii) dropout, and (iv) still enrolled in programs. The objectives are twofold: (i) to study the present situation by measuring graduation and retention rates with benchmarking, and (ii) to determine the effect of twelve continuous and dummy predictors (covariates) on outcomes. The present results show that the pre-admission covariates slightly affect performance in higher education programs. The results indicate that the most important indicator of graduation is the student's achievement in the first year of the program. Finally, it is highly suggested that initiatives be taken to increase graduation and retention rates and to review the admissions policy currently in place*.

Keywords: Admission policy, cohort analysis, education, logistic regression, statistics, university outcome.

I. INTRODUCTION

Graduation and retention rates, as key performance indicators, are important tools for assessing the quality of academic programs and monitoring their performance [1]. They contribute to continuous development processes and decision-making support [2]. It is expected that the academic program measures these performance indicators with benchmarking [3-6]. In addition, announcing graduation and retention rates transparently is one of the rights of the prospective higher-education students, as it helps them choose the academic program that meets their aspirations [3-5].

Manuscript received on November 01, 2021.
Revised Manuscript received on November 16, 2021.
Manuscript published on November 30, 2021.

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There are four possible outcomes for students in higher education, degree completion on time, late degree completion, dropout, and a student presumed to be a graduate but still enrolled.

On-time graduation is defined as an undergraduate student completing his bachelor's degree within minimal academic terms. Otherwise, he/she is considered to have late graduation. On the contrary, a registered student, who is retained after a minimal period and is not graduated, is considered to be enrolled. There are two academic terms per year, additional to an optional summer term. Although, the university rules allow students to finish their study within 150% of the time expected for earning a bachelor's degree as defined by the university rules under the study and examination regulations, 2018. It is worth mentioning that, according to the university rules, a student may be considered 'on-time graduation' even though he/she spend longer than the minimal academic terms. That is because the postponed and summer terms are not accounted for. Moreover, students can be allotted an additional 50% extension according to the suggestion of the college and university committees.

It is well known that students today face challenges from various sources, and many are leaving college before reaching graduation [7, 8]. According to the university rules, if a student stops studying for a term without requesting a postponement, its registration from the university will be closed. The student is considered to have dropped out of the study and is not considered to have failed if he/she did not receive his study schedule during the registration period specified in the academic calendar. However, for the mentioned two cases, the student can re-enrolled within four terms. Therefore, according to the university rules, to count a student as a dropout if he/she shows four consecutive terms without any enrollment. There are several reasons for dropping out of a program such as withdrawing and disappearing due to dislike of study, employment, low or failing grades, marriage, socio-economic reasons [8], transfer to another study field. Dropping out has many significances for both students and institutions [7]. According to the university rules, a student is considered academically dismissed in two cases, if he:

1. Gets three warnings in a row at most because his cumulative grade point average (GPA) is less than 2.0. The GPA is a result of dividing the total points obtained by the student in all courses that he/she studied during that year based on the total units prescribed for those courses.

2. Does not complete the graduation requirements within a period not exceeding half of the period determined for his graduation in addition to the minimal duration of the program.

Graduation and retention rates in higher education are a significant focus of educational research. Unfortunately, there is no published higher-education statistical data in Saudi Arabia, that can be used as national benchmarks. However, the high attrition rates on graduation and retention are a cause for concern. Commonly, first-year students are also recognized as a high risk for attrition [9]. Therefore, assessment and evaluation are considered one of the most important pillars in the processes of continuous improvement and quality assurance, which can be used to improve the quality of educational institutions and increase their outcomes [10]. It is necessary to monitor and analyze the academic performance of students in an institution in a scientific manner.

There are many challenges faced by decision-makers to increase graduation and retention rates [2, 11]. They should take the initiative to elevate higher education performance [2]. Most of the initiatives are centered around student advisory and course design and pedagogy [2, 11]. For instance, over 12 years, Florida state university, FSU, US, has managed to improve its retention rate among first-year students by 6% to be 93% [2, 3] Subsequently, FUS has improved its six-year graduation rate (e.g. two-year later after minimal four-year programs) from 68% to 80.1% and its on-time graduation rate to 68% [2, 3]. It is worth mentioning that the FSU graduation and freshmen retention rate rankings among US institutions are 300 and 207 out of 3,392, respectively [3]. Since graduation and retention rates differ according to each institution, but, the higher rate is the better. Wayne state university, US, has a 79% freshman retention rate which is 10% above the US institution average retention with the rank of 870 out of 3,392 [12]. Therefore, only 43.3% of these students had graduated six years after beginning their four-year degree [12].

