COMPARATIVE DISTRIBUTIONS OF MEDICAL OCCUPATIONS IN MICHIGAN COUNTIES

By

Ann Elizabeth Sampson

A Thesis

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Geography

1986

ABSTRACT

COMPARATIVE DISTRIBUTIONS OF
MEDICAL OCCUPATIONS IN MICHIGAN COUNTIES

By

Ann Elizabeth Sampson

This is a descriptive and analytic study of the spatial distributions of fourteen medical occupations in Michigan. A sample of thirty counties is used: fifteen urban and fifteen rural counties. Gini indices compare each occupation's distribution to that of the base population. County ratios of licensees to population for each occupation are calculated, ranked, and mapped. Results show that most occupations have above-median ratios largely in urban counties; exceptions are LPNs, optometrists, and chiropractors. Hypotheses of dependence on physicians and association with large medical capacity as measured by urbanization are tested by Kendall's rank order correlation. Some occupations show dependence on MDs but not on DOs. Urbanization is strongly associated with ratios of several occupations. Psychologists are the most unevenly distributed group.

ACKNOWLEDGEMENTS

I have become indebted to many teachers, friends, and colleagues during the time I have studied for this degree. In particular I thank my professional supervisor Louise Mueller for her cooperation and encouragement during years of meshing work and school. Dr. John Hunter directed my training in medical geography and with Dr. Richard Groop provided access to data and guided the format of this thesis. Dr. Gary Manson provided funds which helped free me to finish the degree more speedily. Mike Lipsey gave patient aid with the computer-assisted maps. Dr. Olaf Scholten wrote a routine to plot the Lorenz curves and calculate Gini indices, and he inspired a great deal of motivation at a critical time. I also thank my parents for logistical support and for furnishing the background and values that led me to pursue this degree.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter One

INTRODUCTION AND PROBLEM

Introduction

This thesis reports the design and results of a study done to investigate the geographical distribution of health care workers in the State of Michigan. The research is an attempt to describe distributions and to determine whether an aspatial characteristic of the medical system is associated with predictable areal variations in the number of medical workers. This is a cross-sectional "snap shot" study of fourteen categories of medical manpower in a sample of thirty counties of Michigan.

The subject of this thesis lies in the stream of recent geographies of medical service (Bashshur et al., 1971; Stimson, 1981; Haynes and Bentham, 1982; Northcott, 1980.) Many such studies have been confined to locations of and distance to doctors, and occasionally to nurses or dentists. The American medical system is very complex and invites more wide-ranging descriptions, as begun by Joroff and Navarro (1971.) In the research for this thesis the perspective was maintained that we may discover geographic consequences of the medical system's organization. Although the most important single group of personnel in the system is usually agreed to be licensed MDs (medical or allopathic doctors,) people in a score of other occupations perform much of the work to diagnose, treat, and monitor patients' conditions. A few other occupations are recognized as conventional or alternative providers of healing or coping service but are not integrated into the physician dominated system; these occupations include chiropractors, optometrists, psychologists, and, to some extent, pharmacists (Forster, 1982.)

Within the conventional medical system accepted by the American Medical Association most professionals are dependent on doctors because legal and professional strictures require a physician's order before a blood test, an X-ray, a physical manipulation, or a medicine may be performed on or given to a patient. Public convenience and concentration of facilities have also encouraged a subtle dependence based on location, although freestanding pharmacies have long been exceptions. Thus a health occupation's dependence on or independence from physicians may be reflected in the degree of spatial correlation the particular occupation shares with doctors.

Statement of problem and hypotheses

Since few geographies of non-physician health professionals exist this research is both descriptive and analytic. There are three general questions addressed here: To what degree are medical workers apportioned equivalently to population? Are there significant differences in spatial dispersion among the professions? Does the distribution of doctors correspond to need? The main thrust of the study is toward the first two questions. The third question (Does the distribution of doctors correspond to need?) is considerably broader than the scope of this thesis but it is addressed to provide at least a rough indication of the correspondence between aggregate need for medical care and the availability of such care. Recent studies have found great discrepancies across Michigan in the number of available providers per population. (OMHA, 1983; Arbor Associates, 1983.)

The first objective is to show the spatial distributions of fourteen categories of medical personnel, standardized to base

population. The second is to discover spatial differences among the occupations and to test two hypotheses expected to help explain such differences.

The first hypothesis derives from the fact that some non-physician workers are tied by organizational hierarchy and by technical requirements to clinics and hospitals. The speculation is that among all nonphysicians differential distribution exists and that differences are associated with dependence on or independence from practicing doctors. Stated formally, the null hypothesis is that there is low correlation between the distribution of staff physicians and that of the tested occupation. The research hypothesis is that significant positive correlation exists.

The second test for explanation of spatial differences among professions is concerned with urbanization. Urbanization has been demonstrated to be a major factor in physician location and probably has a similar effect on location by other professionals (Steele and Rimlinger, 1963; Cuca, 1980; Richards and Golden, 1980.) In the present study, urbanization serves as a surrogate variable for medical capacity. The number of hospital beds per given area is the usual measure of medical capacity, but a significant proportion of the manpower in this study has little or no association with hospitals. Outpatient clinics of many types, private pharmacies, and chiropractic, dental, and optometric offices employ a large number of medical personnel. Currently there is no measure of aggregate medical capacity — or of aggregate utilization -- that approaches accuracy when outpatient services need to be taken into account. More inpatient and outpatient services are found in larger urban places which, coupled with the

recognized draw of urban areas for providers, led to the choice of urbanization as a correlate variable. Thus in the second statistical analysis a significant positive correlation is expected between urbanization and the ratio of professionals to total population. The null hypothesis states that there is no significant correlation between counties' percentage urban population and the rates of professionals per 10,000 total population. The corresponding research hypothesis thus states that significant positive correlation does exist between these variables.

Since counties in the sample with large cities may mask the degree of correlation in more rural places, the second hypothesis is tested initially over the entire sample, then the thirty counties are stratified by rural or urban character and the hypothesis is retested over the two subsamples.

Scope of work and expected outcomes

This work falls within the realm of geographic availability studies. It is a study of the patterns of dispersion and availability of medical personnel in Michigan at the county level. Knowledge of how much of a service is available, and where, later can be fitted to measurements and spatial patterns of need to demand to obtain the fullest possible understanding of the geography of the service.

A more unusual aspect of this work may be found in the effort to incorporate as full a representation of the conventional medical system as possible. In addition, alternatives to conventional health care are recognized as real preferences for some patients although these preferences constitute an unknown fraction of aggregate demand. Chiropractors and podiatrists are included as measurable representatives

of 'alternate therapists'. The amount of recourse to all such alternates would be measurable only by field study; the percentage of physical and mental or emotional complaints submitted to Christian Science practitioners, faith healers, folk or family remedies and counseling, ethnic healers, and the use of over-the-counter preparations is probably higher than many conventional medical workers suspect. (Freidson, 1960; Helman, 1978; Unschuld, 1980.) Many patients combine 'conventional' and 'alternative' therapies if only by requesting prayers of family and friends.

In summary, this work describes similarities and differences among distributions of medical personnel. The data are examined for disparities between urban and relatively rural areas, and specific emphasis is placed on testing the association of occupations' dependence on physicians with patterns of geographic dispersion. The effect on the spatial distributions of varying medical capacity, as measured by percent urban population, is discussed. Finally, a rough measure of the correspondence of medical need and access to physicians is presented.

Anticipated results of this investigation are fourfold. Firstly, as demonstrated by Gini coefficients and maps, the county rates of all occupations are expected generally to increase with increasing population and urbanization, although patterns of individual occupations are not expected to be identical. Secondly, in regard to the hypothesis testing spatial correlation by physician independence, optometrist, dentists, pharmacists, chiropractors, and podiatrists are expected to be more evenly distributed with respect to population than are MDs and DOs. Psychologists may be the most independent of physicians and technical clinics so they also are expected to show low correlations with staff

doctors. The physician-dependent groups included in the sample are physical therapists, physician assistants, nurses, and dental hygienists; they are expected to be highly correlated with doctors.

Thirdly, we expect to find positive correlation between percent urban population and professionals per 10,000 persons in urban and rural categories, but significantly stronger correlation in the urban subset. Fourthly, a map of ratios of active physicians to a 'high need' subpopulation is expected to show that there are fewer physicians per 10,000 probable patients in rural counties than in urban counties.

Chapter Two

REVIEW OF LITERATURE

Medical geography has developed two major emphases of research. The older emphasis deals with studying geographies of particular diseases such as malaria (Learmonth, 1957; Fonaroff, 1968) and other conditions both infectious and noninfectious. The more recent emphasis, particularly among North American medical geographers, is on the geography of health care delivery, with a corollary interest in identifying and eliminating areas of low access to medical service. These studies usually depend on distance measures (Godlund, 1960; Morrill and Earickson, 1969; Mayer, 1983.) Only a few investigations have succeeded in bridging the apparent dichotomy between disease ecology and service distribution (Pyle and Lauer, 1973; Wennberg and Gittelsohn, 1973; Rahaman et al, 1982.)

The focus of this thesis is entirely within the purview of the second branch of medical geography. Geographic access of potential patients to physicians or hospitals, locational regularities of physicians, and resultant patterns of use of services constitute the three most thoroughly researched topics in the geography of health care. A desire to promote optimal access is a nearly universal feature of these studies. The philosophic and methodologic mires of measuring both need for care and equity of access are discussed by Joseph and Phillips (1984) who present a very comprehensive review of this literature.

Distance from a doctor or hospital and the time required to traverse that distance can be important influences on the accessibility and consequent use of medical care. Many other social attributes of

patient or of provider affect the geography of utilized service (Bashshur, Shannon, and Metzner, 1971.) In the last few decades as the general population moved away from small towns and into suburbs and cities, so too did doctors. This rural-to-urban migration was accentuated by a large increase in new physicians, especially since the 1960s. These new doctors have been found generally to locate preferentially in the more affluent parts of those cities near their medical schools or residency programs (Lankford, 1972; Cuca, 1980.) This situation has given rise to concerns that rural populations are becoming relatively underserved. There are several recent studies of the origin or perpetuation of disparities between rural and urban distributions of doctors (Cooper et al, 1975; Northcott, 1980; Hassinger et al, 1980.) David Brown (1974) described the patterns for doctors and dentists in the upper Midwest as "a reordering in which suburban and larger nonmetropolitan cities are emerging as the providers of specialty medical care for the rural population. These hinterland centers contain the facilities and resources to support specialty medicine." Schwartz et al (1980) confirm that there is movement of primary 'specialists' into nonmetropolitan towns. At the same time, maldistribution of physicians and services within cities has been investigated. Bennett (1981) attempted to resolve such a case in Lansing, Michigan by allocation modelling.

An interesting study by Rushing and Wade (1973) analyzed physician distribution in light of community structure, including the coincident distribution of supporting medical employees and of unrelated professions. They found that aides and orderlies were employed in greater proportion, and registered nurses in less proportion, with

decreasing median family income. Physician to population ratios increased with urbanization, as did ratios of total employed males in professional and technical occupations. In addition, "the effect of community income on health manpower varies directly with the professional development and technical expertise of the occupation." This study emphasized the contexts of the health care system and of urban size and composition in performing and interpreting statistical descriptions of physician distribution. This perspective and the contents of Rushing and Wade's report helped to stimulate the hypotheses in this present investigation.

Nearly all geographies of medical manpower limit themselves to physicians. This practice is certainly justified by the centrality of the physician to the biomedical system dominant in Western countries, but it does overlook the doctor's growing dependence on the so-called ancillary services for diagnosis and treatment. It also overlooks independent practitioners. Choice among a range of providers, or, indeed, choice of no provider, is one aspect of health care systems that is occasionally mentioned (Gesler, 1979) but rarely incorporated into geographic field studies or analyses of at-hand data. Physicians themselves are rediscovering that people often consult optometrists instead of ophthalmologists, podiatrists and chiropractors instead of allopathic or osteopathic doctors, and psychologists instead of psychiatrists (Forster, 1982.) Among ethnic minorities, cultural healers may be employed as well as biomedical healers (Spicer, 1977; Spanier, 1979.) Even in the ethnic majority of Western countries biomedical practitioners find competition (Helman, 1978; Unschuld, 1980.) This is a largely neglected opportunity for research.

The paucity of literature for non-physician medical occupations, particularly for units smaller than States is largely due to a lack of data, or certainly a lack of standard data allowing comparison among areas and occupations. Occasionally a member of a profession in question provides such a report, as in Richards' and Gottfredson's (1978) ecological analysis of the distribution of clinical psychologists. They found that ratios of professionals to population for psychologists, clinical social workers, and school counselors showed similar patterns of concentration "in affluent urban states and in university towns." A study comparing the distribution of physician assistants to new physicians notes that the assistants locate in states where they are educated and where laws are more favorable to their professional activity. "In contrast, new physician licenses tend to be concentrated in states that already have high physician-to-population ratios" (Richards and Golden, 1980.)

The literature cited here provides a good understanding of physician location patterns and a springboard for the problem and design of this research. However, the authors generally are inadequate in fitting designs or results into the complex system of which they investigate parts. The systematic perspective and the notion of physician-dependent and physician-independent occupations arise largely from this author's experience in the conventional medical system instead of from written contributions of other workers.

Chapter Three

METHODS

Sample and sources of data

A sample of thirty counties in Michigan was chosen from the total of eighty-three counties in the State. This sample size provides enough data for normal statistical testing and is not too large for visual inspection of choropleth maps. Because the design requires hypothesis testing across both urban and rural areas, the sample was taken to include equal numbers of each type of county. The fifteen counties called 'urban' in this study are constituents of Standard Metropolitan Statistical Areas (SMSAs) in Michigan and have more than 50% of their populations in urban places. One urban county was selected from each SMSA (except that of Toledo, Ohio which includes Michigan's Monroe county.) Four of the six counties in the Detroit SMSA were included in the sample to reflect the overwhelming size of that metropolis.

