MEDICAL MANPOWER: A MULTIVARIATE ANALYSIS OF THE DISTRIBUTION OF PHYSICIANS IN URBAN UNITED STATES

by

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In medical manpower planning, two dimensions of the concept of availability have to be considered. One is the adequacy of human resources, or availability of sufficient human resources to meet the demand and/or need for them. The other is the geographical distribution of these resources over given areas.

Among the studies pertaining to the first dimension, the adequacy of resources has usually been represented as a ratio of manpower (physicians) to population. In 1933, for instance, Lee and Jones[1] concluded that 192 physicians per 100,000 population was the number required to provide all persons in the U. S. with essential medical care. In 1945, Clark,[2] in designing a group practice plan, proposed a ratio of 125 physicians per 100,000 population. Also in 1945, Pastore[3] suggested a ratio of 165 physicians for the same size population, while Mountin and Pennell[4] in 1949 considered a lower ratio, 118 physicians per 100,000 population, satisfactory. More recently, the widely accepted ratio of 132.7 per 100,000 was recommended in 1959 by the Surgeon General's Group on Medical Education.[5]

Although they are frequently employed, the use of such aggregate national ratios of physicians to population is of little value for manpower planning purposes at the national or regional level unless the components of the ratios are known and their meaning is understood. More meaningful for planning purposes than national averages or ratios are regional and local ratios of physicians to population which make possible the study of not only the availability but also the distribution

of physicians in the U. S. A further step required for planning purposes is the analysis of this distribution and the determination of the variables which can explain it.

In this regard, Leland,[6] for instance, noted in 1934 a higher physician to population ratio in states with a larger number of people and a higher per capita income. Furthermore, Mountin, Pennell and Nicolay[7] in 1940 calculated a greater supply of physicians per population in counties with greater urban concentration, higher number of general hospital beds, a marked population increase (20% or more) over a 15-year period and a higher per capita income.

Later studies have indicated that community characteristics related to physician supply may be different for general practitioners than for specialists. Two studies, in particular, have examined these differences. In 1954, Dickinson[8] found that the rate of specialists varied with the population size of a community but the rate of general practitioners did not; and that there was a positive correlation between specialists and per capita buying power. In 1966 a doctoral dissertation prepared by Marden[9] found that in the U. S. Standard Metropolitan Statistical Areas:

1) A linear relationship was the best description of the association between the demographic size of the metropolitan area and the number of total physicians, general practitioners and specialists;

2) Median education of the population could be coupled with "medical environment" (number of non-Federal general acute hospital beds) as a major explaining factor in the location of specialists, while it had comparatively little importance for

explaining the distribution of general practitioners;

3) Race and age of the population, almost without exception, were the two most important variables accounting for the distribution of general practitioners.

In this paper we examine the relationship between ten community characteristics and the supply of physicians by individual specialty rather than as an aggregate supply of physicians. The relationships identified in this paper have been used by the authors in a later study to establish a distribution indicator of physicians in the urban U. S.[15]

METHODS

In the first phase of this study, the relationship between ten community characteristics (independent variables) and 27 physician-population ratios (dependent variables) is examined. A "community" is defined as either a Standard Metropolitan Statistical Area (SMSA) or a metropolitan area that meets the definition of an SMSA but is not as yet included in the official listing. Two hundred and ninety-nine metropolitan areas are included in this study. Each is "an integrated economic and social unit with a recognized large population nucleus"[10] and is assumed to be a self-sufficient medical service area. Marden's study[9] includes data compiled by Ciocco and Altman[11] supporting this assumption. Most of the areas included fall within the Bureau of the Budget definition of a Standard Metropolitan Statistical Area (SMSA);[10] however, because the physician data are

reported for metropolitan areas as defined by Sales Management, Inc.,[12] several exceptions and additions have been necessary (see Appendix).

The American Medical Association publication, Distribution of Physicians, Hospitals, and Hospital Beds in the United States, 1966, Part 2,[13] is the source of all physician information. This publication lists all medical doctors, including non-members as well as members of the AMA. All non-Federal physicians who are involved in patient care, as opposed to those in administration, research or teaching, are included in this study. Categories by specialty are based on reports from the physicians themselves and do not necessarily indicate board certification.

