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ABSTRACT

This study is an attempt to model the similarities of 84 medical schools with respect to their orientations toward applicants qualified for research and applicants interested in delivering primary care or locating in non-urban settings. These characteristics are defined in 17 institutional variables. The patterns of institutional similarity are described by two modeling techniques: cluster analysis and multidimensional scaling. Multidimensional scaling confirmed that there were essentially two dimensions of difference among medical schools with respect to the 17 variables studied. It appears that there are fewer medical schools with preference for research-oriented students with goals to provide health care directly to patients and in geographic areas currently underserved. Cluster analysis identified four groups of schools as characteristically different from one another. Subsequent analysis of data for schools in each group served to identify each group's distinguishing attributes. Research-oriented schools appear to form a distinct class of institutions. Other schools form three classes according to the degree of their preference for students oriented toward primary care service. A simultaneous presentation of the scaling and clustering models provides the most complete picture of medical school similarities with respect to preferences for students who would provide medical services directly through primary care delivery or indirectly through medical research. (SPG)

RESEARCH AND PRIMARY CARE: TWO DIMENSIONS OF PREFERENCE IN MEDICAL SCHOOL ADMISSIONS

FINAL REPORT

Association of American Medical Colleges
One Dupont Circle, N.W., Washington, D.C. 20036

U.S. Department of Health, Education, and Welfare
Public Health Service
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EXECUTIVE SUMMARY

Research and Primary Care: Two Dimensions of Preference in Medical School Admissions is the last study in a series, conducted by the Association of American Medical Colleges, examining the characteristic ways in which U.S. medical schools are similar and different. This is the second of two institutional studies focusing on two possible preferences in medical school student admissions: a relative preference for students oriented toward primary care delivery and a relative preference for students prepared for medical research.

Data describing medical schools, their applicants and matriculants in 1976-77 were used. Seventeen measures were used to define the similarity of each possible pair of 84 schools. The results of two different methods of modeling applied to medical school similarities data provided compatible and complementary results.

Multidimensional scaling confirmed that there were essentially two dimensions of difference among medical schools with respect to the 17 variables studied. It also showed the joint distribution of schools on the two dimensions. Subsequent regression analysis served to identify the meanings of several directions in the spatial model. It appears that there are fewer medical schools with preference for research oriented students and more schools giving preference to students with goals to provide health care directly to patients and in geographic areas currently underserved. Most but not all of the research schools have lower-than-average preferences for students oriented toward primary care. Other schools, with a more limited research orientation, appear to be distributed smoothly along a continuum of difference in this preference for students with a primary care orientation.

Cluster analysis identified four groups of schools as characteristically different from one another. Subsequent analysis of data for schools in each group served to identify each groups' distinguishing attributes. Research oriented schools appear to form a distinct class of institutions. Other schools form three classes according to the degree of their preference for students oriented toward primary care service.

A simultaneous presentation of the scaling and clustering models provides the most complete picture of medical school similarities with respect to preferences for students who will provide medical services directly through primary care delivery or indirectly through medical research. The cluster analysis served to identify natural groupings of medical schools that, on the multidimensional map appeared to differ smoothly along a continuum. This facilitated identifying the different meanings of regions in the spatial map. The interpretation of regions is more readily comprehensible than the interpretation of directional vectors.

The purpose and methods of this study are exploratory and the results must be treated accordingly. The boundaries drawn between schools are only suggestions of possible distinctions that may be identified. Many schools certainly share the purposes of educating students who will provide <u>both</u> types of health services. The dimensions along which schools have been observed to vary may only exaggerate small, even trivial differences. This is one pitfall of exploratory research.

Chapter I

INTRODUCTION

One major issue currently confronting those involved or interested in medical education is the admissions practices of medical schools. Not only have medical schools received a great deal of attention from the media over this issue, but it has also been the subject of concern from the courts and Congress. The focus of this study is on the preferential selection of students, and how it relates to two institutional purposes of medical schools: training primary care practitioners and practitioners for underserved areas, and advancing medical research.

Background

The study described in this report is one of a series of exploratory studies performed by the AAMC to examine the interrelationships among measures of institutional characteristics and the interrelationships among institutions on those characteristics. The purpose of these studies is twofold: to illuminate patterns in variation, similarities and differences among schools, and to raise questions and generate hypotheses for further analysis.

Previous reports in this series described five factor analytic studies, two of which were replications of earlier work (Sherman, 1976, 1977a, 1977b, 1977c, and McShane and Sherman, 1977); four cluster analysis studies including two replications (Nunn and Lain, 1976; McShane, 1977a, 1976b, and McShane and Sherman, 1977); and two multidimensional scaling studies, one of which was a replication (Sherman, 1977d, 1977e). These studies followed a common general format. Initially, a factor analysis was performed to ascertain patterns of relationship in an assortment of variables from the different domains within which medical school characteristics may be measured, i.e., students, applicants, faculty, finances, facilities, and curricula. The results of the factor analyses were subsequently used to generate factor scores and sets of variables on which to cluster and scale schools.

The range of characteristics analyzed in the earlier studies was broad, covering many quantified aspects of medical school variation, and the results of these studies provides a basis for comparing schools on a broad range of characteristics. The scope of the present study is limited to two principal characteristics.

Several considerations have guided the conduct of the current studies. As a result of the exploratory nature of these analyses, preference was given to new measures and potential new dimensions of institutional variation. Also, since it was observed in earlier studies that the newer, less well established schools were not stable in their patterns of interrelationships, the analyses were further limited to schools that were longer established.

A companion study in this series of exploratory analyses of institutional data examines a range of factors which reflect the admissions practices of medical schools (Sherman, 1977c). One of the dimensions on which medical schools were found to vary was that describing the preference given to applicants who indicated an interest in primary care practice or service in small towns. The percentage of matriculants expressing these career plans varied among established medical schools from 22 to 65 percent. Viewed from a slightly different perspective, the admission odds ratios for these applicants varied among the 84 schools from .51 to 1.27. In other words, an applicant at one school who had the career interests described above had only one-half as good a chance of being admitted to that school as all applicants to that school. At the other extreme, there was one school where the chance of an applicant professing a desire for primary care practice or service in a small town being admitted to that school was 1.27 times as great as that for all applicants. This dimension of preferential acceptance of potential primary care practitioners was additionally found to be independent of other characteristics of the schools' admission activities. Primary Care Orientation was the first dimension selected for closer examination by this study.

Another dimension which emerged from the previous study was research orientation of the medical schools. That factor incorporated such elements as the academic preparation of matriculants, preference for applicants expressing an interest in research and medical teaching, and an emphasis on sponsored research activities within the medical schools. This dimension was similar to one found in the other factor analytic studies cited above. This demonstrates the continuity of results from the several studies. The Research Orientation dimension was selected as the second dimension on which the similarity of medical schools would be modeled, both by cluster analysis and by multidimensional scaling.

Models of Similarity

There are several ways to create a model to represent the similarities and differences among a set of medical schools, or among any other objects or concepts with measurable properties. Modeling, generally, results in a simplification that may be adequate or beneficial for a particular purpose. A simple model of medical schools could be prepared by simply listing the schools in ascending order on some characteristic (e.g., number of undergraduate medical students). Schools having similar ranks and listed near one another would then be considered similar with respect to the property that was measured. A more refined model would be created by developing a linear scale which would encompass the range of the measure being used and writing the names of the schools at the point on the scale representing each school's value on the measure. A less refined model would be constructed by dividing the rank-ordered list of schools arbitrarily into three equal groups of "small", "medium", and "large" schools. The information conveyed by each of these models is different, and each may be appropriate for specific purposes.

