ACADEMIC LINEAGE AND STUDENT PERFORMANCE IN MEDICAL SCHOOL

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This research investigated the association between academic lineage and student performance in medical school. The purposes of the study were to: (1) determine whether the Carnegie classifications of medical school applicants' institutions of origin are associated with academic performance in medical school; (2) consider the relationship between the admission selectivity of the schools of origin and the academic performance of medical school students; (3) compare the performance of medical students from institutions under public governing control with students from privately controlled institutions; and (4) establish a model by which the relative academic strengths of applicants from a variety of undergraduate institutions can be understood more clearly based on the previous performance of medical students from schools with similar institutional characteristics. A review of the literature on medical school admissions was completed and used to develop this research.

Medical students from the University of Texas Southwestern Medical Center at Dallas who enrolled between the years 1990 and 1994 and graduated or were dismissed between the years 1994 and 1998 were selected as the sample for the study (n=933). The undergraduate institution of origin for each student was coded based on its Carnegie classification, admissions selectivity group, and whether its governing control was public or private. Because the sample was not randomly selected and the data likely would not

meet the assumptions of equal means and variance with the population, nonparametric analyses of variance and multiple comparison tests were completed to compare the groups of the independent variables over each dependent variable.

The analyses revealed that for the sample of medical students selected for this study there was an association between academic lineage and student performance in medical school. Differences were found among Carnegie classifications on the dependent variables of cumulative medical school grade point average, class rank, failure rate, and score on Step 1 of the United States Medical Licensure Examination. Further, it was found that admission selectivity was also associated with student performance in medical school for each dependent variable except failure rate. Finally, the study results indicated no association between public or private governing control and student performance in medical school.

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CHAPTER 1

INTRODUCTION

It is difficult to overstate the importance of the admissions process in medical schools. This is true partly because of the competitive nature of the application process to medical school and partly because of the significance the outcome has for the future of healthcare in our society. Medical schools generally consider the admissions process to be a gatekeeping function not just to medical school itself, but also, and more importantly, to the medical profession and the care of patients (Miller, 1990). In addition, the cost of educating medical students far exceeds the tuition and fees charged to them. State-affiliated medical schools, in particular, are heavily subsidized to defray much of the actual cost of a medical education. Therefore, it is vital that applicants' potential for success in medical school be evaluated prior to their selection for entry into the training program (Tekian, 1998a).

The problems facing those involved with medical school admissions surround two important and distinctive issues. The first involves the selection of the most qualified applicants from a much larger group of candidates. The problems related to selection are, of course, based on the premise that the number of places in a medical school class are limited and that the pool of applicants (even of those who are qualified) exceeds this limited number (Smith and Hayling, 1998). For example, according to the Association of American Medical Colleges, the national pool of applicants for entry into American medical schools in 1998 was 40,281 of which only 12,309 (30.6%) were admitted (AAMC, 1998). In such an extraordinarily competitive process most medical schools use, at varying levels, quantitative measures to indicate the degree to which applicants are academically qualified and thus narrow the pool of potential students for further evaluation. However, these quantitative data are used by admissions committees in a subjective process to determine which applicants will make good medical school students and, ultimately, good physicians.

The second issue affecting medical school admissions involves predicting the academic performance of students in medical school. A great deal of the research about performance in medical school focuses on the predictive value of cognitive measures of standardized tests and previous academic performance as indicated by grade point averages (Brooks, Jackson, Hoffman, and Hand, 1981; Jones and Thomae-Forgues, 1984; Leonardson, Wilson, and Charboneau, 1987; Mitchell, 1987, 1990; Silver and Hodgson, 1997; and Koenig, Sireci, and Wiley, 1998). This research has generally supported the notion that cognitive measures are useful in predicting student performance in medical school, albeit the results are more notable for predicting the basic science years performance. However, other studies have noted the important predictive value of noncognitive qualities such as psychological characteristics, socio-economic status, disadvantaged background, and family and social support (Feletti, Sanson-Fisher, and Vidler 1985; Weiss, Lotan, Kedar, and Ben-Shakhar, 1988; Sedlacek and Prieto, 1990; Coombs, 1991; Tekian, 1998a). These studies have directed attention to the benefits of non-cognitive characteristics in predicting performance in the clinical years of medical school.

Medical school admissions committees normally use a variety of available indicators to help them make the arduous decisions before them. Most notably, committees utilize scores on the Medical College Admissions Test (MCAT), previous academic performance at the undergraduate or graduate level (grade point averages), extracurricular and volunteer activities, letters of evaluation, and results of personal interviews with applicants to influence the selection process (Mitchell, 1990). Many times the most problematic and, potentially, the most helpful of the measures are applicants' undergraduate academic records. After all, admissions committees are, most fundamentally, charged with selecting applicants who will be good students and there may be no better indicator of future academic performance than past academic performance. However, disparate grading procedures and variations of academic rigor make the use of undergraduate GPA difficult, particularly when admissions committees deal with applicants from schools for which they have little knowledge and experience (Silver, 1997). Is an applicant from a well-known Ivy League university with a GPA of 3.3 a better college student than an applicant from a less-known regional state university with a GPA of 3.8? Are there reasons to believe that the two applicant's differ enough to affect their potential for strong performance in medical school? Clearly, there are numerous variables that affect students' performance in college and the resulting quantitative measure of a grade point average. But can general judgments be made about students' potential for success in medical school based on their undergraduate institution?

Previous research has attempted to identity the potential of applicants, taking into account numerous variables including undergraduate institution (Anderson and Mitchell, 1986; Johnson, Lloyd, Jones, and Anderson, 1986; and McGuire, 1982). However, these studies concentrate exclusively on the admission selectivity of the undergraduate institution and are complicated multiple regression analyses utilizing a variety of quantitative measures to predict student performance in medical school. Admissions committees would benefit from a clearer understanding of the relationship between schools, or categories of schools, the premedical preparation received by students at given institutions, and the potential for success in medical school indicated by attendance at those schools. Uncertainty with regard to these issues leads admissions committees to give more credence to applicants from well-known institutions and larger universities that produce more premedical students. Conversely, applicants from smaller colleges and less-known schools may be overlooked or not be regarded as highly.

Statement of the Problem

The study sought to determine the relationship between academic lineage and student performance in medical school.

Purposes of the Study

The purposes of the study were to: (1) investigate whether the Carnegie classification of medical school applicants' institutions of origin are associated with academic performance in medical school; (2) consider the relationship between the admission selectivity of the schools of origin and the academic performance of medical school students; (3) compare the performance of medical students from institutions under public governing control with students from privately controlled institutions; and (4) establish a model by which the relative academic strengths of applicants from a variety of undergraduate institutions can be understood more clearly based on the previous performance of medical students from schools with similar institutional characteristics.

Research Hypotheses

The study was concerned with the association between academic lineage and student performance in medical school. Consequently, twelve research hypotheses guided the study. The first set of hypotheses pertained to the association between the Carnegie classification of students' schools of origin and student performance in medical school. These hypotheses were:

1. There is no association between the Carnegie classification of students' schools of origin and the students' cumulative medical school grade point average.
2. There is no association between the Carnegie classification of students' schools of origin and medical school class ranks of students.
3. There is no association between the Carnegie classification of students' schools of origin and medical school failure rates of students.
4. There is no association between the Carnegie classification of students' schools of origin and performance of students on the United States Medical Licensure Examination, Step 1.

The second set of hypotheses considered the relationship between the admission selectivity of students' institutions of origin and student performance in medical school. These hypotheses were:

5. There is no association between the admission selectivity of students' schools of origin and students' cumulative medical school grade point average.
6. There is no association between the admission selectivity of students' schools of origin and medical school class ranks of students.
7. There is no association between the admission selectivity of students' schools of origin and medical school failure rates of students.
8. There is no association between the admission selectivity of students' schools of origin and performance of students on the United States Medical Licensure Examination, Step 1.

The final set of hypotheses related to the association between the governing control of students' institutions of origin, whether public or private, and student performance in medical school. These four hypotheses were:

9. There is no association between the governing control of students' schools of origin, whether public or private, and their cumulative medical school grade point average.
10. There is no association between the governing control of students' schools of origin, whether public or private, and medical school class ranks of students.
11. There is no association between the governing control of students' schools of origin, whether public or private, and the medical school failure rate of students.
12. There is no association between the governing control of students' schools of origin, whether public or private, and performance of students on the United States Medical Licensure Examination, Step 1.

Significance of the Study

Because admission to medical school is a highly competitive process, medical schools are interested in ways to predict the potential performance of applicants. If the potential for success of applicants from various groups of undergraduate institutions (based on their Carnegie classification, admission selectivity, or public/private governing control) can be determined, admissions committees can use this information as a part of their selection process. Students interested in careers in medicine could also use the findings of this study as an aid in determining their paths of undergraduate preparation. Additionally, undergraduate institutions could use the report as a basis for examining the strengths and weaknesses of their undergraduate premedical programs. Further, the present study may serve as a model for future research among other graduate and professional programs as to the predictive value of institution of origin and with regard to the relative preparatory benefit of the educational experience at different types of undergraduate institutions.

Definition of Terms

<u>Academic Lineage, Institution of Origin, School of Origin</u> – the principal undergraduate institution as defined by applicants in their medical school application normally indicating the colleges or universities from which they received their bachelor’s degrees or, if no degrees were received, the schools from which they obtained the most college credit.

<u>Admission Selectivity</u> – information regarding the competitiveness in admission of the schools of origin as indicated by the selectivity rating number in *Time*

Magazine/The Princeton Review College Guide (1998). This rating is a "general assessment determined by considering several factors, among them the percentage of applicants accepted, percentage of acceptees to enroll, and the academic profile of the freshman class." Schools were grouped by rating number according to the following scale: less than 70 (Group A – not selective), 70-79 (Group B – selective), 80-89 (Group C – highly selective), and 90-99 (Group D – most selective).