On the other hand, the literature review reveals contradictions in the factors influencing students' academic achievements [8, 13]. The fact that students' characteristics are differentiated according to their study field and social influence. It is important to take an investigation regarding Saudis' society and environment. It is worth mentioning that the higher-education study is free in Saudi Arabia, on the contrary, the student is paid monthly expenses. Commonly, students apply to their hometown institutions.

In Saudi Arabia, the general secondary school (GSS) certificate is the last stage of the 12-years general education, after which students move to higher-education institutions. The academic knowledge of secondary school students qualifies them to engage in higher education [14]. Entry into engineering and medicine courses is highly competitive, with demand exceeding available places. Applicants are high performers who have already achieved exceptional results in their general secondary school. The Qiyas standardized tests, general aptitude (GAT), and specialized academic achievement (SAT) have been introduced as an additional selection parameter [15]. To be eligible for a specific program, according to the capacity and adopted admission policy at most of Saudis' universities, applicants must achieve the highest weighted average score of GSS and the two Qiyas tests.

The present research utilizes the multinomial logistic regression similar to the previous studies [16-19] to model and analyzes the outcome events of undergraduate students of engineering and medical programs of a higher-education institution in Saudi Arabia. To the knowledge of the authors, this is the first study to be conducted in Saudi institutions using logistic regression for longitudinal data. The objectives of the investigation described in this paper are twofold:

1. Statistical analysis of the cohort graduation and retention rates.
2. Correlate and analyze the effect of twelve independent variables on student retention and degree completion using multinomial logistic regression.

II. METHODOLOGY

A. Regression Models

Regression is a statistical model used to describe data and to explain the relationship between one dependent binary variable (outcome or indicator) and one or more nominal independent variables (covariates or predictors). Once one has identified how these multivariable relate to the dependent variable, one can take information about all of the independent variables and use it to make much more powerful and accurate predictions about why things are the way they are. In particular, the regression has two objectives [20, 21]:

1. Establish if there is a statistically significant relationship between dependent and independent variables.
2. Forecast new observations based on the relationship.

Linear regression which uses more than one independent variable, X_n, can be expressed as [20]:

$$E(Y|X) = \beta_0 + X_1 + \beta_2 X_2 + \cdots + \beta_n X_n \quad (1)$$

Y is a dependent variable with binary outcomes:

$$Y = \begin{cases} 1, if\ success \\ 0, if\ otherwise \end{cases}$$

Many published studies used linear regression for education applications [22-24]. However, modeling with linear regression can produce inaccurately predicted probabilities. Moreover, the logistic regression can model independently multivariable [20]. Logistic regression is preferable to linear regression for many aspects. For more information, readers are referred to the references [20, 21]. The nonlinear logistic function based on the observed sample is given by [20]:

$$E(Y|X) = \frac{e^{(\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_n X_n)}}{1+e^{(\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_n X_n)}} \quad (2)$$

However, different mathematical approaches can be implemented to estimate the values of the coefficients, β, such as maximum likelihood estimation rather than ordinary least-squares, as in linear regression. The maximum likelihood estimates of β are b. Therefore, the estimated logistic probability, Pr, can be given by [20]:

$$Pr(Y = 1|X) = Pr(1) = \frac{e^{(b_0+b_1 x_1+\cdots+b_n x_n)}}{1+e^{(b_0+b_1 x_1+\cdots+b_n x_n)}} \quad (3)$$

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The above formula can be written in linear form as:

$$ln\left(\frac{Pr(1)}{1-Pr(1)}\right) = b_0 + b_1x_1 + \cdots + b_nx_n \quad (4)$$

The term $exp(b)$ is the population-averaged effect of covariates, known as odds. The term $Pr(1)/Pr(0)$, which is called odds ratio (OR), measures the probability of success relative to the probability of failure [20]. If, for example, OR equals 2, it means the outcome when Y=1 is two times as likely as the outcome when Y=0. The higher the OR, the higher the probability that the event will occur. Ease of interpretation of OR is another feature of logistic regression over linear regression [20].

