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ABSTRACT

In 1976, the Association of American Medical Colleges developed a map-like model to describe the global picture of the U.S. medical school similarities with respect to two loosely defined concepts: an institutional emphasis on research and an emphasis on clinical and graduate medical training. This study is an attempt to replicate the results of the 1976 study using more recent data. Public and private medical school similarities were modeled using mulitdimensional scaling. Twelve variables were used to define and compute similarities between pairs of schools. Two- and three-dimensional models were derived. Multiple regression methods were used to determine how well school differences on each of the twelve variables of the scaling and regression replications were compared with those of the 1976 study. (SPG)

REPLICATION OF A MULTIDIMENSIONAL MODEL OF MEDICAL SCHOOL SIMILARITIES

AAMC

FINAL REPORT

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

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DIVISION OF OPERATIONAL STUDIES
ASSOCIATION OF AMERICAN MEDICAL COLLEGES

FINAL REPORT

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EXECUTIVE SUMMARY

Replication of A Multidimensional Model of Medical School Similarities is one of four studies performed in 1977 by the Association of American Medical Colleges (AAMC) to examine and to re-examine the characteristics of U.S. medical schools and the interrelationships among variables that describe them. This report is an attempt to replicate the results of a study performed in 1976.

Public and private medical school similarities were modeled using multidimensional scaling. With minor exceptions, the same twelve variables, although more recent data, were used to define (and compute) similarities between pairs of schools. The twelve measures had been shown in earlier research to be related to research and graduate medical education intensiveness.

Two- and three-dimensional models were again derived. The two-dimensional models for public and private schools were plotted, with schools identified, to describe the overall similarities of schools within each set.

Multiple regression methods were again used to determine how well school differences on each of twelve simple variables were represented by the multidimensional models. The results of the scaling and regression replications were compared with those of the original 1976 study.

Private school similarities were again better modeled than public school similarities. The public school model was improved with respect to graduate program differences, and diminished in its representation of research related characteristics. The set of public schools includes most of the newer and developing schools that are less likely to fit a descriptive model that applies to more established public medical schools. The private school model showed little change, except for the two variables with revised definitions. It is probable that private medical schools are more stable and homogeneous with respect to the basic measures and characteristics examined in this pair of studies.

The models of similarity derived and compared in these studies are attempts to simplify the information contained in data provided by the medical schools and by the NIH's records of grant applications. The validity of the private school model was supported by successful replication. That of the public school model remains in question. An assessment of the relative merits of the successive models for public schools may best be made by individuals with an informed familiarity with many schools.

Chapter I

INTRODUCTION

In 1976, the Association of American Medical Colleges (AAMC) developed a map-like model to describe the global picture of the U.S. medical school similarities with respect to two loosely defined concepts: an institutional emphasis on research and an emphasis on clinical and graduate medical training. The present study is an attempt to replicate the results of the 1976 study using more recent data.

Background

Since 1975, the AAMC has conducted an ongoing series of studies examining quantified characteristics of medical schools in the United States. Available data from a number of different sources are routinely collected and stored. The major portion of data used in this series is accumulated annually through the student application and institutional research activities of the AAMC.

Using multivariate statistical methods, the studies in this series examine and re-examine several questions: In what basic ways are medical schools similar and different? What groups of schools are similar to one another? What is the global picture of institutional similarity with respect to specific characteristics?

In previous studies it had been found that, distinct from measures of institutional size, research emphasis and gradutate medical education emphasis were reliably observable and independent dimensions of medical school differences. A Multidimensional Model of Medical School Similarities (Sherman, 1977) was developed and reported to describe the joint distributions of public and private medical schools on these two dimensions. School similarity with respect to research and clinical emphasis was defined by the overall similarity of the schools' profiles on twelve variables. Multidimensional scaling techniques were used to translate all of the school-pair similarity measures into a set of two-dimensional coordinates. The identities of public and private schools were plotted on two-dimensional axes. The interpretive meaning of several directions in the derived "map" were identified using multiple regression methods. Finally, the results of the multidimensional scaling were compared with the results of school clustering from a related study.