The 'rural' counties of the sample were drawn from a subset of twenty-seven counties outside any SMSA. (There are a few counties in SMSAs that are largely rural in character.) To be selected, a rural county had to have more than 20,000 inhabitants, but be less than 50% urbanized. A minimum population of 20,000 was chosen for two reasons. It helped to reduce errors in ratios calculated on a per 10,000 basis and to ensure that each county in the sample had enough population to support a modest range of conventional medical facilities and practitioners. Fifteen of these twenty-seven counties were then selected to maximize spatial independence; noncontiguous counties were chosen whenever possible.

The sample design therefore does contain significant bias away from the most rural and least peopled counties of Michigan. Such counties will always be tributary to higher-order places and they certainly account for a very small percentage of practicing health professionals. The choice was made to concentrate this analysis on the moderately and highly populated parts of the State. Nevertheless, the sample still allows comparison of highly urbanized counties with rural and remote ones (i.e., the medicine- and university-dominated Ann Arbor area of Washtenaw with northern Alpena.) Such a range of locations can also be found in many other States.

The following counties constitute the sample (see Figure 1):

Table 1

Counties in the Sample

Rural	Urban
Alpena	Bay
Branch	Berrien
Cheboygan	Calhoun
Chippewa	Genessee
Grand Traverse	Ingham
Gratiot	Jackson
Houghton	Kalamazoo
Iosco	Kent
Isabella	Macomb
Lenawee	Muskegon
Mason	Oakland
Mecosta	Saginaw
Menominee	St. Clair
Sanilac	Wayne
Wexford	Washtenaw

The variables in this study measure population characteristics and numbers or rates of professionals by county. There are three population variables: total population; percentage urban population; and HINEED, a subpopulation that is likely to have the highest aggregate demand for

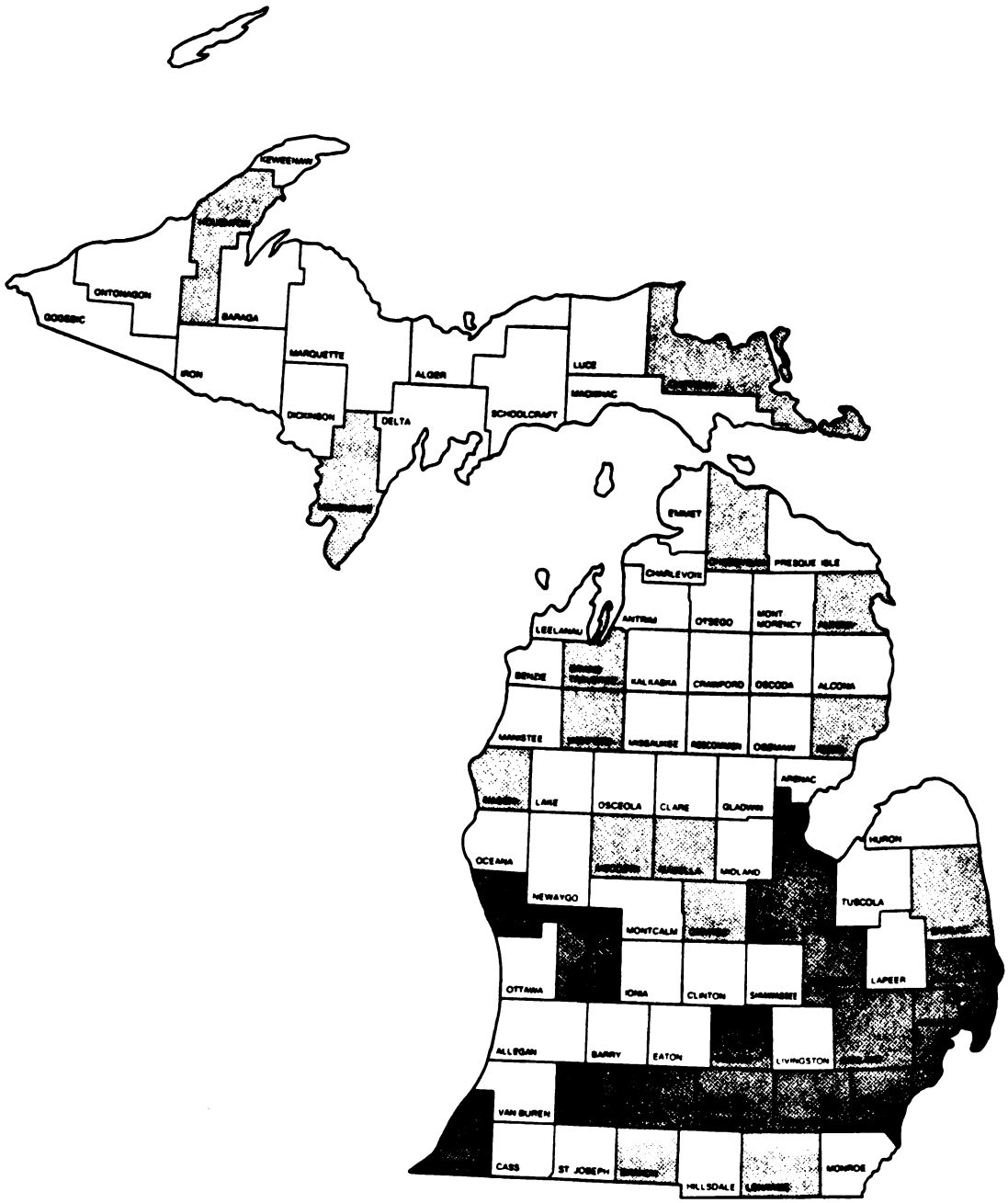


Figure 1. Counties included in the study. Rural counties in light shade. Urban counties in dark shade. Unsampled counties in white.

medical services. Fourteen categories of health workers constitute the other variables, which are described more fully below.

Standard Metropolitan Statistical Area boundaries, total population figures and counts of segments of each county's population were taken from the 1980 United States Census. Percentages of urban population were derived by subtracting rural population (census table 52) from total population (census table 171) to obtain the number of people in urban areas, and determining their percentage of the county's total population. Children from birth through age nine years, women of childbearing age (fifteen to forty-five years,) and all persons sixty-five years of age and older constitute the variable HINEED. Values for each county are from census table 171.

Data for the health care occupations were obtained from two sources. The Michigan Department of Public Health's Bureau of Health Services supplied tallies of osteopathic and allopathic physicians and podiatrists who admitted patients to general hospitals in 1982. These providers can be considered to be in active practice and they constitute the aggregate variable STAFDOCS (staff doctors.) The State Bureau of Licensing and Regulation provided numbers of current licensees as of 1983 in all the discrete occupations studied here. Licenses are renewed every three years, so there is some inflation of the correct number due to retiring or departing personnel not dropped from the rolls until their licenses expire. There is no designation of whether each licensee was in active practice, whether employed full or part time, or whether the county assignment was for a residential or professional address. These are restrictive shortcomings.

The occupations or license groups included in this study are registered nurses (RNs), licensed practical nurses (LPNs), chiropractors, physician's assistants (PAs), optometrists, physical therapists (PTs), psychologists, medical or allopathic physicians (MDs), osteopathic physicians (DOs), dentists, dental hygienists, podiatrists, and pharmacists.

Medical technologists (laboratory professionals) and radiologic technicians (X-ray professionals) are two widely employed groups pertinent to this research. However, they are not licensed or registered by the State but by national professional boards, and therefore had to be excluded because data were difficult to obtain.

Appendices I and II present the data base in tabular form.

Descriptive techniques

Two calculations are applied to the county data to allow quantitative description of each occupation's distribution and availability. Some of the values obtained for description are used later for statistical testing of the hypotheses.

The first technique used here to explore the data is the Lorenz curve and its associated Gini coefficient. In this investigation a Lorenz curve is constructed for each occupation such that a county's percentage contribution to an occupation, on the y axis, is compared to the county's percentage contribution to total population, on the x axis. The Gini coefficient is then calculated as shown:

$$G = 1 - \sum_{i+1} (x_{i+1} - x_i)(y_i + y_{i+1})$$

Alternatives to the Gini coefficient as described by Theil (1967) were considered. Variance of the logarithms of each occupation was tested on

three occupation groups, but gave no more information than did the range of rates combined with the Gini index.

The second calculation, which is used both for descriptive and analytic purposes, gives the ratio of each occupation per 10,000 population, by county.

$$\frac{\text{(number of licensed persons) (10,000)}}{\text{county population}}$$

These ratios are first studied without specific reference to the counties they come from. Then the rates are ranked to determine the median value, and are mapped. The maps use a bivariate choropleth technique to enhance visual comparison between urban and rural counties and among the occupations. There are only two classes on these maps: values above the median and below the median. Thus, the maps are intended for elucidation of broad patterns only. Counties within each class are designated rural or urban by color and by direction of hatch marks. Counties with no hatch marks are not in the sample.

A similar bivariate choropleth map is made from the variable HINEED as a nonrigorous test of the correspondence between aggregate need for medical care and availability of such care. Each county's value of the following equation is determined and mapped as above or below the median value.

$$\frac{\text{(number of staff doctors) (10,000)}}{\text{(0 - 9) + (F15 - F45) + (65+)}}$$

The denominator is a high need subpopulation composed of young children, women in the reproductive years, and the elderly. Geographic patterns of disparity in available care may be more easily discerned by a focus on this population.

Hypothesis testing

In the second section of the analysis the hypotheses are tested using Kendall's tau, a distribution-free statistic measuring rank order correlation. A software package, called SYSTAT, was used to calculate values of tau. The z-score probability asociated with each tau is calculated as recommended by Hammond and McCullough (1978) and compared to a significance cutoff of .01.

Chapter Four

RESULTS AND DISCUSSION

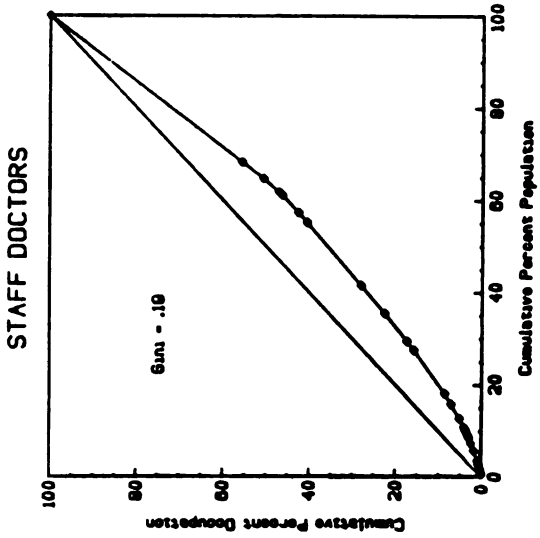
Lorenz curves, Gini coefficients, and county rates

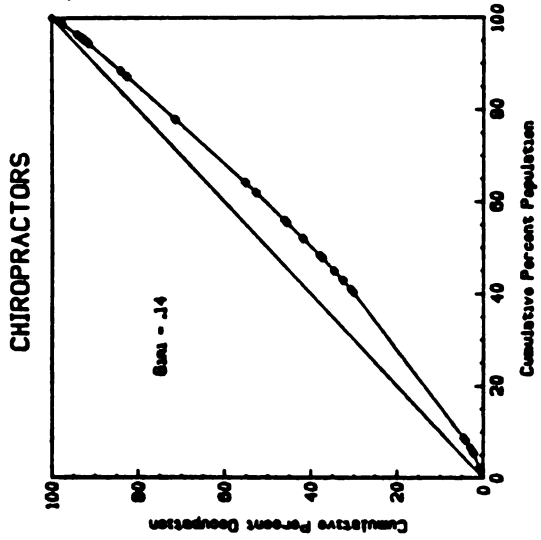
Lorenz curves are displayed in Figures 2 through 5. Each curve compares counties' cumulative contributions to the total percentages of an occupation and to the base population.

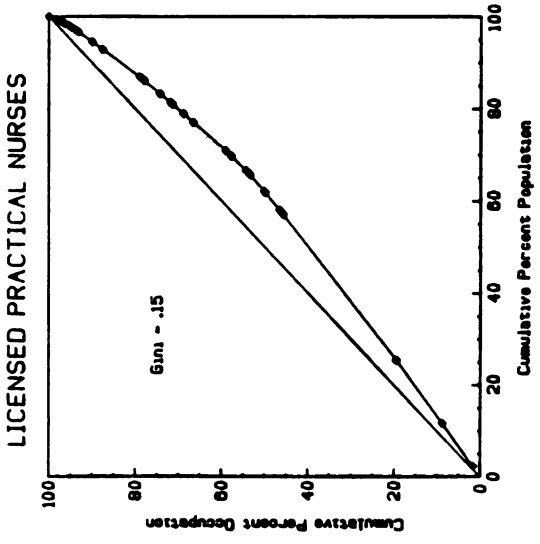
A brief review of the Lorenz curves gives an impression of generally gentle curves slightly or moderately removed from the diagonal of perfectly equal allotment. One may infer that several of the occupations are similarly distributed, but some are more evenly allocated over population than others. A few curves are relatively close to the diagonal: those for chiropractors, registered nurses, licensed practical nurses, dentists, and staff doctors. A larger group with moderate deviation from the diagonal is composed of dental hygienists, podiatrists, pharmacists, osteopathic physicians, allopathic physicians, optometrists, physical therapists, and physician assistants. The psychologists appear to be in a class of their own with, comparatively, a markedly steep curve. In this case, the three counties that contribute the final twenty percent of population account for nearly sixty percent of the psychologists.