The population figures in each metropolitan area represent total resident population as of December 31, 1965, estimated by Sales Management, Inc.[12]

The ten measurable community characteristics (independent variables) are: population size, population density; per capita buying power; per household buying power;[16] the existence of one or more medical schools within the metropolitan area; the existence of a more populous metropolitan area within 75 miles; median years of education of the population; percentage of population aged 65 years and over; percentage of population categorized as "white" and the number of non-Federal acute general hospital beds per 1,000 population.

The 27 physician-population ratios denote physicians in "patient care", which includes physicians "in that activity who are self-employed,

under retainers, or salaried by hospitals, other institutions, industry, or government."[13] Actually, it includes all active physicians, except those on medical school faculties, in administration and research. This category is then divided into two subgroups: first, "solo, partnership, group or other practice" hereafter referred to as "private practice";[17] second, "hospital based practice," composed of all Federal and non-Federal physicians practicing in hospitals, including interns, residents and fellows, as well as full-time physician staff.

Of the 27 ratios used, five are within the overall category physicians providing "patient care": total physicians; general practitioners; medical specialists; surgical specialists and other specialists.[13] One ratio is included for total physicians in full-time "hospital based practices." The remaining 21 ratios concern physicians in "private practice": total physicians; general practitioners; medical specialists; internists; pediatricians; allergists; dermatologists; other medical specialists, including cardiovascular specialists, gastroenterologists, pediatric allergists, pediatric cardiologists and pulmonary specialists; surgical specialists; general surgeons; obstetricians and gynecologists; ophthalmologists; otolaryngologists; urologists; other surgical specialists, including neurological surgeons, orthopedic surgeons, plastic surgeons; colon and rectal surgeons and thoracic surgeons; anesthesiologists; pathologists, including general pathologists and forensic pathologists; psychiatrists, including clinical psychiatrists, neurologists, and child psychiatrists; radiologists, including diagnostic and therapeutic radiologists;

and remaining other specialists, including those in the fields of aviation medicine, occupational medicine, physical medicine and rehabilitation, general preventive medicine and public health.

The data have been analyzed by means of Sonquist and Morgan's Automatic Interaction Detector (AID) program,[14] a multivariate procedure through which one can statistically determine which independent variable(s) most improves the ability to predict values of the dependent variable. In other words, which of the ten community characteristics in order of importance increases the chance of correctly predicting physician-population ratios by specialty in the 299 communities.

Figure 1 shows the predictor tree, which illustrates the result of the AID analysis. In this instance, the tree exhibits the relationship between the ratio of general practitioners in private practice to population and the characteristics of that population.

The box labeled "group 1" includes all 299 communities. The mean ($\bar{x}$) number of general practitioners per 100,000 population for all 299 communities is 28.0 Each of the community characteristics (independent variables) is then considered in turn to determine which of the ten could significantly increase (at the .05 level) the ability to predict the ratio of general practitioners to population. Within the total 299 communities, the first split* occurred in the "percent

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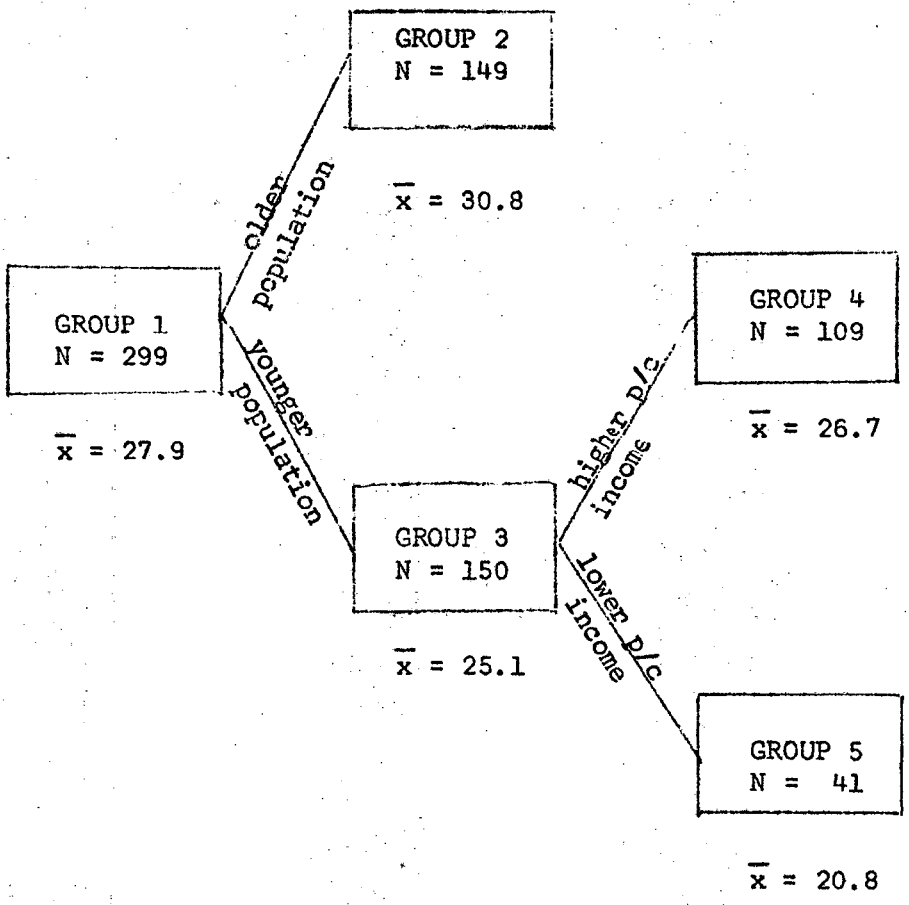
*"Split" is the point at which the independent variable is dichotomized in order to maximize the between-group variation of the dependent variable. This split may also be defined as the point at which the independent variable can significantly predict the physician-population ratio.