The present report will not repeat the results of the previous study, but will present the results of the replication and will discuss the similarity of the results of the two studies. A review of related literature and conceptual details of the methodology are presented in the 1976 report.

Chapter II

METHOD

Since the present study is a replication, selection of variables was pre-determined and was not a methodological consideration. Data and quantitative methods used, however, are as similar as possible to those used in 1976. The following sections discuss the data, the index of similarity, the method used to derive the spatial model, and the method used to interpret the meaning of directions in the derived spaces. Again, public schools and private schools are analyzed separately.

Data

The twelve variables used in 1976 and again, although with data more recent by one year, are:

(1) Ratio of housestaff (interns and residents) to undergraduate medical students.

(2) Ratio of medical students to full-time faculty.

(3) Percentage of 1960-69 graduates (M.D. recipients) in general practice. (In 1976 percentage of all living alumni was used.)

(4) Average salary of strict-full-time associate professors in basic science departments.

(5) Mean standardized priority score assigned by NIH Initial Review Groups to applications for single investigator (R01) research grants.

(6) Percentage of full-time faculty holding M.D. or M.D. and Ph.D. degrees. (In 1976 the percentage was based on full-time and part-time faculty.)

(7) Ratio of basic medical science graduate students (Ph.D. and M.A.) to undergraduate medical students (M.D.).

(8) Ratio of basic medical science graduate students to full-time faculty in basic science departments.

(9) Percentage of total funds expended for sponsored research.

(10) Percentage of total funds received from federal sources (including the recovery of indirect costs).

(11) Percentage of funds expended for administrative and other general expenses.

(12) Rate of approval of competing applications for NIH single investigator (R01) research grants.

The first six variables are more strongly related to a graduate medical orientation, and the second six are more strongly related to a research orientation.

The means and standard deviations of the 12 measures for both years are presented in Table 1. There appear to be few differences between 1976 and 1977 values for comparable measures. The approval rate of research proposals declined slightly. So did the percentages of total expenditures for sponsored research. The number of graduate students per basic science faculty rose, as did faculty salaries.

The only sizeable difference is due to a change of variable. The percentage of M.D. graduates of the 1960's going into general practice (about 11%) was lower than the percentage of all pre-1973 alumni currently in general practice (14%), the measure used in 1976. The new variable was chosen both to avoid simple repetition and to utilize a measure that would better describe the current nature of evolving institutions.

Data used in the present study were obtained directly or derived from the Liaison Committee on Medical Education annual questionnaires, Parts I and II, for 1975-76; the AAMC Faculty Salary Survey for 1976; the AAMC Faculty Roster System; Medical School Alumni, published by the American Medical Association, 1975; and the Division of Research Grants at the National Institutes of Health.

Data were available for at least 11 of the 12 measures for 101 of the 113 fully accredited medical schools in the United States (including one school of the basic

Table 1

Means and Standard Deviations of Variables
Used in Construction of Models of Medical School Similarities, 1976 and 1977