More complicated models of similarity may be necessary when the concepts defining the similarity are more complex, such as the similarity of medical schools with respect to both numbers of medical students and basic science graduate students. A simple ranking, scaling or grouping of schools on the sum of the two counts may be of little meaning or value. A scatter plot of school names between coordinate axes corresponding to the two separate student counts could be more interesting and convey much more information. Schools plotted close to each other would be seen as "similar". A simpler model would result by assigning each school to one of nine groups according to large-medium-small on both measures. If one group contained no school names (e.g., relatively small counts of medical students and large numbers of Ph.D. students) the model would be even simpler (8 instead of 9 groups) yet would be just as accurate in representing two long lists of numbers. Again, schools listed together may be regarded as similar with respect to the two measures, and possibly with respect to other related measures.

Multidimensional scaling and cluster analysis are two methods of creating simplified models of medical school similarities when the similarity measures are obtained directly or derived from selections of several measures on which schools vary. Clustering results in groupings of schools with similar schools in the same group and dissimilar schools in different groups, according to a mathematical criterion. Scaling produces a map of schools, having a usefully small number of dimensions, where distances between schools on the map correspond closely to the measured similarity between schools. Scaling allows for continuous gradients of difference in a space of possibly reduced dimensionality, while clustering represents empirical grouping, without gradation, in a space of full dimensionality.

Overview

The present study is an attempt to model the similarities of 84 well-established U.S. medical schools with respect to their orientations toward applicants qualified for research and applicants interested in delivering primary care or locating in non-urban settings. These characteristics are defined by seventeen institutional variables. The patterns of institutional similarity are described by two modeling techniques: cluster analysis and multidimensional scaling.

It is important to note that the models presented in this report are models of the activities of medical schools with respect to applicants and matriculants. They may or may not reflect the schools' stated admissions policies, but could provide an indication of how each school compares with other schools in attracting and matriculating students to train to provide direct and indirect health care services through primary care and research.

Chapter II

METHODS

There were five major methodological considerations which guided the conduct of the study described in this report. Those considerations were (1) the selection of variables, (2) the selection of schools, (3) the computation of a similarity index, (4) multidimensional scaling and regression, and (5) cluster analysis. Each of the five considerations is discussed in detail in the following sections.

Selection of Variables

Since the concept of similarity is most appropriately applied with reference to some property or characteristic (even though that characteristic may not be well defined), the variables which were used in this study were carefully selected to represent two underlying dimensions: research orientation and primary care orientation. These two dimensions were explicated in Sherman's factor analytic study of the admissions practices of medical schools (Sherman, 1977c), and "orientation" as it is used in this context refers to the orientation of the applicants for whom medical schools display preference. The variables which composed these two factors were analyzed and some deletions were made from the original list to reduce redundancy. The final data set contained 17 variables which measured either the research orientation or the primary care orientation of the medical schools.

Due to the sensitivity of both multidimensional scaling and cluster analysis to extreme or missing data, the data were carefully verified with original sources. Missing values for the seventeen variables used were replaced either with the value for that school from an earlier year, or with the mean of that variable for all schools. Out of a possible 1,428 data points, there were only 9 missing values (less than 0.1 percent), and no school was missing data for more than one variable.

The medians, means and standard deviations of the 17 variables used in this study are presented in Table 1. A glossary of abbreviations used in the variable labels is presented in Appendix A. Three of the variables are institutional measures which have been found in previous

TABLE 1

MEDIANS, MEANS, AND STANDARD DEVIATIONS OF 17 VARIABLES USED IN MULTIDIMENSIONAL SCALING AND CLUSTER ANALYSIS

VARIABLE	DESCRIPTION	MEDIAN	MEAN	STANDARD DEVIATION
STC192	AMA: % 60-69 ALUMNI DOING RESEARCH OR TCH	5.51	6.86	.46
STC121	AMA: % 60-69 GRADS IN PATIENT CARE	91.26	89.90	.55
STC113	FRS: AMA EST % ALUMS ON FT FAC OF ANY SCH	[illegible]	6.15	.35
STC189	% MATRICS WHO WERE ALSO ACCEPTED ELSEWHR	[illegible]	34.46	2.69
STR371	MEAN MCAT. SCIENCE SCORES OF MATRC. TOTAL	[illegible]	620.37	3.72
STC043	RAT: HOUSESTAFF TO UNDERGRAD MD STUD	.70	.79	.05
INC017	% TOTAL EXPD FOR SPON RESEARCH	21.88	23.01	1.22
STC013	% 1ST-YR MD STUD: PRE-MED GPA 3.6-4.0	46.77	47.15	1.72
STC180	% MATRICS SEEKING CAREER IN RES & TCH	20.13	22.10	1.03
INR142	NIH RØ1 GRANTS: MEAN STD PRIORITY SCORE	.07	.11	.04
STC169	ADM ODDS RATIO IF RAISED IN SMALL LOC	1.03	1.03	.03
STC161	ADM ODDS RATIO IF INDICATED PRAC IN SM PLACE	1.02	.99	.02
STC183	% MATRICS WANTING TO LOCATE IN SM PLACE	45.68	45.52	1.63
STC187	% MATRICS RAISED IN SMALL LOCATION	35.25	38.22	1.50
STC181	% MATRICS SEEKING PRIMARY CARE PRACTICE	46.29	45.30	[illegible].06
STC157	ADM ODDS RATIO IF SPEC IN PRIMARY CARE	.97	.95	.02
STC151	ADM ODDS RATIO FOR CAREER AS GP	.97	.91	.02

studies to be related to the research or graduate medical education emphasis of the medical schools: (1) the ratio of housestaff to undergraduate medical students, (2) the percentage of total expenditures for sponsored research, and (3) the mean standardized priority score of RØ1 (single investigator) research grant applications. Three other variables assess the current activity of the schools' alumni: (1) the percentage of 1960-69 alumni who were active in research or teaching, (2) the percentage of 1960-69 alumni active in patient care, and (3) the percentage of alumni on any medical school faculty.

The remaining eleven variables describe characteristics of the schools' admission practices. These variables include the percentage of matriculants in medical schools who profess a particular career orientation or preference, the admission odds ratio for applicants having a particular orientation, and the academic preparation of matriculants. The data on applicants and matriculants to medical schools were derived from institutional aggregates obtained from the AAMC's Medical Student Information System (MSIS) for the 1976-77 entering classes. These data are supplied by applicants for research purposes and not to be reported to medical school admissions committees. Schools may obtain similar information through other channels.

The admission odds ratios for applicants with various characteristics were computed as relative indications of medical schools' preference for students with certain characteristics. For a given school, the admission odds for an applicant to the school is defined as the number of matriculants divided by the number of applicants less the number of matriculants. This figure would represent the chance that an applicant to a particular school would have of enrolling at that school. In the same manner, admission odds may be computed for applicants who have particular characteristics, such as a preference for primary care, or a background in the arts or humanities. The admission odds ratio is equal to the admission odds for applicants with a given characteristic divided by the admission odds for all applicants to a medical school. An admission odds ratio of 1.00 would mean that an applicant with a particular characteristic would have the same chance of getting into a medical school as all applicants; an admission odds ratio over 1.0 would mean that applicants with that characteristic have a better chance of getting in; and an admission odds ratio of less than 1.0 would mean a less than average chance of getting into the school. These measures may reflect the preference of each school for or against applicants with certain characteristics. They may also, to some degree, reflect the preference of some acceptees for certain schools. For a more complete explanation of the measures used in this study, see Sherman (1977c).