CHART 1

PREDICTOR TREE FOR THE DISTRIBUTION OF
GENERAL PRACTITIONERS IN PRIVATE PRACTICE
IN URBAN U. S.



of population aged 65 and over" factor, showing this independent variable to be the most important single predictor factor. Figure 1 shows the 299 communities divided into two other groups, Group 2, totaling 149 communities with nine percent or more of the population aged 65 and over, and Group 3, containing 150 communities with less than nine percent of the population aged 65 and over. The mean number of general practitioners in private practice per 100,000 population in Group 2 is 30.8, significantly different (at a .05 level) from the mean number of general practitioners in private practice in Group 3, which is 25.1.

The next step in the analysis in Figure 1 is to consider again the predictability of all ten independent variables with reference to the 149 communities in "Group 2". It is found for Group 2 that none of the independent variables significantly increases the ability to predict the ratio of general practitioners in private practice to population. The same procedure is followed for the 150 communities in "Group 3". In this group, it is found that per capita buying power further increases our predictive ability. The 109 communities with a per capita buying power of $2,000 and over (Group 4) have a mean general practitioner ratio of 26.7 while communities with a per capita buying power of less than $2,000 (Group 5) have a significantly different mean ratio of 20.8.

The computations for all 27 different specialties are calculated with the same procedure and are available from the authors.

FINDINGS

Table 1 presents a summary of those community characteristics which are significantly related (at the .05 level) and predicts the ratio of physicians to population per each type of physician. The primary predictors are the independent variables that determine the first split of the total group of communities; for example, "percent of population aged 65 and over" is the factor determining the first split of communities with general practitioners in private practice, as shown in Figure 1.

The secondary predictors are the independent variables that determine the second split; for example, per capita buying power is shown as causing Groups 4 and 5 in Figure 1.

The tertiary predictors are the independent variables that determine the third split. Had they existed in Figure 1, they would have caused Groups 6 and 7.

There are five independent variables which caused the formation of Groups 2 and 3. These are: the existence of a medical school in the community; the general hospital bed rate (per 1,000 population); the median education of the population; the percentage of the population aged 65 and over and the per capita buying power.

The existence of a medical school in the community is found to be the most useful variable for predicting eight of the 21 private practice specialties under consideration (total physicians, medical specialties,

TABLE 1

SUMMARY OF SIGNIFICANT INDEPENDENT VARIABLES
IN ORDER OF SIGNIFICANCE TO EXPLAIN
PHYSICIAN DISTRIBUTION PER SPECIALTY

DEPENDENT VARIABLE PHYSICIAN SPECIALTIES	Primary Predictors Separating Group 1 Into Groups 2 and 3*	Secondary Predictors Separating Group 3 into Groups 4 and 5*	Tertiary Predictors Separating Group 2 into Groups 6 and 7*
Total physicians, patient care	Existence of medical school	Population size	
General practice, patient care	Percent of population aged 65 and over		
Medical specialties, patient care	Existence of medical school	Population size	
Surgical specialties, patient care	Existence of medical school	Population size	
Other specialties. patient care	Existence of medical school	Population size	
Total hospital based physicians	Existence of medical school	Population size	
Total physicians in private practice	Existence of medical school		
General practice, private practice	Percent of population aged 65 and over	Per capita buying power	
Medical specialties, private practice	Existence of medical school	Population size	

*See Chart 1

TABLE 1 (Cont.)