The Lorenz curve for the LPNs (Figure 2) is different from the others in that there are few points below sixty percent of cumulative population. For this group only we find high ratios of percent occupation to percent population in rural counties. Most of the remaining curves show a more even scattering of points, with those for chiropractors and optometrists appearing most evenly dispersed.

Figure 2. Lorenz Curves. Staff Doctors, Licensed Practical Nurses, Registered Nurses, Chiropractors.


STAFF DOCTORS
Gini = .10
Cumulative Percent Population
Cumulative Percent Occupation
0
20
40
60
80
100


CHIROPRACTORS
Gini = .14
Cumulative Percent Population
Cumulative Percent Occupation
0
20
40
60
80
100


LICENSED PRACTICAL NURSES
Gini = .15
Cumulative Percent Population
Cumulative Percent Occupation
0
20
40
60
80
100

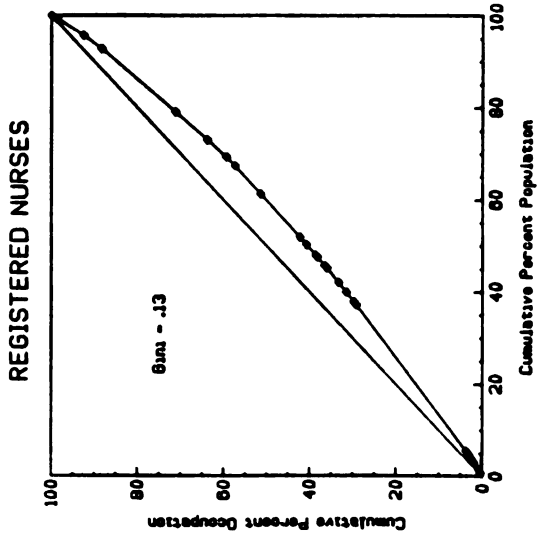
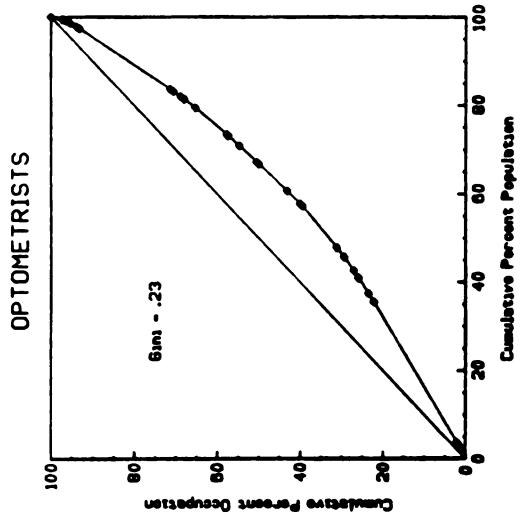
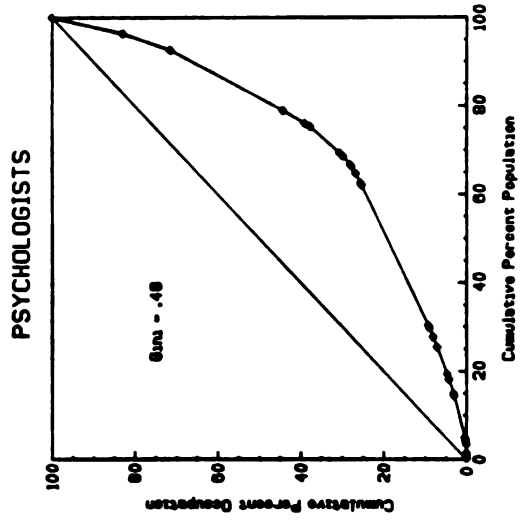
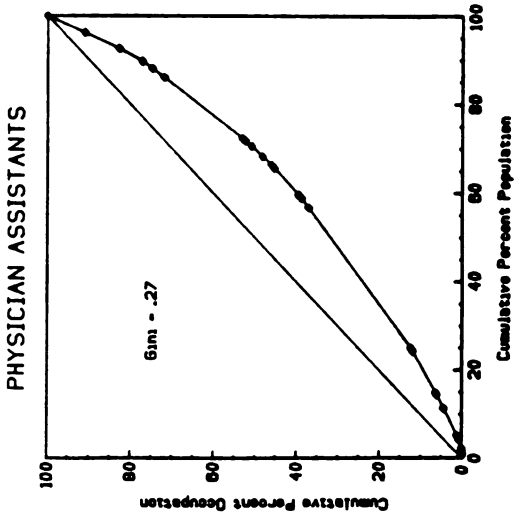

REGISTERED NURSES
Gini = .13
Cumulative Percent Population
Cumulative Percent Occupation
0
20
40
60
80
100

Figure 3. Lorenz Curves. Physician Assistants, Optometrists, Physical Therapists, Psychologists.


OPTOMETRISTS
Gini = .23
Cumulative Percent Occupation
Cumulative Percent Population
0
20
40
60
80
100


PSYCHOLOGISTS
Gini = .48
Cumulative Percent Occupation
Cumulative Percent Population
0
20
40
60
80
100


PHYSICIAN ASSISTANTS
Gini = .27
Cumulative Percent Occupation
Cumulative Percent Population
0
20
40
60
80
100

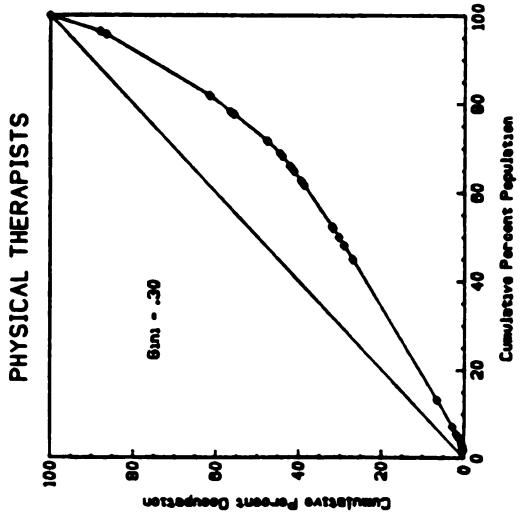
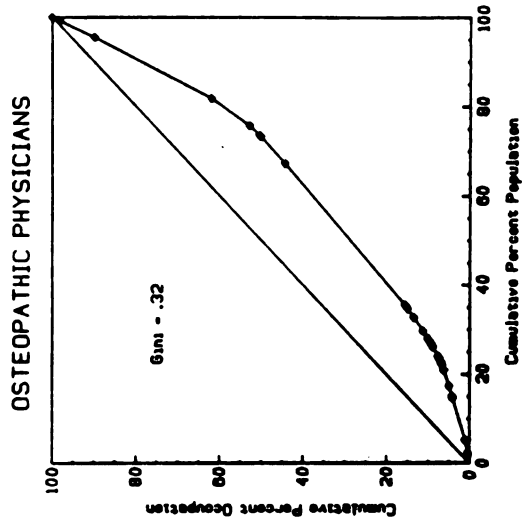
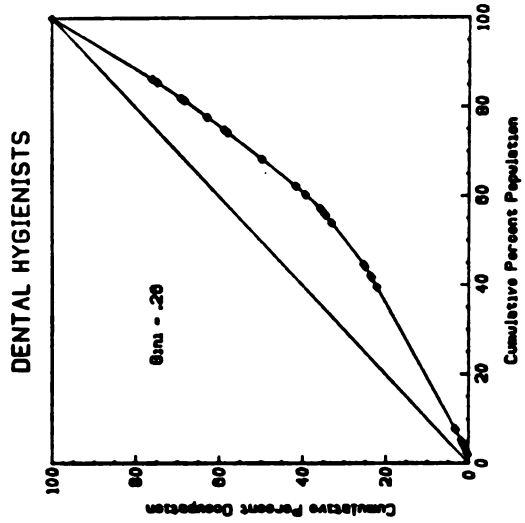
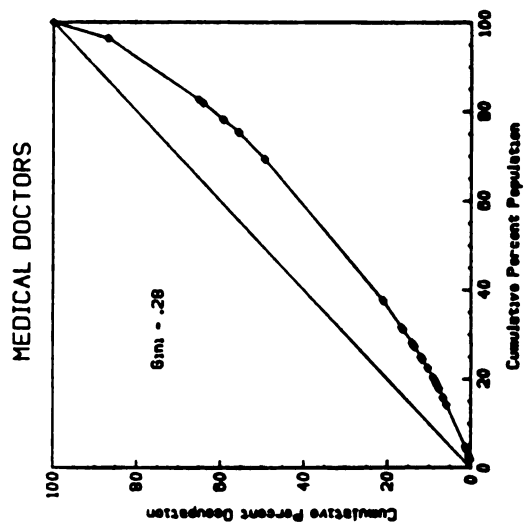

PHYSICAL THERAPISTS
Gini = .30
Cumulative Percent Occupation
Cumulative Percent Population
0
20
40
60
80
100

Figure 4. Lorenz Curves. Medical Doctors, Osteopathic Doctors, Dentists, Dental Hygienists.


OSTEOPATHIC PHYSICIANS
Gini = .32
Cumulative Percent Occupation
Cumulative Percent Population
0
20
40
60
80
100


DENTAL HYGIENISTS
Gini = .26
Cumulative Percent Occupation
Cumulative Percent Population
0
20
40
60
80
100


MEDICAL DOCTORS
Gini = .28
Cumulative Percent Occupation
Cumulative Percent Population
0
20
40
60
80
100

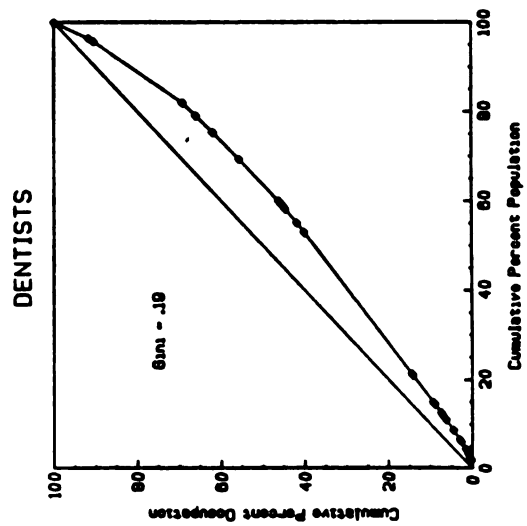
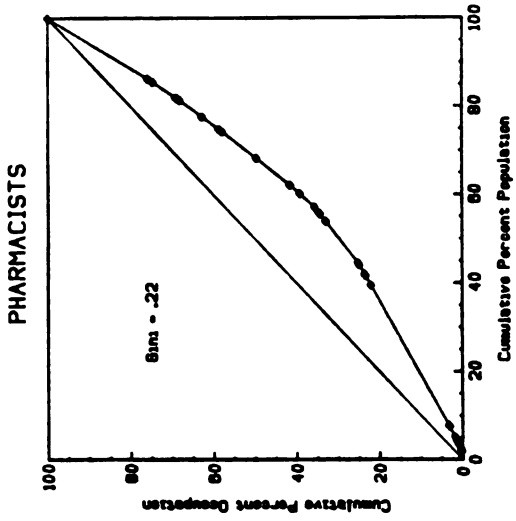
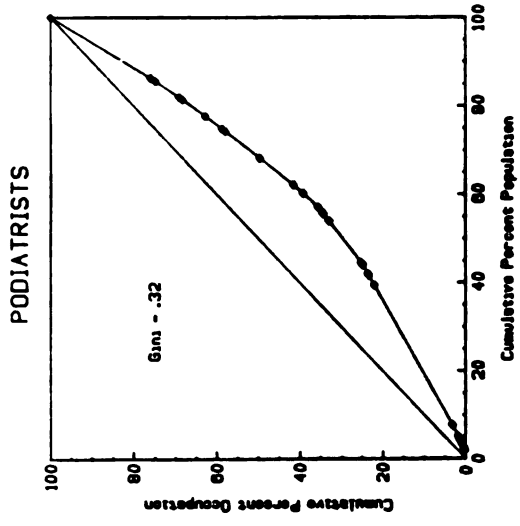

DENTISTS
Gini = .19
Cumulative Percent Occupation
Cumulative Percent Population
0
20
40
60
80
100

Figure 5. Lorenz Curves. Podiatrists, Pharmacists.


PHARMACISTS
Gini = .22
Cumulative Percent Population
Cumulative Percent Occupation
0
20
40
60
80
100


PODIATRISTS
Gini = .32
Cumulative Percent Population
Cumulative Percent Occupation
0
20
40
60
80
100

The visual suggestions of comparatively equitable, or inequitable, distributions given by the Lorenz curves are made clearer by an examination of the Gini coefficients. These values are presented in Table 2 along with the ranges of county rates of the number of people licensed in each profession per 10,000 persons. The Gini values range from 0.13 to 0.48; because of the linear relationship of these coefficients, this is practically a fourfold difference. This first descriptor therefore indicates that there are notable spatial differences among the sampled occupations.

TABLE 2

Gini Coefficients and Ranges of County Rates

Occupation	Gini	Range of rates	Magnitude
RN	.13	46.20 - 149.0	3x
Chiropractor	.14	0.65 - 3.64	5x
LPN	.15	25.57 - 88.53	3x
Staff doctor	.19	5.15 - 35.87	7x
Dentist	.19	1.08 - 17.07	16x
Pharmacist	.22	1.51 - 15.50	10x
Optometrist	.23	0.59 - 6.49	11x
Dental hygienist	.26	0.58 - 10.10	16x
Physician assistant	.27	0.00 - 1.34	
MD	.28	1.59 - 82.76	55x
Physical therapist	.30	0.22 - 7.82	39x
DO	.32	0.65 - 8.20	12x
Podiatrist	.32	0.00 - 1.68	
Psychologist	.48	0.0 - 7.21	

Registered nurses, chiropractors, and licensed practical nurses are the most equitably distributed occupations as shown by nearly identical low coefficients of 0.13, 0.14, and 0.15 respectively. Slightly higher are the staff doctors and dentists, closely followed by pharmacists and optometrists. The undifferentiated licensed MD, DO, and podiatrist groups show values of 0.28, 0.32, and 0.32, indicating that doctors

providing patient services in general hospitals (staff doctors) are more equivalently distributed than the total of their licensed cohorts. This is not a surprising finding when specialist, academic, research, administrative, and retired but licensed physicians are considered. Similar Gini coefficients are found for physician assistants (0.27), physical therapists (0.30), and dental hygienists (0.26).

