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Determining Undergraduate Factors that Predict Academic Success in Pharmacy School

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Executive Summary

Admission into pharmacy school is a very competitive process, and as a result multiple authors have looked at a variety of factors in an effort to create a systematic process that admissions committees can use to identify candidates who are likely to succeed in the rigorous pharmacy curriculum. One of the issues with this approach is that these analyses tend to be very institution-specific. In this paper I hope to identify a mechanism that the University of Kentucky (UK) College of Pharmacy admissions committee can use to efficiently and thoroughly evaluate candidates using scientifically validated factors.

This study uses a retrospective multivariate regression analysis completed using data collected from the UK College of Pharmacy admissions office for the Class of 2013. A variety of factors including pre-pharmacy Grade Point Average (GPA), math GPA, science GPA, Pharmacy College Admission Test (PCAT)-composite and subject scores, extracurricular activities, pharmacy work experience, pharmacy technician certification, obtainment of prior degree, number of years of pre-pharmacy coursework, and performance on the Health Sciences Reasoning Test (HSRT) served as the independent variables. First-year GPA and cumulative GPA are the dependent variables. For GPAs, PCAT scores, and HSRT performance, Pearson correlation coefficients were used to identify significant relationships between the variables. I used dummy variables to analyze characteristics such as extracurricular involvement, work experience, obtainment of prior degree, and technician certification in regressions. From the factors identified having significance, regressions were executed to analyze factors that affect first-year GPA and cumulative GPA.

This analysis identified a set of factors that have a statistically significant effect on first-year GPA: pre-pharmacy GPA, science GPA, math GPA, PCAT, PCAT-chemistry, PCAT-biology, and HSRT-deduction scores. Statistically significant factors for cumulative GPA included pre-pharmacy GPA, science GPA, math GPA, PCAT-composite, PCAT-biology, and HSRT-deduction. A predictive index for first-year GPA using science GPA, PCAT-biology, and HSRT-deduction accounts for 38% of the variance in first-year GPA. Using the same factors, a predictive index for cumulative GPA accounts for 37% of the variance in cumulative GPA.

From this study, I make several recommendations for the current admissions process used at the University of Kentucky. First, the HSRT provides valuable information to the admissions decision. I propose making this a required portion of the admissions process. Second, I recommend that a predictive index utilizing the science GPA, PCAT-biology score, and HSRT-deduction score be calculated and reported to the admissions committee for consideration when selecting candidates to admit.

Background

In the United States, there are 129 pharmacy programs with full or candidate status accreditation and an additional program is in pre-candidate status.[1] Despite the recent expansion of pharmacy programs, the American Association of Colleges of Pharmacy (AACP) reported an average application to enrollment rate of 6.4:1 for the fall 2012 semester[1]; the enrollment ratio for the Class of 2017 at the University of Kentucky (UK) College of Pharmacy is 4.3:1. As previously stated the demand for seats in pharmacy programs still exceeds the available supply, leaving schools to develop methods to best determine how to fill their limited spots. At UK, about 130 students are enrolled each year. With four times as many applicants it is easy to imagine how time consuming and complicated the admissions process can be.

Each school is looking to fill its incoming class with a diverse, competent, and highly competitive group of students. Many hours are spent in recruiting, hosting open houses, reviewing applications, and making admissions decisions. Each program has adopted its own way of determining admissions, but even a long-standing program, such as UK's, continues to tweak its admissions considerations to react to the changes in the profession and market demand. Pharmacy schools face pressure to admit the best candidates, to maintain high retention and graduation rates, to achieve high passing rates on the North American Pharmacist Licensure Examination (NAPLEX) and the Multistate Pharmacy Jurisprudence Examination (MPJE), and to obtain high career placement rates. All of these indicators are significant to recruiting, to receiving high national rankings, and to obtaining funding from the associated university and donors/alumni.

Despite the recent opening of several new pharmacy schools, there remains a high number of students interested in pharmacy as a profession; this demand may be attributed to the high salaries that pharmacists receive, the pharmacist shortage that existed a few years ago, as well as the evolving, exciting new responsibilities for pharmacists. With interest in pharmacy as a profession remaining high and the surplus of pharmacists, schools have seen their career placement rates drop. This has contributed to what some consider a moral obligation of the pharmacy schools. An obligation for the pharmacy programs to produce bright, competent, and engaged pharmacists who will maintain the standards of the profession, advance the profession to new heights, and maintain pharmacists' position as the second most trusted profession.[2]

Admissions committee members are cognizant of the fact that the admissions process can be very subjective, but are also aware that each individual case is different and deserves careful consideration. No one is calling for a scientific approach that only objectively determines the best candidate; however, schools are searching for statistical methods to identify characteristics that predict academic success.