Selection of Schools

Previous studies in this series have used data from all medical schools which are in operation in the United States. The results of these early studies have shown that newer, still developing schools are not as stable in their patterns of relationships as older schools. In order to construct a stable, homogeneous subset of schools in which patterns of variation could be more easily detected and interpreted, the analysis was limited to fully accredited medical schools which granted M.D. degrees in 1967.

As the result of the considerations described above, data for 84 U.S. medical schools were analyzed in this study. Of the 84 schools, 43 were private and 41 public. Their enrollment of undergraduate medical students in 1975-76 ranged from 305 to 1,272 with an average enrollment of 583.8. An average of 89.9 percent of the alumni of these schools who graduated between 1960 and 1969 were active in patient care in 1973, while an average of 6.9 percent of these alumni were engaged in medical teaching or research.

Similarity Index

Prior to the computation of a similarity index, each of the variables was standardized to have a mean of zero and a standard deviation of 1.0. The purpose of the standardization was to give the variables a common scale, thus giving them equal weight in the computation of the similarity index.

An index of similarity was subsequently computed for every possible pair of medical schools. The similarity between two schools was defined as the square root of the sum of squared differences between the two schools' values for each of the 17 standardized measures. This is simply a 17-dimensional analog of the familiar two-dimensional formula for the length of the hypotenuse of a triangle:

$$H = \sqrt{A^2 + B^2}.$$

In the present case, the 17 "legs" are the differences between two schools' values on the 17 standardized variables. Two schools with nearly identical values on all 17 measures would have a similarity index near zero. Two schools with very different values would have a large index of similarity.

The indices may be conceptualized as distances in 17-dimensional space. Such a space, however, is impossible to visualize. The purpose of the multidimensional scaling model is to represent, as well as possible, the 17-dimensional space in a smaller number of dimensions that can be readily visualized. Comparatively, the purpose of cluster analysis is to create groups of schools such that all schools in a group are similar to each other on the 17 dimensions and different from schools in other clusters.

Multidimensional Scaling

Metric multidimensional scaling is a computational algorithm that accepts an N-by-N symmetric matrix of similarity (or dissimilarity) measurements between all pairs of N objects, and produces a set of spatial coordinates for each of the N objects. The mathematical underpinnings of metric multidimensional scaling are detailed in Torgerson (1958) and explained in more general language in Nunnally (1967). Basically, the matrix of distances is mathematically transformed and then factored by the principal axes method. In metric multidimensional scaling, the distances must be established on a ratio scale of measurement, e.g., a dissimilarity index with a value of 4 must represent twice the dissimilarity between two objects which have an index of 2. This assumption is met when the similarity measures are computed from a set of variables, as was done here.

In the present study, metric multidimensional scaling was performed through the use of a versatile computer program, KYST, developed at Bell Telephone Laboratories and the University of North Carolina at Chapel Hill (Kruskal, et al., 1977). The matrix of similarities of the 84 schools was scaled in two dimensions.

The major axes used to plot the "locations" of each school are not intended to be interpreted (as are the principal axes after rotation in factor analysis). The locations of the schools relative to one another are the object of multidimensional scaling. The configuration of plotted points can be rotated or reflected on the map without changing the model. If some of the many possible directions on the spatial map have meaning, they are revealed by subsequent subjective or objective analysis. A person thoroughly familiar with many of the schools could subjectively identify the common characteristics of schools in the upper-left side of the map, say, as distinguished from schools in the lower-right area. A more objective (though not necessarily better) method is to draw a vector on the map that best represents known institutional variation with respect to a particular measure. This is accomplished by using the two spatial coordinates as predictor variables and an external variable of interest (or several, but one at a time) as a criterion variable in a regression model.

The b-coefficients of the derived regression equation may be used as coordinates of one point on a vector passing through the origin of the space. The vector represents the direction of best fit in the space. The multiple correlation coefficient describes the degree of that best fit. Perpendicular projections of school locations onto the vector (or any line parallel to it) correlate with the criterion variable to the degree indicated by the multiple correlation coefficient. Schools far from the center in the direction of the head of the vector tend to have high values of the criterion variable; schools projecting onto the tail have low values. The relative values of the multiple correlation coefficients can be used to evaluate how well different criterion variables are described by the model.

Cluster Analysis

The final stage of the analysis for this study was to use the 17 variables, measuring primary care and research orientations of preferred applicants, to cluster the medical schools into groups of like schools. In much the same way that factor analysis is used to examine patterns of correlation among variables, cluster analysis is used to examine patterns of similarity among objects, in this case institutions, across a number of variables. Just as factor analysis derives groups of items that are similar to one another and different from items in other groups, cluster analysis groups together objects (schools) that are similar to each other but different in some way from schools in other groups.

As in the earlier studies, the cluster analysis was performed in two steps. The first step was a hierarchical cluster analysis using the method developed by Ward (1963). Hierarchical cluster analysis techniques initially view each object as belonging to a cluster of size 1. In the first step of the analysis the two most similar groups are combined to form a single, larger group of size 2. In each subsequent step, the two most similar groups are combined into a single group. One limitation of hierarchical cluster analysis is that once a combination of two groups has been formed, the objects which make up that group remain joined for the duration of the analysis. By forcing all objects to be combined and remain intact once they are combined, hierarchical cluster analysis may cause distortions of natural clusters by the inclusion of outlying objects.

To overcome the artifacts of hierarchical cluster analysis, the hierarchical solution was refined through the use of a second step, non-hierarchical cluster analysis, which places objects into a predetermined number of clusters in such a way that a specified criterion is optimized. Non-hierarchical cluster analysis allows objects to move among clusters until a "best" solution is found, and thus reduces the distorting effect of outlying objects on cluster membership. Non-hierarchical cluster analysis, however, does require specification of initial estimates of the location of the centers of the clusters as well.

In this study, a non-hierarchical cluster analysis technique developed by Forgy (1965) was used. In this method, using the number of clusters and cluster centroids specified by the user, each object is assigned to the cluster which has the closest centroid. After all objects have been initially assigned to clusters, new cluster centroids are computed for each cluster based on the objects assigned to the cluster. The distance from each object to the centroids of each cluster is then computed and objects are reassigned, if necessary, to the cluster which now has the closest centroid. After the reassignment of objects, the cluster centroids are recomputed and a new cycle of computing distances, assigning objects to clusters, and recomputing cluster centroids is begun. The cycle is repeated until no objects are reassigned after cluster centroids have been calculated. This procedure, like the Ward approach, minimizes the differences among the objects within a cluster.

In the present study, the 17 variables were used to cluster schools using the Ward hierarchical cluster analysis approach. The results of this analysis (presented in Appendix B) were then used to select seedpoints and determine the number of clusters to be derived in the Forgy cluster analysis. Forgy cluster analysis was performed on 8, 6, and 4 clusters using two sets of initial seedpoints. One of the 4 cluster solutions was selected as the most meaningful representation of 84 schools on the two dimensions of interest. The selected cluster solution and the two-dimensional scaling solution are presented in the following chapter.

Chapter III

RESULTS

As a result of the procedures outlined in Chapter II, two representations of the similarity of 84 medical schools to one another were derived. In this chapter a multidimensional scaling model and a multivariate cluster model are presented, evaluated and contrasted with one another. Using these results, specific schools may be compared with one another. Finally a general interpretation of the overall pattern is presented.