Multinomial logistic regression is used to predict the probabilities of nominal indicators, more than two outcomes. It is important for possible nominal outcomes, an outcome is chosen as the reference (baseline) and then the other outcomes are regressed against it. For instance, if there are three outcomes such as A, B, and C, and outcome A is chosen as the baseline, the multinomial logistic regressions are performed for B-A and C-A. This would proceed as follows [20]:

$$OR_{\mathrm{B-A}} = \frac{Pr(Y=B|X)}{Pr(Y=A|X)} = \frac{Pr(B)}{Pr(A)} \quad (5)$$

$$Pr(B) = OR_{\mathrm{B-A}} \times Pr(A) \quad (6)$$

Similarly,

$$Pr(C) = OR_{\mathrm{C-A}} \times Pr(A) \quad (7)$$

Since,

$$Pr(A) + OR_{\mathrm{B-A}} \times Pr(A) + OR_{\mathrm{C-A}} \times Pr(A) = 1 \quad (8)$$

Therefore,

$$Pr(A) = \frac{1}{1+OR_{\mathrm{B-A}}+OR_{\mathrm{C-A}}} \quad (9)$$

B. Longitudinal Data

Data is retrieved from the administrative archive of one of the Saudi universities (see Table 1). It consists of 4571 engineering students enrolled in thirteen academic terms from 2010 to 2015 in six departments. The data also involves 632 medicine students enrolled in five academic years from 2010 to 2014. The university archive contains some personal characteristics such as age at enrolment, gender, nationality, and place of residence and data on students' pre-university education (results of the general secondary school and Qiyas tests). Moreover, admission and university performance data is accessible.

Table 1: Configuration of the study sample.

Description	Engineering	Medicine
System	Term	Year
Minimal completion period	10 terms	6 years
Cohort	13 terms	5 years
Population size	4571	632
Admission cohort	2010 – 2015	2010 – 2014
Observation period	2010 – 2020	2010 – 2020

C. Covariates

The multivariable used in the present models include personal data, educational background, admission related, and university performance. Twelve independent variables, drawn from the student record system, are:

(i) Continuous covariates:

1. Age at enrollment,
2. GSS (general secondary school) score,
3. GAT (Qiyas general aptitude test) score,
4. SAT (Qiyas specialized academic achievement test) score,
5. GPA (grade point average) by the end of the first year at a college.

(ii) Categorical (dummy) covariates:

1. Sex (0-female, 1-male),
2. Nationality (0-Saudi, 1-others),
3. Resident (0-local, 1-others),
4. Admission type (0- regular, 1-transfer),
5. Rank of options for admission to the program (0-first, or 1-other),
6. Admission term (1-first, or 2-second),
7. Department.

The current research investigates the impact of the above variables on the following four program outcomes:

1. On-time degree completion: A student obtains the degree within a minimal period.
2. Degree completion with delay: A student obtains the degree in more than a minimal period.
3. Dropout: A student does not re-enroll.
4. Enrolled: A student is supposed to be graduated but is still enrolled.

III. SITUATION ANALYSIS

First, it is necessary to study the current status of program outcomes. Figure 1 illustrates the overall outcomes for engineering and medicine cohorts shown in Table 1. In general, medicine college performance is better than engineering college. The overall on-time graduations are 28.2% and 43.5% for engineering and medicine, respectively (Fig. 1). Moreover, Fig. 1 indicates that about a quarter of the students have earned a bachelor's degree in more than the assigned minimal period.

Excluding on-time completion, the average late completion rates with years after the minimal graduation period are shown in Fig. 2. It is obvious that for both disciplines, about two-thirds of the students have finished their degree within an extra one year (Fig. 2). Only 3-4% of the late graduates remain in the college for more than three years, Fig. 2. This segment of students is a very special case who is not motivated because they do not have the appropriate cognitive ability to study the program.

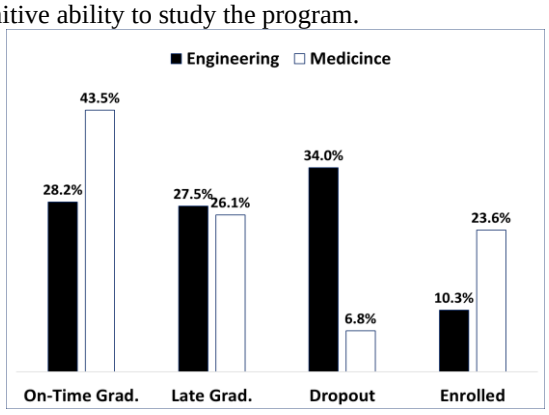

Fig. 1: Overall outcomes for the cohort shown in Table 1.