1977 I.D.	VARIABLE LABEL	PRIVATE 1976 MEAN (N 44)	PRIVATE 1977 MEAN (N 45)	PUBLIC 1976 MEAN (N 58)	PUBLIC 1977 MEAN (N 56)	ALL MEAN 1976	ALL MEAN 1977	ALL ST. DEV. 1976	ALL ST. DEV. 1977	ALL N 1976	ALL N 1977
STC043	RAT: HOUSESTAFF TO UNDERGRAD MD STUDENTS	.97	.88	.72	.71	.83	.81	.72	.56	114	114
INC058	RAT: MD STUDENTS TO FT FACULTY	1.66	1.67	1.84	1.80	1.76	1.72	.84	.81	113	114
FAR053	FSS: AV SAL SFT ASSOC PROF BAS SCIENCE	24.85	26.31	24.66	25.73	24.84	26.12	2.87	3.19	104	104
STC105	AMA: % 60-69 ALUMNI IN GENL PRACTICE[1]	12.91	6.87	16.00	14.70	14.29	10.86	7.19	7.84	98	82
INR142	NIH R01 GRANTS: MEAN STD PRIORITY SCORE	.03	.06	.13	.12	.08	.09	.33	.48	107	111
FAC001	FRS: %FT SAL FACULTY WITH MD OR MD-PHD[2]	68.29	66.30	60.11	58.75	62.92	61.55	12.12	12.40	114	112
STC045	RAT: BMS GRAD STUD TO UNDERGRAD MD STUD	.23	.27	.23	.26	.22	.27	.18	.20	114	114
INC061	RAT: BMS GRD STUD TO BAS SCI FT FACULTY	1.09	1.36	1.36	1.47	1.23	1.37	1.09	.97	113	114
INC017	% TOTAL EXPD FOR SPONSORED RESEARCH	28.19	26.19	18.93	17.81	21.78	21.02	12.22	12.00	111	112
INC007	% REV FROM FED SOURCES & RCOV IND COSTS	43.91	41.52	32.74	30.40	37.32	34.72	13.17	12.03	106	104
INC026	EXPD FOR ADMIN & GENL EXPENSE	9.97	10.21	9.88	9.71	10.33	10.73	5.71	5.28	111	112
INR137	NIH R01 GRANTS: APPROVAL RATE OF APPLS	73.83	66.87	73.37	71.16	69.01	67.47	21.94	19.40	114	114

[1] In 1976 the percentage of all living alumni was used.

[2] In 1976 the percentage of full-time and part-time faculty was used.

medical sciences). Of the 101 schools, 45 are private and 56 are publicly controlled. The mean values for all public or private schools having data were substituted in cases of missing data. The 12 schools excluded for excessive lack of data were Baylor, North Dakota, Texas at San Antonio, Medical College of Virginia, University of Washington at Seattle, University of California at San Diego, University of Hawaii, Louisiana State University at Shreveport, University of Missouri at Kansas City, Florida State, Rush, and Mayo.

Index of Similarity

An index of similarity was computed separately for every possible pair of public schools and every pair of private 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 12 standardized measures. This is simply a 12-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 12 "legs" are the differences between two schools' values of the 12 variables after each variable has first been standardized to have a mean of zero and a standard deviation of one. (Standardization removes the effect of having different units of measure for different variables.) As a result values of the index may seem more accurately described as measures of dissimilarity. Two schools with nearly identical values on all 12 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 12-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 12-dimensional space in a smaller number of dimensions that can be readily visualized.

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 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 public and private matrices were each scaled into three and two dimensions. Thus four models were derived and compared. Two of these models are presented in the next chapter. (Nonmetric scalings were also performed, using KYST, with results nearly identical to the metric scaling results. For simplicity, only the metric scaling results are reported here).

Regression

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 or three) 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 one model and how well competing models account for one criterion variable.

Chapter III

RESULTS AND DISCUSSION

1977 Spatial Models of Medical School Similarities

Figures 1 and 2 present the 1977 replications of the two-dimensional models of private and public medical school similarity resulting from metric multidimensional scalings of computed similarities. Close proximity on the map represents a high degree of similarity with respect to twelve input variables, while large distances represent dissimilarity. For example, Yale and Chicago-Pritzker are again (as in 1976) represented as similar to one another (in the upper-left corner) and dissimilar to Mt. Sinai (lower-left) and to Loma Linda (lower right). Mt. Sinai is again most similar to Harvard. Possible interpretations of the meanings of directions and regions in the multidimensional map are addressed in later sections of this chapter.