Carnegie Classifications – taxonomy of institutions of higher education in the United States that groups colleges and universities into categories based on their mission and educational functions (*A Classification of Institutions of Higher Education*, 1994).

Medical School Failure – failing one or more medical school course(s), being forced to repeat one or more courses or an entire medical school year, or being dismissed from medical school for academic reasons.

Medical College Admissions Test (MCAT) - a standardized, multiple-choice examination designed to help admission committees predict which of their applicants will perform adequately in the medical school curriculum. It provides a standardized measure of academic performance for all examinees under equivalent conditions (Medical School Admission Requirements, 1998).

Public/Private – institutional governance as indicated by the appointment process of the governing board, control by a private governing board or control by a governing board appointed by publicly elected officials, determined for each institution from the *Higher Education Directory* (1998).

Student Performance – academic performance of students in medical school as indicated by their cumulative medical school grade point averages, class ranks at graduation, USMLE Step 1scores, and failure rate.

United States Medical Licensure Examination (USMLE), Step 1 - the licensure examination used by most states to determine the knowledge of medical school graduates and to officially license them for medical practice. The USMLE is given in three stages or steps. Step 1 is administered after the second year of medical education and assesses the ability to apply the knowledge and understanding of key concepts of basic biomedical sciences. Steps 2 and 3 are examinations administered after medical school and residency clinical experiences that assess the ability to apply medical and clinical science in the supervised and unsupervised practice of medicine, respectively (*United States Medical Licensure Examination*, 1998).

Delimitations

This study was delimited inasmuch as only medical school matriculants to the University of Texas Southwestern Medical Center at Dallas were considered. This may affect its general applicability to other medical school programs and may affect the ability of its conclusions to be generalized to other graduate or professional programs. A further delimitation resulted by studying only applicants who matriculated as first-year medical students during the years 1990 to 1994 and who had completed or been dismissed from the medical school program by 1998. Delimiting the study to these years enabled the use of all possible quantitative indicators of performance in medical school including cumulative grade point average, class rank upon graduation, any failures or academic difficulties in medical school, and score on the United States Medical Licensure Examination, Step 1. Additionally, because of the small number of students coming from some institutions, determination of the value of the schools of origin were based on the Carnegie classifications, admission selectivity groups, and public or private control.

CHAPTER 2

SYNTHESIS OF RELATED LITERATURE

Because of the importance of the admissions process to medical schools, and ultimately to society, a great deal of literature relates to the selection of applicants and the prediction of student performance. Published articles on medical school admission primarily fall into four broad categories: articles evaluating the admission process in general, its successes and failures, and recommendations for change; research studies on the value of noncognitive predictors of student performance in medical school; studies conducted on the value of various cognitive measures in predicting student performance in medical school; and studies on the undergraduate academic preparation of premedical students and its effect on prediction and selection.

General Evaluations of Medical School Admissions

Predicting the performance of students in medical school has been important for decades, particularly with the reduction in the number of American medical schools as a result of Abraham Flexner's (1910) report on medical education in American (Meyer, 1957). Competition among those hoping to matriculate in medical schools became more intense with the reduced number of programs. Medical schools were forced to evaluate more carefully the aptitudes of applicants and, if possible, to predict their performance in order to reduce attrition and to increase the quality of graduating physicians. As early as 1925, not long after the Flexner Report, statistical methods were being used to predict performance (Bott, 1925). Gottheil and Michael (1957) have succinctly characterized the medical school admissions effort: “Not only are there more applicants than there are places for students, and not only is it desirable to reduce the number of students who fail to graduate, but adequate selection is desirable in order to choose those students who will make the ‘best’ doctors” (p. 131). This three-fold creed is the basis for all research on the selection of students for medical school and the prediction of their performance.

Gottheil and Michael evaluated 95 studies on predictor variables employed in research on the selection of medical students carried out between 1925 and 1956. The predictor variables frequently evaluated included premedical grades, aptitude tests, intelligence tests, achievement tests, reading tests, interest tests, personality tests, the interview, and certain background variables. They found ample evidence in these research studies to indicate that predictor variables were useful and concluded that “predictions may actually be . . . more efficient than they have been generally thought to be” (1957, p. 141). Indeed, the concerns relating to medical school admission, of predicting performance, and of selecting the best candidates, are perennial.

Rudolph Weingartner (1980), Dean of the College of Arts and Sciences at Northwestern University, evaluated the medical school admission process from the perspective of those who help prepare undergraduate students. He made 10 recommendations involving premedical education and the medical school admissions process including elimination of the premed major, requiring a broad educational background evidenced by receipt of the bachelor’s degree, the importance of a difficult entrance examination, and using knowledge about different undergraduate institutions to understand the GPA. Coombs and Paulson (1990) also emphasized the importance of a broad premedical undergraduate experience, suggesting that “premed syndrome” (a single-minded pursuit of admission to medical school by undergraduates) has been “linked to a perceived lack of physician concern for patients, interpersonal warmth, and humanitarian care” (p. 13).

Powis (1994) presented a model for the selection of medical students. He concentrated on the pragmatic approach of using all available means to affect the desired outcome. Medical schools define the desired characteristics of incoming students, use a number of valid and reliable tools to select those candidates who exhibit these characteristics, and reject those applicants who do not. An important activity for medical schools is to evaluate systematically the process in order to understand whether student outcomes actually match the desired characteristics prior to entry. He presents a “functional strategy for student selection” that involves selecting motivated students from the larger pool of applicants, rejecting applicants who do not meet minimal academic criteria, evaluating the non-cognitive aspects of applicants, and, from a pool of qualified and essentially suitable applicants, selecting on the basis of a quota system for age, gender, ethnic origin, and domicile, etc.

In March 1990, *Academic Medicine*, the journal of the Association of American Medical Colleges, devoted an entire issue to medical school admission. McGaghie (1990a) emphasized the important issues regarding admission including the fact that almost all students who are admitted to medical school graduate, thus contributing to economic security and high professional status. Yet, he lamented the continued reliance of medical schools on weak links between aptitude and achievement, undergraduate GPA and MCAT scores as primary tools for selection, and their refusal to understand better the characteristics of self-reliance and motivation. Spooner (1990) discussed the roles of cognitive and noncognitive variables in the selection process emphasizing that the existing literature clearly analyzes research findings, and recommends sound practices. He concluded by suggesting that the process of selecting medical school students must be one that takes into account academic predictors but also uses factors in applicants' backgrounds that are difficult to quantify. Finally, Self (1990) presented three case studies to demonstrate moral dilemmas that complicate the admissions process. The situations ranged from common to uncommon, yet involved important moral and ethical issues for which admissions committees should be prepared.

Noncognitive Measures Used in Prediction and Selection

Consensus among most medical school admissions officers is that cognitive variables alone are not sufficient for selecting students for medical school. The degree to which these cognitive variables are used in the admissions process of any given medical school will vary. Some medical educators, however, are vociferous in their discontent over what they consider an admissions process weighted too heavily toward quantitative measures such as GPA and MCAT score (Anderson, 1990). Smith and Hayling (1998) argued that admissions professional "buy into the seductive but fallacious belief in the precision of quantitative tests" (p. 1054). They encouraged the identification of other criteria that may be indicative of characteristics and skills necessary for the quality patient care. The concentration on empirically measurable admission criteria, suggested

Coombs (1991), invariably leads to applicants who are "emotionally inexpressive, grade-conscious, competitive and narrowly specialized in science" (p. 539).

Individual Applicant Characteristics

The use of non-cognitive, or qualitative, variables in medical school admissions is based on the assumption that identifiable personal characteristics contribute to success as a medical student and physician. McGaghie (1990b) identified such qualities as character and integrity, evidence of leadership, breadth of knowledge, work habits, motivation for study, a personal orientation toward service, value of altruism, and personal effectiveness. He emphasized that more attention should be given to the end product, the qualities necessary to being a good clinician, rather than the presumed requirements for medical education. Nowacek and Sachs (1990) broadened the field of noncognitive qualities that should be considered in admission selection by discussing demographic variables. They suggest that formal decision making by admissions committees should include religion, birth order, size of hometown, citizenship, socioeconomic status, and political orientation in addition to those already in use such as age, gender, race or ethnicity, state of residency, and marital status. They admit that the usefulness of some of these variables (age, gender, race) are limited by federal statute, but that they can continue to be useful in admissions research. Other researchers (Johnson, 1971a; Feletti, 1985) have also emphasized the utility of demographic variables in the selection of medical students.

Personality Variables

A number of researchers have studied the benefit of personality variables in combination with cognitive criteria. Gough and Hall (1964) attempted the prediction of performance in medical school based on performance on the California Psychological Inventory (CPI). They concluded that the psychological characteristics identified by the CPI were predictive of successful performance during the course of medical training. Tutton (1993) also evaluated the potential of using the CPI as another measure in selection and found that it was highly correlated with structured interview scores that had "little overlap with prior scholastic results" (p. 328) and meaningfully appraise personal attributes necessary for success in medical school. Many researchers in the area of personality variables used in selection (Roessler, Lester, Butler, Rankin, and Collins, 1978; Lipton, Huxham, and Hamilton, 1984; and Weiss, 1988) have concluded that the use of personality inventories such as the CPI, the Eysenck Personality Inventory, or the Minnesota Multiphasic Personality Inventory greatly enhance the prediction of performance in medical school, particularly in clinical training.

Ethnicity

Noncognitive predictors of students' performances in medical school have received much attention within the context of minority student admission. Indeed, the focus given to noncognitive qualities will continue to increase because of legal challenges to affirmative action. Medical school admissions committees will continue to be charged with selecting classes that represent ethnic diversity, yet may be unable to use race or ethnicity as a variable in the selection process. The issues surrounding minority student admission to medical school, therefore, have become the subjects of several research studies. Sedlacek and Prieto (1990) emphasized that traditional predictors of success in medical school (MCAT and GPA) have more modest correlations with performance for minority students. They suggested that a system using noncognitive variables organized into eight dimensions would be helpful in identifying qualified minority students who might otherwise be overlooked. The nontraditional variable dimensions were self-concept, realistic self-appraisal, understanding and dealing with racism, long-range goals, having a strong support person, showing leadership, having community involvement, and nontraditional knowledge acquired. They concluded that combining these qualities with the traditional cognitive measures is best in the selection of minority applicants. Tekian (1998b) also emphasized that quantitative variables such as MCAT and GPA are not "sufficiently sensitive" to differentiate between students who will success and those who will withdraw. He suggested that a judicious combination of cognitive and noncognitive factors be developed and used in the medical school admission process.