Spatial Model of Medical School Similarities

Figure 1 presents a two-dimensional model of medical school similarities resulting from a metric multidimensional scaling of computed similarities. Limitations of space necessitated the use of abbreviations of school names. A list of abbreviations and school names is presented in Table 2. Close proximity on the map-like representation represents a high degree of similarity with respect to seventeen input variables, while larger distances represent dissimilarity. For example, Harvard and Johns Hopkins are depicted as similar to one another (on the right side of the map) and dissimilar to Meharry (upper left) and Vermont (lower left). Harvard is equally similar to Johns Hopkins and the University of Chicago. Johns Hopkins is most similar to Yale.

The major horizontal and vertical axes do not carry inherent meaning. What is modeled by this method are the distances between schools, not the coordinate system. The direct distances between points on the map correspond closely with, but are not equal to, the computed similarity indices. Possible interpretations of the meanings of directions and regions in the multidimensional map may be ascertained through subsequent regression analysis and by examining data for the original variables for schools in designated regions of the space. The former is addressed in the next section. The latter is presented below in conjunction with the results of cluster analysis.

FIGURE 1 TWO-DIMENSIONAL SIMILARITY MODEL OF 84 MEDICAL SCHOOLS WITH RESPECT TO INSTITUTIONAL MEASURES OF PREFERENCE FOR STUDENTS ORIENTED TOWARD RESEARCH AND/OR PRIMARY CARE

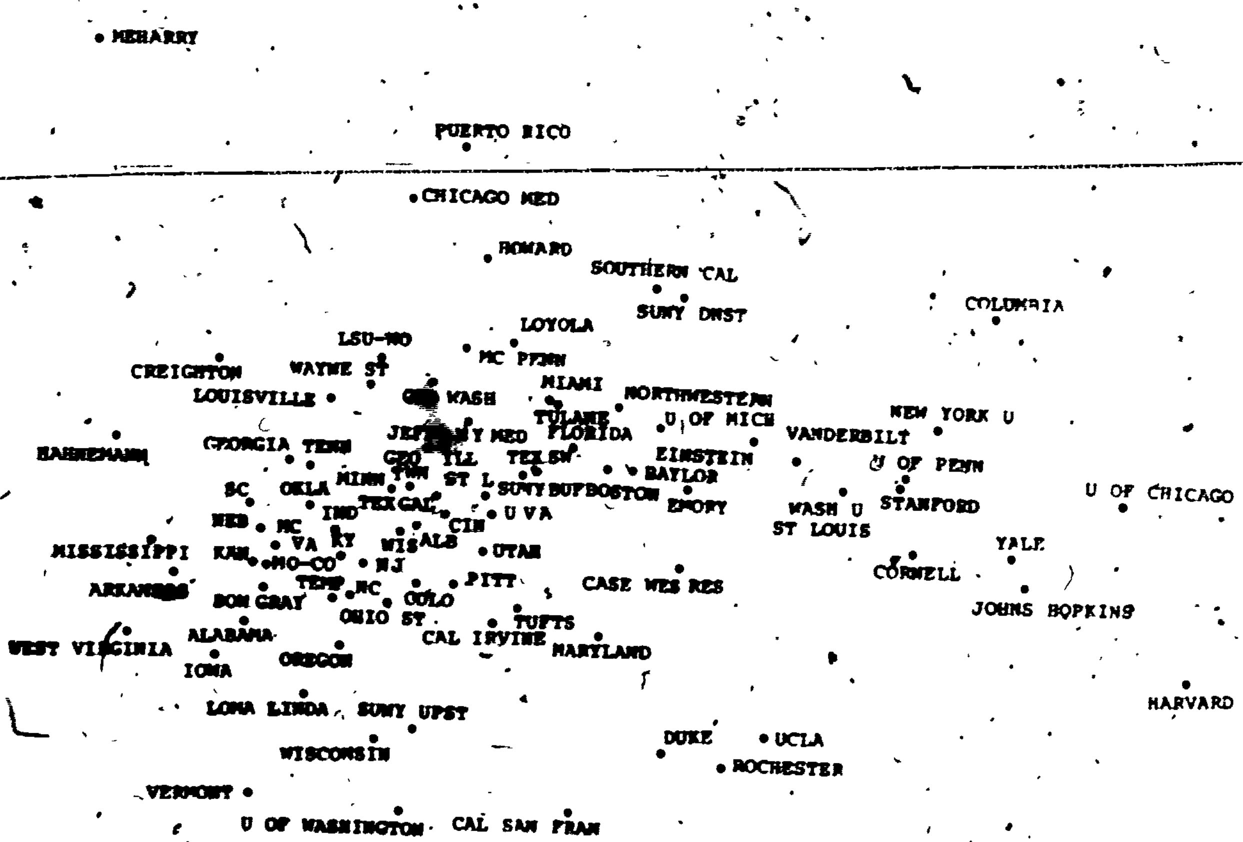


TABLE 2

ABBREVIATIONS AND NAMES OF 84 MEDICAL SCHOOLS USED IN MULTIDIMENSIONAL SIMILARITY MODEL

ALABAMA	UNIV. OF ALABAMA SCHOOL OF MEDICINE
ALB	ALBANY MEDICAL COLLEGE OF UNION UNIV.
ARKANSAS	UNIV. OF ARKANSAS COLLEGE OF MEDICINE
BAYLOR	BAYLOR COLLEGE OF MEDICINE
BOSTON	BOSTON UNIV. SCHOOL OF MEDICINE
BOW GRAY	BOWMAN GRAY SCH. OF MEDICINE OF WAKE FOREST UNIV.
CAL IRVINE	UNIV. OF CALIFORNIA,IRVINE,CALIFORNIA COLLEGE OF MEDICINE
CAL SAN FRAN	UNIV. OF CALIFORNIA,SAN FRANSISCO,SCH. OF MEDICINE
CASE WES RES	CASE WESTERN RESERVE UNIV. SCHOOL OF MEDICINE
CHICAGO MED	UNIV. OF HEALTH SCIENCES/THE CHICAGO MEDICAL SCHOOL
CIN	UNIV. OF CINCINNATI COLLEGE OF MEDICINE
COLO	UNIV. OF COLORADO SCHOOL OF MEDICINE
COLUMBIA	COLUMBIA UNIV. COLLEGE OF PHYSICIANS & SURGEONS
CORNELL	CORNELL UNIV. MEDICAL COLLEGE
CREIGHTON	CREIGHTON UNIV. SCHOOL OF MEDICINE
DUKE	DUKE UNIV. SCHOOL OF MEDICINE
EINSTEIN	ALBERT EINSTEIN COLLEGE OF MEDICINE OF YESHIVA UNIV.
EMORY	EMORY UNIV. SCHOOL OF MEDICINE
FLORIDA	UNIV. OF FLORIDA COLLEGE OF MEDICINE
GEO WASH	GEORGE WASHINGTON UNIV. SCHOOL OF MEDICINE & HEALTH SCIENCES
GEORGIA	MEDICAL COLLEGE OF GEORGIA SCHOOL OF MEDICINE
GEOTWN	GEORGETOWN UNIV. SCHOOL OF MEDICINE
HAHNEMANN	HAHNEMANN MEDICAL COLLEGE & HOSPITAL OF PHILADELPHIA
HARVARD	HARVARD MEDICAL SCHOOL
HOWARD	HOWARD UNIV. COLLEGE OF MEDICINE
ILL	UNIV. OF ILLINOIS COLLEGE OF MEDICINE
IND	INDIANA UNIV. SCHOOL OF MEDICINE
IOWA	UNIV. OF IOWA COLLEGE OF MEDICINE
JEFF	JEFFERSON MEDICAL COLLEGE OF THOMAS JEFFERSON UNIV.
JOHNS HOPKINS	JOHNS HOPKINS UNIV. SCHOOL OF MEDICINE
KAN	UNIV. OF KANSAS SCHOOL OF MEDICINE
KY	UNIV. OF KENTUCKY COLLEGE OF MEDICINE
LOMA LINDA	LOMA LINDA UNIV. SCHOOL OF MEDICINE
LOUISVILLE	UNIV. OF LOUISVILLE SCHOOL OF MEDICINE
LOYOLA	LOYOLA UNIV. OF CHICAGO STRITCH SCHOOL OF MEDICINE
LSU-NO	LOUISIANA STATE UNIV. SCHOOL OF MEDICINE IN NEW ORLEANS
MARYLAND	UNIV. OF MARYLAND SCHOOL OF MEDICINE
MC PENN	MEDICAL COLLEGE OF PENNSYLVANIA
MC VA	MEDICAL COLLEGE OF VIRGINIA/VIRGINIA COMMONWEALTH UNIVERSITY SCHOOL OF MEDICINE
MEHARRY	MEHARRY MEDICAL COLLEGE SCHOOL OF MEDICINE
MIAMI	UNIV. OF MIAMI SCHOOL OF MEDICINE
MINN	UNIV. OF MINNESOTA MEDICAL SCHOOL IN MINNEAPOLIS
MISSISSIPPI	UNIV. OF MISSISSIPPI SCHOOL OF MEDICINE
MO-CO	UNIV. OF MISSOURI-COLUMBIA SCHOOL OF MEDICINE
NC	UNIV. OF NORTH CAROLINA SCHOOL OF MEDICINE
NEB	UNIV. OF NEBRASKA COLLEGE OF MEDICINE
NEW YORK U	NEW YORK UNIV. SCHOOL OF MEDICINE
NJ	COLLEGE OF MEDICINE & DENTISTRY OF NEW JERSEY/ NEW JERSEY MEDICAL SCHOOL
NORTHWESTERN	NORTHWESTERN UNIV. MEDICAL SCHOOL
NY MED	NEW YORK MEDICAL COLLEGE
OHIO ST	OHIO STATE UNIV. COLLEGE OF MEDICINE