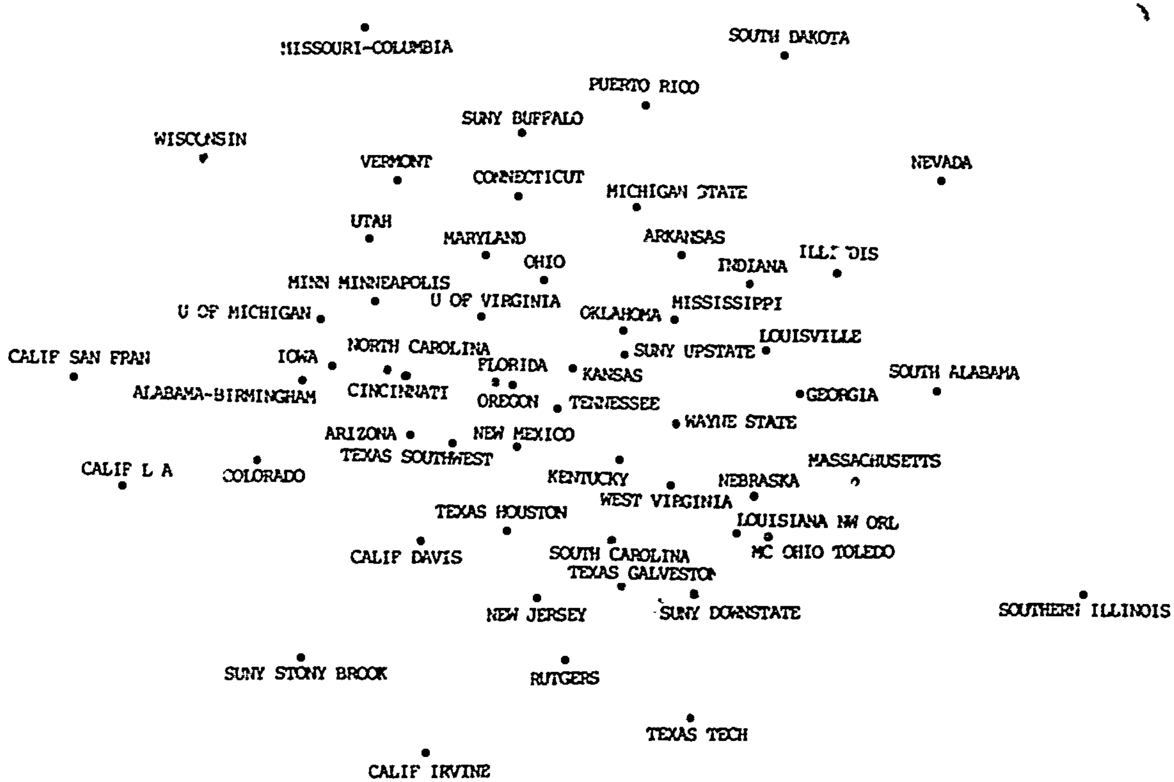
1976 and 1977 Models Compared

The 1976 and 1977 spatial representations of the private schools are basically very similar. (The 1976 models are not reproduced in this report.) Most private schools are located in similar areas with like neighbors on both maps. Small shifts in position are noticeable for most schools, indicating a lack of rigidity of the model. Some larger shifts are also apparent. Columbia, Harvard's nearest neighbor in the lower-left quadrant on the 1976 map, is located in the upper-left quadrant on the 1977 map, now closer to Yale than to Harvard or Mt. Sinai.

There are several possible causes of such apparent shifts in institutional emphasis. (1) A school's relative standing on any or several of the 12 variables may actually have changed. (2) A school's data for one year, the other year, or both years may be in error. (3) Two dimensions may be too few to adequately represent the variability in the 12 variables. (4) A school's alumni from the 1960's may differ greatly from all living alumni with respect to medical specialization. (5) Relative institutional emphasis with respect to graduate medical education or biomedical research may have actually changed.