Van Winkle and Perhac (1996) studied 16 minority premedical students who participated in a six-week program at the Chicago College of Osteopathic Medicine and compared their academic credentials prior to the program and their performance in the program. Eight of the students successfully completed the program and were offered early admission to the medical school while the other half either failed several of the courses in the program or did not complete the program. The authors emphasized the benefit of this short and relatively inexpensive pre-medical school matriculation program in identifying minority students at apparent academic risk but who, nevertheless, are prepared to succeed in medical school.

Disadvantaged Background

Much of the literature on noncognitive measures and minority student admission deals with disadvantage, whether educational, economic, or both. Fadem, Schuchman, and Simring (1995) found a relationship between parental income and performance, particularly for minority females. Bediako, McDermott, Bleich, and Colliver (1996) studied minority students who participated in Ventures in Education, a project to increase the number of disadvantaged minorities entering the health professions. The percentage of Ventures students who applied to and enrolled in medical school was "significantly higher than the corresponding percentages for the general population" (p. 190). They concluded that with a greater commitment of resources to individualized attention, minority students can apply, enroll, and succeed in medical school. Miller, Thomson, Smith, Thompson, and Camacho (1992) surveyed admissions officials at 144 American and Canadian medical schools and found a generalized perception that some ethnic groups have not received equal educational opportunity. The authors lamented that this perception is disturbing because most admissions committees work only with the top applicants within each ethnic group. They suggested that the academic community must rectify deficiencies in the academic preparation of students.

Personal Interview

The admission interview, a required part of the process for successful applicants, has been noted as a primary means for identifying and evaluating many noncognitive qualities. Tekian (1998) surveyed 15 medical schools with high minority enrollments to evaluate the admission process. Of special note was the importance placed on the interview by most of the responding schools. Articles by Peck, Krowka, and May (1978), Edwards, Johnson, and Molidor (1990), Taylor (1990), Elam and Androykowski (1991), Elam, Johnson, Wiese, Studts, and Rosenbaum (1994), Collins, White, Petric, and Willoughby (1995), Shaw (1995), Studts, Elam, and Johnson (1995), Nowacek, Bailey, and Sturgill (1996), and Harasym, Woloschuk, Mandin, and Brundin-Mather (1996) provide various analyses on the importance of the interview and its effect on the selection of applicants. Other studies have evaluated the importance of the application essay (Hull et al., 1996), recommendation letters (Johnson et al., 1998), and premedical student expectations (Chuck, 1996).

Traditional Predictors of Student Performance

Medical schools have traditionally used quantitative measures to identify groups of applicants to be considered further, to evaluate the aptitude of applicants, and to compare applicants with each other. Scores on the Medical College Admission Test (MCAT) and undergraduate grade point averages are used in some combination to indicate the preparation and abilities of applicants. Much of the research literature focuses on validating the use of these data as predictors of performance. Koenig (1998) utilized a large sample (11,279) to evaluate the predictive validity of MCAT scores across diverse applicant groups. She found that MCAT scores alone and in combination with GPA are good predictors of medical school performance. This conclusion supports previous research which indicated correlations as high as +.66 between MCAT score and scores on the national licensing examinations (Brooks, 1981; McGuire, 1982; Colliver, Verhulsstand, and Williams 1989; Elam, 1994; and Silver, 1997). Most of these studies, in addition to others (Jones, 1984; Johnson, Lloyd, Jones, and Anderson, 1986; Leonardson, 1987; and Mitchell, Haynes, and Koenig, 1994), indicate the increased validity of prediction when the MCAT score is used in combination with either cumulative or science GPA. However, they also caution that the strength of these predictions is realized in the first two years of medical school, the pre-clinical or basic science years. Almost without exception, these studies indicate that the power of prediction of the traditional variables is greatly reduced for the clinical years.

Other studies on the traditional predictors reveal how medical school admissions committees use them in the process of selection. Mitchell (1987) evaluated the admission process at 113 American medical schools and found that some factors were more highly valued than others. Among those factors most highly valued by admission committees were cumulative and science grade point averages, MCAT scores, quality of degree-granting institution, letters of evaluation, interview ratings, breadth and/or difficulty of course work. Of significance to the current study, Mitchell found that thirty-one percent of the responding schools used the MCAT score to adjust the GPA to account for unfamiliar institutions. Further, it was found that forty percent altered their consideration of the MCAT score itself for applicants from institutions for which they had little experience. In a later study, Mitchell (1990) affirmed the "substantial value of traditional academic predictors of performance in medical school" (p. 149). In this study, it was acknowledged that adjusting the GPA for school selectivity strengthened the level of prediction.

Sampling error creates a conundrum for many of the studies noted above. The research is, of necessity, based only on those applicants who did enroll in medical school. In order for the prediction technique to be completely valid, those applicants who did not enroll would have to be considered. Do the factors in question also predict performance for them? DeVaul et al. (1987) were able to approximate, in some small portion, this effort. Fifty applicants who were originally rejected were subsequently allowed to enroll in the medical school. The researchers evaluated these fifty along side their classmates who had originally been admitted. He found no differences in performance in medical school between the two groups.

Undergraduate Academic Preparation

Undergraduate academic preparation is a key element of admission to medical school. Premedical course requirements are strictly enforced by most medical schools in order to guarantee that students have the prerequisite science exposure necessary to be successful in the medical curriculum. However, debate over the importance of the undergraduate major has been a focus of much research. Do students' choices of undergraduate major affect their performance during medical school? Extensive research (Dickman, Sarnacki, Schimpfhauser, and Katz, 1980; Creditor and Creditor, 1982; Yens and Stimmel, 1982; Zeleznik, Hojat, and Veloski, 1983; Sade and Lancaster, 1983; Neame, Powis, and Bristow, 1992; Crockford, Gupta, and Grace, 1995; Hall and Stocks, 1995; and Smith, 1998) has indicated that no difference in performance exists, in basic science years, clinical years, or on standardized licensure examinations, between students who majored in fields of science and those who did not.

Obviously, the most utilized factor of academic preparation is the grade point average. However, the difficulty of understanding the GPA across diverse institutions makes it problematic. Studies have acknowledged this difficulty (Johnson, 1986; Mitchell, 1987; Colliver, 1989; Silver, 1997; and Koenig, 1998), but little research has focused on the differences in performance of students from various undergraduate institutions and the research that does exist presents conflicting results. Clapp and Reid (1976) concluded that institutional selectivity, as indicated by a 7-point scale created by Alexander Astin, enhanced the predictive validity of GPA. However, this study is dated, 1972-1973, and suffers from a small sample size, 110 students. Sarnacki (1982) also evaluated student performance with regard to undergraduate institution selectivity. Though also suffering from a small sample size, 194, this study revealed no difference between institutional selectivity groups on the dependent measures of medical school course work and standardized licensure examinations.

Johnson (1971b) examined the selection process of medical schools with regard to differences between public and private institutions. This research, studying applicants from British institutions seeking admission into the University of Leeds, indicated that a disproportionately large number of medical students were educated in private schools. However, the study did not evaluate the performance of students based on their institution of origin's governing control, whether public or private.

Conclusions

A great deal of research has been produced on the various individual factors, whether cognitive or noncognitive, involved in the prediction of student performance in medical school and applicant selection. In particular, the validity of traditional predictors (MCAT and GPA) has been extensively studied and established, even over diverse applicant groups. However, the effects of institutional differences (mission and educational function, governing control, and admission selectivity) have not been adequately studied. Medical schools, colleges and universities, and applicants can possibly benefit from extended research on this subject.

CHAPTER 3

METHODOLOGY

Introduction

This study investigated the academic performance of medical school students based upon their academic lineage. Of specific interest were institutional characteristics of the students' schools of origin, admission selectivity, and whether the schools' governing control was public or private. For the purposes of the study, "performance" was defined by these outcome measures: (1) cumulative medical school grade point average, (2) class rank, (3) failure rate, and (4) United States Medical Licensure Examination (USMLE), Step 1, score.

A description of the methods and procedures for the collection of data is delineated in this chapter. The procedures for collection of data, procedures for sample selection, classification of institutions, classification of admissions selectivity groups, and procedures for coding and analysis of data are included.

Procedures for the Collection of Data

The data used in the study were collected from the Registrar's Office at the University of Texas Southwestern Medical Center at Dallas. These data were related to the pre-matriculation academic profile and the medical school performance results of the sample identified. The registrar of the medical school was notified and requested to submit information with regard to the individuals in the identified sample. A database of this information was created and used to sort, query, and analyze the data. The following data fields were available for each student in the sample:

1. Class Rank in Medical School;
2. Cumulative Medical School Grade Point Average;
3. Dismissal from Medical School (Was the student dismissed?);
4. Failure in Medical School (Did the student fail a class/year?);
5. Graduation Year from Medical School;
6. Highest MCAT Score Total;
7. Last Term in Medical School;
8. Matriculation Year;
9. Name of Institution of Origin;
10. Student Identification Number;
11. Total Undergraduate GPA;
12. United States Licensure Examination (Step 1) Score.

To these initial data fields were added information regarding institutional characteristics of each student's school of origin including: (1) Carnegie classification, (2) admissions selectivity group, and (3) whether the governing control of the institution was public or private.

Instruments

No instruments were used because all the information was obtained from data resident in the Student Information System database at the University of Texas Southwestern Medical Center at Dallas. The study was conducted utilizing a Microsoft

Access database configured specifically for the data fields applicable to the population and the independent and dependent variables being analyzed.