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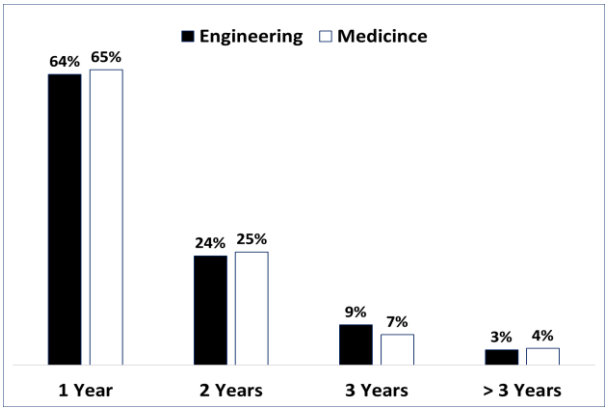
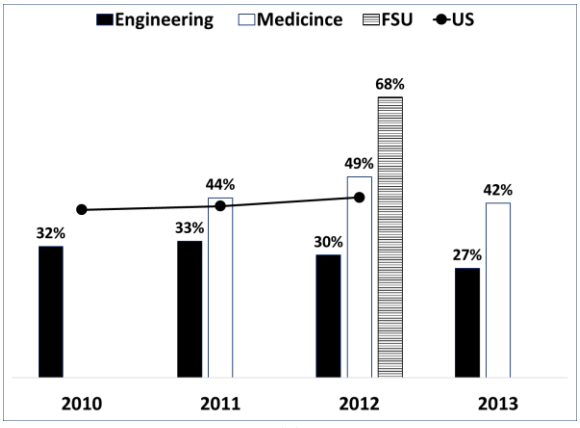


Fig. 2: Overall late graduation rate with years after the minimal period.

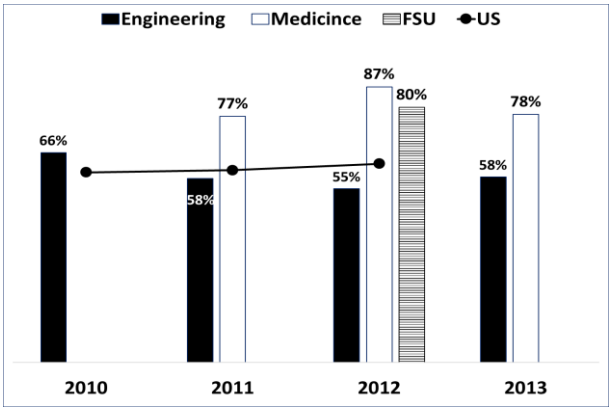
Graduation rates for four single cohort entry years, 2010 through 2013, are shown in Fig. 3. The corresponding results are compared with the graduation rates of Florida state university [3] and the US average [4]. The US institutions have consistently improved the trend of the graduation rates, Fig 3. Moreover, former comparative data are also available as an additional benchmark index; it is reported by some Canadian universities that 80% of students enrolled in 2002 were completed their degree seven years later [2].

The first plot, Fig. 3(a), illustrates the degree completion rates at a minimal period. Figure 3(b) depicts the graduation two years after the minimal period. Relatively, engineering students have modest graduation rates. They are graduating slower than expected because the published data indicates that the graduation rate of engineering students is higher than that of medical students [3, 4, 17]. For the cohort starting 2013, only 27% of college students graduate in a minimal period or less, Fig. 3(a). For the same cohort, 58% of students who take part in the five-year engineering college manage to graduate within the first seven years, Fig. 3(b).

Medical study has high graduation rates because it admits students of higher cognitive levels. It is considered the most challenging program. Most students have the desire to study medicine. This can be attributed to the community culture in Saudi Arabia. Nonetheless, it is noticeable that the trends of the graduation rates are fluctuating for both disciplines, Fig. 3. It can be attributed to that there were no institutional initiatives aimed at improving graduation rates.



(a)



(b)

Fig. 3: Graduation rates for four single cohorts starting 2010-2013; Compared with FSU [3] and US average [4]: (a) At a minimal period; (b) Two years after a minimal period.