Psychologists are by far the most inequitably distributed group of this sample as measured by a Gini value of 0.48. As remarked earlier, the Lorenz curve is dramatically deeper for this occupation compared with all others.

The rates of each occupation per 10,000 people, by county, are first examined to contrast the ranges of population-corrected values for the sample. In general, the variation in an occupation's rate roughly parallels the Gini coefficient, but some remarkably wide ranges are seen. LPN and RN rates vary only threefold, chiropractors fivefold, and staff doctors sevenfold over the sample. One may note that a sevenfold fluctuation in population-corrected ratios of active practitioners indicates inequities in distribution.

The ranges of other groups are higher. Pharmacists, optometrists, DOs, dentists, and dental hygienists show ranges of ten to sixteen times their lowest rates. Physical therapists have a greater variation; the county with the highest value has forty times the rate of the county with the lowest value of therapists per 10,000 persons. The MD category including all licensed medical doctors has a very large difference of fifty-five times over its range. Variations are more difficult to describe for psychologists, physical therapists, and podiatrists because in each case there are several counties with no licensed representative

of the profession. Nevertheless the range of zero to one or two providers per 10,000 found in the latter two groups is smaller than the range of zero to seven providers seen for the psychologists.

Several of these ranges seemed suspiciously large so a simple check for a smooth continuum of values was attempted. Elimination of the two extreme values was found to narrow the range significantly for six of the fourteen occupations. For MDs, the variation dropped from fifty-five to five times. This modified range is much more congruent with the sevenfold variation found for practicing allopathic, osteopathic, and podiatric physicians. Less spectacularly, other variations decreased from eleven to four times for optometrists, from thirty-nine to ten times for physical therapists, from sixteen to four times for dentists, from sixteen to five times for hygienists, and from ten times to approximately four times for pharmacists. In five of these six cases, St. Clair county had the lowest value. Washtenaw was the highest county in three cases and Oakland in two cases. The extreme counties for the optometrists were Jackson on the low end and Mecosta on the high end of the original range.

Maps and ranks of county rates

The rank ordering of all counties for all occupations is given in Appendix III. An average rank has been calculated for each county to allow comparison of aggregate services.

Maps of each profession's rates by county are found in Figures 6 through 9. They demonstrate comparatively high or low rates and show by color and direction of hatches whether the rate belongs to a county designated rural or urban. Counties with no hatches (white) are not in the sample.

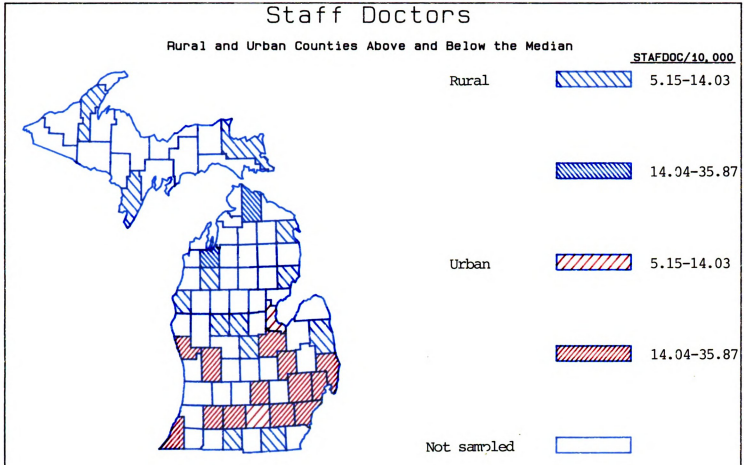


Figure 6. Map. Staff Doctors per 10,000.

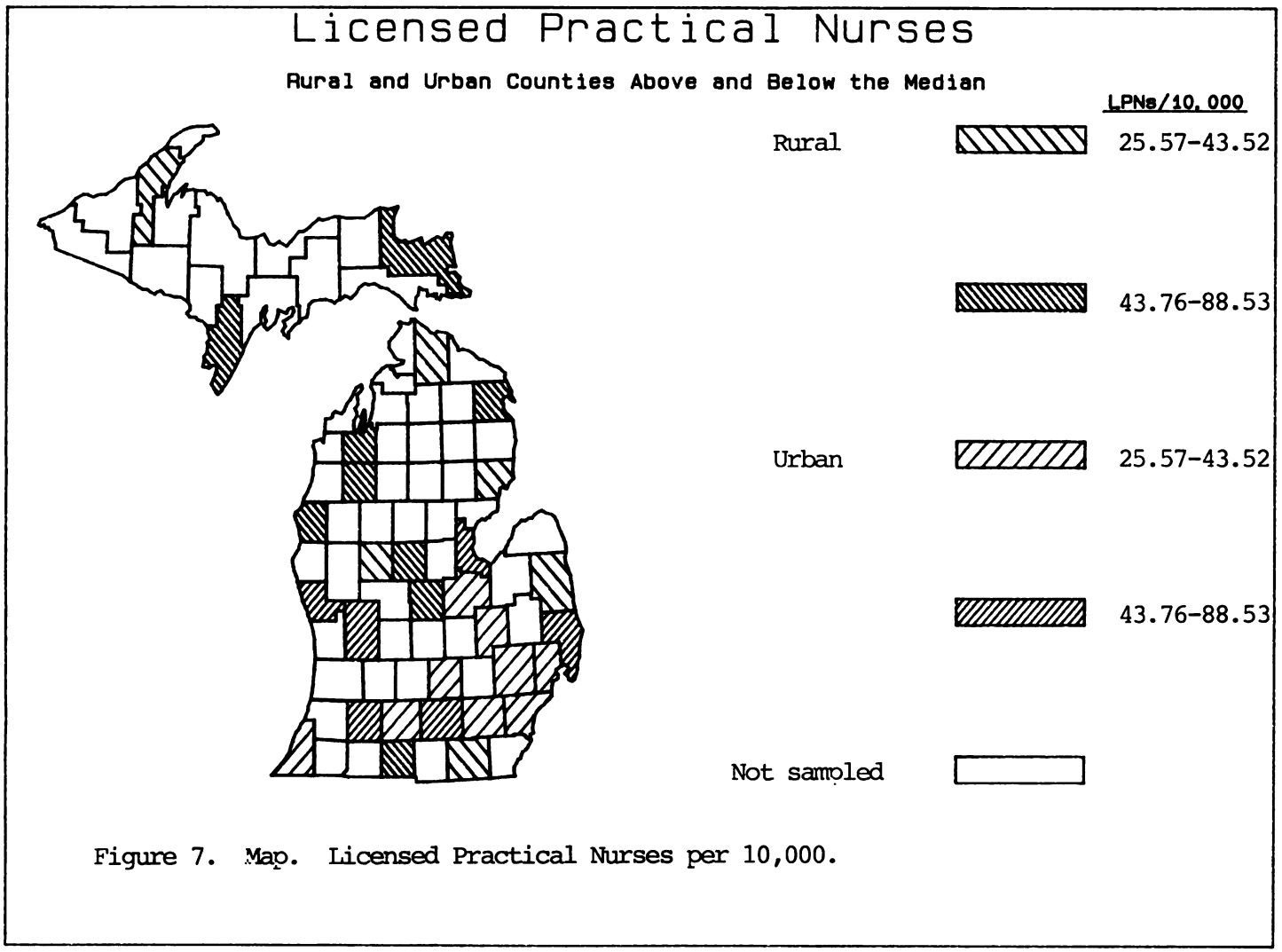


Figure 7. Map. Licensed Practical Nurses per 10,000.

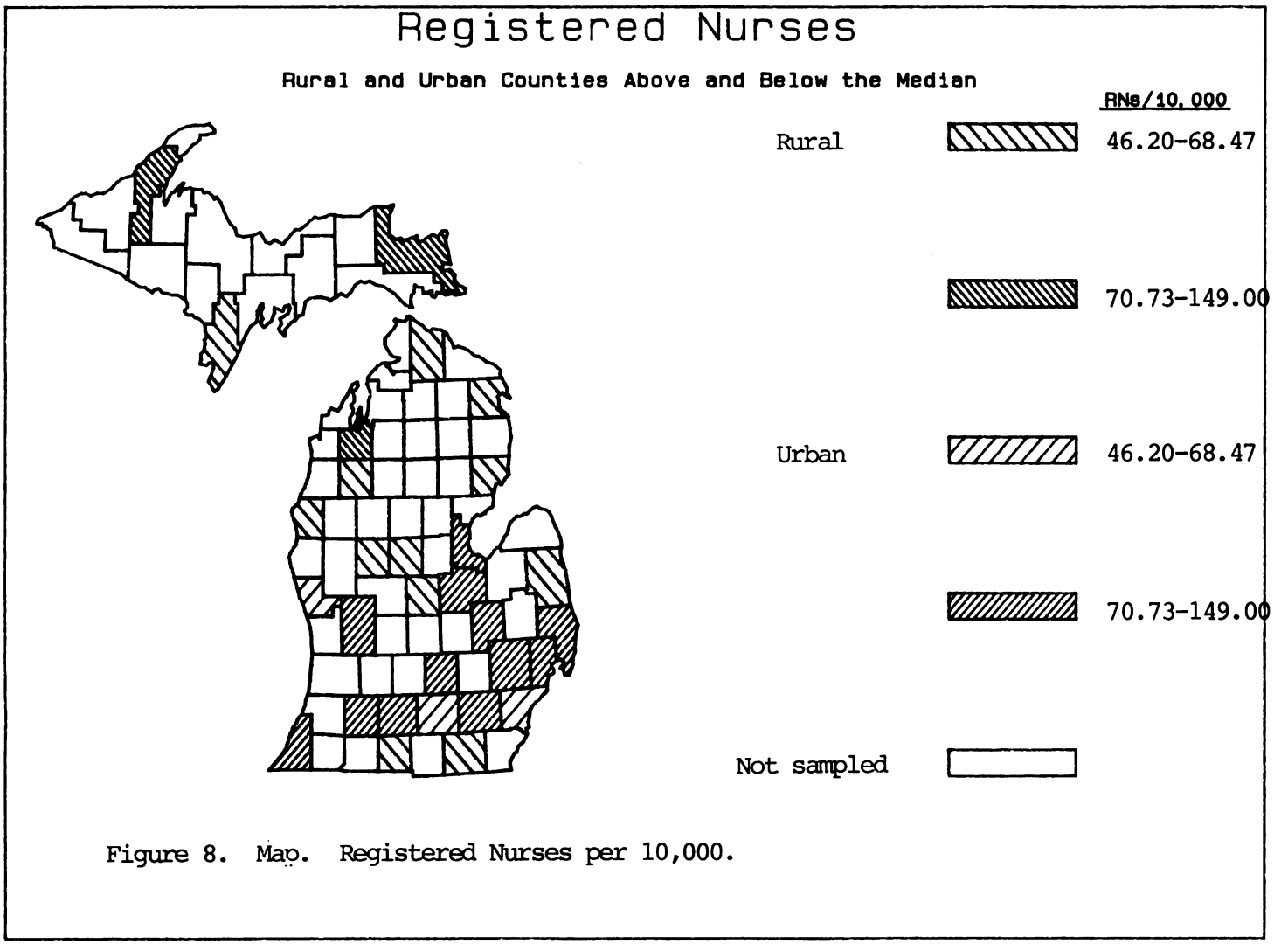


Figure 8. Map. Registered Nurses per 10,000.