DEPENDENT VARIABLE PHYSICIAN SPECIALTIES	INDEPENDENT VARIABLES Primary Predictors Separating Group 1 into Groups 2 and 3*	Secondary Predictors Separating Group 3 into Groups 4 and 5*	Tertiary Predictors Separating Group 2 into Groups 6 and 7*
Internal medicine, private practice	Existence of medical school	Population size	
Pediatrics, private practice	Existence of medical school	Population density	Population size
Allergy, private practice	Existence of medical school	General hospital bed rate	
Dermatology, private practice	General hospital bed rate	Population size	
Other medical specialties, private practice	Existence of medical school	Population size	
Surgical specialties, private practice	General hospital bed rate		
General surgery, private practice	General hospital bed rate	Per household buying power	Population density
Obstetrics and gynecology, private practice	Existence of medical school	Population size	
Ophthalmology, private practice	Median education	General hospital bed rate	
Otolaryngology, private practice	General hospital bed rate	Per household buying power	

* See Chart 1

TABLE 1 (Cont.)

DEPENDENT VARIABLE PHYSICIAN SPECIALTIES	INDEPENDENT VARIABLES Primary Predictors Separating Group 1 into Groups 2 and 3*	Secondary Predictors Separating Group 3 into Groups 4 and 5*	Tertiary Predictors Separating Group 2 into Groups 6 and 7*
Urology, private practice	General hospital bed rate	Per capita buying power	
Other surgical specialties, private practice	Median education	General hospital bed rate	
Other specialties, private practice	Median education	Population density	
Anesthesiology, private practice	Median education	General hospital bed rate	
Pathology, private practice	Median education	Population density	
Psychiatry, private practice	Existence of medical school	Population size	
Radiology, private practice	General hospital bed rate	Existence of medical school	
Remaining other specialties, private practice	Per capita buying power	Population size	

* See Chart 1

internal medicine, pediatrics, allergy, other medical, obstetrics-gynecology and psychiatry). Table 2 lists these specialties along with the mean rates found after the first split. For example, a mean rate of 118.9 physicians in private practice per 100,000 population occurs in those communities with a medical school and is significantly different (at a .05 level) from the mean rate of 89.1 in communities without a medical school. A medical school in the community is also found to be most useful in predicting rates of the total physicians in patient care and general practice, medical specialties, surgical specialties, and others, in patient care.

The general hospital bed rate is most useful in predicting six private practice specialty rates (surgical specialties, general surgery, otolaryngology, urology, dermatology and radiology). The majority of these are surgical specialties but dermatology and radiology are also included. Table 3 lists the physician-population ratios derived from the first split of these specialties. It should be noted that the general hospital bed rate at which the split is accomplished differs by specialty.

Median years of education of the population is most valuable in predicting the mean rate of five of the 21 private practice specialties (ophthalmology, other surgical specialties, anesthesiology, other specialties, and pathology). Table 4 presents the mean physician-population ratios derived after the first split for these five specialty groups.

The percentage of the population aged 65 and over is the cause of the initial split for general practitioners in patient care as well as

TABLE 2

AVERAGE PHYSICIAN-POPULATION RATES
PER 100,000 POPULATION FOR SPECIALTIES
WITH FIRST SPLIT BEING BY "THE EXISTENCE
OF A MEDICAL SCHOOL"

Specialty (private practice)	With medical school	Without medical school
Total physicians	118.9	89.1
Obstetrics-gynecology	9.3	6.3
Pediatrics	7.7	5.0
Allergy	.7	.4
Medical specialties	30.9	17.6
Internal medicine	19.7	10.0
Other medical	1.8	.7
Psychiatry	8.5	3.2

TABLE 3

AVERAGE PHYSICIAN-POPULATION RATES
PER 100,000 POPULATION FOR SPECIALTIES
WITH FIRST SPLIT BEING BY "GENERAL
HOSPITAL BED RATE"