Problem Statement

There are several problems that contribute to the difficult admissions processes that pharmacy programs employ. First, with so many applications, a more systematic approach based on scientific evidence would alleviate some of the burdens of the admissions process and help to create a more efficient process. Second, most of the literature regarding this topic was published several years ago. Since then, there has been a large shift in the marketplace for pharmacy programs as many new schools have opened, providing students with more options of programs to apply. Therefore, a new analysis examining these factors in the new market situation is warranted. Last, there are many factors such as work experience, pharmacy technician certification, and extracurricular activities that have not been considered in previous studies. It is widely believed that these experiential factors contribute value to the candidate but data validating an effect on academic success based on GPA does not currently exist.

One of the limitations of this type of study commonly documented throughout the literature, is that the results are not always translatable to other pharmacy programs; therefore, the purpose of this study is to identify a mechanism that the UK admissions committee can use to efficiently evaluate candidates using scientifically validated factors, including experiential factors.

Literature Review

Factors associated with success in pharmacy school are examined in several studies. The first wave of literature approaching this topic is from the late 1970's, with another wave following in the 1990's, the result of a redesign of the Pharmacy College Admission Test (PCAT). In these studies, a number of factors have been examined; however, it is important to note that authors defined even similar factors differently.[3-20] These factors include, pre-pharmacy GPA, specific content area GPAs (commonly math GPA, science GPA, combined math and science GPA, and pharmacy prerequisites GPA), organic chemistry average, science value (an institutional-unique way to measure math and science courses), number of college credits received in specific areas (most commonly in the math and sciences, especially above and beyond the prerequisites), PCAT-composite and subject areas [Biology, Chemistry, Quantitative Ability, Reading, and Verbal] subscores, interview scores, essay scores, American College Testing (ACT) score, and critical thinking assessment scores (of which there are several different testing methods used).

Other factors less frequently considered include completion of prior degree, leadership experience, work experience, extracurricular involvement, time spent studying, time spent working, time spent on college/extracurricular activities, Myers-Brigg personality indicator, and type of program where organic chemistry coursework is completed (two vs. four year program). The most common definition of academic success used is GPA after the first year of the pharmacy curriculum.

Chisholm and colleagues published several of the foundational articles. In a 1995 study, they found that the most significant factors for predicting first year academic performance were combined math and science GPA and completion of a four year degree.[3] This finding was confirmed in a follow-up study.[4] In 1999, they examined various factors to predict whether students would rank in the top 25 percent or bottom 25 percent of the class.[5] This time they found that combined math and science GPA and prior degree were statistically significant for determining assignment group. They also identified that students ranked in the upper 25 percent had higher math/science GPAs and pre-pharmacy GPAs. One possible outcome of their research is that a growing number of pharmacy schools now require the completion of a baccalaureate degree for admission; in 2013 it was reported that individuals with a baccalaureate degree submitted over 44 percent of applications to pharmacy programs and over 75 percent of applicants had three or more years of postsecondary experience.[21]

Since Chisholm's first study, many other studies have been performed at various pharmacy programs across the United States. However, the factors considered in each study vary. Multiple studies have found pre-pharmacy GPA[5,7,9,14-17], math and science combined GPA[3-5,8,14,15-16], four year or previous degree[3-5,9,11,14], PCAT-composite score[7-10,12,14,16], PCAT-chemistry subscore[9], PCAT-reading subscore[9,17], PCAT-biology subscore[9,17], PCAT-quantitative ability[9,12], performance on critical thinking skills assessments[7,10], pre-pharmacy prerequisites GPA[7], interview scores[7,17], average organic chemistry grade[11], science value[11], ACT[11], and advanced biology courses[15] to be significant predictors of first-year GPA. Fewer factors have been identified as predictors of cumulative GPA. These include: pre-pharmacy GPA[6,12], essay score[10], performance on critical thinking skills assessments[10], PCAT-chemistry subscore[12], and four year or previous degree.[15]

Kuncel et al., in a meta-analysis identified the PCAT-verbal subscore as having the lowest validity as a predictor of academic success in pharmacy school.[12] Two other major findings were reported. First, they found that the PCAT is a better predictor of performance than the ACT and SAT, and last, they concluded that the combination of PCAT scores tend to closely resemble pre-pharmacy GPA.