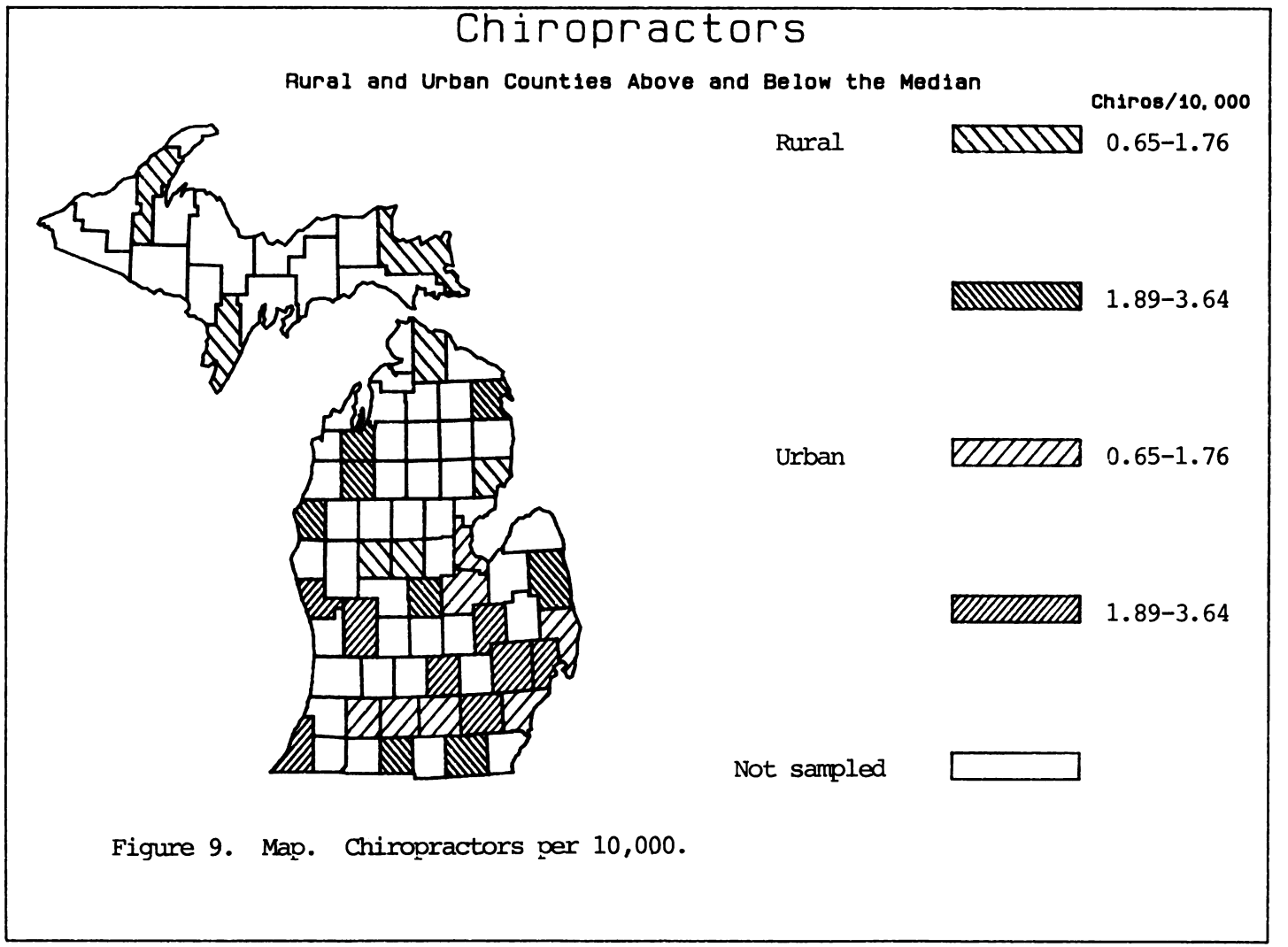


Figure 9. Map. Chiropractors per 10,000.

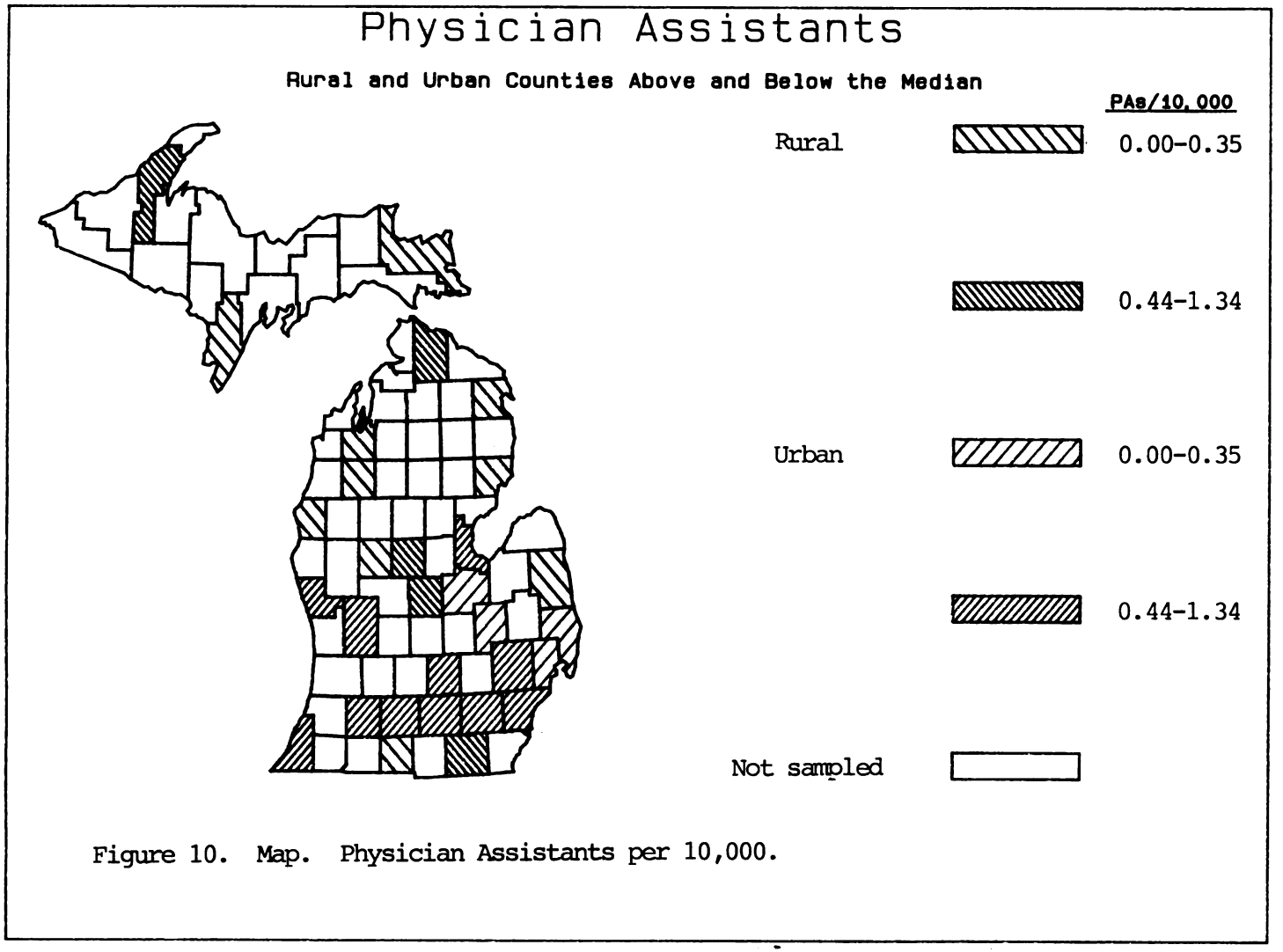


Figure 10. Map. Physician Assistants per 10,000.

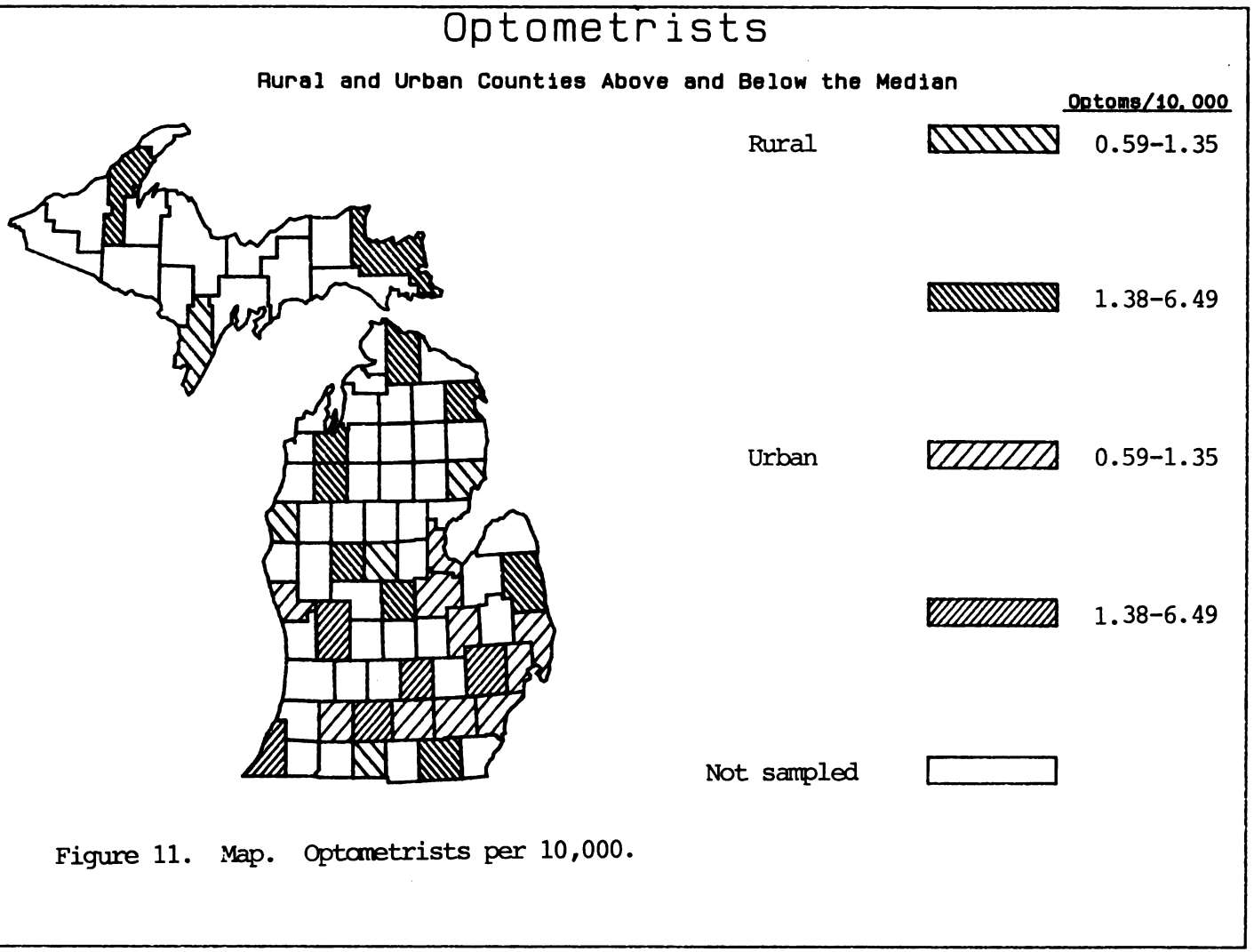


Figure 11. Map. Optometrists per 10,000.

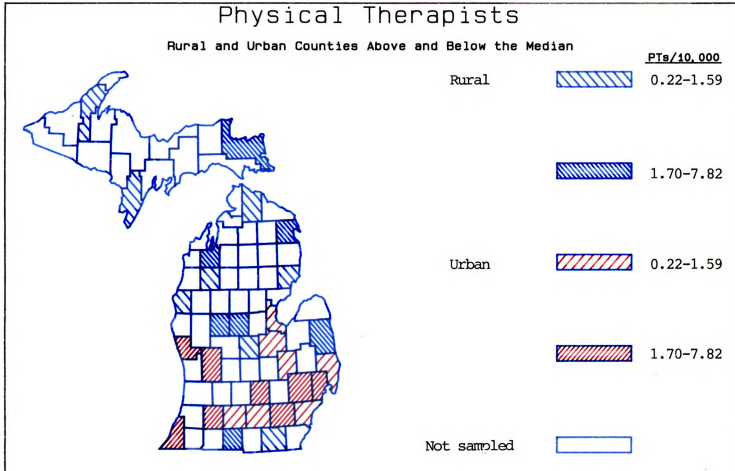


Figure 12. Map. Physical Therapists per 10,000.

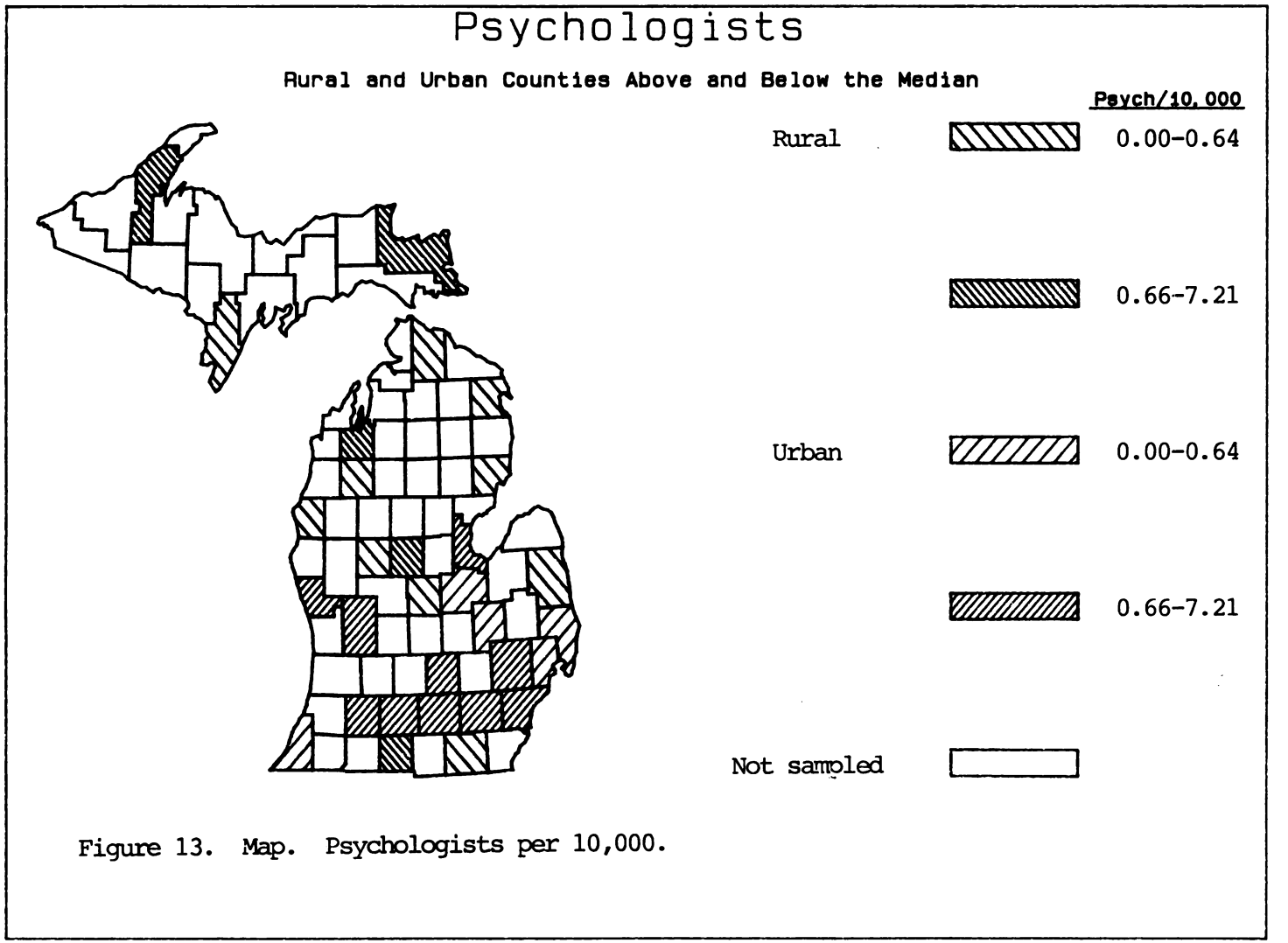


Figure 13. Map. Psychologists per 10,000.