The Sample

The sample for the study included the medical students at the University of Texas Southwestern Medical Center at Dallas who initially enrolled during the years 1990 to 1994 and who completed, or were dismissed from, the medical school by 1998 (N=933). This time frame was selected because it allowed for the use of all pertinent measures of academic performance to be considered including student performance on the USMLE. Prior to 1992, state board examinations were used for medical licensure and score comparison with USMLE test takers would have been difficult. Additionally, it was considered important for the study to include the performance of students who have actually completed, or been dismissed from, the medical curriculum.

Description and Selection of the Sample

The data were originally collected by the Registrar's Office at UT Southwestern from individual applications, transcripts, grade reports, instructor evaluations, and other external sources. These data have been stored in the institution's main frame computer in the Student Information System (SIS) database. Data from the student records were downloaded from SIS into the Microsoft Access database and analyzed by using SPSS statistical software.

Each student's institution of origin was categorized according to the Carnegie Foundation (1994) classification system. For the purposes of this study, some of the Carnegie classifications were collapsed to provide for a more reasonable structure for evaluation. The differentiating criteria between the classifications within each of these categories were not germane to the present study. Definitions of the categories included in this study are as follows (Boyer, 1994):

Research I universities offer a full range of baccalaureate programs, are committed to graduate education through the doctorate, and give high priority to research. They award 50 or more doctoral degrees each year and receive annually $40 million or more in federal support. Research II universities differ only in the amount of federal support they receive, between $15.5 million and $40 million annually. Research I and Research II classifications were combined for the purposes of this study.

Doctoral I universities offer a full range of baccalaureate programs and are committed to graduate education through the doctorate. They award at least 40 doctoral degrees annually in five or more disciplines. Doctoral II universities differ only in the number of doctoral degrees awarded annually, at least 10 doctoral degrees – in three or more disciplines – or 20 or more doctoral degrees in one or more disciplines. Doctoral I and Doctoral II categories were combined for this study.

Master's (Comprehensive) I colleges and universities offer a full range of baccalaureate programs and are committed to graduate education through the master's degree. They award 40 or more master's degrees annually in three or more disciplines. Master's (Comprehensive) II institutions award 20 or more master's degrees annually in one or more disciplines. MA I and MA II institutions were also combined for this study.

Baccalaureate (Liberal Arts) I colleges are primarily undergraduate colleges with major emphasis on baccalaureate degree programs. They are selective in admissions and award 40 percent or more of their baccalaureate degrees in liberal arts fields. Baccalaureate II colleges are primarily undergraduate colleges with major emphasis on baccalaureate degree programs. They are less selective in admissions and award less than 40 per cent of their baccalaureate degrees in liberal arts fields. These two categories were also collapsed.

The Carnegie classifications of Associate of Arts Schools, Professional Schools, and Specialized Institutions were excluded from this study. The number of medical students who presented schools in these classifications as their primary baccalaureate institution were so limited (N=10) that their use was considered unnecessary and any data analysis potentially misleading.

Table 1
Number of Institutions and Students by Carnegie Classifications

Carnegie Classification	Population of Schools Nationally	Number of Students In Study Population (N)
Research	125	594
Doctoral	111	190
Master's	529	82
Baccalaureate	637	57
Total	1,402	923

Individual institutions in the student's records were coded based on the institution's Carnegie classification. Research I and II institutions were coded "4", Doctoral I and II institutions were coded "3", Master's I and II institutions were coded "2", and Baccalaureate I and II institutions were coded "1". The 10 student records that contained institutions not in these categories were not coded and therefore were not used in the statistical analysis based on Carnegie classifications.

Additionally, each student's institution of origin was categorized by admission selectivity based on the selectivity rating number in *Time Magazine/The Princeton Review College Guide* (1998). This rating is a "general assessment determined by considering several factors, among them the percentage of applicants accepted, percentage of acceptees to enroll, and the academic profile of the freshman class." Schools were grouped by rating number according to the following scale: Group A (not selective) less than 70; Group B (selective) 70-79; Group C (highly selective) 80-89; and Group D (most selective) 90-99.

Table 2
Selectivity Groups and Number of Students

Selectivity Group	Number of Students in Population (N)
Group A (not selective)	61
Group B (selective)	270
Group C (highly selective)	395
Group D (most selective)	201
Total	927

Individual institutions in the student's records were coded based on the institution's selectivity rating number. Group A institutions were coded "1", Group B institutions were coded "2", Group C institutions were coded "3", and Group D institutions were coded "4". The 6 student records that contained institutions that were not included in *The Princeton Review* rating scheme were not coded and therefore not used in the statistical evaluation based on selectivity groups.

Finally, each student's institution of origin was categorized by whether its governing control was public or private based on institutional entry in the *Higher Education Directory* (1998). Individual institutions in the student's records were coded based on the institution's governing control. Public institutions were coded "1" and private institutions were coded "2". All student records (n=933) were included in the study.

Table 3
Institutional Control and Number of Students

Institutional Control	Number of Students in Population (N)
Public	533
Private	400
Total	933

Procedures for the Analysis of Data

Data were collected for analysis from the medical student records database at UT Southwestern. Included in the record for each student was the independent variable of college of origin and its coded descriptors of Carnegie classification, admission selectivity group, and public or private governing control. Also included for each student were results of their medical school performance as indicated by the dependent variables of cumulative medical school grade point average, class rank, USMLE step 1 score, and whether or not the student failed a course or year and/or was dismissed from school (binary). All statistical tests were completed via SPSS 9.0 computer software.

Twelve null hypotheses were tested. H1, H2, H3, and H4 hypothesized no association between Carnegie classification and student's medical school GPA, medical school class ranks of students, medical school failure rates of students, and performance of students on the USMLE, Step 1, respectively. The second set hypothesized no association between the admission selectivity of students' schools of origin and the cumulative medical school GPA of students (H5), medical school class ranks of students (H6), medical school failure rates of students (H7), and performance of students on the USMLE, Step 1, (H8). Finally, H9, H10, H11, and H12 hypothesized no association between the governing control of students' schools of origin and medical school GPA, medical school class ranks of students, medical school failure rates of students, and performance of students on the USMLE, Step 1, respectively.

Nonparametric statistical tests were used in the study for several reasons. The sample of students used in the study was not randomly selected. From the population of students who have attended UT Southwestern since it was founded in 1943, only those students who matriculated between 1990 and 1994 and who graduated or were dismissed between 1994 and 1998 were used. The use of this convenience sample was based on the needs of the study, the available data, and changes in the licensure examination procedures for medical students. Additionally, it was unlikely that the sample means for any of the dependent variables would be equal to the population means, nor would the sample variances be equal to the population variances. Because many of the assumptions of parametric statistics were violated by the sample parameters, nonparametric tests were considered appropriate.

Observed scores for the dependent variables of cumulative GPA, class rank, and USMLE score were ranked lowest to highest for each Carnegie classification and admission selectivity group. Mean ranks were calculated and the null hypotheses (no difference between the mean ranks) were tested using the Kruskal-Wallis Test, often called the "analysis of variance by ranks," at the .05 alpha level (Zar, p. 199). If the null hypothesis for any individual outcome measure was rejected, post-hoc multiple comparison tests (the Dunn method for nonparametric statistics; see Zar, p.227) were performed also at the .05 alpha level to identify which classification(s)/group(s) differed.

For comparison of the public or private governing control groups, observed scores for cumulative medical school grade point average, medical school class rank, and performance on the USMLE, Step 1, were ranked and a mean rank computed for each group. The null hypotheses (no difference between mean ranks) were tested by using the Mann-Whitney U test at the .05 alpha level (Hinkle, Wiersam, Juns, 1994, p. 562).

For the dependent variable of failure/dismissal rate, the proportion of all students who failed a course/year or were dismissed from school was calculated for each level of each independent variable. The Tukey-type multiple comparison test among proportions (Zar, p. 560) was used at the .05 alpha level to determine whether a significant difference existed between groups.

Data pertaining to the independent variables in the study (Carnegie classification of institutions of origin, admission selectivity, and institutional control) were analyzed using the Mueller-Schuessler Index of Qualitative Variation (Champion, 1970, p.46).

CHAPTER 4

RESULTS

The results of a study investigating the association between academic lineage and student performance in medical school are reported in this chapter. The first section of the chapter presents the results of the Mueller-Schuessler Index of Qualitative Variation test (IQV) (Champion, 1970, p. 46) for each of the independent variables. Section two of the chapter presents the data related to the hypotheses that no association exists between Carnegie classifications and student performance in medical school. The data pertaining to the hypotheses that no association exists between the admission selectivity of the students' schools of origin and student performance in medical school are presented in section three of this chapter. The final section of the chapter presents the data related to the hypotheses that no association exists between governing control of students' schools of origin, whether public or private, and student performance in medical school.

Variation Among Groups of Independent Variables

Data pertaining to the independent variables in the study (Carnegie classifications of institutions of origin, admission selectivity, and institutional control) were analyzed using the Mueller-Schuessler Index of Qualitative Variation test. The purpose of this analysis was to determine the homogeneity or heterogeneity of the members of the population when grouped according to the independent variables.

Table 4
Observed and Maximum Differences for Carnegie Classification

	A	B
Carnegie Classification	**Number of Students in Study Population (N) (Observed Differences)**	**Number of Students if Spread Equally (Maximum Differences)**
Research	594	230.75
Doctoral	190	230.75
Master's	82	230.75
Baccalaureate	57	230.75
Total	923	923

Column (A) of table 4 above shows the observed distribution of students according to the Carnegie classification of their schools of origin. Column (B) shows the maximum heterogeneity which would exist if student were distributed equally throughout each classification. The observed differences, however, show that a degree of homogeneity existed – considerably more students graduated from schools classified as research institutions than students who graduated from schools classified in the other three categories. To determine the degree of heterogeneity numerically, an Index of Qualitative Variation (IQV) was computed by dividing the total observed differences by the maximum possible differences and multiplying by 100. The IQV for Carnegie classifications was 70.90106, meaning that there was approximately 71 percent of maximum heterogeneity among the students with respect to Carnegie classification.