TABLE 2, CONTINUED

OKLA	UNIV. OF OKLAHOMA COLLEGE OF MEDICINE
OREGON	UNIV. OF OREGON HEALTH SCIENCES CENTER SCHOOL OF MEDICINE
PITT	UNIV. OF PITTSBURGH SCHOOL OF MEDICINE
PUERTO RICO	UNIV. OF PUERTO RICO SCHOOL OF MEDICINE
~~ROCHESTER~~	~~UNIV. OF ROCHESTER SCHOOL OF MEDICINE & DENTISTRY~~
SC	MEDICAL UNIV. OF SOUTH CAROLINA COLLEGE OF MEDICINE
SOUTHERN CAL	UNIV. OF SOUTHERN CALIFORNIA SCHOOL OF MEDICINE
ST L	ST. LOUIS UNIV. SCHOOL OF MEDICINE
STANFORD	STANFORD UNIV. SCHOOL OF MEDICINE
SUNY BUF	STATE UNIV. OF NEW YORK AT BUFFALO SCH. OF MEDICINE
SUNY DNST	STATE UNIV. OF NEW YORK DOWNSTATE MEDICAL CENTER COLLEGE OF MEDICINE
SUNY UPST	STATE UNIV. OF NEW YORK UPSTATE MEDICAL CENTER COLLEGE OF MEDICINE
TEMP	TEMPLE UNIV. SCHOOL OF MEDICINE
TENN	UNIV. OF TENNESSEE COLLEGE OF MEDICINE
TEX GAL	UNIV. OF TEXAS MEDICAL BRANCH AT GALVESTON MEDICAL SCHOOL
TEX SW	UNIV. OF TEXAS SOUTHWESTERN MEDICAL SCHOOL
TUFTS	TUFTS UNIV. SCHOOL OF MEDICINE
TULANE	TULANE UNIV. SCHOOL OF MEDICINE
U OF CHICAGO	UNIV. OF CHICAGO/THE PRITZKER SCH. OF MEDICINE
U OF MICH	UNIV. OF MICHIGAN MEDICAL SCHOOL
U OF PENN	UNIV. OF PENNSYLVANIA SCHOOL OF MEDICINE
U OF WASHINGTON	UNIV. OF WASHINGTON SCHOOL OF MEDICINE (SEATTLE)
U VA	UNIV. OF VIRGINIA SCHOOL OF MEDICINE
UCLA	UNIV. OF CALIFORNIA,LOS ANGELES,SCH. OF MEDICINE
UTAH	UNIV. OF UTAH COLLEGE OF MEDICINE
VANDERBILT	VANDERBILT UNIV. SCHOOL OF MEDICINE
VERMONT	UNIV. OF VERMONT COLLEGE OF MEDICINE
WASH U.	WASHINGTON UNIV. SCHOOL OF MEDICINE
WAYNE ST	WAYNE STATE UNIV. SCHOOL OF MEDICINE
WEST VIRGINIA	WEST VIRGINIA UNIV. SCHOOL OF MEDICINE
WIS	MEDICAL COLLEGE OF WISCONSIN
WISCONSIN	UNIV. OF WISCONSIN MEDICAL SCHOOL
YALE	YALE UNIV. SCHOOL OF MEDICINE

Directional Interpretations

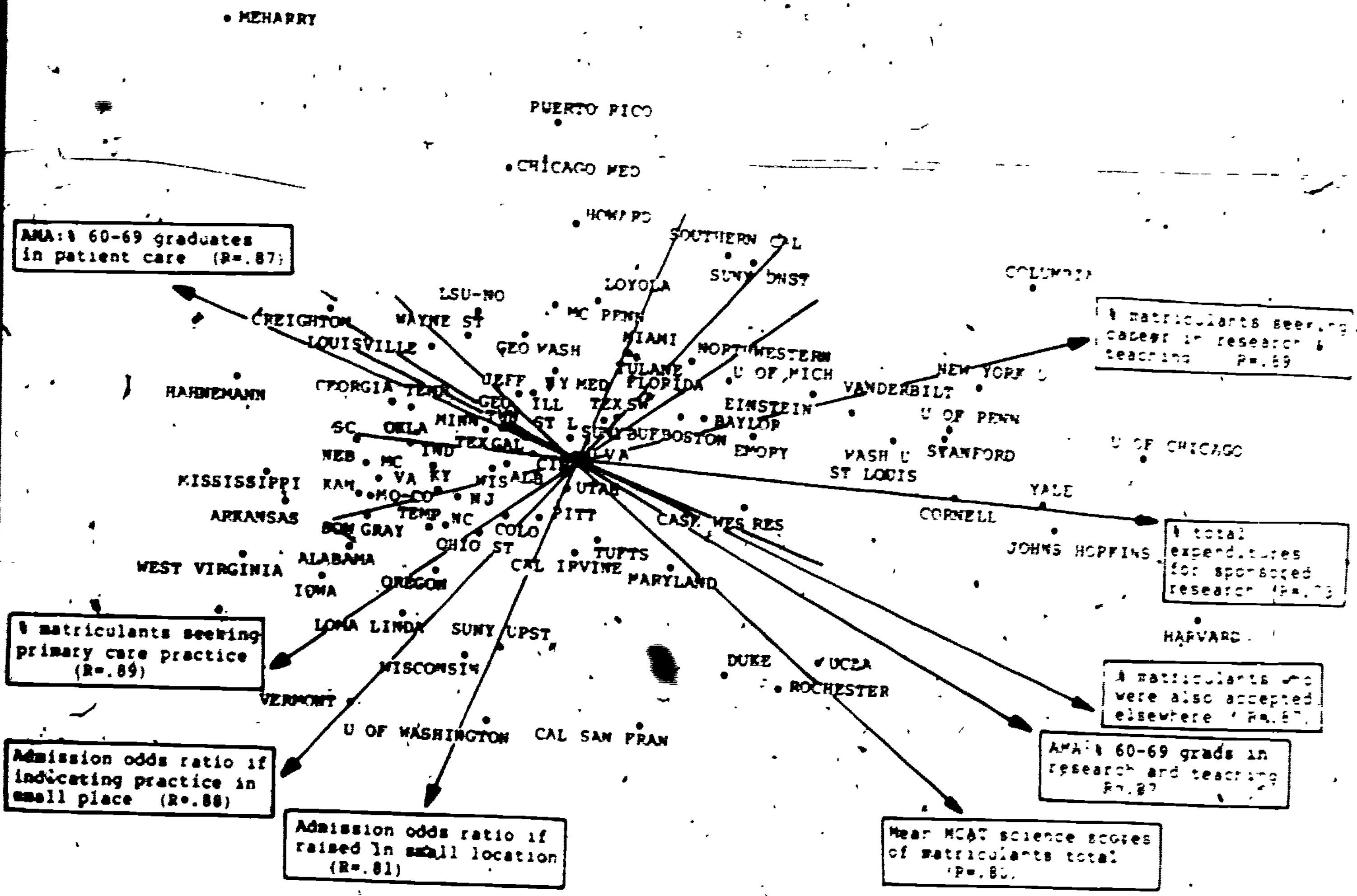
As described in the preceding chapter, multiple regression may be used post hoc to indicate possible meanings of directions on the map. Institutional values for individual measures are "predicted" from the pairs of scaling coordinates. The b-coefficients and the origin define the vector; the multiple correlation coefficient indicates the goodness-of-fit.