Thomas and Draugalis in a 2002 study took a slightly different approach. In their study they identified significant factors and then created a model to predict first-year GPA. Their model used the PCAT-chemistry score and combined math and science GPA; the model accounted for 45% of the variance and is represented as: Predicted GPA at 1 Yr = 0.879 + 0.00965*PCAT-chemistry + 0.472*math/science GPA.[9]

Performance on critical thinking assessments has been included in many of the published studies. At the University of Kentucky, all admitted pharmacy students are required to take a HSRT during their orientation week at the beginning of first year and again during the week prior to graduation. The test is designed to assess critical thinking skills without requiring any prior knowledge of healthcare. Two studies found that the HSRT score did not contribute to the prediction of first-year pharmacy school

GPA.[18, 20] Additionally, two studies also noted that composite and several subscores of the PCAT were significantly associated with HSRT scores.[19, 20]

The potential negatives of using predictive factors and the creation of a regression using these factors to aid in admissions decisions has been noted several times. Even as early as 1984, Kawahara et al., cited an example of a program using a predictive index comprised of the PCAT-chemistry score, pre-pharmacy science GPA (actually includes math and science college courses), and a feeder school index (derived from average Medical College Admission Test scores).[22] The predictive index represented between 30-40% of variance in GPA, but in the 1980's faculty questioned a decline in the quality of students accepted. As a result, the authors studied six years of PCAT data and found great variability between genders and years in which the test was taken. The variability in this one factor led the authors to question the utility of a single predictive equation to determine admissions. In a more recent article, Latif presents a view that is commonly echoed throughout the profession: academic success does not necessarily translate into successful clinical performance.[13]

In conclusion, several things stand out. First, there is little consistency outside of pre-pharmacy GPA, combined pre-pharmacy math and science GPA, and PCAT composite score, in what factors have predictive power to determine first-year pharmacy and cumulative GPA. Second, each study defined factors differently, even common determinants such as GPA and PCAT, making a complete analysis and comparison difficult. Third, the utility of GPA as the endpoint has been questioned as it does not necessarily translate into clinical or practice success. Fourth, factors such as leadership, extracurricular involvement, work experience and qualitative data have often been left out of the analysis but are anecdotally believed to be a significant contributor to student success, especially when success is defined as something other than GPA. Last, the results found in each study are institution-specific and are difficult to replicate; this limits the utility of such research.

Methods

This study evaluates a variety of undergraduate factors in an effort to identify those that serve as a predictor of academic success, defined as pharmacy grade point average (GPA) after the first year and final year of pharmacy school. Table 1 includes a list of the factors considered in this study. I chose these factors in response to a literature review that revealed these as common factors considered and the availability of this data. A detailed description of each factor is included in Appendix 1. I performed two separate analyses with the first estimating the relationship between the factors below and first-year GPA and the second, the relationship between the same factors and cumulative GPA.

Table 1. Factors considered in this study.

Independent Variables	Dependent variables
▪ Pre-pharmacy GPA ▪ science GPA ▪ math GPA ▪ type of undergraduate institution (public vs. private) ▪ prior pharmacy employment ▪ extracurricular involvement ▪ Pharmacy College Admission Test (PCAT) composite and subject subscores ▪ number of years of pre-pharmacy education ▪ performance on the Health Sciences Reasoning Test (HSRT) ▪ individual/group/total interview scores ▪ pharmacy technician certification	▪ first-year pharmacy school GPA ▪ cumulative GPA

All data is from the University of Kentucky College of Pharmacy Class of 2013. I only included students who completed the first-year of the pharmacy curriculum in the first-year GPA analysis (n=116). In the cumulative GPA analysis I included only students who graduated with a Doctor of Pharmacy (PharmD) degree in May 2013 (n=112). Data was gathered from pre-admissions materials and academic records. Due to the Family Educational Rights and Privacy Act (FERPA) considerations, Institutional Review Board (IRB) approval was sought and received on November 14, 2013.

In order to determine distribution patterns I graphed both dependent variables, first-year GPA and final GPA, and both dependent variables fit a normal distribution. Next, I calculated Pearson correlation coefficients for each of the continuous factors using Microsoft Excel (Microsoft, Redmond, WA) to determine statistically significant relationships. Statistical significance for p-values was a priori determined at 0.05. I then entered the significant factors into the statistical software STATA (STATA, College Station, TX) to create a multivariate regression. Using STATA I identified several cases of multicollinearity and created a simplified regression that predicted first year and cumulative GPA.