According to the statistical analysis (See Fig. 1), about a third (34%) of students have dropped out of the engineering program and they will not return the following year. This indicates that the overall retention rate of engineering discipline is about 66% (=100–34%), which is extremely lower than medical-discipline retention (93.2%), Fig. 1. The overall retention shown in Fig. 1 is breakdown into several years that a student spends in college (e.g. it is not graded). Florida state university (FSU) has claimed that the retention rate among first-year students is 93% [3]. The trends of retention for both colleges are experiencing oscillating high values. The high annual retention rates can be attributed to students experiencing less social and economic stress as the higher-education study in Saudi Arabia is free. However, the engineering rate dipped (89%) in the period after the students spent more than four years in their college career; subsequently wasting the institution's resources [7]. The data shows that most of the dropping out students have not passed the first or the second year of the program. The college of engineering contains six departments, architectural, civil, chemical, electrical, industrial, and mechanical. The six departments show a variation of student outcomes as depicted in Fig. 5. It is illustrated that the architecture and industrial departments have the lowest rate of retention and on-time graduations. The electrical department has the highest retention (75%), Fig. 5.

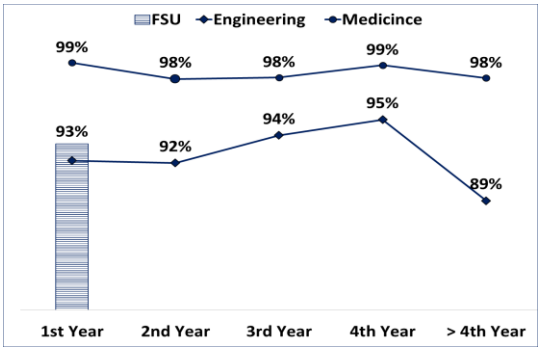


Fig. 4: Overall annual retention; Compared with FSU [3].

Retrieval Number: 100.1/ijbsac.F0466113621
DOI:10.35940/ijbsac.F0466.113621
Journal Website: www.ijbsac.org

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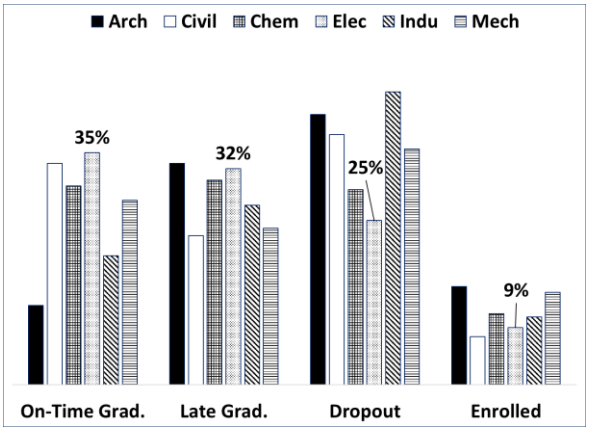

Fig. 5: Engineering departmental outcomes.

IV. PREDICTION ANALYSIS

The multinomial logistic regression models are applied to estimate the effects of multiple covariates on student outcomes. It is worth mentioning that the students who are still enrolled are considered as a baseline (reference) outcome associated with a confidence interval (CI) of 95%. Tables 3 and 5 present the predicted effects of covariates on the engineering and medicine outcomes, on-time graduation, late graduation, and dropout, respectively. The tables show the odds ratio (OR), confidence interval (CI), and *p*-value. As mentioned before, the odds ratio measures the probability of success relative to the probability of failure. The OR value of 1 suggests no difference, i.e. the null hypothesis. Alternatively, an OR greater/less than 1 suggests a higher/lower chance the event (outcome) will occur. The higher the OR, the higher the probability that the event will occur. Moreover, the term (OR-1) represents the percentage contribution of a covariate to the OR of an event for each unit increase of a covariate [20]. The smaller the range between the lower and upper boundaries of the CI, the higher certainty can be attributed to the regression [20]. Statistical significance indicates that the results in the data are not explainable by chance alone [20]. The shaded values in the shown tables indicate a statistically significant result ($p < 0.05$), otherwise, it is not significant. Another sign of insignificant covariate is that the lower and upper boundaries of the CI do not overlap 1.0 [20]. To make the explanation more understandable, the results of the covariate probability on the outcomes are presented. The effect of the covariates on the probabilities of the four possible student outcomes is estimated using equations (5) – (9).