Nine vectors corresponding to the best fit of nine selected individual variables into the space are plotted in Figure 2. The multiple correlation coefficient describing the degree of fit is presented beside the variable name near the arrowhead on each vector. A multiple correlation of 1.00 would indicate perfect fit; zero would indicate no fit. The plotted vectors all have fairly high associated multiple correlations, ranging from .73 to .89.

Generally, vectors pointing to the right and lower right sides of the map correspond to variables related to the schools' research orientation. Schools in the right and lower-right regions tend to have relatively high values on the following variables: percentage of matriculants seeking careers in research and teaching, percentage of expenditures for sponsored research, percentage of matriculants also accepted by other schools, percentage of alumni in research or teaching positions, mean MCAT-Science score of matriculants.

At roughly right angles to the research dimension are three vectors representing measures describing the relative apparent preference schools give to applicants expressing interests in fulfilling another mission of medical schools, educating physicians who will provide primary care where it is now most needed. The three variables selected to provide meaning to this axis of the space include: the percentage of matriculants contemplating careers in primary care medicine, the admission odds ratio for persons desiring to locate a practice in a small city or town, and the admission odds ratio for persons raised in small cities and towns. (Several additional variables also fit well on the map, but since they provide essentially identical interpretations they are not presented.)

FIGURE 2 TWO-DIMENSIONAL SIMILARITY MODEL OF 84 MEDICAL SCHOOLS WITH RESPECT TO INSTITUTIONAL MEASURES OF PREFERENCE FOR STUDENTS ORIENTED TOWARD RESEARCH AND/OR PRIMARY CARE WITH VECTORS REPRESENTING BEST FIT OF SEVERAL INDIVIDUAL MEASURES



With the interpretation provided by the vectors, the map can be better used to compare individual schools with one another. For example, Vermont, Wisconsin, Iowa, West Virginia and the University of Washington at Seattle are represented as more likely to admit students who are from small (by population) locations, interested in primary care specialization, and interested in locating in small locations than are Southern California, SUNY-Downstate, Columbia, Puerto Rico or Chicago Medical. Harvard, the University of Chicago, Johns Hopkins and Yale attract more students prepared for research careers than do Meharry, Chicago Medical, Creighton or Hahnemann. Many less extreme comparisons are also possible.

Cluster Analysis

The second multivariate model of the similarities of 84 medical schools on the 17 selected variables was constructed through the use of multivariate cluster analysis. Whereas scaling creates a map of schools such that the distances between schools represent their similarity on the selected variables, cluster analysis groups schools so that the schools within a cluster are similar to each other and different from schools in other clusters.

The memberships of the four clusters determined by the analysis which was used in this study are presented in Table 3. There are 29 schools in cluster 1, 24 in cluster 2, 17 in cluster 3 and 14 in cluster 4. The numbers listed opposite the names of each school represent the distance in 17 dimensional space of each school from the centroid of the cluster. The cluster centroid is the "center" point of a group of schools in the 17 dimensional space. The distance of each school from that point is then computed in the same manner as the initial index of similarity between any two schools. The distances from the centroid may be used to evaluate how strongly each school is associated with its cluster. Schools which have small values tend to be more representative of the entire cluster. The greater the distance from a school to the cluster centroid, the weaker is its association with that group. For example, the University of Nebraska, Georgetown University, Northwestern University, and the University of Pennsylvania are the schools which represent the characteristics of the four clusters most closely. Meharry University, the University of California-

TABLE 3

CLUSTER MEMBERSHIPS AND DISTANCES OF MEDICAL SCHOOLS FROM CLUSTER CENTROIDS OF FOUR CLUSTERS BASED ON 17 VARIABLES

Cluster 1	
NEBRASKA	1.8149
KANSAS	2.5226
BOWMAN GRAY	2.9030
MISSOURI-COLUMBIA	2.9158
OKLAHOMA	3.0833
SOUTH CAROLINA	3.1355
KENTUCKY	3.6408
M C OF VIRGINIA	4.1369
GEORGIA	4.2151
NEW JERSEY	4.3195
NORTH CAROLINA	5.1528
TENNESSEE	5.3025
TEMPLE	5.6595
OREGON	5.9814
ALABAMA	6.1562
ARKANSAS	6.2391
OHIO STATE	6.3177
IOWA	6.3305
INDIANA	6.5659
MISSISSIPPI	7.3248
WEST VIRGINIA	8.8402
LOUISVILLE	9.0896
CREIGHTON	10.3891
WISCONSIN	10.6148
HAHNEMANN	11.3559
VERMONT	11.6952
LOMA LINDA	13.2469
U of WASHINGTON	16.7358
MEHARRY	44.3857

Cluster 2	
GEORGETOWN	2.2027
ALBANY	2.6795
CINCINNATI	2.6824
M C OF WISCONSIN	2.8989
ST LOUIS	3.3415
ILLINOIS	3.7972
SUNY BUFFALO	3.7972
TEXAS GALVESTON	4.0896
JEFFERSON	4.2357
COLORADO	4.2939
PITTSBURGH	4.3016
NEW YORK MED	4.3837
MINNESOTA MINNEAPOLIS	4.4603
U OF VIRGINIA	4.6672
WAYNE STATE	5.8616
UTAH	6.1552
GEORGE WASHINGTON	6.2458
TUFTS	6.2746
LOUISIANA NEW ORLEANS	7.8619
CALIFORNIA IRVINE	8.9528
SUNY UPSTATE	11.3733
MARYLAND	12.9233
CHICAGO MEDICAL	16.7684
CALIF SAN FRANCISCO	21.2602