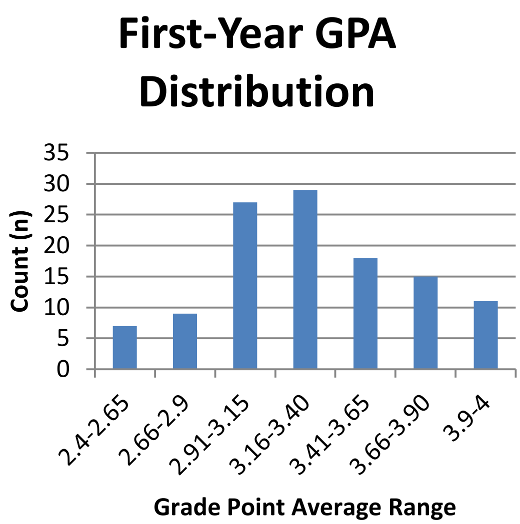
Several factors examined in this study are discrete variables, and to examine these factors, I used dummy variables. Presence of the trait is scored one; absence of the trait is scored zero. I then conducted linear regressions on each variable to determine significance. Significance was a priori determined at 0.05. I included any factors identified to be significant in the final regression.

Hypothesized significant factors include pre-pharmacy GPA, science GPA, PCAT-composite, PCAT-chemistry subscore, PCAT-biology subscore, and HSRT-overall performance.

Results

Both dependent variables first-year GPA and cumulative GPA fit a normal distribution allowing for linear regression to be used in this analysis. Figure 1 and Figure 2 demonstrate this distribution pattern.

Figure 1: First Year GPA Distribution: Normally distributed.
Figure 2: Cumulative GPA Distribution: Normally distributed.



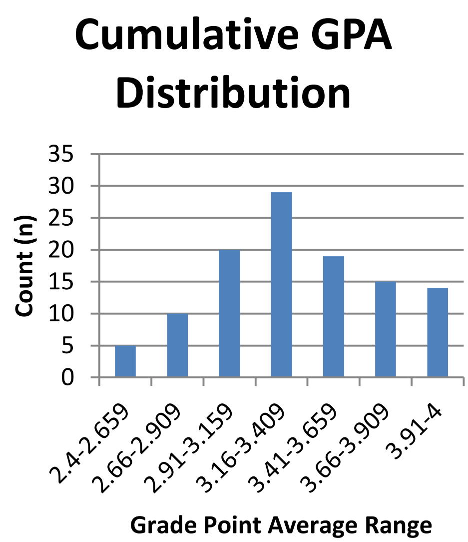


Table 2 includes the summary statistics. The first year GPA analysis consists of 116 students while the cumulative GPA analysis has only 112 students (four students did not complete the program within the four year period).

Table 2: Summary Statistics

Factor	Mean	Median	Std. Dev.	Minimum	Maximum
N=116					
Pre-pharmacy GPA	3.6	3.62	0.28	2.54	4
Science GPA	3.48	3.47	0.34	2.72	4.0
Math GPA	3.62	3.78	0.46	1.71	4.0
PCAT-composite (%)	74.86	76	14.67	22	99
PCAT-chemistry (%)	71.48	73	20.11	14	99
PCAT-biology (%)	73.09	77.5	17.71	14	99

PCAT-math (%)	65.07	67	21.92	9	99
PCAT-verbal (%)	71.4	74.5	19.15	20	98
PCAT-reading (%)	65.98	69	19.67	17	99
Individual Interview	167.73	170	21.68	58	200
Group Interview	173.41	175	9.2	141	194
Total Interview	341.14	345.5	25.96	224	387
HSRT-overall	23.16	23	3.12	12	30
HSRT-induction	7.74	8	1.29	3	10
HSRT-deduction	7.62	8	1.66	4	10
HSRT-analysis	4.67	5	5	2	6
HSRT-inference	3.89	4	1.14	1	6
HSRT-evaluation	4.98	5	1.08	2	6
First-year GPA	3.30	3.26	0.392	2.42	4
Cumulative GPA	3.37	3.34	0.39	2.46	4

Table 3 includes the Pearson correlation coefficients for each of the continuous factors. The p-value is reported next to each coefficient. For first-year GPA significant predictors include: pre-pharmacy GPA, science GPA, math GPA, PCAT-composite, PCAT-chemistry, PCAT-biology, and HSRT-deduction. For cumulative GPA, significant predictors include: pre-pharmacy GPA, science GPA, math GPA, PCAT-composite, PCAT-biology, and HSRT-deduction.