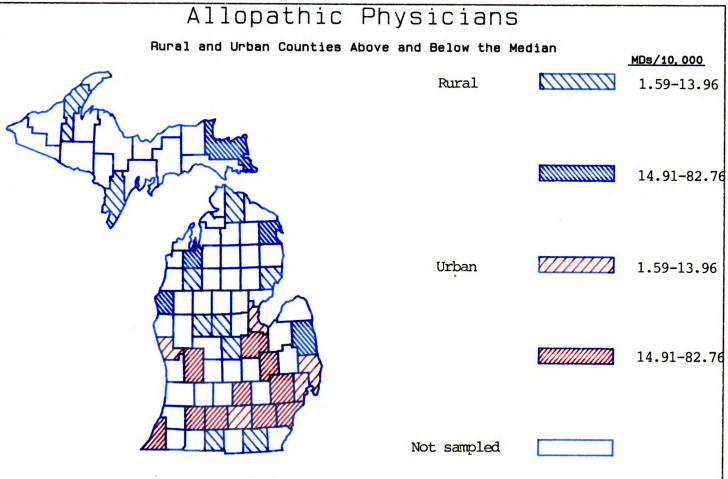


Figure 14. Map. Allopathic Physicians per 10,000.

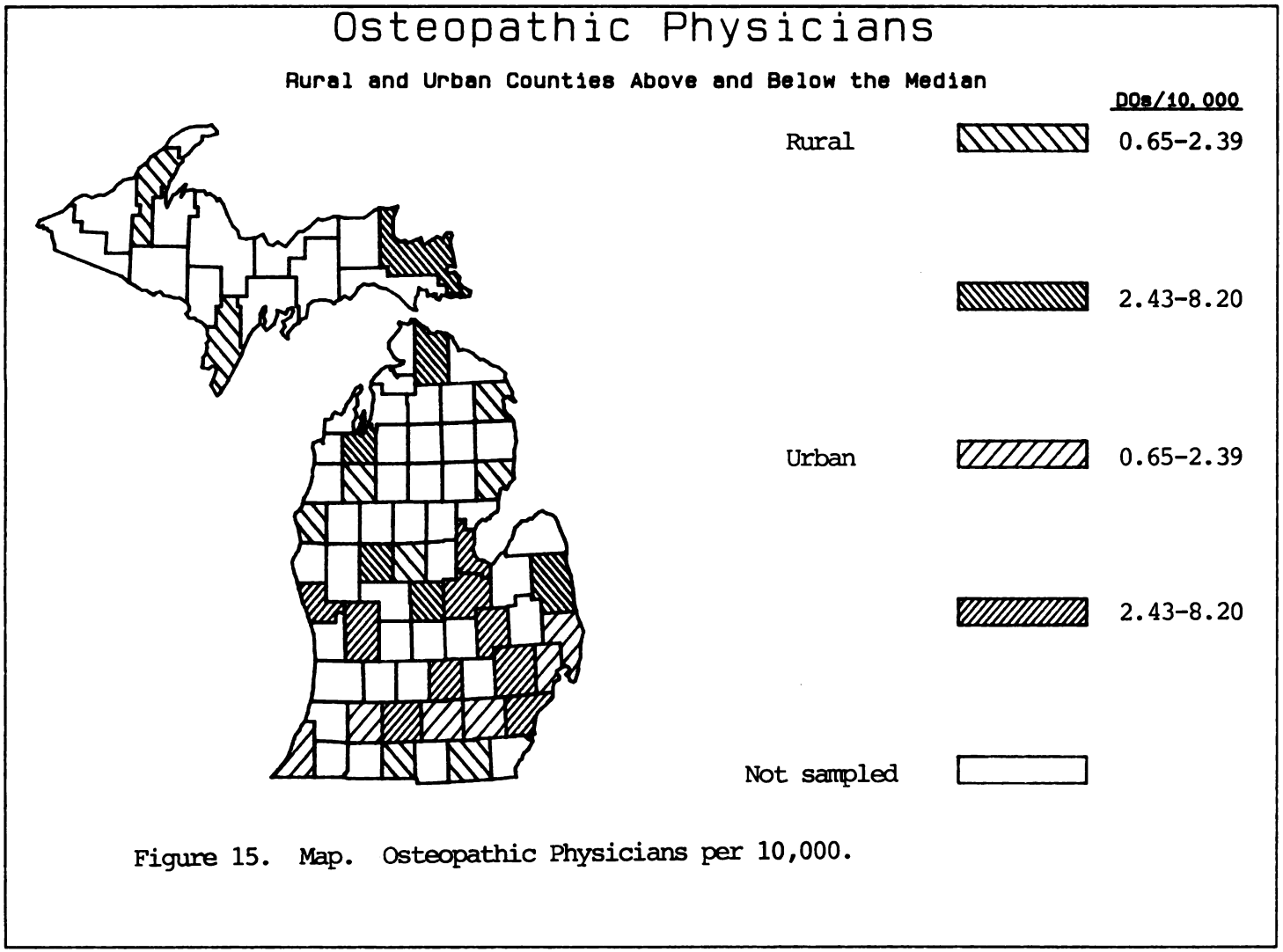


Figure 15. Map. Osteopathic Physicians per 10,000.

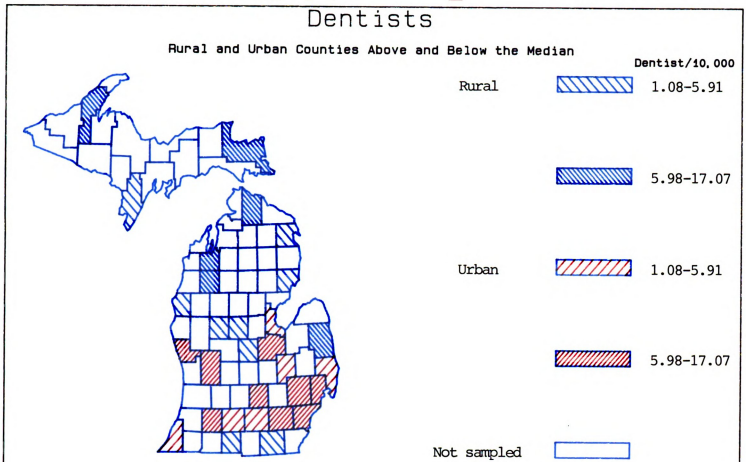


Figure 16. Map. Dentists per 10,000.

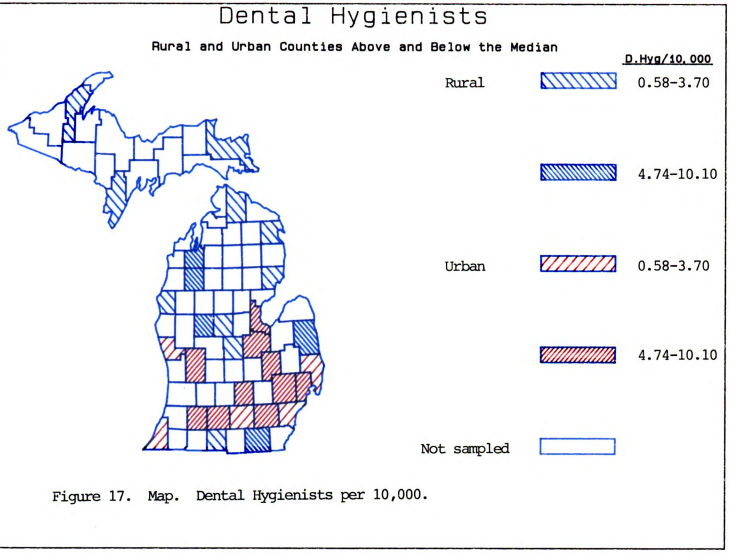


Figure 17. Map. Dental Hygienists per 10,000.

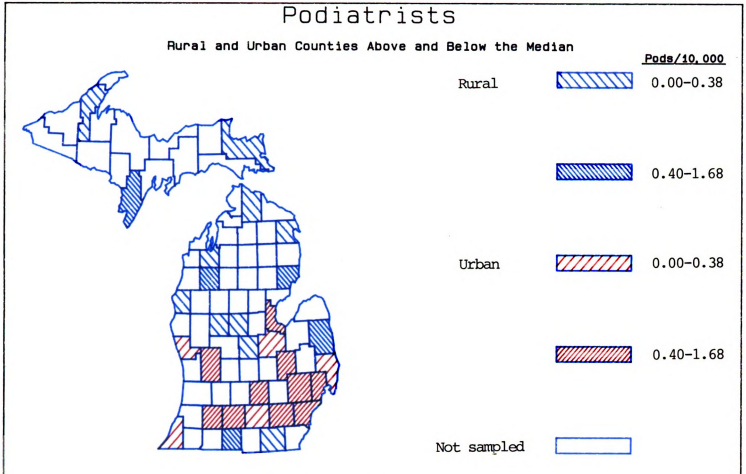


Figure 18. Map. Podiatrists per 10,000.

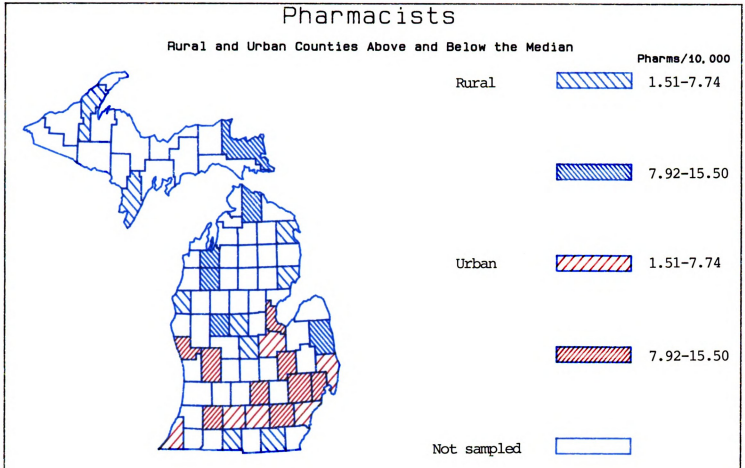


Figure 19. Map. Pharmacists per 10,000.

The maps and the table of rank orders show that urban counties generally have higher ratios than have the rural areas. Thus the majority of occupations not only have high absolute numbers in urban counties, but are relatively overrepresented there also. Since urban counties occur only in the southern half of the lower peninsula, this relative overproviding puts a large area of the State at a disadvantage.

There are three distinctive patterns in the maps. In the first pattern urban counties constitute two-thirds or more of the higher class, leaving two-thirds of the values below the median to rural counties. Staff doctors and registered nurses show an especially sharp delineation between rural and urban areas. Other groups demonstrating this first pattern are psychologists, physician assistants, hygienists, MDs, podiatrists, and pharmacists. The second pattern, which is shared by four occupations, is a nearly even mix of rural and urban counties both above and below the median. Osteopaths, dentists, physical therapists, and chiropractors show this type of distribution. Finally, optometrists and licensed practical nurses have high ratios of licensees to population in rural counties; urban counties are relatively underserved in these two categories.

Joint scrutiny of the maps and the table of ranks reveals not only shared patterns but anomalies. Registered nurses (Figure 8) in three urban counties have ratios below the median: Muskegon; Jackson; and Wayne (Detroit.) Wayne county in particular would be expected to have a concentration of RNs serving the numerous and specialized hospitals there. This reverse finding may be explained by large numbers of nurses who live in neighboring counties but work in Wayne, and who gave their residential address to the licensing bureau.

Staff doctors (Figure 6,) composed mostly of MDs, are present in low rates in only two urban counties: Bay (Bay City); and Jackson. No suggestion to explain Bay's lower performance is apparent, but Jackson county may be seen as an undesirable location due to the large prison there. Conversely, the two rural counties with higher-than-median ratios of staff doctors are regional centers of the northern lower peninsula: Cheboygan and Grand Traverse (Traverse City.)

The four lowest ratios of LPNs (Figure 7) belong to Berrien (Benton Harbor - St. Joseph), Macomb, Oakland, and Wayne counties (metropolitan Detroit.) Washtenaw (Ann Arbor) and Ingham (Lansing - East Lansing) also rank low. Yet even in this reversed pattern Grand Traverse has the highest rate. This map is consistent with the anomalous distribution of points on the Lorenz curve of LPNs.

Podiatrists (Figure 18) are strongly concentrated in metropolitan Detroit and show moderately high rates in rural Iosco and Menominee counties -- two places that do not stand out in many distributions.