Cluster 3	
NORTHWESTERN	1.6396
TULANE	2.4367
BAYLOR	3.1370
TEXAS SOUTHWEST	3.4075
FLORIDA	3.4646
U of MICHIGAN	4.0280
MIAMI	4.1989
LOYOLA	6.4435
EMORY	6.8755
M C of PENNSYLVANIA	6.8771
BOSTON	7.9267
EINSTEIN	8.1087
SUNY DOWNSTATE	8.3738
CASE WESTERN RESERVE	11.1631
HOWARD	11.7292
SOUTHERN CALIFORNIA	14.4186
PUERTO RICO	23.1973

Cluster 4	
U of PENNSYLVANIA	2.2885
STANFORD	2.8755
WASH U ST LOUIS	3.0477
JOHNS HOPKINS	4.5989
CORNELL	5.1320
NEW YORK UNIV	5.7156
VANDERBILT	5.7453
YALE	6.1803
U OF CHICAGO	13.1077
COLUMBIA	13.7151
ROCHESTER	16.8734
DUKE	17.0538
HARVARD	18.0488
UCLA	19.2419

San Francisco, the University of Puerto Rico, and UCLA, in contrast, are the four schools which are least representative of their respective clusters. They are, however, closer to the centroids of the cluster in which they are placed than to those of any other cluster.

The mean values of the four clusters on the 17 variables on which the clustering was based are presented in Table 4. From the evidence presented in Table 4, it is apparent that cluster 4 is the most distinctive. The schools in this cluster had an average of 81 percent of their alumni from the decade of the 1960's active in patient care compared with 90 percent in the other three clusters. They had 14.6 percent of their alumni in research and medical teaching compared with 5 percent in other groups.

The research orientation of the schools in cluster 4 is further emphasized by their mean values for the percentage of total expenditures devoted to sponsored research, the mean standardized priority scores of R01 research grant applications, the mean MCAT science score of first-year medical students, and the percentage of first year medical students with pre-medical undergraduate grade point averages between 3.5 and 4.0.

The admission practices of the schools in cluster 4 show a stronger preference for students oriented toward research than do the schools in the other three clusters. The schools in cluster 4 had the highest percentage of matriculants who professed an interest in research or teaching careers and the highest percentage of matriculants who were also accepted at other medical schools. Also, the schools in cluster 4 had low percentages of matriculants raised in small towns or rural areas, low percentages of matriculants who desired to locate their practices in these locations, and low percentages of matriculants who indicated a desire for careers in the primary care specialties or as general practitioners. The admission odds ratios for applicants to the schools in cluster 4 who were raised in small towns or rural areas, who desired to practice in these areas, or who expressed an interest in a career in primary general care were also the lowest of any of the groups of schools. In fact, the averaged admission odds ratios for the schools in cluster 4 for applicants with the four characteristics mentioned above were all below 1.0, indicating that applicants with any of these characteristics had less of a chance to enroll in these schools than all applicants to the school.

The other three clusters each showed evidence of preferring students with a primary care orientation to those with a research orientation. However, there was an apparent gradation in the degree of preference for medical students with primary care orientation among the three clusters. The schools in cluster 1 appeared to show the greatest preference for students oriented toward primary care. They had the highest percentage of matriculants with each of the characteristics associated with a preference for careers in primary care and had the highest admission odds ratios for applicants with primary care orientation. Conversely, the schools in cluster 1 had the lowest mean values of the four clusters on each of the variables associated with a research orientation.

Clusters 2 and 3 seemed to be somewhere between the extremes of cluster 4 and cluster 1 in the preference for students with research and primary care orientation. These schools did not show as strong a preference for students with an orientation toward primary care as did the schools in cluster 1. Moreover, the schools in cluster 2 showed no preference for applicants who were oriented toward primary care (admission odds ratios all approximately equal to 1.0), and the schools in cluster 3 showed a negative preference for applicants who indicated an orientation toward primary care, even though an average of almost 90 percent of their 1960-69 alumni were active in patient care. It appears as if schools in cluster 3 are attempting to create a different balance in their mix of students.

Scaling and Clustering Result Contrasted

Figure 3 presents the results of the multidimensional scaling and clustering simultaneously. Three straight lines divide the space into four regions. The region labled "1" contains only schools in the first cluster; "2", the second cluster; "3", the third cluster and "4", the fourth cluster.

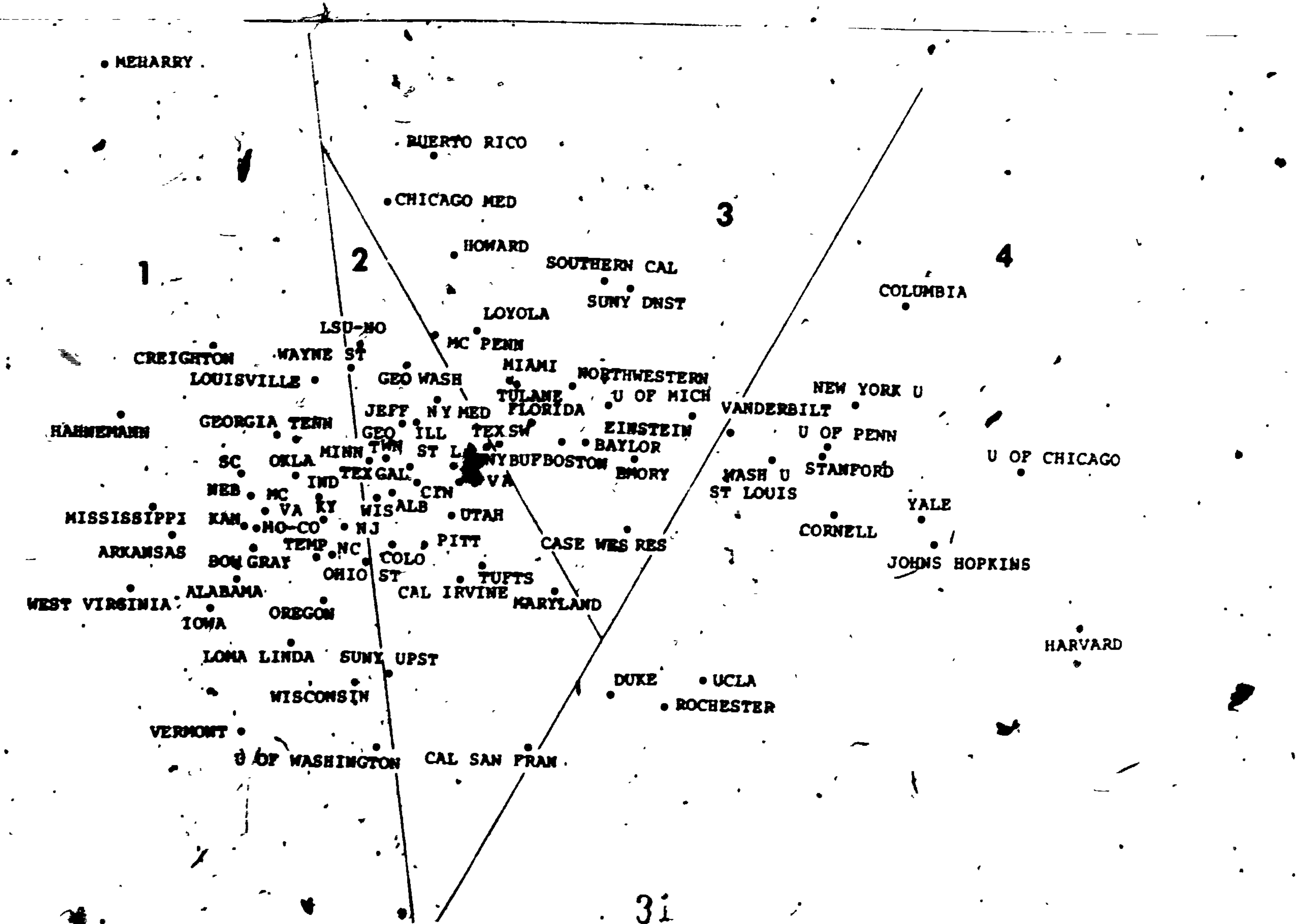
Regional boundaries are nearly perpendicular to the vectors plotted in Figure 2. Schools in Region 4 have