Table 5 below presents the data related to the observed and maximum differences for admissions selectivity groups. The computed IQV for admission selectivity groups was 90.967411, meaning that there was 91 percent of maximum heterogeneity among students with respect to admission selectivity group.

Table 5
Observed and Maximum Differences for Admission Selectivity Groups

	A	**B**
Admission Selectivity Group	**Number of Students in Study Population (N) (Observed Differences)**	**Number of Students if Spread Equally (Maximum Differences)**
Group A (not selective)	61	231.75
Group B (selective)	270	231.75
Group C (highly selective)	395	231.75
Group D (most selective)	201	231.75
Total	927	927

The data pertaining to observed and maximum differences for public or private governing control groups are presented in table 6 below. The computed IQV for governing control groups was 97.96792, meaning that there was 98 percent of maximum heterogeneity among students with respect to governing control group, whether public or private.

Table 6
Observed and Maximum Differences for Governing Control Groups

	A	**B**
Governing Control Groups	**Number of Students in Study Population (N) (Observed Differences)**	**Number of Students if Spread Equally (Maximum Differences)**
Public	533	466.5
Private	400	466.5
Total	933	933

Carnegie Classifications

The first set of hypotheses pertained to the relationship between Carnegie classification and student performance. Four hypotheses were tested. These hypotheses stated that no association exists between Carnegie classification of the students' schools of origin and students' cumulative medical school grade point averages (H1), medical school class ranks of students (H2), medical school failure rates of students (H3), and performance of students on the USMLE, Step 1 (H4).

Cumulative Medical School GPA

Tables 7 and 8 present the data for the hypothesis of no association between academic lineage and medical school GPA. Mean cumulative medical school GPA and the mean rank were calculated for each Carnegie classification as part of the Kruskal-Wallis test (Zar, p. 197), a nonparametric analysis-of-variance test. The null hypothesis states that no difference exists between the group mean ranks. The test statistic (H_C) was calculated and found to be 12.645. The critical value of chi-square at the .05 alpha level with 3 degrees of freedom ($X^2_{0.05,3}$) is 7.815. Because the calculated value of H exceeded the critical value of X^2, the null hypothesis was rejected.

Table 7
Hypothesis 1: Carnegie Classification Association with CumGPA

Carnegie Classification	Students in Sample (N)	Mean CumGPA	Sum of the Ranks	Mean Rank (Kruskal – Wallis)
(1) Baccalaureate	57	3.4320	24,397	428.02
(2) Master's	82	3.3598	31,535	384.57
(3) Doctoral	190	3.4661	83,746	440.77
(4) Research	594	3.5171	286,748	482.74
Total	923	3.4874	426,426	

Table 8
Kruskal-Wallis Test Results
Carnegie Classification and CumGPA

Test Statistics	Value
H_c	12.645
$X^2_{0.05,3}$	7.815

The null hypothesis of no difference between the mean ranks was rejected based on the Kruskal-Wallis test. To ascertain which groups differed from which other groups, the Dunn method multiple comparison test with unequal sample sizes and tied ranks present was used (Zar, p. 227). The Dunn method is a nonparametric analog to the parametric Tukey multiple comparison tests for ANOVA analysis. In table 9 are the data for the multiple comparison tests between the Carnegie classifications for cumulative medical school grade point average.

Table 9
Dunn Multiple Comparison Tests
for Carnegie Classification and CumGPA

Comparison	Difference between mean ranks	Standard Error	Test Statistic Q	Critical Value ($Q_{0.05,4}$)	Conclusion
1 vs 2	43.45	45.96121	0.945362	2.639	Accept H_0
1 vs 3	12.75	40.2497	0.316773	2.639	Accept H_0
1 vs 4	54.72	36.95628	1.480668	2.639	Accept H_0
2 vs 3	56.2	35.21512	1.595905	2.639	Accept H_0
2 vs 4	98.17	31.39797	3.126635	2.639	Reject H_0
3 vs 4	41.97	22.21347	1.889394	2.639	Accept H_0

According to these data, the *p* values in the group comparisons ranged from 0.316773 to 3.126635. The only significant difference found was between groups 2 (master's) and 4 (research), p=3.126635. Therefore, the null hypothesis of no difference between the mean ranks of groups 2 and 4 was rejected. The remaining null hypotheses were accepted.

Class Rank

The data for the second hypothesis, that no association exists between Carnegie classification and medical school class rank of students, are presented in Tables 10 and 11. Mean class ranks and the mean rank were calculated for each Carnegie classification as part of the Kruskal-Wallis test. The null hypothesis states that no difference exists between the group mean ranks. The test statistic (H_C) was calculated at 12.707 which exceeded the critical value of chi square ($X^2_{0.05,3}$=7.815). Therefore, the null hypothesis was rejected.

Table 10
Hypothesis 2: Carnegie Classification Association with Class Rank

Carnegie Classification	Students in Sample (N)	Mean Class Rank	Sum of the Ranks	Mean Rank (Kruskal – Wallis)
(1) Baccalaureate	56	104.3214	27,274	487.04
(2) Master's	81	115.2346	43,643	538.80
(3) Doctoral	189	102.8730	90,841	480.64
(4) Research	589	93.6027	257,552	437.27
Total	915	98.0885	419,310	

Table 11
Kruskal-Wallis Test Results
Carnegie Classification and Class Rank

Test Statistic	Value
H_c	12.707
$X^2_{0.05,3}$	7.815

The null hypothesis of no difference between the mean ranks was rejected based on the results of the Kruskal-Wallis test. Table 12 presents the data for the multiple comparison tests between the Carnegie classifications for medical school class rank.

Table 12
Dunn Multiple Comparison Tests
for Carnegie Classification and Class Rank

Comparison	Difference between mean ranks	Standard Error	Test Statistic Q	Critical Value ($Q_{0.05,4}$)	Conclusion
1 vs 2	51.76	45.9163	1.127254	2.639	Accept H_0
1 vs 3	6.40	40.19823	0.159211	2.639	Accept H_0
1 vs 4	49.77	36.94681	1.347072	2.639	Accept H_0
2 vs 3	58.16	35.08789	1.657552	2.639	Accept H_0
2 vs 4	101.53	31.31021	3.242712	2.639	Reject H_0
3 vs 4	43.37	22.08768	1.963538	2.639	Accept H_0

According to these data, the only significant difference found was between groups 2 (master's) and 4 (research), p=3.242712. Therefore, the null hypothesis of no difference between the mean ranks of groups 2 and 4 was rejected. The remaining null hypotheses were accepted.

Failure Rate

Table 13 presents the data for the third hypothesis which stated that no association exists between Carnegie classification and the failure rate of students in medical school. The number of students who failed or were dismissed was computed and a failure rate or proportion was calculated for each Carnegie classification.

Table 13
Hypothesis 3: Carnegie Classification Association with Failure Rate

Carnegie Classification	Total N	Percent	Valid N	Percent (p)	Missing N	Percent (q)
(1) Baccalaureate	57	100%	7	12.3%	50	87.7%
(2) Master's	82	100%	17	20.7%	65	79.3%
(3) Doctoral	190	100%	21	11.1%	169	88.9%
(4) Research	594	100%	58	9.8%	536	90.2%

The null hypothesis states that no difference exists between the group proportions and was tested using the Tukey-type multiple comparison test among proportions (Zar, p. 560). The test statistic (*Q*) was calculated and compared with the critical value of *Q* at the .05 alpha level with 4 degrees of freedom ($Q_{0.05,\infty,4}$) which was 3.633. The data presented in table 14 show that only classifications 2 (master's) and 4 (research) differed significantly, Q=3.796687. Therefore, the null hypothesis was rejected. The null hypotheses for the other comparisons were retained because the calculated test statistics did not exceed the critical value of *Q*.

Table 14
Tukey-type Multiple Comparison Tests
for Carnegie Classification and Failure Rate

Comparison	Test Statistic Q	Critical Value ($Q_{0.05,\infty,4}$)	Conclusion
1 vs 2	1.79461	3.633	Accept H_0
1 vs 3	0.47833	3.633	Accept H_0
1 vs 4	0.99414	3.633	Accept H_0
2 vs 3	2.8886	3.633	Accept H_0
2 vs 4	3.796687	3.633	Reject H_0
3 vs 4	0.786953	3.633	Accept H_0

Performance on the USMLE, Step 1

The data for the fourth hypothesis, that no association exists between Carnegie classification and student performance on the USMLE, Step 1, are presented in Tables 15 and 16. Mean USMLE scores and the mean rank were calculated for each Carnegie classification as part of the Kruskal-Wallis test. The null hypothesis states that no difference exists between the group mean ranks. The test statistic (H_C) was calculated at 16.690 which exceeded the critical value of chi square ($X^2_{0.05,3}$=7.815). Therefore, the null hypothesis was rejected.

Table 15
Hypothesis 4: Carnegie Classification Association with USMLE Score

Carnegie Classification	Students in Sample (N)	Mean USMLE Score	Sum of the Ranks	Mean Rank (Kruskal – Wallis)
(1) Baccalaureate	56	205.57	24,368	435.15
(2) Master's	79	201.16	30,051	380.39
(3) Doctoral	188	204.18	78,261	416.28
(4) Research	589	208.84	283,651	481.58
Total	912	207.01	416,331	

Table 16
Kruskal-Wallis Test Results
Carnegie Classification and USMLE Score

Test Statistic	Value
H_c	16.690
$X^2_{0.05,3}$	7.815

The null hypothesis of no difference between the mean ranks was rejected on the basis of results of the Kruskal-Wallis test. Table 17 presents the data for the multiple comparison tests between the Carnegie classifications for USMLE score.