Washtenaw county (Ann Arbor), with its great concentration of medical teaching and services at the University of Michigan and veteran's hospital, presents most clearly the distinctions between physician-dependent and physician-independent professions. This county ranks in the top three of the sample (and undoubtedly the State) for all studied occupations except LPNs, chiropractors, optometrists, osteopathic physicians, and podiatrists. The ranks of these latter occupations are near or below their medians.

Kent county (Grand Rapids) has the most consistent rankings of all counties tested. It is well served, with ranks ranging from a low of nineteen to a high of twenty-six.

Two counties are notable as anomalies in their own groups. St. Clair, classified as urban, very often occupies the lowest rank. In the aggregate, it places lowest among the five 'least-served' counties: St. Clair; Menominee; Iosco; Isabella; and Mason. Conversely, the rural county of Grand Traverse ranks second among the medical and metropolitan centers of Oakland, Kent, Ingham, and Washtenaw, the 'most-served' counties as indicated by average rank.

Test of first hypothesis

Table 3 presents results of Kendall's rank correlation of county rates of each group of licensees with county rates of active physicians (STAFDOCS). The correlation coefficient, tau, ranges from negative one to positive one. Occupations whose county rates are significantly highly correlated with rates of staff doctors are marked by an asterisk. In these cases the null hypothesis is rejected.

TABLE 3

Staff doctors/10,000 correlated with Other Occupations/10,000

Occupation	tau	z	Significance	
LPN	-.062	-0.481	.318	
RN	+.494	+3.829	.000	*
all nurses	+.389	+3.016	.001	*
Chiropractor	+.067	+0.519	.309	
Physician ass't	+.184	+1.426	.081	
Optometrist	-.034	-0.264	.040	
Physical ther.	+.177	+1.372	.086	
Psychologist	+.313	+2.426	.008	*
M.D.	+.393	+3.047	.001	*
D.O.	+.198	+1.535	.081	
Dentist	+.384	+2.977	.002	*
Dental hygienist	+.278	+2.155	.016	
Podiatrist	+.212	+1.643	.058	
Pharmacist	+.209	+1.620	.055	

Most correlations are positive, confirming that where one finds active physicians one also finds other medical personnel. Deviations from this pattern, although not statistically significant, are interesting. The licensed practical nurses have shown unusual patterns before. The finding here, compared to the results of significantly high correlation for registered nurses, confirms that the two groups behave differently geographically. These divergent spatial patterns may be explained by the tendency for LPNs to staff nursing homes and community hospitals. These places of employment are a much more prominent feature of the medical landscape in nonurban areas. Registered nurses are those most frequently employed by large hospitals, thus the tendency for their distribution to correlate strongly with doctors who admit patients to hospitals.

The aggregate of 'all nurses' included in the table behaves like the RN category. Although LPNs are part of this aggregate, their pattern is completely overridden. They could be assumed to behave similarly to RNs if separate measurement were lacking. Other license groups in the sample, especially MDs, are aggregates of specialties and as such may mask divergent patterns within the groups.

Significantly high positive correlation is found between staff physicians and two additional occupations: psychologists and dentists. Dental hygienists showed positive correlation short of the significance cutoff. A strong association between psychologists and staff doctors was unexpected on the grounds of professional and technical independence of psychologists. That such an association is found may be explained by coincident presence of staff doctors in counties where psychologists choose to locate.

To examine the correlations among professions more closely, the same procedure was applied to the specific license groups, MDs and DOs. Tables 4 and 5 display these correlation results. When total licensed MDs are correlated with other occupations, we find significant spatial correlation with six groups, twice the number correlated with staff doctors. Groups that do not correlate with MDs are chiropractors, LPNs, optometrists, DOs, podiatrists, and, surprisingly, physician assistants. Psychologists, dentists, and pharmacists show a strong association with MDs, contrary to expectation.

Doctors of osteopathy show no significant association with any other profession. Their correlation with LPNs is the only instance in which the LPN group carries a positive sign on the coefficient. The correlation with MDs and dentists approaches the significant level, but it is clear that osteopathic physicians are not spatially predictable in the same manner as allopathic physicians. This unexpected finding reinforces the statement in the introduction that medical doctors (MDs) are considered to be the most important single group in the structure of the medical system; their location, at least, is strongly associated with that of several other health professions.

Table 4

Correlation of MDs with Other Occupations

Occupation	Tau	Z	Significance	
LPN	-.051	-0.395	.345	
RN	.487	3.775	.000	*
Chiropractor	.168	1.302	.097	
Physician assistant	.123	0.953	.171	
Optometrist	.039	0.302	.382	
Physical therapist	.480	3.721	.000	*
DO	.276	2.140	.017	
Psychologist	.498	3.860	.000	*
Dentist	.531	4.116	.000	*
Dental hygienist	.379	2.939	.002	*
Podiatrist	.202	1.566	.060	
Pharmacist	.393	3.047	.001	*

Table 5

Correlations of DOs with Other Occupations

Occupation	Tau	Z	Significance
LPN	.057	0.442	.330
RN	.152	1.178	.120
Chiropractor	.101	0.783	.212
Physician assistant	.042	0.326	.380
Optometrist	.193	1.496	.067
Physical therapist	.184	1.426	.078
MD	.276	2.140	.017
Psychologist	.204	1.581	.055
Dentist	.290	2.248	.013
Dental hygienist	.267	2.070	.020
Podiatrist	.093	0.721	.242
Pharmacist	.235	1.822	.036

Tests of second hypothesis

The hypothesis relating ratios of occupations to urbanization is subjected to three tests. Again, Kendall's procedure is used. Results are given here, reserving interpretation for the next chapter. Table 6 presents results of the first correlation. This is an unstratified test of the association with urbanization over all thirty counties.

TABLE 6

Percent Urban Population correlated with Occupation/10,000

Occupation	tau	z	Significance	
Staff Doctor	+.499	+3.868	.000	*
LPN	-.297	-2.302	.011	
RN	+.453	+3.512	.000	*
Chiropractor	-.113	-0.876	.200	
Physician ass't	+.365	+2.829	.003	*
Optometrist	-.131	-1.016	.136	
Physical ther.	+.191	+1.481	.070	
Psychologist	+.382	+2.961	.002	*
M.D.	+.287	+2.225	.014	
D.O.	+.157	+1.217	.115	
Dentist	+.260	+2.046	.023	
Dental hygien.	+.264	+2.046	.023	
Podiatrist	+.277	+2.147	.016	
Pharmacist	+.131	+1.016	.159	

Most occupations correlate positively with percent urban population. Four groups have a strong positive association with urbanization: active doctors, registered nurses, physicians' assistants, and psychologists. MDs and podiatrists show positive correlation approaching the significance cutoff. Three occupations show a tendency to negative correlation. They are LPNs, chiropractors, and optometrists; only the LPNs approach statistical significance.

The research design called for a stratified test of the second hypothesis to determine if the rural and urban counties behave similarly to each other as urbanization increases. Stratified correlation is actually conducted twice due to consideration of earlier results. The second time, two counties are reassigned. These counties are Grand Traverse, included as a rural county in the original stratification and changed to urban, and St. Clair, first considered as urban and second as rural. Results of the correlations on the original division are displayed in Table 7.

Four occupation cohorts show significant positive correlation with urbanization, but two of these groups are measuring many of the same people: staff doctors and MDs. Only the urban subsets of these groups correlate well. Most occupations show a weak negative association with percentage urban population among rural counties changing to a stronger, if still not significant, positive association in urban counties.

Chiropractors are an exception; their rural segment achieves nearly significant negative correlation with urbanization. LPNs have the only urban cohort that decreases with increasing urban population.

TABLE 7

Percent Urban Population correlated with Occupation/10,000

Original Rural-Urban Stratification

Occupation	Type	Tau	Z	Significance	
LPN	R	.010	0.052	.500	
	U	-.352	-1.833	.036	
RN	R	-.029	-0.151	.440	
	U	.257	1.339	.097	
Staff doctor	R	-.124	-0.646	.255	
	U	.543	2.828	.003	*
Chiropractor	R	-.429	-2.234	.014	
	U	.314	1.635	.055	
Physician ass't	R	.250	1.302	.097	
	U	.067	0.349	.360	
Optometrist	R	-.048	-0.250	.400	
	U	.238	1.240	.105	
Physical therapist	R	-.105	-0.547	.285	
	U	.352	1.833	.036	
Psychologist	R	.128	0.667	.250	
	U	.295	1.536	.067	
MD	R	-.143	-0.745	.238	
	U	.448	2.333	.010	*
DO	R	-.048	-0.250	.400	
	U	.390	2.031	.023	
Dentist	R	-.143	-0.745	.238	
	U	.524	2.729	.004	*
Dental hygienist	R	-.143	-0.745	.238	
	U	.429	2.234	.014	
Podiatrist	R	-.265	-1.380	.081	
	U	.543	2.828	.003	*
Pharmacist	R	-.238	-1.240	.105	
	U	.410	2.135	.018	

In comparing Tables 6 and 7 one may note that stratification did not produce stronger or more numerous significant correlations. The rural cohort behaved more weakly than the urban cohort as shown by usually smaller absolute correlation coefficients and z-scores for rural counties. The urban subsample correlates positively with percent urbanization for all occupations but two: LPNs and PAs. The rural subsample, by contrast, usually correlates negatively with percent urbanization. Only rural RNs, PAs, and psychologists show varying degrees of non-significant positive correlation. Let us examine in more detail the results for occupations that flirted with or achieved statistical significance in either test of the second hypothesis.

LPNs demonstrated a strong negative correlation with urbanization that was just below the significance cutoff in the full sample. When stratified, the correlation fell apart with a tau near zero in the rural segment and a non-significant negative value in the urban segment.

Podiatrists and dentists showed a high but not significant positive correlation in the full sample that was strengthened in the urban cohort sufficiently to reject the null hypothesis.

Chiropractors form the only group that showed a negative correlation strengthened by stratifying the sample. Insignificant negative correlation in the full sample was transformed to a strong negative relationship for the rural cohort. The urban cohort was insignificantly positively associated with urbanization.

The staff doctors, an aggregation of active MDs, DOs, and podiatrists, showed significant positive correlation with percent urban population in both full and stratified tests. The association was

maintained at a slightly lower level in the urban cohort in the second test; the rural cohort showed no correlation at all with urbanization.

RNs, PAs, and psychologists supported the research hypothesis of high correlation with percent urbanized population in the full-sample test, but stratified samples no longer gave significant results for these three occupations.

The consistent placement of Grand Traverse among urban counties and St. Clair among rural counties suggests that they may be more appropriately placed in those classes. This modification was done and the new correlation results are seen in Table 8.

There are now only two groups with significant associations with urbanization. Rural chiropractors show significant negative correlation in this new grouping, and urban podiatrists retain their positive association. Urban LPNs approach significant negative correlation. Thus this change in the sample strengthened the cohorts whose ratios decline with increasing urbanization and weakened all positive correlations.

Table 8

Percent Urban Population correlated with Occupation/10,000

Modified Stratification

Occupation	Type	Tau	Z	Significance	
LPN	R	.067	0.349	.360	
	U	-.429	-2.234	.014	
RN	R	.143	0.745	.238	
	U	.067	0.349	.360	
Staff Doctor	R	.067	0.349	.360	
	U	.371	1.932	.029	
Chiropractor	R	-.505	-2.630	.005	*
	U	.048	0.250	.400	
Physician ass't	R	.147	0.766	.220	
	U	.067	0.349	.360	
Optometrist	R	-.067	-0.349	.360	
	U	.010	0.052	.500	
Physical therapist	R	-.181	-0.943	.172	
	U	.105	0.547	.286	
Psychologist	R	.108	0.563	.282	
	U	.124	0.646	.258	
MD	R	-.219	-1.141	.126	
	U	.219	1.141	.126	
DO	R	-.124	-0.646	.258	
	U	.124	0.646	.258	
Dentist	R	-.219	-1.141	.126	
	U	.276	1.438	.079	
Dental hygienist	R	-.219	-1.141	.126	
	U	.181	0.943	.172	
Podiatrist	R	-.330	-1.719	.045	
	U	.486	2.531	.006	*
Pharmacist	R	-.314	-1.635	.055	
	U	.181	0.943	.172	

The final exercise conducted on the data was to test whether doctors are distributed according to need. The result does conform to the expectation that lower ratios of active practitioners to potential patients are found in rural counties, but this map (Figure 20) of staff doctors to high-need population is virtually identical to the map of staff doctors to total population. Here again we see a sevenfold range of providers to patients, with only two urban counties, Jackson and Bay, below the median rate. The sequence of counties from lowest to highest ratio is almost the same as for staff doctors to total population. This seems to be due to the reliance on census estimates for the subpopulation. If these estimates are derived from a formula applied to all counties in Michigan, any denominator based proportionally on census data would give the same result. It would be unusual for all counties in the sample actually to have equal proportions of young children, young women, and old people.

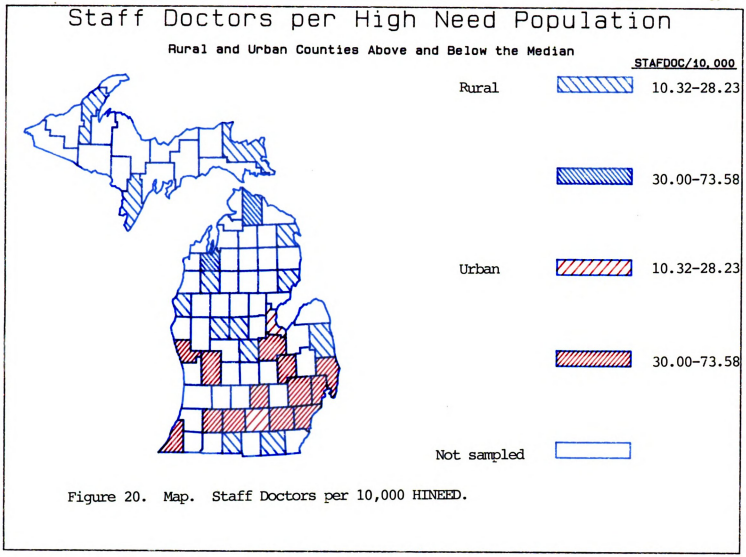


Figure 20. Map. Staff Doctors per 10,000 HINEED.