A. Engineering Discipline

As shown in Tables 3 and 4, the effect of most of the personal characteristics (age, nationality, and place of residence) on engineering outcomes are statistically insignificant. Except for the local residents, who have a low tendency to drop out of programs (OR:0.418, CI:0.323-0.54, p<0.0001, *Pr*:0.13). The present findings raise concerns about the ability of secondary education to prepare students adequately for higher-education study. Since all outcomes have approximately equal probabilities, *Pr* (see Table 4), therefore, the analysis revealed that the achievements of pre-university education (e.g. GSS, GAT, and SAT) do not affect higher-education performance.

In more detail, the GSS (OR:1.054, CI:1.02-1.089, p<0.005, *Pr*:0.26) and the SAT (OR:1.037, CI:1.013-1.063, p<0.0001, *Pr*:0.24) have trivial positive influence on the on-time graduation. On the contrary, the GAT (OR:0.898, CI:0.879-0.917, p<0.005, *Pr*:0.26) has a negative relationship with the expectation of graduation on time. For instance, the Odds ratio, OR, of a student to graduate on time increases by only 5.4% (=1.054–1.0) for each unit increase of GSS. As shown in Table 3 that the GSS is more predictive of graduation than the specialized SAT (1.054>1.037). It can be concluded that the effect of the GSS is higher than that of Qiyas tests, and; the SAT effect is stronger than the GAT. A similar conclusion was drawn by a previous study using multiple linear correlations to investigate the ability of the pre-university achievements (GSS, GAT, and SAT) to predict the GPA for first-year students in some Saudi universities [15]. Moreover, for students studying in different fields at a Saudi university, the multiple linear correlations of [22, 23] found that the Qiyas standardized tests (GAT and SAT) are not closely related to higher-education achievement; and SAT is a little better than GAT. As an international benchmark, similar results were also found for the American college testing (ACT), which is a standardized selection test used for college admissions in the United States [14, 17].

A quantitative critique of the higher-education admission process also has been conducted. It is found that the admission process characteristics have a positive significant impact on the student outcomes (Tables 3 and 4). It is found that a first-time student who began his higher-education program following graduation from secondary education has about three-time (OR:3.161, CI:2.17-4.604, p<0.0001, *Pr*:0.41) higher chance to complete the program in a minimal period than the transferred student (Tables 3 and 4). A student whose engineering discipline is his first option has a high chance to finish his program early (OR:1.915, CI:1.517-2.418, p<0.0001, *Pr*:0.26) or even late (OR: 2.695, CI:2.144-3.387, p<0.0001, *Pr*:0.37). However, his ability to graduate is greater than the chance of dropping out of the program (OR: 1.747, CI: 1.376, 2.218, p<0.0001, *Pr*:0.24). A comparable relation is found for the first-term admission student. A student who registers in the first term can finish his program earlier than a student who registers in the second term (Tables 3 and 4). It is found that the grade point average (GPA) of the first year has a great impact on all outcomes (Tables 3 and 4). One-level increases of the GPA will increase the OR of the on-time completion by 246% (OR=3.46: CI:2.865-4.179, p<0.0001, *Pr*:0.62); compared to 5.4% of the GSS which was clarified previously. The results emphasize the importance of preparatory achievement as a promoter for enhanced higher-education performance [9]. However, regarding GPA, the present finding does not agree with Briggs [17]. Finally, predicting the influence of departments on graduation and retention rates has also been investigated. As shown in Tables 3 and 4, most of the covariates are statically insignificant.

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Take into consideration that the industrial department is set as a baseline. The students of the chemical (OR:2.074, CI:1.376-3.127, p<0.05, Pr:0.14) and architecture (OR: 0.494, CI:0.273-0.894, p<0.0001, Pr:0.36) departments seem to be the most and least, respectively, likely to graduate on time. Students of the electrical department are likely either late in completing the program (OR:1.973, CI: 1.334-2.918, p<0.005, Pr:0.33) or dropping out (OR:1.87, CI:1.237-2.829, p<0.005, Pr:0.31).