FIGURE 1 TWO-DIMENSIONAL REPLICATED MODEL OF SIMILARITIES BETWEEN 45 PRIVATE MEDICAL SCHOOLS WITH RESPECT TO MEASURES OF RESEARCH EMPHASIS AND GRADUATE MEDICAL EDUCATION EMPHASIS

FIGURE 2 TWO DIMENSIONAL REPLICATED MODEL OF SIMILARITIES BETWEEN 56 PUBLIC MEDICAL SCHOOLS WITH RESPECT TO MEASURES OF RESEARCH EMPHASIS AND GRADUATE MEDICAL EDUCATION EMPHASIS



In the 1976 study it was observed that private school similarities were more adequately modeled by two dimensions than were public school similarities. A comparison of Figures 1 and 2 with Figures 1 and 2 of the 1976 report reveals that the private school model was also more successfully replicated in 1977. The two public school models bear less resemblance to one another than do the two private school models. Differences between the variability among public and among private medical schools is also manifest in the multiple regression coefficients that aid in the interpretation of possible directions on the map-models.

Multiple Correlations

As described in the preceding chapter, multiple regression may be used *post hoc* to indicate the possible meanings of directions on the map. The b-coefficients and the origin define the vector; the multiple-R indicates goodness- of-fit.

Some of the vectors corresponding to the best fit (as defined in Chapter II) of several individual variables into the space are plotted in Figures 3 and 4. The multiple correlation coefficient describing the degree of fit is presented beside the variable name near the head of each vector. (The major coordinate axes do not have meaning of their own.) A multiple correlation of 1.00 would indicate perfect fit; zero would indicate no fit. The ratio of basic science graduate students to undergraduate medical students, one possible indicator of research emphasis, has a fairly high index of fit, .84 in Figure 3, .73 in Figure 4. Lines that could be drawn from the points representing Yale and Chicago perpendicular to the vector would intersect the vector near to the drawn arrowhead. This indicates that Yale and Chicago again probably have the highest basic science to medical student ratios of all private schools. Loma Linda and Chicago Medical probably have among the lowest values. (The word "probably" is used because the model represents a best "fit" and not a perfect representation.)
Mt. Sinai again lies farthest out of all private schools in the direction of the vector representing the ratio of housestaff to medical students, probably indicating a relatively strong institutional emphasis on graduate medical education. In the model of public school similarities (Figure 4), California at San Francisco and Irvine, UCLA, and Stony Brook appear to place the

the greatest emphasis on graduate medical education.

The set of vectors plotted is not entirely the same as the set plotted in 1976. For those that do correspond, however, the general orientation is highly similar. For example, the vectors representing the ratio of medical students to full time faculty and the ratio of basic science graduate students to medical students appear to be at approximately right angles in all spatial configurations.

The multiple correlations indicating the relative goodness-of-fit on the twelve descriptive variables in each of six models are presented in Table 2. The multiple correlation coefficients may be used to compare the 1977 and 1976 public and private models, and the three- and two-dimensional models.

The three-dimensional spaces necessarily provide an equivalent or better fit for all variables than do the two-dimensional spaces. (Likewise, two-dimensions usually provide for better fit than would the one-dimensional models.)

In the case of private schools, two dimensions are sufficient. Three dimensions do not provide a significant improvement over the multiple correlations for 10 of the 12 variables. The two exceptions are the percentage of faculty holding M.D. degrees, which improves from a fit of .65 to .88, and the percentage of revenue for administrative and general expenses, changing from .32 to .72. The expenditure percentage showed a similar difference in 1976. The faculty percentage did not fit in either two- or three-dimensional models in 1976.

In the case of public schools, most variables related to graduate program emphasis show a weak fit in the two-dimensional model and only moderate improvement in three-dimensions. Four graduate program variables, however, show improved fit in 1977. Research emphasis variables, again, were fairly well modeled in both multidimensional spaces, but the measures of fit in 1977 were not as high as in 1976.