Specialty (private practice)	Higher bed rate	Lower bed rate
Surgical specialties	34.8[a]	28.1
General surgery	13.5[c]	9.5
Otolaryngology	3.1[b]	2.2
Urology	3.9[c]	2.4
Dermatology	1.8[a]	1.3
Radiology	5.9[c]	3.5

Higher bed rate defined as:

a 3.5 beds per 1,000
b 5.0 beds per 1,000
c 6.0 beds per 1,000

TABLE 4

AVERAGE PHYSICIAN-POPULATION RATES
PER 100,000 POPULATION FOR SPECIALTIES
WITH FIRST SPLIT BEING BY "MEDIAN EDUCATION"

Specialty (private practice)	Higher median education	Lower median education
Ophthalmology	5.0[a]	3.6
Other surgical	7.7[a]	5.1
Anesthesiology	4.9[a]	3.0
Other specialties	23.3[b]	13.3
Pathology	3.3[b]	1.5

Higher median education defined as:

[a] 11.5 years and over
[b] 12.0 years and over

in private practice, as explained in the example given in the methodology. The per capita buying power is found to be useful in predicting the mean rates for the remaining other specialty group in private practice. In communities with a per capita buying power of $2,500 or more, the mean rate of the remaining other specialties per 100,000 population is 2.3 while for communities with a per capita buying power of under $2,500 the rate is 1.3, significantly different at a .05 level.

SUMMARY AND CONCLUSIONS

According to this study, the best predictor of general practitioner rates was the percentage of the population aged 65 years and over. This finding supported Marden's results that age was one of the two most important variables accounting for the distribution of general practitioners. Race, the other variable in Marden's study, was not found to be significantly important.

For specialties, Marden's variables, education and "medical environment," were also supported by this study. However, in this paper which divided specialties into three groups, it was found that medical specialties were most strongly related to the existence of a medical school in a community; general hospital bed rate was the best predictor of surgical specialty distribution, and other specialties were most strongly related to median years of education. Even within the above specialty categories, individual specialist distribution was related to different variables. Some specialties, such as obstetrics and gynecology, and psychiatry, were influenced by the same variables as the aggregate medical specialty category. Two specialties, dermatology and radiology,

were primarily related to general hospital bed rate as was the surgical specialty category. Ophthalmology, a surgical specialty, followed the same pattern as the other specialty category.

From the results of this study it was possible to conclude that better understanding of physician-population ratios was accomplished by examining these ratios along with community characteristics. Further clarity was gained when individual specialties or groups of specialties were considered rather than an aggregate physician-population ratio.

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APPENDIX

ADDITIONS AND DELETIONS OF COMPONENTS OF SMSAs AS DEFINED BY THE BUREAU OF THE BUDGET IN 1967

CHANGES

Baltimore, Md.	Harford County deleted
Birmingham, Ala.	Shelby County and Walker County deleted
Boston, Mass.	Include only Essex, Middlesex, Norfolk and Suffolk Counties
Bridgeport, Conn.	Include only Fairfield County
Brockton, Mass.	Include only Plymouth County
Corpus Christi, Tex.	San Patricio County deleted
Dallas, Tex.	Kaufman and Rockwell Counties deleted
Durham, N.C.	Orange County deleted
Greensboro, N.C.	Randolph and Yakin Counties deleted
Hartford, Conn.	Include only Hartford and Tolland Counties
Indianapolis, Ind.	Boone County deleted
Lewiston, Me.	Include only Androscoggin County
Lima, Ohio	Putnam and VanWert Counties deleted
Little Rock, Ark.	Saline County deleted
Manchester, N.H.	Include only Hillsborough County
Milwaukee, Wisc.	Washington County deleted
New Bedford, Mass.	Include only Bristol County
New Haven, Conn.	Include only New Haven County
New London, Conn.	Include only New London County
Pittsfield, Mass.	Include only Berkshire County
Portland, Me.	Include only Cumberland County
Providence, R.I.	Include only Bristol, Kent, Newport, and Providence Counties
Springfield, Mass.	Include only Hampden and Hampshire Counties
Washington, D.C.	Loudon and Prince William Counties deleted
Wilmington, N.C.	Brunswick County deleted
Worcester, Mass.	Include only Worcester County

DELETIONS

Fall River, Mass.
Fitchburg, Mass.
Lawrence, Mass.
Lowell, Mass.
Mayaguez, P. R.
Meriden, Conn.
New Britain, Conn.
Norwalk, Conn.
Ponce, P. R.
San Juan, P. R.
Sherman, Tex.
Stamford, Conn.
Waterbury, Conn.