B. Medical Discipline

Similar to engineering, the effects of personal characteristics (age, gender, and place of residence) on medicine outcomes are statistically insignificant (see Tables 5 and 6). However, elder students are more exposed to leaving the college without completing the program (OR: 1.577, CI: 1.082-2.297, p<0.05, Pr:0.31). In addition, the local students have about a two-time higher chance to complete the program in minimal time (OR: 2.161, CI: 1.046-4.465, p<0.05, Pr:0.40) than non-local students. On the other hand, in general, similar to engineering, the effects of the pre-university achievement (GSS, GAT, and SAT) have little to do with graduation and retention rates. However, there are some slight differences between engineering and medicine. GSS is considered to have the largest positive effect (OR:1.054) on the achievement of engineering students, while it has a negative effect on studying medicine (OR:0.832). GAT assesses generic learning outcomes of quantitative (arithmetic) and verbal skills, it was therefore supposed to have a positive impact on the engineering study rather than the medical major. Unfortunately, GAT has a negative effect on both colleges (OR <1.0). Since the learning outcomes of SAT are specialized in Biology, Chemistry, Physics, Mathematics, and English, as expected SAT has a greater impact on a medical major (OR:1.062) than on an engineering major (OR:1.037). Accordingly, the weighted average score, which is a combination of three exams eligible for college admission, is assumed to be different for the two majors. Finally, the grade point average (GPA) of the first year has a great impact on all outcomes (Tables 5 and 6). One-level increases of the GPA will increase the OR of the on-time program completion by 529% (OR=6.297: CI: 4.106-9.657, p<0.0001, Pr:0.72). It is almost double the chance of engineering students to finish the program.

V. CONCLUSION

Multinomial logistic regression models are implemented for 5203 students enrolled in the Colleges of Engineering and Medicine. The observation period is extended for ten academic years from 2010 to 2020. There are four possible student outcomes considered in the current study, graduation on time, late graduation, dropout, and still enrolled. Twelve independent covariates retrieved from the student data are tested in predicting the occurrence of the four outcomes. The study revealed predictors that influence the likelihood that students are more likely to achieve one of the four outcomes. The results of the models affirmed that the covariates such as age, gender, nationality, and place of residence are either statistically insignificant or have a minor impact on the outcomes. Moreover, it is found that students' achievement before entering higher education has equal probabilities for all outcomes. The present analysis investigates the ability of university admission criteria to predict student performance. The available engineering data about the admission process predicts that a student of regular admission, first-option fulfilled, and first-term admission has a higher chance of completing an engineering degree in a minimal period. The results emphasize the importance of the primary year achievement as a motivator for excellent higher education performance.

In addition to controlling the achievement factors reviewed, it is strongly suggested that the decision-makers should take initiatives to:

- Improve student performance in first-year programs.
- Sustainably raise graduation and retention rates; the higher the better.
- Review the current admission policy.

ACKNOWLEDGMENT

The authors would like to thank the university senior management represented by the deanship of admission and registration for collaboration and providing the required data. Thanks to all those who made the present study possible. The patient cooperation of Walid Obeidat is appreciated.

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Table 2. Descriptive statistics according to the covariates.

Covariate	Engineering		Medicine	
	n	%	*n*	%
Age (≥18 years)	2986	65.3%	339	53.6%
Sex (Female)	0	0	326	51.6%
Nationality (Saudi)	4288	93.8%	632	100%
Residence (local)	3031	66.3%	553	87.5%
Admission type (regular)	4173	91.3%	-	-
Admission option (1st)	2771	60.6%	632	100%
Admission term (1st)	2513	55%	N/A	N/A

Table 3: Predicted effects of covariates on engineering outcomes.

Covariate	On-time Graduation		Late Graduation		Dropout	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Age	0.908 (0.802-1.028)	0.126	0.940 (0.835-1.058)	0.305	0.964 (0.850-1.093)	0.567
Nationality (Saudi)	1.542 (0.956-2.486)	0.076	1.061 (0.659-1.709)	0.808	1.429 (0.747-2.732)	0.281
Residence (Local)	1.087 (0.834-1.418)	0.537	0.800 (0.622-1.028)	0.082	0.418 (0.323-0.540)	0.000
GSS	1.054 (1.020- 1.089)	0.002	0.975 (0.947-1.004)	0.086	0.969 (0.940-0.998)	0.039
GAT	0.898 (0.879-0.917)	0.000	0.916 (0.897-0.935)	0.000	0.969 (0.948-0.990)	0.005