Table 17
Dunn Multiple Comparison Tests
for Carnegie Classification and USMLE Score

Comparison	Difference between mean ranks	Standard Error	Test Statistic Q	Critical Value ($Q_{0.05,4}$)	Conclusion
1 vs 2	54.76	46.00259	1.190368	2.639	Accept H_0
1 vs 3	18.87	40.09082	0.470681	2.639	Accept H_0
1 vs 4	46.43	36.82571	1.260804	2.639	Accept H_0
2 vs 3	35.89	35.30906	1.016453	2.639	Accept H_0
2 vs 4	101.19	31.55295	3.20699	2.639	Reject H_0
3 vs 4	65.3	22.05956	2.960167	2.639	Reject H_0

According to these data, significant differences were found between groups 2 (master's) and 4 (research), p=3.20699, and groups 3 (doctoral) and 4 (research), p=2.960167. Therefore, the null hypothesis of no difference between the mean ranks of groups 2 and 4 was rejected along with the null hypothesis of no difference between groups 3 and 4. The remaining null hypotheses were accepted.

Admission Selectivity

The second set of hypotheses pertained to the relationship between the admission selectivity of students' schools of origin and student performance. Four hypotheses were tested. These hypotheses stated that no association exists between the admission selectivity group of the students' schools of origin and students' cumulative medical school grade point averages (H5), medical school class ranks of students (H6), medical school failure rates of students (H7), and performance of students on the USMLE, Step 1 (H8).

Cumulative Medical School GPA

Tables 18 and 19 present the data for the first hypothesis which stated that no association exists between admission selectivity and medical school GPA. Mean cumulative medical school GPA and the mean rank were calculated for each admission selectivity group as part of the Kruskal-Wallis test. The null hypothesis states that no difference exists between the group mean ranks. The test statistic (H_C) was calculated and found to be 15.246. The critical value of chi-square at the .05 alpha level with 3 degrees of freedom ($X^2_{0.05,3}$) is 7.815. Because the calculated value of H exceeded the critical value of X^2, the null hypothesis was rejected.

Table 18
Hypothesis 5: Admission Selectivity Group Association with CumGPA

Admission Selectivity Group	**Students in Sample (N)**	**Mean CumGPA**	**Sum of the Ranks**	**Mean Rank (Kruskal - Wallis)**
Group A (not selective)	61	3.3418	22,122	362.65
Group B (selective)	270	3.4727	122,542	453.86
Group C (highly selective)	395	3.4890	182,818	462.83
Group D (most selective)	201	3.5503	102,647	510.68
Total	927	3.4878	430,129	

Table 19
Kruskal-Wallis Test Results
Admission Selectivity Group and CumGPA

Test Statistic	**Value**
H_c	15.246
$X^2_{0.05,3}$	7.815

The null hypothesis of no difference between the mean ranks was rejected on the basis of the Kruskal-Wallis test. To determine which admission selectivity groups differed, the Dunn method multiple comparison test with unequal sample sizes and tied ranks present was used (Zar, p.227). In table 20 are the data for the multiple comparison tests between the admission selectivity groups for cumulative medical school grade point average.

Table 20
Dunn Multiple Comparison Tests
for Admission Selectivity Groups and CumGPA

Comparison	Difference between mean ranks	Standard Error	Test Statistic Q	Critical Value ($Q_{0.05,4}$)	Conclusion
A vs B	91.21	37.94662	2.403639	2.639	Accept H_0
A vs C	100.18	36.82349	2.720546	2.639	Reject H_0
A vs D	148.03	39.12854	3.783172	2.639	Reject H_0
B vs C	8.97	21.13666	0.424381	2.639	Accept H_0
B vs D	56.82	24.93656	2.278582	2.639	Accept H_0
C vs D	47.85	23.1917	2.063239	2.639	Accept H_0

According to these data, the *p* values in the group comparisons ranged from 0.424381 to 3.783172. Significant differences were found between groups A (not selective) and C (highly selective), p=2.720546, and groups A (not selective) and D (most selective), p=3.783172. Therefore, the null hypothesis of no difference between the mean ranks of groups A and C was rejected, as was the null hypothesis between groups A and D. The remaining null hypotheses were accepted.

<u>Class Rank</u>

The data for the sixth hypothesis which stated that no association exists between admission selectivity group and medical school class rank of students are presented in

Tables 21 and 22. Mean class ranks and the mean rank were calculated for each admission selectivity group as part of the Kruskal-Wallis test. The null hypothesis states that no difference exists between the group mean ranks. The test statistic (H_C) was calculated at 16.569 which exceeded the critical value of chi square ($X^2_{0.05,3}$=7.815). Therefore, the null hypothesis was rejected.

Table 21
Hypothesis 6: Admission Selectivity Group Association with Class Rank

Admission Selectivity Group	**Students in Sample (N)**	**Mean Class Rank**	**Sum of the Ranks**	**Mean Rank (Kruskal – Wallis)**
Group A (not selective)	61	120.7213	34,428	564.39
Group B (selective)	267	100.1985	125,394	469.64
Group C (highly selective)	393	98.5522	181,546	461.95
Group D (most selective)	198	87.3687	81,370	410.96
Total	919	98.0925	422,738	

Table 22
Kruskal-Wallis Test Results
Admission Selectivity and Class Rank

Test Statistic	**Value**
H_c	12.707
$X^2_{0.05,3}$	7.815

Table 23 presents the data for the multiple comparison tests between the admission selectivity groups for medical school class rank to determine which groups differed.

Table 23
Dunn Multiple Comparison Tests
for Admission Selectivity Groups and Class Rank

Comparison	Difference between mean ranks	Standard Error	Test Statistic Q	Critical Value ($Q_{0.05,4}$)	Conclusion
A vs B	94.75	37.65816	2.516055	2.639	Accept H_0
A vs C	102.44	36.51821	2.805176	2.639	Reject H_0
A vs D	153.43	38.85931	3.948346	2.639	Reject H_0
B vs C	7.69	21.04567	0.365396	2.639	Accept H_0
B vs D	58.68	24.88748	2.357812	2.639	Accept H_0
C vs D	50.99	23.12638	2.204842	2.639	Accept H_0

According to these data, significant differences were found between groups A (not selective) and C (highly selective), p=2.805176, and groups A (not selective) and D (most selective). Therefore, the null hypothesis of no difference between the mean ranks of groups A and C was rejected, as was the null hypothesis for groups A and D. The remaining null hypotheses were accepted.

Failure Rate

Table 24 presents the data for the seventh hypothesis which stated that no association exists between admission selectivity of students' schools of origin and the failure rate of students in medical school. The number of students who failed or were dismissed was computed and a failure rate or proportion was calculated for each admission selectivity group.

Table 24
Hypothesis 7: Admission Selectivity Association with Failure Rate

Admission Selectivity Group	Total N	Percent	Valid N	Percent (p)	Missing N	Percent (q)
Group A (not selective)	61	100%	13	21.3%	48	78.7%
Group B (selective)	270	100%	33	12.2%	237	87.8%
Group C (highly selective)	395	100%	40	10.1%	355	89.9%
Group D (most selective)	201	100%	17	8.5%	184	91.5%

The null hypothesis states that no difference exists between the group proportions and was tested using the Tukey-type multiple comparison test among proportions (Zar, p. 560). The test statistic (Q) was calculated and compared with the critical value of Q at the .05 alpha level with 4 degrees of freedom ($Q_{0.05,\infty,4}$) which is 3.633. The data presented in Table 25 show that none of the groups differ significantly because the calculated test statistics did not exceed the critical value of Q. Therefore, the null hypotheses for all comparisons were retained.

Table 25
Tukey-type Multiple Comparison Tests
for Admission Selectivity Group and Failure Rate

Comparison	Test Statistic Q	Critical Value ($Q_{0.05,\infty,4}$)	Conclusion
A vs B	2.517747	3.633	Accept H_0
A vs C	3.288673	3.633	Accept H_0
A vs D	3.61325	3.633	Accept H_0
B vs C	1.208895	3.633	Accept H_0
B vs D	1.837917	3.633	Accept H_0
C vs D	.874382	3.633	Accept H_0

<u>Performance on the USMLE, Step 1</u>

The data for hypothesis 8 which stated that no association exists between admission selectivity group and student performance on the USMLE, Step 1 are presented in Tables 26 and 27. Mean USMLE scores and the mean rank were calculated for each admission selectivity group as part of the Kruskal-Wallis test. The null hypothesis states that no difference exists between the group mean ranks. The test statistic (H_C) was calculated at 18.213 which exceeded the critical value of chi square ($X^2_{0.05,3}$=7.815). Therefore, the null hypothesis was rejected.

Table 26
Hypothesis 8: Admission Selectivity Association with USMLE Score

Admission Selectivity Group	Students in Sample (N)	Mean USMLE Score	Sum of the Ranks	Mean Rank (Kruskal – Wallis)
Group A (not selective)	60	200.28	22,028	367.14
Group B (selective)	265	205.61	116,735	440.51
Group C (highly selective)	393	206.81	178,811	454.99
Group D (most selective)	198	211.44	102,414	517.24
Total	916	207.03	419,988	

Table 27
Kruskal-Wallis Test Results
Admission Selectivity Group and USMLE Score

Test Statistic	Value
H_c	18.213
$X^2_{0.05,3}$	7.815

Table 28 presents the data for the multiple comparison tests between the admission selectivity group for USMLE score to determine which groups differed.

Table 28
Dunn Multiple Comparison Tests
for Admission Selectivity Group and USMLE Score

Comparison	Difference between mean ranks	Standard Error	Test Statistic Q	Critical Value ($Q_{0.05,4}$)	Conclusion
A vs B	73.37	37.81518	1.940226	2.639	Accept H_0
A vs C	87.85	36.66066	2.396302	2.639	Accept H_0
A vs D	150.10	38.97849	3.850844	2.639	Reject H_0
B vs C	14.48	21.02407	0.0688734	2.639	Accept H_0
B vs D	76.73	24.84609	3.088212	2.639	Reject H_0
C vs D	62.25	23.0509	2.700545	2.639	Reject H_0

According to these data, significant differences were found between groups A (not selective) and D (most selective), p=3.850844, group B (selective) and group D (most selective), p=3.088212, and groups C (highly selective) and D (most selective), p=2.700545. Therefore, the null hypothesis of no difference between the mean ranks of groups A and D, B and D, and C and D were rejected. The remaining null hypotheses were accepted.