ADDITIONS

SMSA	County
Alexandria, La.	Rapides County
Anchorage, Alas.	3rd Judicial Division
Anderson, S. C.	Anderson County
Anniston, Ala.	Calhoun County
Appleton, Wisc.	Outagamie County
Ashtabula, Ohio	Ashtabula County
Bangor, Me.	Penobscot County
Battle Creek, Mich.	Calhoun County
Bellingham, Wash.	Whatcom County
Beloit, Wisc.	Rock County
Benton Harbor, Mich.	Berrien County
Bremeton, Wash.	Kitsap County
Bristol, Va.	Washington County
Burlington, N. C.	Alamance County
Burlington, Vt.	Chittenden County
Cheyenne, Wyo.	Laramie County
Cumberland, Md.	Mineral County, W. Va. Allegany County, Md.
Danville, Ill.	Vermilion County
Daytona Beach, Fla.	Volusia County
Eau Claire, Wisc.	Chippewa and Eau Claire Counties
Elkhart, Ind.	Elkhart County
Elmira, N. Y.	Chemung County
Florence, Ala.	Colbert and Lauderdale Counties
Fond du Lac, Wisc.	Fond du Lac County
Gainesville, Fla.	Alachua County
Galesburg, Ill.	Knox County
Gastonia, N. C.	Gaston County
Grand Forks, N. D.	Polk and Grand Forks Counties
Hagerstown, Md.	Washington County
Hutchinson, Kans.	Reno County
Jamestown, N. Y.	Chautauga County
Joplin, Mo.	Newton and Jasper Counties
Kankakee, Ill.	Kankakee County
Kannapolis, N.C.	Cabbarrus and Rowan Counties
Kokomo, Ind.	Howard County
LaCrosse, Wisc.	LaCrosse County
Lakeland, Fla.	Polk County
Lebanon, Pa.	Lebanon County
Longview, Tex.	Gregg County
Manitowoc, Wisc.	Manitowoc County
Marion, Ind.	Grant County
Meridian, Miss.	Lauderdale County

SMSA	County
Michigan City, Ind.	La Porte County
Middletown, Conn.	Middlesex County
Modesto, Calif.	Stanislaus County
Newark, Ohio	Licking County
Newburgh, N. Y.	Orange County
New Brunswick, N. Y.	Somerset County Middlesex County
New Castle, Pa.	Lawrence County
Oshkosh, Wisc.	Winnebago County
Owensburg, Ky.	Davies County
Panama City, Fla.	Bay County
Parkersburg, W. Va.	Wood and Wirt Counties
Pasco, Wash.	Franklin and Benton Counties
Petersburg, Va.	Independent City, Prince George County and Dinwiddie County
Port Huron, Mich.	St. Clair County
Portsmouth, Ohio	Scioto County
Poughkeepsie, N. Y.	Dutchess County
Quincy, Ill.	Adams County
Rapid City, S. D.	Pennington County
Richmond, Ind.	Wayne and Union Counties
Rocky Mount, N.C.	Edgecombe and Nash Counties
Salina, Kans.	Salina County
St. Cloud, Minn.	Stearns County
Sandusky, Ohio	Erie County
Santa Rosa, Calif.	Sonoma County
Sarasota, Fla.	Sarasota County
Sharon, Pa.	Mercer County
Sheyboygan, Wisc.	Sheboygan County
Spartanburg, S. C.	Spartanburg County
Temple, Tex.	Bell County
Watertown, N. Y.	Jefferson County
Wausau, Wisc.	Marathon County
Williamsport, Pa.	Lycoming County
Yakima, Wash.	Yakima County
Zanesville, Ohio	Muskingum County

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16. Per household buying power is an indicator of market potential that has been developed by Sales Management Magazine for its annual survey of buying power. It is a weighted index similar to what the Federal government defines as the disposable personal income.

17. The "other practice" includes physicians who render patient care and who are salaried or retained by other physicians or employed by non-Federal organizations other than hospitals.