SAT	1.037 (1.013-1.063)	0.003	1.018 (0.994-0.042)	0.153	0.992 (0.967-1.018)	0.539
Admission type (Regular)	3.161 (2.170- 4.604)	0.000	1.906 (1.332-2.727)	0.000	1.722 (1.150-2.578)	0.008
Admission option (1st)	1.915 (1.517-2.418)	0.000	2.695 (2.144-3.387)	0.000	1.747 (1.376-2.218)	0.000
Admission term (1st)	1.627 (1.230-2.152)	0.001	1.492 (1.136-1.960)	0.004	1.082 (0.807-1.450)	0.600
GPA of 1st year	3.460 (2.865-4.179)	0.000	0.924 (0.780-1.095)	0.364	0.214 (0.179-0.256)	0.000
Mechanical	0.764 (0.522-1.119)	0.167	0.735 (0.511- 0.057)	0.097	0.946 (0.655-1.367)	0.768
Architecture	0.494 (0.273-0.894)	0.020	1.106 (0.680-0.800)	0.684	0.817 (0.494-1.353)	0.433
Chemical	2.074 (1.376-3.127)	0.000	1.266 (0.850-1.885)	0.246	1.419 (0.949-2.121)	0.088
Civil	0.942 (0.639-1.390)	0.764	1.241 (0.860-1.792)	0.248	1.088 (0.742-1.595)	0.665
Electrical	1.220 (0.812-1.833)	0.337	1.973 (1.334-2.918)	0.001	1.870 (1.237-2.829)	0.003

Table 4: Covariate probability on the engineering outcomes.

Covariate	On-time Graduation	Late Graduation	Dropout	Enrolled
Age	0.24	0.25	0.25	0.26
Nationality (Saudi)	0.31	0.21	0.28	0.20
Residence (Local)	0.33	0.24	0.13	0.30
GSS	0.26	0.24	0.24	0.25
GAT	0.24	0.24	0.26	0.26
SAT	0.26	0.25	0.25	0.25
Admission type (Regular)	0.41	0.24	0.22	0.13
Admission option (1st)	0.26	0.37	0.24	0.14
Admission term (1st)	0.31	0.29	0.21	0.19
GPA of 1st year	0.62	0.17	0.04	0.18
Mechanical	0.22	0.21	0.27	0.29
Architecture	0.14	0.32	0.24	0.29
Chemical	0.36	0.22	0.25	0.17
Civil	0.22	0.29	0.25	0.23
Electrical	0.20	0.33	0.31	0.16

Table 5: Predicted effects of covariates on medicine outcomes.

Covariate	On-time Graduation		Late Graduation		Dropout	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Age	1.213 (0.898-1.637)	0.208	1.308 (0.955-1.790)	0.094	1.577 (1.082-2.297)	0.018
Sex (Female)	0.896 (0.559-1.435)	0.648	0.949 (0.580-1.552)	0.835	0.721 (0.283-1.838)	0.493
Residence (Local)	2.161 (1.046-4.465)	0.037	1.510 (0.772-2.955)	0.228	0.731 (0.289-1.848)	0.507
GSS	0.832 (0.668-1.036)	0.101	0.914 (0.747-1.119)	0.384	0.854 (0.651-1.120)	0.254
GAT	0.925 (0.892-0.959)	0.000	0.916 (0.881-0.953)	0.000	1.009 (0.929-1.096)	0.827
SAT	1.062 (1.024-1.101)	0.001	1.087 (1.045-1.131)	0.000	1.099 (1.023-1.181)	0.010
GPA of 1st year	6.297 (4.106-9.657)	0.000	1.013 (0.736-1.394)	0.938	0.387 (0.260-0.575)	0.000

Table 6: Covariate probability estimation of the medicine outcomes.

Covariate	On-time Graduation	Late Graduation	Dropout	Enrolled
Age	0.24	0.26	0.31	0.20
Sex (Female)	0.25	0.27	0.20	0.28
Residence (Local)	0.40	0.28	0.14	0.19
GSS	0.23	0.25	0.24	0.28
GAT	0.24	0.24	0.26	0.26
SAT	0.25	0.26	0.26	0.24
GPA of 1st year	0.72	0.12	0.04	0.11

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Blue Eyes Intelligence Engineering
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