Public or Private Governing Control Groups

The final set of hypotheses pertained to the relationship between governing control of students' institutions of origin, whether public or private, and cumulative medical school grade point averages of students. Four hypotheses were tested. These hypotheses stated that no association exists between public or private governing control of the students' schools of origin and student performance in medical school (H9), medical school class ranks of students (H10), medical school failure rates of students (H11), and performance of students on the USMLE, Step 1 (H12).

Cumulative Medical School GPA

The data for hypothesis 9, no association between public or private governing control groups and medical school GPA, are presented in Tables 29 and 30. Mean cumulative medical school GPA and the mean rank were calculated for both governing control groups and the difference tested by using the Mann-Whitney *U* test for large sample sizes (Hinkle, Wiersma, Jurs, 1994, p. 563). The null hypothesis states that no difference exists between the group mean ranks. The test statistic (*Z*) was calculated and found to be .755. The critical value of *Z* at the .05 alpha level ($Z_{0.05}=t_{0.05,\infty}$) was 1.96. Because the calculated value of *Z* did not exceed the critical value, the null hypothesis was retained. There was no significant difference between the mean ranks of the two groups.

Table 29
Hypothesis 9: Governing Control Association with CumGPA

Governing Control Group	Students in Sample (N)	Mean CumGPA	Sum of the Ranks	Mean Rank (Mann-Whitney)
Public	533	3.4810	245,835	461.23
Private	400	3.5004	189,876	474.69
Total	933	3.4893	435,711	

Table 30
Mann-Whitney *U* Test Results
Governing Control Groups and CumGPA

Test Statistics	Value
U (*Z*)	.755
$Z_{0.05}$ ($t_{0.05,\infty}$)	1.96

<u>Class Rank</u>

The data for the tenth hypothesis which stated no association exists between the public or private governing control groups and medical school class ranks of students, are presented in Tables 31 and 32. Mean class ranks and the mean rank were calculated for both governing control groups as part of the Mann-Whitney *U* test. The null hypothesis states that no difference exists between the group mean ranks. The test statistic (*Z*) was calculated at 1.050 which does not exceed the critical value of *Z* at the .05 alpha level (*Z*=1.96). Therefore, the null hypothesis was retained.

Table 31
Hypothesis 10: Governing Control Association with Class Rank

Governing Control Group	Students in Sample (N)	Mean Class Rank	Sum of the Ranks	Mean Rank (Mann-Whitney)
Public	533	3.4810	245,835	461.23
Private	400	3.5004	189,876	474.69
Total	933	3.4893	435,711	

Table 32
Mann-Whitney *U* Test Results
Governing Control Groups and Class Rank

Test Statistics	Value
U (Z)	1.050
$Z_{0.05}$ ($t_{0.05,\infty}$)	1.96

<u>Failure Rate</u>

Tables 33 and 34 present the data for the eleventh hypothesis which stated that no association exists between governing control whether public or private, of students' schools of origin and the failure rate of students in medical school. The number of students who failed or were dismissed was computed and a failure rate or proportion calculated for both governing control groups. The null hypothesis states that no difference exists between the two group proportions and was tested using the *Z* test for differences between proportions (Champion, 1970, p. 136). The test statistic (*Z*) was calculated at .4368741 and compared to the critical value of *Z* ($Z_{0.05}$), which is 1.96. Because the calculated value of *Z* did not exceed the critical value of *Z* at the .05 alpha level, the null hypothesis was retained.

Table 33
Hypothesis 11: Governing Control Association with Failure Rate

Governing Control Group	Total N	Percent	Valid N	Percent (p)	Missing N	Percent (q)
Public	533	100%	61	11.4%	472	88.6%
Private	400	100%	42	10.5%	358	89.5%

Table 34
***Z* Test Results for**
Governing Control Groups and Failure Rate

Test Statistics	Value
Z	.4368741
$Z_{0.05}$	1.96

Performance on the USMLE, Step 1

The data for the twelfth, and final, hypothesis of no association between governing control, whether public or private, of students' institutions of origin and student performance on the USMLE, Step 1, are presented in Tables 35 and 36. Mean USMLE scores and the mean rank were calculated for both governing control groups as part of the Mann-Whitney U test. The null hypothesis states that no difference exists between the group mean ranks. The test statistic (*Z*) was computed at .439604, which did not exceed the critical value of *Z* (1.96) at the .05 alpha level. Therefore, the null hypothesis was retained.

Table 35
Hypothesis 12: Governing Control Association with USMLE Score

Governing Control Group	Students in Sample (N)	Mean USMLE Score	Sum of the Ranks	Mean Rank (Mann-Whitney)
Public	533	207.30	245,430	464.83
Private	400	206.82	180,073	457.04
Total	933	207.09	425,503	

Table 36
Mann-Whitney *U* Test Results
Governing Control Groups and USMLE Score

Test Statistic	Value
U (Z)	.439604
$Z_{0.05}$ ($t_{0.05,\infty}$)	1.96

Summary

The results of a study investigating the association between academic lineage and student performance in medical school are reported in this chapter. The results of the Mueller-Schussler Index of Qualitative Variation were reported for each independent variable. Twelve hypotheses were then examined using appropriate statistical tests and the null hypotheses were either rejected or retained based on the results. In the first set (H1, H2, H3, and H4), pertaining to Carnegie classifications, all hypotheses were rejected and multiple comparison tests completed to determine where the difference(s) exist. The same results were obtained when hypotheses H5, H6, H7, and H8 (dealing with admission selectivity) were tested. Finally, the third set of hypotheses (H9, H10, H11, and H12), relating to public or private governing control, was tested and in all cases the null hypothesis was retained.

Tables 37 and 38 present the data for the independent variable group comparisons of Carnegie classification and admissions selectivity groups. Group comparisons are sorted in descending order according to *p* value. Shaded cells represent the comparisons where the null hypothesis was rejected, indicating a significant difference between those two groups. Public/private governing control groups are not detailed because of the insignificant differences obtained in all the dependent variable tests.

Table 37
Carnegie Classification Comparisons for Each Dependent Variable
Sorted According to P Value

CumGPA		**Class Rank**		**Failure Rate**		**USMLE Score**	
Groups	P Value	Groups	P Value	Groups	P Value	Groups	P Value
2-4	3.13	2-4	3.24	2-4	3.80	2-4	3.21
3-4	1.89	3-4	1.96	2-3	2.89	3-4	2.96
2-3	1.59	2-3	1.66	1-2	1.79	1-4	1.26
1-4	1.48	1-4	1.35	1-4	.99	1-2	1.19
1-2	.95	1-2	1.13	3-4	.79	2-3	1.02
1-3	.32	1-3	.16	1-3	.48	1-3	.47

Table 38
Admissions Selectivity Group Comparisons for Each Dependent Variable
Sorted According to P Value

CumGPA		**Class Rank**		**Failure Rate**		**USMLE Score**	
Groups	P Value	Groups	P Value	Groups	P Value	Groups	P Value
A-D	3.78	A-D	3.99	A-D	3.61	A-D	3.85
A-C	2.72	A-C	2.81	A-C	3.29	B-D	3.09
A-B	2.40	A-B	2.52	A-B	2.52	C-D	2.70
B-D	2.28	B-D	2.36	B-D	1.84	A-C	2.40
C-D	2.06	C-D	2.20	B-C	1.21	A-B	1.94
B-C	.42	B-C	.36	C-D	.87	B-C	.07

Tables 39 and 40 summarize the group means for the dependent variables of cumulative GPA, class rank, and USMLE score and the group percentages for failure rate. Public/private governing control groups are not detailed because of the insignificant difference obtained in all the dependent variable tests.

Table 39
Summary Table of Dependent Variables for Carnegie Classifications

Carnegie Classification	Mean Cum GPA	Mean Class Rank	Failure Rate	Mean USMLE Score
Group 1 (Baccalaureate)	3.43	104	12.3%	206
Group 2 (Master's)	3.36	115	20.7%	201
Group 3 (Doctoral)	3.47	102	11.1%	204
Group 4 (Research)	3.52	94	9.8%	209

Table 40
Summary Table of Dependent Variables for Admission Selectivity Groups

Admission Selectivity	Mean Cum GPA	Mean Class Rank	Failure Rate	Mean USMLE Score
Group A (Not Selective)	3.34	121	21.3%	200
Group B (Selective)	3.47	100	12.2%	206
Group C (Highly Selective)	3.49	99	10.1%	207
Group D (Most Selective)	3.55	87	8.5%	211

CHAPTER 5

SUMMARY, DISCUSSION, CONCLUSIONS, RECOMMENDATIONS

Summary

This study examined the association between academic lineage and student performance in medical school. Academic lineage was defined as the principal undergraduate institution of the medical school students normally representing the school from which they received their baccalaureate degree. Student performance was broadly defined as academic performance of students in medical school as indicated by their cumulative medical school grade point averages, class ranks at graduation, failure rate, and United States Medical Licensure Examination (USMLE), Step 1 scores. The specific purposes of the study were to: (1) investigate whether the Carnegie classification of medical school applicants' institutions of origin are associated with academic performance in medical school; (2) consider the relationship between the admission selectivity of the schools of origin and the performance of medical school students; (3) compare the performance of medical students from institutions under public governing control with students from privately controlled institutions; and (4) establish a model by which the relative academic strength of applicants from a variety of undergraduate institutions can be understood more clearly based on the previous performance of medical students from schools with similar institutional characteristics. This chapter discusses the findings, advances conclusions, and offers recommendations for future research on the association between academic lineage and student performance.