Table 3: Correlation Results

Factor	Correlation with First-year GPA	Correlation with Cumulative GPA
Pre-pharmacy GPA	0.55 (α<0.001)	0.6 (α<0.001)
Science GPA	0.58 (α <0.001)	0.59 (α<0.001)
Math GPA	0.36 (α <0.001)	0.41 (α<0.001)
PCAT-composite (%)	0.25 (α <0.001)	0.2 (α=0.004)
PCAT-chemistry (%)	0.28 (α <0.001)	0.17 (α=0.07)
PCAT-biology (%)	0.30 (α <0.001)	0.22 (α<0.017)
PCAT-math (%)	0.08 (α=0.38)	0.12 (α=0.21)
PCAT-verbal (%)	0.01 (α=0.93)	0.08 (α=0.41)
PCAT-reading (%)	0.03 (α=0.73)	-0.04 (α=0.7)
Individual Interview	0.01 (α=0.84)	0.05 (α=0.57)
Group Interview	0.04 (α=0.64)	0.03 (α=0.75)

Total Interview	0.03 (α=0.74)	0.06 (α=0.55)
HSRT-overall	0.13 (α=0.17)	0.10 (α=0.27)
HSRT-induction	0(-) (α=0.98)	0.05 (α=0.64)
HSRT-deduction	0.2 (α=0.03)	0.19 (α=0.05)
HSRT-analysis	0.14 (α=0.15)	0.09 (α=0.36)
HSRT-inference	0.15 (α=0.1)	0.18 (α=0.06)
HSRT-evaluation	0.03 (α=0.79)	0.09 (α=0.36)

Table 4 includes the coefficients and p-values for the linear regressions conducted with the discrete variables. To run linear regressions, I used dummy variables. In the extracurricular, pharmacy work experience, and technician certification analyses I coded the absence of the trait as zero while one represented presence of the trait. For years of pre-pharmacy, I conducted three separate regressions, each time changing the trait. For institution, I considered private institution as the trait. I found none of these factors to be significant predictors of academic success and they were not included in the final linear regression for either dependent variable.

Table 4: Discrete Variables: Coefficients and Significance (bivariate analysis)

Factor	Coefficient First-year GPA (p-value)	Coefficient Cumulative GPA (p-value)
	N=116	N=112
Years of Pre-pharmacy		
2 years=1	-0.05 (α=0.49)	0.07 (α=0.28)
3+years=1	-0.08 (α=0.51)	-0.11(α=0.36)
BS/BA/Doct=1	0.11 (α=0.26)	0.04 (α=0.74)
Institution	0.19 (α=0.09)	0.06 (α=0.62)
Extracurricular	0.13 (α=0.43)	0.17 (α=0.29)
Pharmacy Work Experience	-0.06 (α=0.39)	0.02 (α=0.82)
Technician Certification	-0.08 (α=0.49)	-0.13 (α=0.26)

Using the significant factors previously identified, I created two separate regressions. The findings from the regression for first-year GPA are included below in

Table 5. This model provides an R^2 value of 0.416 meaning that these six factors determine about 42% of the variance of the first-year GPA.

(1) Predicted GPA_{Y1}= -0.101 (Pre-pharmacy GPA) + 0.605 (Science GPA) + 0.128 (Math GPA) + -0.003 (PCAT-composite) + 0.001 (PCAT-chemistry) + 0.005 (PCAT-biology) + 0.035 (HSRT-deduction) + 0.543

Table 5: Linear regression with robust standard errors for first-year GPA

Factor	Coefficients	Standard Error	t-statistic	p-value
N=116		R^2=0.416		
Pre-pharmacy GPA	-0.101	0.308	-0.33	0.743
Science GPA	0.605	0.202	2.99	0.03
Math GPA	0.128	0.087	1.48	0.141
PCAT-composite	-0.003	0.003	-0.89	0.374
PCAT-chemistry	0.001	0.002	0.65	0.520
PCAT-biology	0.005	0.002	2.81	0.006
HSRT-deduction	0.035	0.018	1.94	0.054
Intercept/Constant	0.543	0.396	1.37	0.173

Using the significant factors for cumulative GPA, I created a linear regression. This model provides an R^2 value of 0.422 meaning that the five factors shown in Table 6 determine about 42% of the variance of the cumulative GPA.