Multiple correlations with the several scales serve to indicate which variables dominate the differences among schools. Of the 12 selected variables, percentage

FIGURE 3 TWO-DIMENSIONAL REPLICATED MODEL OF SIMILARITIES BETWEEN 45 PRIVATE MEDICAL SCHOOLS WITH RESPECT TO MEASURES OF RESEARCH EMPHASIS AND GRADUATE MEDICAL EDUCATION EMPHASIS, WITH VECTORS REPRESENTING BEST FIT OF SEVERAL INDIVIDUAL MEASURES

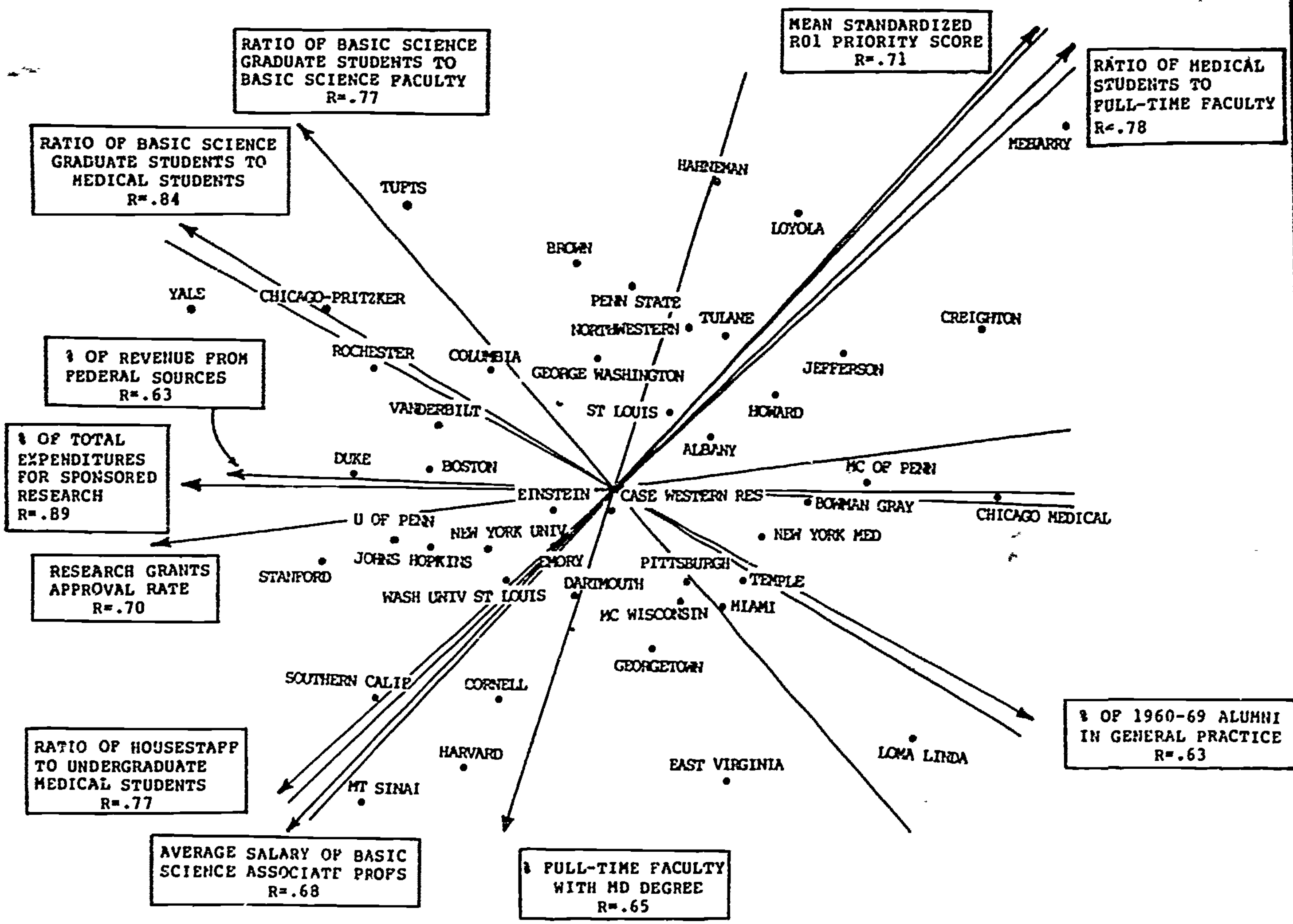


FIGURE 4 TWO-DIMENSIONAL REPLICATED MODEL OF SIMILARITIES BETWEEN 56 PUBLIC MEDICAL SCHOOLS WITH RESPECT TO MEASURES OF RESEARCH EMPHASIS AND GRADUATE MEDICAL EDUCATION EMPHASIS, WITH VECTORS REPRESENTING BEST FIT OF SEVERAL INDIVIDUAL MEASURES