Data for the study were collected from the student information database at the University of Texas Southwestern Medical Center at Dallas. Individual student records containing GPA, class rank, USMLE score, failure/dismissal, and undergraduate institution of origin were coded to indicate Carnegie classification, admission selectivity group, and public or private governing control. Nonparametric tests were conducted to ascertain the association between variables. The results of the study included a sample of 933 students who matriculated at UT Southwestern between 1990 and 1994 and graduated or were dismissed between 1994 and 1998.

Discussion

Few studies have adequately examined the relationship between academic lineage and student performance in medical school. Some studies have acknowledged the difficulty of understanding the college grade point average across diverse institutions (Johnson, 1986; Mitchell, 1987; Colliver, 1989; Silver, 1997; Koenig, 1998), but little research has focused on the differences in performance of students from various undergraduate institutions. The research that does exist (Johnson, 1971b; Clapp and Reid, 1976; and Sarnacki, 1982) presents conflicting results regarding the relationship between academic lineage and student performance. This study presents an attempt to more clearly understand this relationship based on the undergraduate institutional characteristics of Carnegie classification, admission selectivity, and public or private governing control.

Carnegie Classification and Student Performance

The first set of hypotheses tested in this study dealt with the association between the Carnegie classification of the institution of origin and the student performance measures of cumulative medical school GPA, class rank, failure rate, and USMLE score. The Carnegie classifications were reduced to 4 groups for the purposes of this study. Baccalaureate I and II were combined as were the classifications of Master's I and II, Doctoral I and II, and Research I and II. When the mean medical school grade point averages of students were compared based on the Carnegie classification of their institutions of origin (H1), it was found that the mean GPA of students from Master's colleges and universities differed significantly from the mean GPA of students from Research institutions.

Similarly, the performance of students in medical school as indicated by class rank was tested according to the Carnegie classification of their schools of origin (H2). Like GPA, class rank differed only between Master's and Research school categories. Identical results were found when comparing the failure rate of students' institutions of origin (H3). Finally, when comparing USMLE scores (H4), significant differences were found between Master's colleges/universities and Research schools as well as between Doctoral institutions and Research schools. With remarkable consistency, the findings indicated that students in the sample who came to medical school from Master's institutions performed less well in terms of all tested dependent variables than did students who came from Research universities. These findings may indicate that the students in this sample who attended Master's classification schools were not prepared as well as the students in the sample who attended colleges and universities in the other Carnegie classifications. The findings also indicated that students in the sample from Doctoral schools performed less well on the USMLE than did students from Research institutions.

Although statistical differences at the .05 alpha level were detected only between Master's schools and Research institutions for GPA, class rank, failure rate, and USMLE score, trends are noticeable. In evaluating the means for each dependent variable, the Master's group means are lowest on all 4. Baccalaureate and Doctoral group means are close for each dependent variable, and the Research group mean is highest for each dependent variable (see table 39, Chapter 4). When viewed from this perspective, the likelihood of students from research institutions to do well is evident. Conversely, these data highlight the increased academic performance difficulties of students from Master's schools.

Admission Selectivity

The second set of research hypotheses tested for differences between the four student performance variables based on the admission selectivity of the institution of origin. Academic selectivity was determined using the *Time Magazine/The Princeton Review* academic selectivity rating which categorized schools by not selective, selective, highly selective, and most selective. Significant differences between not selective institutions and both highly selective and most selective schools in terms of medical school GPA were found (H5). The tests for both class rank (H6) and USMLE score (H7) produced the same results indicating that students in the sample from not selective colleges and universities performed less well than students from both highly selective and most selective schools. However, results of the tests for failure rate (H8) indicated no differences among the four admission selectivity groups.

The findings from this group of hypotheses indicated that students from not selective schools in the sample did not perform as well on three of the four dependent variables as did students from highly selective and most selective institutions. These findings are consistent with previous research. Koenig (1998) and Mitchell (1990) indicate that when GPA or science GPA are adjusted according to the selectivity of the undergraduate institution, the predictive value of the measure for performance in medical school is increased. Indeed, one might expect that students who had been successful in a rigorous and selective undergraduate admission process and had benefited from exposure to other highly qualified students throughout their college education would do better in medical school than those who were not exposed to as high a level of competition and peer stimulation in the classroom.

Further, the findings indicated that students who attended the most selective colleges and universities performed better on the United States Medical Licensure Examination, Step 1, than did students who attended not selective, selective, or highly selective institutions. Also consistent with the literature (Koenig, 1998), these findings indicate the power of institutional selectivity on the prediction of performance, particularly on the USMLE, and the importance of considering institutional selectivity when admitting medical students.

When dependent variable means for each admission selectivity group are viewed intuitively (see table 40, Chapter 4), a linear quality is apparent. In all dependent variable groups, the "not selective" group mean is lowest in relative value, the "selective" and "highly selective" group means are next, and the "most selective" group means are highest. This linear quality emphasizes the relative benefit to student performance in medical school, within the sample population, from attendance at more selective institutions.

Public and Private Governing Control

The final set of hypotheses considered the association between student performance in medical school and the governing control of students' institutions of origin, whether public or private. Governing control was determined by the institutional listing in the *Higher Education Directory* (1998). The findings indicated that student performance with regard to grade point average (H9), class rank (H10), failure rate (H11), or USMLE score (H12) did not differ between students from public schools and those in the sample from private institutions. There was no association between student performance in medical school and institutional governing control, whether public or private.

Conclusions

Because of the nature of the sample selected for this study, any conclusions are tentative at best and their applicability to the general population of medical students in the United States is suspect. The sample was not randomly selected from the universe of medical school students in general nor was the sample randomly selected from all students who have attended UT Southwestern. Therefore, conclusions cannot be drawn about the universe of medical students in the United States or even about the universe of medical students who have ever attended the University of Texas Southwestern Medical Center at Dallas. However, the following conclusions about the sample in this study can be drawn.

1. Within the convenience sample of medical students used for this study, there appears to be an association between academic lineage and student performance in medical school. Students who had attended undergraduate institutions that are classified by the Carnegie Foundation as Master's colleges and universities do not perform as well in medical school as students who graduate from institutions classified as Research. In fact, the test results were consistent across all four dependent variables (grade point average, class rank, failure rate, and USMLE score). In all cases, the performance of students from Master's institutions differs significantly from the performance of students from Research institutions. However, students from schools classified as Baccalaureate or Doctoral do not differ in performance from those of either Research or Master's schools.

2. Students in the study's sample from undergraduate institutions that are not selective in admission do not perform as well in medical school, particularly with regard to grade point average and class rank, as the students in the sample from either highly selective schools or the most selective colleges and universities. Conversely, within the study's sample there also seems to be a negative association between student performance in medical school and students who come from undergraduate environments

that were not selective in admission. It seems clear that based on this research and within a sample such as the one used here, the variable of admission selectivity of the undergraduate institution does impact student performance in medical school.

3. An association does exist between admission selectivity of the school of origin and performance on the United States Medical Licensure Examination when considering students from a sample such as the one used in this study. Students from undergraduate institutions that are the most selective in admission perform better than the students in the sample from not selective, selective, or highly selective colleges and universities.

4. There is no association between student performance in medical school and the governing control of students' institutions of origin, whether public or private, among students like those in the sample studied.

5. The research among the sample in this study seems to indicate that there is an association between academic lineage and student performance in medical school. When tested over the four dependent variables of student performance (cumulative GPA, class rank, failure rate, and USMLE score), two of the three independent variables (Carnegie classification and admission selectivity group) proved to provide a difference for the students.

6. The trend evident with regard to the data on Carnegie classifications suggests that students coming to medical school from Master's schools may have more difficulty academically, while students from Baccalaureate and Doctoral institutions do better and students from Research universities perform at a much higher level. Additionally, the data with regard to admission selectivity indicated a linear quality that suggests that the

more selective the undergraduate institution of origin, the more likely the student is to perform at a higher level in medical school.

Recommendations

This study sought to examine an area that has been only loosely examined by medical school admissions researchers over the past twenty-five years. Those studies that do exist provide either complicated multiple regression analyses of admission variables such as admission selectivity (McGuire, 1982; Anderson and Mitchell, 1986; and Johnson, Lloyd, Jones, and Anderson, 1986) or they provide conflicting and misleading results (Clapp and Reid, 1976 and Sarnacki, 1982). This study has provided a new model by which to evaluate the actual performance of medical school students based on characteristics of the undergraduate institutions from which they came. Yet, because of the nature of the sample used for this study, students from one medical school during one time frame, the generalizability of its conclusions is restricted.

Based on the findings of this study the following recommendations for future research are offered:

1. Additional research should be pursued which randomly selects a group of medical schools and, from within these schools, randomly selects students to be studied. It would then be realistic to use inferential statistics to understand better the association between academic lineage and student performance in medical school.

2. Additional variables should be added to any future research on student performance including medical school basic science grade point average, clinical grades,

and USMLE (step 2) to further enhance our understanding of what effects academic lineage has on student performance.

3. Additional research should also focus on the interaction between the two independent variables found to be of significance in this study (Carnegie classification and admission selectivity). A matrix format should be pursued whereby the effects of these institutional characteristics together can be better understood with regard to the performance of students in medical school.

4. For the admissions committee charged with selecting a medical school class, efforts should be made to understand better the meaning of undergraduate grade point average, particularly based on the institution from which it was awarded, and what that means within the context of that medical school and its mission and goals. This study suggests that there is an association between academic lineage and student performance in medical school.

Based on the results of this study, admissions committees may want to evaluate more carefully students from "not selective" colleges and universities and from Master's institutions. Also, admissions committees may want to consider giving some preference to students who have performed well at Research universities and/or very selective schools. Indeed, this study provides a model by which medical schools can evaluate the relationship between types of undergraduate institutions and student performance in medical school. Such on-going, campus-based research could prove valuable to the medical school admissions process.

5. Students interested in attending medical school may want to use these findings to select which college or university to attend. The relative benefit of studying at a Research institution as opposed to a Master's classification school could be an important factor to consider. Additionally, gaining admission to, and performing well at, a highly selective school could be beneficial to a student's ability to gain admission to medical school and to perform well in the medical curriculum.

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