(2) Predicted $GPA_{cum.}$= 0.22 (Pre-pharmacy GPA) + 0.432 (Science GPA) + 0.106 (Math GPA) + -0.002 (PCAT-composite) + 0.004 (PCAT-biology) + 0.03 (HSRT-deduction) + 0.358

Table 6: Linear regression with robust standard errors for cumulative GPA

Factor	Coefficients	Standard Error	t-statistic	p-value
N=112		$R^{2=}$0.422		
Pre-pharmacy GPA	0.220	0.238	0.92	0.357
Science GPA	0.432	0.172	2.50	0.014
Math GPA	0.106	0.076	1.40	0.164
PCAT-composite	-0.002	0.002	-1.09	0.280
PCAT-biology	0.004	0.002	2.09	0.039
HSRT-deduction	0.030	0.019	1.62	0.107

Intercept	0.358	0.363	0.98	0.327

One of the concerns with this study is the possibility of multicollinearity. I used the variance inflation factor function of STATA to determine multicollinearity. Findings are reported below in Table 7. A VIF of greater than 10 indicates the possibility of multicollinearity.

Table 7: Multicollinearity in factors for 1st Year and Cumulative GPA

Factor (1st Year)	1st Year GPA VIF	Cumulative GPA VIF
	N=112	N=116
Pre-pharmacy GPA	10.71	10.85
Science GPA	8.61	8.70
Math GPA	2.29	2.29
PCAT-composite (%)	29.12	29.16
PCAT-chemistry (%)	6.15	6.15
PCAT-biology (%)	2.83	2.78
PCAT-math (%)	5.25	5.23
PCAT-verbal (%)	5.19	4.98
PCAT-reading (%)	3.56	3.52
Individual Interview*	NA	9.86
Group Interview*	1.75	NA
Total Interview	1.82	10.34
HSRT-overall	6.30	6.67
HSRT-induction	8.34	8.35
HSRT-deduction	2.85	2.94
HSRT-analysis	1.81	1.76
HSRT-inference	6.89	6.70
HSRT-evaluation	2.05	2.07
*STATA omitted individual interview from the 1st year analysis and group interview from the cumulative analysis.		

To eliminate multicollinearity, I created a simplified regression model for each dependent variable. Given that PCAT-biology and science GPA were found to be significant in the prior regressions and the multicollinearity between the various GPAs and PCAT scores I chose these two factors to represent these components. I chose to include the HSRT-deduction score since it was the only significant finding from the HSRT. This simplified model for first-year GPA is shown in Table 8 and has an R^2 value of 0.398, accounting for about 40% of the variance.

(3) Predicted GPA_{Y1}= 0.609 (Science GPA) + 0.004 (PCAT-biology) + 0.038 (HSRT-deduction) + 0.583

Table 8: Simplified linear regression with robust standard errors for first-year GPA

Factor	Coefficients	Standard Error	t-statistic	p-value
N=116		$R^{2=}$0.398		
Science GPA	0.609	0.088	6.89	<0.001
PCAT-biology	0.004	0.002	2.41	0.018
HSRT-deduction	0.038	0.017	2.24	0.027
Intercept	0.583	0.337	1.73	0.087

The simplified model for cumulative GPA is shown in Table 9 and has an R^2 value of 0.391 and accounts for 39% of the variance.

(4) Predicted $GPA_{cum.}$= 0.64 (Science GPA) + 0.003 (PCAT-biology) + 0.034 (HSRT-deduction) + 0.698

Table 9: Simplified linear regression with robust standard errors for cumulative GPA

Factor	Coefficients	Standard Error	t-statistic	p-value
N=112		R^2=0.391		
Science GPA	0.640	0.081	7.90	<0.001
PCAT-biology	0.003	0.002	1.49	0.138
HSRT-deduction	0.034	0.017	1.98	0.050
Intercept	0.698	0.335	2.08	0.040

Discussion

Various studies have been conducted in an effort to identify factors that predict a student's performance in the pharmacy curriculum. While many different studies exist, there is a lack of reliability and consistency in both the methods employed and findings reported. These previous attempts inspired this study.

For first-year GPA the following factors are significantly related: pre-pharmacy GPA, math GPA, science GPA, PCAT-composite score, PCAT-chemistry score, PCAT-biology score, and HSRT-deduction score. These findings are similar to what has been demonstrated in previous references. I identified examples of multicollinearity relationships between factors including pre-pharmacy GPA, PCAT-composite. Using the six significant factors identified above, I created a multivariate regression (Table 5) with robust standard errors for first-year GPA. Including robust standard errors takes into account concerns for heterogeneity and lack of normality while retaining the point estimates of the coefficients derived in an ordinary regression. This model accounts for about 42% of the variance in the first-year GPA. This finding is similar to what has been reported in earlier studies.[9] In the multivariate regression, only the science GPA and PCAT-biology scores are statistically significant. In a second and simplified multivariate regression, (Table 8) only science GPA, PCAT-biology scores, and HSRT-deduction scores were considered. This simplified model accounts for 40% of the variance in first-year GPA.