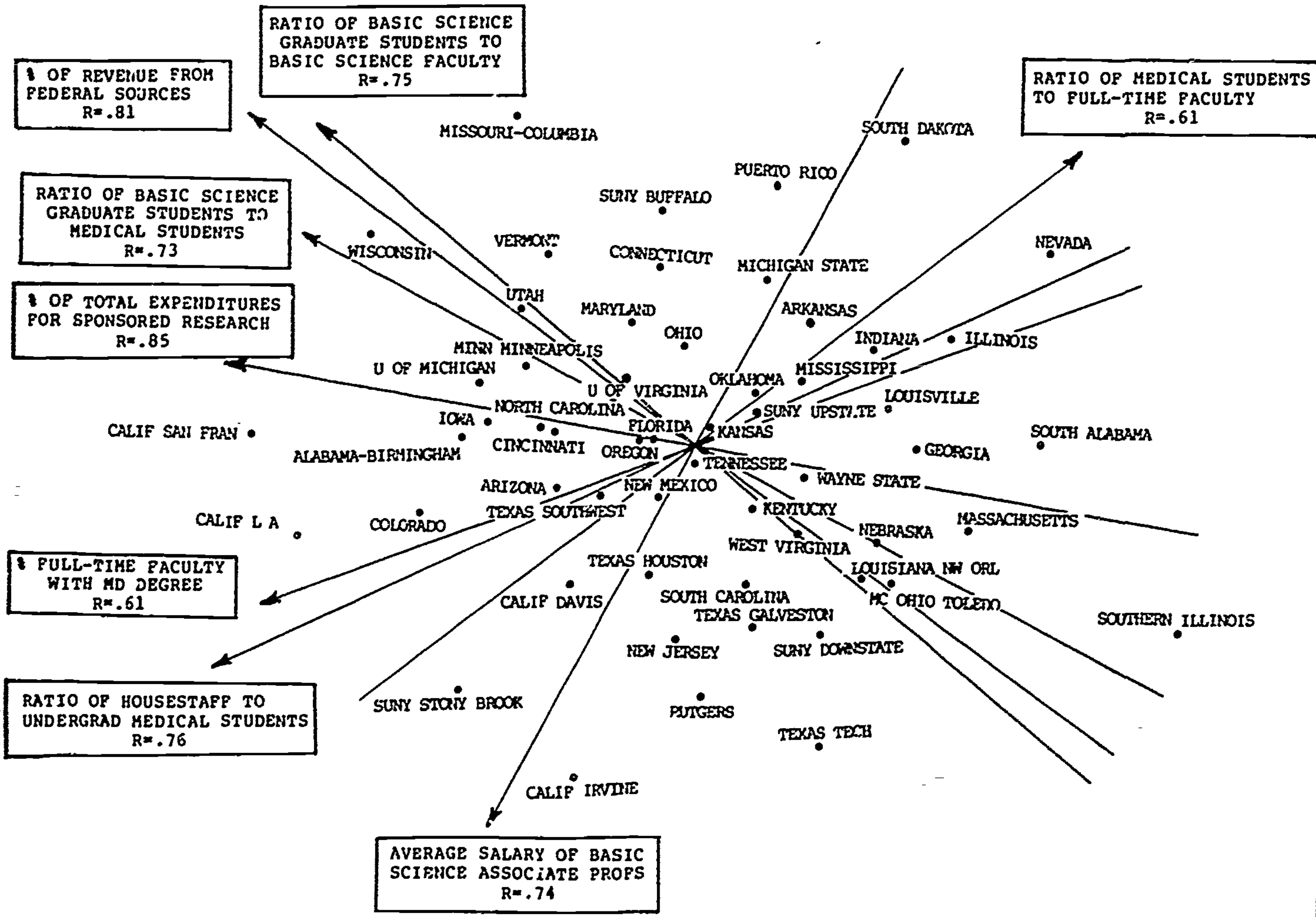


Table 2

Multiple Regression Coefficients
Indicating Goodness-of-Fit of 12 Vectors in each of 4 Spaces for 1976 and 1977 Scaling Results
(Decimal Points Omitted)