TABLE 4

MEAN VALUES FOR MEDICAL SCHOOLS IN FOUR CLUSTERS ON 17 VARIABLES USED AS THE BASIS OF CLUSTER ANALYSIS

Variable	Description	Cluster 1	2	3	4
STC192	AMA: % 60-69 ALUMNI DOING RESEARCH OR TCH	4.58	5.39	6.44	14.58
STC121	AMA: % 60-69 GRADS IN PATIENT CARE	92.86	91.64	89.74	80.99
STC113	FRS: AMA EST % ALUMS ON FT FAC OF ANY SCH	4.86	4.78	5.89	11.47
STC189	% MATRICS WHO WERE ALSO ACCEPTED ELSEWHR	16.60	28.89	38.33	76.32
STR371	MEAN MCAT SCIENCE SCORES OF MATRC.TOTAL	595.09	627.07	622.44	658.76
STC043	RAT: HOUSESTAFF TO UNDERGRAD MD STUD	.59	.73	.88	1.22
INC017	% TOTAL EXPD FOR SPON RESEARCH	16.62	22.02	24.07	36.68
STC013	% 1ST-YR MD STUD: PRE-MED GPA 3.6-4.0.	43.64	44.08	43.47	64.16
STC180	% MATRICS SEEKING CAREER IN RES & TCH	14.25	20.64	24.41	38.06
INR142	NIH R01 GRANTS: MEAN STD PRIORITY SCORE	.29	.09	.09	-.19
STC169	ADM ODDS RATIO IF RAISED IN SMALL LOC	1.24	1.00	.81	.92
STC161	ADM ODDS RATIO IF INDIC PRAC IN SM PLACE	1.17	1.03	.83	.72
STC183	% MATRICS WANTING TO LOCATE IN SM PLACE	60.69	45.14	35.28	27.19
STC187	% MATRICS RAISED IN SMALL LOCATION	53.17	33.79	26.84	28.66
STC181	% MATRICS SEEKING PRIMARY CARE PRACTICE	54.20	47.85	37.77	31.63
STC157	ADM ODDS RATIO IF SPEC IN PRIMARY CARE	1.06	1.01	.83	.78
STC151	ADM ODDS RATIO FOR CAREER AS GP	1.03	1.00	.79	.67

FIGURE 3 SIMULTANEOUS PRESENTATION OF FOUR-GROUP CLUSTERING MODEL AND TWO-DIMENSIONAL SCALING MODEL OF 84 MEDICAL SCHOOLS



characteristically high values on the variables represented by the vectors drawn to the lower right. This is also confirmed by the means in Table 3. For example, 14 percent of alumni of schools in region 4 are doing research or teaching compared with 4, 5 and 6 percent in regions 1, 2 and 3, respectively.

Schools not in region 4 are distinguishable on the dimensions represented by the vectors drawn to the lower left. This, too, is confirmed by the means in Table 3. For example, the percentages of matriculants wanting to locate in a small city or town are 61%, 45% and 35% in regions 1, 2 and 3, respectively.

The dimension representing a primary care orientation also applies to schools in region 4. The admissions odds ratios and percentages of matriculants raised in small places, wanting to locate in small places and seeking primary care specialization are all higher for Rochester and U.C.L.A. than for Columbia or N.Y.U. Schools in region 4, however, are more distinguished from other schools by their research orientation than with respect to their relative preference for potential providers of primary care.

Chapter IV

CONCLUSION

The results of two different methods of modeling applied to medical school similarities data provided compatible and complementary results.

Multidimensional scaling confirmed that two dimensions of difference among medical schools adequately represented the 17 variables studied. It also showed the joint distribution of schools on the two dimensions. Subsequent regression analysis served to identify the meanings of several directions in the spatial model. It appears that there are fewer medical schools with preference for research oriented students and more schools giving preference to students with goals to provide primary health care and to treat patients in areas currently underserved. Most but not all of the research schools have lower-than-average preferences for students oriented toward primary care. Other schools, with a more limited research orientation, appear to be distributed smoothly along a continuum of difference in this preference for students with a primary care orientation.

Cluster analysis identified four groups of schools as characteristically different from one another. Subsequent analysis of data for schools in each group served to identify each groups' distinguishing attributes. Research oriented schools appear to form a distinct class of institutions. Other schools form three classes according to the degree of their preference for students oriented toward primary care service.

A simultaneous presentation of the scaling and clustering models provides the most complete picture of medical school similarities with respect to preferences for students who will provide medical services directly through primary care delivery or indirectly through medical research. The cluster analysis served to identify natural groupings of medical schools that on the multidimensional map appeared to differ smoothly along a continuum. This facilitated identifying the different meanings of regions in the spatial map. The interpretation of regions is more readily comprehensible than the interpretation of directional vectors.

The clear separability of schools in different clusters by the use of straight lines drawn on the scaling map demonstrates the compatibility of the results of the two modeling methods. Natural clusters of schools on the map are not readily apparent to the eye. Indeed, the elongated shapes of the second of four regions suggests that some distortion was necessary to represent 17 dimensions of difference in a two-dimensional simplification.

The purpose and methods of this study are exploratory and the results must be treated accordingly. The boundaries drawn between schools are only suggestions of possible distinctions that may be identified. Many schools certainly share the purposes of educating students who will provide both types of health services. The dimensions along which schools have been observed to vary may only exaggerate small, even trivial, differences. This is one pitfall of exploratory research.

It appears from the joint presentation of the scaling and clustering models, that the schools providing the most even balance of preference for students with both orientations are Duke, the University of California at San Francisco, and the University of Washington at Seattle. These schools appeared in separate clusters but in the same general area of the map derived by scaling. Persons familiar with these (or other) medical schools, in ways not measured by the few variables studied here, may better be able to elucidate such findings. The results of exploratory analysis provide an overview and a stimulus for further thought.

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APPENDIX A

Abbreviations Used in Variable Labels

Symbol	Definition
ADM	ADMISSION
ALUMS	ALUMNI
AMA	AMERICAN MEDICAL ASSOCIATION
ELSEWHR	ELSEWHERE
EST	ESTIMATED
EXPD	EXPENDITURES
FAC	FACULTY
FRS	FACULTY ROSTER SYSTEM
FT	FULL-TIME
GP	GENERAL PRACTICE
GRADS	GRADUATES
INDIC	INDICATING
LOC	LOCATION
MATRC/MATRICS	MATRICULANTS
MD	MEDICAL
NIH	NATIONAL INSTITUTES OF HEALTH
PRAC	PRACTICE
RAT	RATIO
RES	RESEARCH
RØ1	SINGLE INVESTIGATOR RESEARCH
SCH	SCHOOL
SCR	SCORE
SPON	SPONSORED
STD	STANDARDIZED
STUD	STUDENTS
TCH	TEACHING
%	PERCENT

APPENDIX B.

Result of Ward Hierarchical Cluster Analysis of 84 U.S. Medical Schools on 17 Variables Measuring Two Dimensions of Preference in Medical School Admissions