For cumulative GPA the following factors are significantly associated: pre-pharmacy GPA, math GPA, science GPA, PCAT-overall, PCAT-biology, and HSRT-deduction. I created a multivariate regression using the six significant factors (see Table 6), which accounts for about 42% of the variance of cumulative GPA. In this model, science GPA and PCAT-biology scores are statistically significant predictors of cumulative GPA. I identified examples of multicollinearity relationships between factors including pre-pharmacy GPA, PCAT-composite, and total interview score. To eliminate this multicollinearity I created a simplified regression model using science GPA, PCAT-biology score, and HSRT-deduction scores (Table 9) that accounts for 39% of the variance in cumulative GPA.

A few studies found that students who obtained a previous degree performed better in pharmacy school than those who had not.[3-5,9,11,14,15] This finding was not supported in this study. In addition, I noted no significant difference in performance between students completing only two years of pre-pharmacy education, three+ years of pre-pharmacy education, and those students completing a baccalaureate degree. I found no significant difference in first-year GPA or cumulative GPA in students based on type of institution attended for pre-pharmacy, past pharmacy work employment, technician certification, or extracurricular involvement.

Limitations

Several limitations exist in this study. One of the biggest limitations to this study is the type of data that is available to be collected. Since this study resides in the educational domain, the Family Education Records and Privacy Act (FERPA) was considered. Additionally, I had to obtain Institutional Review Board (IRB) approval. As such, information pertaining to demographics that could have revealed the identity of any individual student was not collected. This required that several variables be defined simply as yes or no. One example of this is the public vs. private institution attended for pre-pharmacy. Since it is possible to identify students based on their previous institution, I was required to simply categorize this as private or public. This prevented the use of using other ranking methods to further differentiate between the quality of the pre-pharmacy programs. Additionally, I am unable to compare the genders, races, or age of the student. FERPA does include several exemptions that allow for the release of this data for research purposes, but I was unable to make the fullest use of this allowance as our IRB approval process took several months. The Medical IRB committee assigned our protocol was unfamiliar with FERPA requirements, and to protect the privacy of the subjects the committee was cautious about what information could be provided. To accommodate their concerns, I was very selective in requesting information.

Another large limitation to this data is that I collected much of the data via an application process. In reality, this is similar to a survey method and potential biases exist. The most common bias present through this study is a reporting bias. Things such as extracurricular involvement, pharmacy employment, and pharmacy technician certification are not necessary for admission into pharmacy school; however, they may be encouraged. As such, there is not a defined portion of the application requesting this information. Some individuals included this information, but it is highly likely that many did not and therefore falsely influenced any relationship or lack of with the dependent variables.

One limitation with the analysis of the discrete variables is the use of binary variables in the extracurricular activity. I coded this information simply as yes or no. Therefore, an individual reporting one activity was given the same value as a person who reported ten. This did not allow for the separation of the data and minimized the utility of this variable as a potential factor.

Another limitation to this study affects the pre-pharmacy GPA, math GPA, and science GPA variables. These scores are reported and verified through the PharmCAS system. Some students are admitted during the fall semester (early decision) before entering pharmacy school; others are admitted in the spring semester prior to starting pharmacy school. These GPAs were pulled from PharmCAS data and reflect the final GPA reported to the system. Many of the students admitted during the fall semester do not have grades from their final year of undergraduate education uploaded into PharmCAS. This is significant especially for students admitted after two years of pre-pharmacy education. Often these students have yet to take some of the more rigorous pre-pharmacy pre-requisites such as organic chemistry and physics courses. This may lead to a falsely elevated pre-pharmacy GPA and science GPA. In fact, this may explain why no significant difference was noted between students who completed their pre-pharmacy education in two years versus those who complete it in the three+ years or received a bachelor's degree.

Another limitation is that the data collected was from graduates of the Class of 2013. I removed several students from the initial class due to incompletion of the program. Several of these individuals were held back due to academic reasons and the removal of their data potentially inflates the relationship between undergraduate factors and GPA.

There are also limitations to the internal validity of this study. In this study, I am only considering the relationship between pre-admission variables and GPA. However, there are many other factors during school that can affect GPA: jobs, family (marriages, divorces, children), burn out (some students work really hard to get in but have little need to do better than average once admitted), guaranteed job after graduation (influences motivation), time management, adjustment to new city/state, adjustment to rigorous program, and class size. I did not include these factors since the study only considers undergraduate factors and much of this information is not available without a survey to gather it.