			3 Dimensions				2 Dimensions			
			Public		Private		Public		Private	
			1976	1977	1976	1977	1976	1977	1976	1977
1.	STC043	RAT: HOUSESTAFF TO UNDERGRAD MD STUDENTS	73	80	83	79	67	76	83	77
2.	INC058	RAT: MD STUDENTS TO FT FACULTY	54	65	82	83	59	61	82	78
3.	FAR053	FSS: AV SAL SFT ASSOC PROF BAS SCIENCE	66	83	71	72	64	74	65	68
4.	STC105	AMA: % 60-69 ALUMNI IN GENL PRACTICE[1]	66	64	91	66	53	37	89	63
5.	INR142	NIH R01 GRANTS: MEAN STD PRIORITY SCORE	69	60	82	75	67	41	57	71
6.	FAC001	FRS: %FT SAL FACULTY WITH MD OR MD-PHD[2]	76	63	24	88	41	61	23	65
7.	STC045	RAT: BMS GRAD STUD TO UNDERGRAD MD STUD	94	77	90	86	84	73	82	84
8.	INC061	RAT: BMS GRAD STUD TO BAS SCI FT FACULTY	93	78	91	81	88	75	86	77
9.	INC017	% TOTAL EXPD FOR SPONSORED RESEARCH	90	87	87	90	88	85	85	89
10.	INC007	% REV FROM FED SOURCES & RCOV IND COSTS	88	85	72	69	86	81	72	63
11.	INC026	% EXPD FOR ADMIN & GENL EXPENSE	68	68	72	72	60	43	28	32
12.	INR137	NIH R01 GRANTS: APPROVAL RATE OF APPLS	72	70	88	75	51	42	69	70

[1] In 1976 the percentage of <u>all</u> living alumni was used.

[2] In 1976 the percentage of full-time and part-time faculty was used.

of expenditures for sponsored research is the most salient component of difference for both public and private schools, with multiple-R's all higher than .83 in the various models. Other variables, however, evidence differences between public and private schools. Percentage of alumni in general practice differentiates private schools more than it does public schools. Research grant priority scores and approval rates also better distinguish private schools from one another than public schools.

In summary, private school similarities again appear to be better modeled than public school similarities. Furthermore, while the spatial orientation of several well-fitting vectors in the models for private and public schools bear strong resemblance to one another, some differences are noticeable.

Chapter IV

SUMMARY

Public and private medical school similarities were modeled using multidimensional scaling in an attempt to replicate the results of an earlier study. Similarity was defined with respect to the same twelve variables (with minor exceptions). More recent data, however, were used to compute the numerical indices of similarity between pairs of schools. The twelve measures had been shown in earlier research to be related to research and graduate medical education intensiveness.

Two- and three-dimensional models were again derived. The two-dimensional models for public and private schools were plotted, with schools identified, to describe the overall similarities of schools within each set.

Multiple regression methods were again used to determine how well school differences on each of twelve simple variables were represented by the multidimensional models. The results of the scaling and regression replications were compared with those of the original 1976 study.

Private school similarities were again better modeled than public school similarities. The public school model was improved with respect to graduate program differences, and diminished in its representation of research related characteristics. The set of public schools includes most of the newer and developing schools, that are less likely to fit a descriptive model that applies to more established public medical schools. The private school model showed little change, except for the two variables with changed definitions. It is probable that private medical schools are more stable and homogeneous with respect to the basic measures and characteristics examined in this pair of studies.

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