There also exists limitations with this study in terms of external validity. In fact, this is common throughout literature on this topic. As seen in the literature review, many of the significant factors in one study have not been successfully replicated in other studies. No two pharmacy programs are alike and even their admissions decisions differ significantly. Looking at a program like UK as a comparator would probably only fit for large traditional pharmacy programs connected to an academic medical center with a strong focus on clinical pharmacy and research.

Conclusions

The results found in this study are similar to what has been reported in the literature. Pre-pharmacy GPA, math GPA, science GPA, and PCAT scores are commonly recognized as predictors in the literature and many colleges of pharmacy have placed an emphasis on these scores when evaluating candidates. This study also found that using a subsection of the Health Sciences Reasoning Test, the deduction portion, has utility as a predictor. Two simplified models were created that place an emphasis on the science GPA, PCAT-biology score, and HSRT-deduction score, and accounts for 40% of the variance for first-year and cumulative GPA.

Recommendations

The purpose of this study is to identify what undergraduate factors predict a student's academic success, defined as pharmacy school GPA. A model using only 3 factors that are readily available from applications and pre-admissions exams account for 40% of the variance in first-year and cumulative GPA. The University of Kentucky College of Pharmacy can use this model to quickly and more efficiently assess candidates. These factors leave 60% of the GPA unaccounted for, thus other characteristics must be considered during the admissions process (contribution to diversity, in/out of state, etc.). It would not be appropriate to make this model the singular component of the admissions criteria.

From this study there are several recommendations I propose. First, the HSRT is usually given post-admission to the pharmacy program during the first week of orientation. Since this assessment has a predictive relationship I propose that the test be given during the interview day and the deduction section be used in the admissions decision.

This recommendation does have financial implications. Currently it costs $10 to administer the online test. Since a larger number of students would be taking the test than previously, this would increase the cost that the college incurs. To mitigate this I recommend that this $10 cost be added to the applicant's application fee. Currently, the fee is $80 and it is unlikely that another $10 will defer a student that really wants to attend UK from applying here.

Logistically, the HSRT is a timed test. As part of the interview process every student would spend the designated time in the College of Pharmacy's computer lab taking this assessment. Scores from the testing company will then be sent back to UK for inclusion in the admissions decision.

Second, I propose that the simplified model including science GPA, PCAT-biology score, and HSRT-deduction be considered a predictive index that is calculated and reported to the admissions criteria. This information is important for the admissions committee to have as this study found that science GPA, PCAT-biology, and the HSRT-deduction section are robust predictors of academic success. A quick scan at this value can help to efficiently determine candidates who may or may not meet the rigors of the UK pharmacy curriculum.

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Appendix 1

Factor	**Description**
Pre-pharmacy GPA:	overall GPA for all coursework completed and verified by PharmCAS system at time of application
Science GPA:	GPA for all science coursework completed and verified by PharmCAS system at time of application
Math GPA:	GPA for all math coursework completed and verified by PharmCAS system at time of application
Primary Institution:	where undergraduate work is completed; public vs. private
Pre-pharmacy Education:	at the University of Kentucky students may enter pharmacy school after 2 years of pre-pharmacy work; number of years of pre-pharmacy work; 2 years vs. 3+ years vs. BS/BA vs. Masters/Doctorate
Pharmacy College Admission Test (PCAT): composite score -subscores: 1. PCAT-chemistry 2. PCAT-biology 3. PCAT-math/quantitative ability 4. PCAT-verbal 5. PCAT-reading	based on percentile score
Extracurricular involvement:	self-reported on PharmCAS application; if any activity was listed then marked yes; categorized as yes vs. no
Prior pharmacy employment	self-reported on PharmCAS application; if any pharmacy employment was listed then marked yes; categorized as yes vs. no

Pharmacy technician certification:	self-reported on PharmCAS application; if certification was listed then marked yes; categorized as yes vs. no
Individual interview score:	out of 200 points possible; interviews are conducted with 1 candidate and 2 interviewers (1 faculty member and 1 community practitioner); a rubric is used for scoring purposes
Group interview score:	out of 200 points possible; interviews are conducted with 4-5 candidates and 4 interviewers (mix of faculty, current students, and community practitioners); a rubric is used for scoring purposes
Total interview score:	out of 400 points possible; combined score from the individual and group interview scores
Health Sciences Reasoning Test (HSRT):	
Overall	(max=33)
-subscores:	
1. Induction	(max=10)
2. Deduction	(max=10)
3. Analysis	(max=6)
4. Inference	(max=6)
5. Evaluation	(max=6)