Chapter Five

CONCLUSIONS AND RECOMMENDATIONS

Three questions were asked in the introduction to direct the course of this research. Lorenz curves, ratios, and maps were used to help answer the first two queries: To what degree are medical workers apportioned equivalently to population? and Are there significant differences in spatial dispersion among the professions? After finding differences, tests of two hypotheses were conducted to help explain the distributions.

There are three major conclusions drawn from the results. Firstly, there are differences in the spatial distributions among the occupations studied here. Secondly, there is some evidence supporting the hypothesis that spatial patterns are associated with a profession's dependence on or independence from physicians. Thirdly, there is evidence supporting the hypothesis that ratios of health care workers to population do have a direct correlation with percentage of urban population. This concentration in urban areas means there is a relative underserving by several occupations of rural, especially the most northern, parts of Michigan.

More detailed observations and conclusions are made from particular sections of the research. The Lorenz curves and Gini coefficients show that most occupations are slightly to moderately removed from the line of equity, and that the 'independent' groups are not necessarily more equitably distributed than 'dependent' ones. The Gini values obtained here are similar to those reported by Morrow (1977.)

There is wide variation in the ratios of professionals to population, and active physicians, by the measure used here, have one of the lower ranges of these values.

A study of the ranks of the county ratios confirms many other reports that urban areas are generally better served than rural areas. Washtenaw county's rankings reinforce the speculated distinction between dependent and independent occupations. Previous studies and these results suggest that dentists and psychologists have parallel patterns of location preference to MDs, which would explain the high correlation that was not expected on systematic grounds.

An overview of the maps indicates that more of the highly technical professions are concentrated in urban counties and that chiropractors, LPNs, optometrists, and physical therapists are doing some of the work done in urban areas by the 'higher' occupations. This conclusion is similar to one of Rushing and Wade's findings.

Maps and correlations provide some evidence that many occupations show spatial correspondence with doctors, whether the latter are measured as staff doctors or as MDs. The lack of significant correlations with DOs suggests that the two types of physicians function differently in the system; osteopaths apparently do not support (or are not supported by) the other occupations studied here.

To obtain a significant direct relationship between rates of health personnel and urbanization, this research indicates that one should include both rural and urban places when testing at the county level. Rural or urban cohorts apparently are too homogeneous when segregated since they seldom give a coherent pattern by themselves.

The final question of correspondence between need and physicians is not successfully answered by the technique used. The map indicates that there is not a good correspondence; rural counties show up to seven times fewer practitioners available. Unfortunately the target subpopulation is not specific enough and is too closely related to the base population to provide more information that does the map of the total patient pool.

Recommendations

The most effective change in this study would be to repeat both the descriptive and correlative sections with precise data. At the least, only actively employed licensees should be included, and their county of employment must be known.

Given this major improvement, four other refinements would provide a much more ideal design. Professional registries and other sources could divulge useful numbers of additional occupations to map and correlate, such as radiologic technicians, dietitians, medical technologists, and social workers. The MD category should be disaggregated, at least into the two large groups of primary and specialist providers. Particular specialists such as psychiatrists also could be investigated. Lastly, the geographic scale ideally should be more on the order of townships to more accurately portray locally available personnel.

The other major difficulty in the design of this research is the need for a better measure of medical service capacity. Modelling a measure that includes outpatient services as well as hospitalization would require much more centralized data than one can reasonably expect to obtain on utilization of laboratories, X-ray departments, doctor's

offices, and so on. In the absence of an adequate measure it may still be best to rely on ratios of providers to populations or subpopulations.

Bibliography

Arbor Associates, 1983. Physician Distribution in Northeastern Lower Michigan 1973 - 1982.

Bashshur R, G Shannon, C Metzner. 1971. Some ecological differentials in the use of medical services. Hlth. Ser. Res. Spring. 61-75.

Bennett W. 1981. A location-allocation aproach to health care facility location: a study of the undoctored population in Lansing, Michigan. Soc. Sci. Med. 15D:305-312.

Brown D. 1974. The redistribution of physicians and dentists in incorporated places of the upper Midwest, 1950 - 1970. Rur. Soc. 39:205-223.

Brown S. 1980. Consumer attitudes toward physicians and health care. Ariz. Med. 37:33-36.

Cooper F, K Heald, M Samuels, S Coleman. 1975. Rural or urban practice: factors influencing the location decision of primary care physicians. Inquiry. 12:18-25.

Cuca J. 1980. 1978 U.S. medical school graduates: practice setting preferences, hometowns, and spouses' hometowns. J. Med. Educ. 55:220

_____ 1980. 1978 U.S. medical school graduates: practice setting preferences, other career plans, and personal characteristics. J. Med. Educ. 55:465-468.

DiLisio J. 1981. Health manpower supply and demand: the case of a family practice residency program. Soc. Sci. Med. 15D:295-303.

Dolan A. 1980. Antitrust law and physician dominance of other health practitioners. J. Hlth. Polit. Pol. Law. 4:675-689.

Fonaroff L. 1968. Man and malaria in Trinidad: ecological perspectives of a changing health hazard. Annals, AAG. 58:526-556.

Forster J. 1982. How much of your turf do the non-M.D. doctors have? Med. Econ. 27:67-76.

Freidson E. 1960. Client control and medical practice. Am. J. Sociol. 65:374-382.

Gesler W. 1979. Illness and health practitioner use in Calabar, Nigeria. Soc. Sci. Med. 13D:23-30.

Godlund S. 1961. Population, regional hospitals, transport facilities, and regions: a methodological localization study for hospital planning in Sweden. Lund Studies Geog. 21

Hahn R, A Kleinman. 1983. Biomedical practice and anthropological theory: frameworks and directions. Ann. Rev. Anthro. 12:305-333.

Hammond, Robert and Patrick McCullough. Quantitative Techniques in Geography: An Introduction. 2nd ed. Oxford: Clarendon Press. 1978.

Hassinger E, L Gill, D Hobbs, R Hageman. Perceptions of rural and metropolitan physicians about rural practice and the rural community, Missouri, 1975. Pub. Hlth. Rep. 95:69-79.

Haynes R, C Bentham. 1982. The effects of accessibility on general practitioner consultations, outpatient attendances and inpatient admissions in Norfolk, England. Soc. Sci. Med. 16:561-569.

Helman C. 1978. 'Feed a cold, starve a fever' - folk models of infections in an English suburban community, and their relation to medical treatment. Cult. Med. Psych. 2:107-137.

Hynes K, N Givner. 1983. Physician distribution in a predominantly rural state: predictors and trends. Inquiry 20:185-190.

Joroff S, V Navarro. 1971. Medical manpower: a multivariate analysis of the distribution of physicians in urban United States. Med. Care. 9:428-438.

Joseph A, D Phillips. 1984. Accessibility and utilization: geographical perspectives on health care delivery. New York: Harper and Row.

Kleinman A, L Eisenberg, B Good. 1978. Culture, illness, and care: clinical lessons from anthropologic and cross-cultural research. Ann.Int. Med. 88:251-258.

Knox P, J Bohland, N Shumsky. 1983. The urban transition and the evolution of the medical care delivery system in America. Soc. Sci. Med. 17:37-43.

Lankford P. 1974. Physician location factors and public policy. Econ. Geog. 50:244-255.

Mayer J. 1983. The distance behavior of hospital patients: a disaggregated analysis. Soc. Sci. Med. 17:819-827.

Morrill R, R Earickson. 1969. Locational efficiency of Chicago hospitals: an experimental model. Hlth. Ser. Res. Summer. 128-141.

Morrow J. 1977. Toward a more normative assessment of maldistribution: the Gini index. Inquiry. 14:278-292.

Mullner R, T O'Rourke. 1974. A geographic analysis of counties without an active non-federal physician, United States, 1963-71. Hlth. Ser. Rep. 89:256-262.

Northcott H. 1980. Convergence or divergence: the rural-urban distribution of physicians and dentists in census divisions and incorporated cities, towns, and villages in Alberta, Canada 1956-1976. Soc. Sci. Med. 14D:17-22.

Office of Health and Medical Affairs, Dept. of Management and Budget, State of Michigan. 1983. Further increases in the physician supply will do little to improve access to health services. Issues in Health Policy. no. 4.

Poole M, P O'Farrell. 1971. The assumptions of the linear regression model. Trans. Inst. Brit. Geog. 52:145-158.

Pyle G, B Lauer. 1975. Comparing spatial configurations: hospital service areas and disease rates. Econ. Geog. 51:50-68.

Rahaman M, K Aziz, M Munshi, Y Patwari, M Rahman. A diarrhea clinic in rural Bangladesh: influence of distance, age, and sex on attendence and diarrheal mortality. Am. J. Pub. Hlth. 72:1124-1128.

Richards J, A Golden. 1980. Human ecology and the geographic distribution of physician assistants. Eval. Hlth. Prof. 3:225-236.

Richards J, G Gottfredson. 1978. Geographic distribution of U.S. psychologists: a human ecological analysis. Am. Psychol. 33:1-9.

Riley J. 1980. Client choices among osteopaths and ordinary physicians in a Michigan community. Soc. Sci. Med. 14B:111-120.

Rimlinger G, H Steele. 1963. An economic interpretation of the spatial distribution of physicians in the U.S. So. Econ. J. 30:1-12.

Rushing W, G Wade. 1973. Community-structure constraints on distribution of physicians. Hlth.Ser.Res. Winter. 283-297.

Schwartz W, J Newhouse, B Bennett, A Williams. 1980. The changing geographic distribution of board-certified physicians. N. Eng. J. Med. 303:1032-1038.

Shannon G, J Skinner, R Bashshur. 1973. Time and distance: the journey for medical care. Int. J. Hlth. Ser. 3:237-244.

Spanier R. 1979. Should folk healers have a place in health care? Forum Med. 2:788-789.

Spicer E.,ed. 1977. Southwestern healing traditions in the 1970s: an introduction. Ethnic Medicine in the Southwest. Univ. of Arizona Press.

Stimson R. 1981. The provision and use of general practitioner services in Adelaide, Australia: application of tools of locational analysis and theories of provider and user spatial behaviour. Soc. Sci. Med. 15D:27-44.

Tarlov A. 1983. Shattuck lecture -- the increasing supply of physicians, the changing structure of the health-services system, and the future practice of medicine. N.Eng.J.Med. 308:1235-1244.

Theil H. Studies in Mathematical and Managerial Economics. vol. 7: Economics and Information Theory. Chicago: Rand McNally & Co. 1967.

Unschuld P. 1980. The issue of structured coexistence of scientific and alternative medical systems: a comparison of East and West German legislation. Soc. Sci. Med. 14B:15-24.

Wennberg J, A Gittelsohn. 1973. Small area variations in health care delivery. Science. 182:1102-1108.

Yesalis C, R Wallace, W Fisher, R Tokheim. 1980. Does chiropractic utilization substitute for less available medical services? Am. J. Pub. Hlth. 70:415-417.

APPENDIX I

Population Profile

County	Type	Population	% Urban	HINEED	HINEED/10000
Alpena	R	32315	37.8	15806	489
Bay	U	119881	65.0	58372	487
Berrien	U	171276	54.8	84878	496
Branch	R	40188	23.5	20143	501
Calhoun	U	141557	67.9	69188	489
Cheboygan	R	20649	24.7	10271	497
Chippewa	R	29029	49.8	14039	484
Genessee	U	450449	76.8	220218	489
Grand Traverse	R	54899	28.3	27861	507
Gratiot	R	40448	41.3	20518	507
Houghton	R	37872	40.4	17987	475
Ingham	U	275520	85.3	139005	505
Iosco	R	28349	27.3	14087	497
Isabella	R	54110	43.9	27539	509
Jackson	U	151495	56.6	71589	473
Kalamazoo	U	212378	73.0	104400	492
Kent	U	444506	81.8	222763	501
Lenawee	R	89948	38.0	44389	493
Macomb	U	694600	94.8	321048	462
Mason	R	26365	33.9	13344	506
Mecosta	R	36961	38.9	17780	481
Menominee	R	26201	39.5	12962	495
Muskegon	U	157589	71.3	77830	494
Oakland	U	1011793	89.5	475662	470
Saginaw	U	228059	67.2	113618	498
Sanilac	R	40789	0.0	20351	499
St. Clair	U	138802	52.4	68696	495
Washtenaw	U	264748	77.6	128424	485
Wayne	U	2337891	98.4	1141460	488
Wexford	R	25102	40.6	12675	505

APPENDIX II

Numbers of Licensees by County

County	STAFDOC	(MD)	(DO)	(Pod)	LPN	RN	Chiro	PA
Alpena	41	36	5	0	272	204	8	1
Bay	123	85	38	0	620	910	15	10
Berrien	286	274	5	7	438	1297	46	11
Branch	32	26	5	1	223	223	10	1
Calhoun	302	256	38	8	616	1192	24	9
Cheboygan	29	22	7	0	65	107	3	1
Chippewa	17	12	5	0	130	219	2	1
Genessee	1043	820	213	10	1946	3535	87	13
Grand Traverse	155	108	37	0	486	818	20	0
Gratiot	44	36	7	1	287	207	9	3
Houghton	34	32	2	0	115	280	4	2
Ingham	716	572	131	13	864	2638	52	37
Iosco	16	15	1	0	95	154	5	1
Isabella	39	35	4	0	261	250	6	3
Jackson	154	115	38	1	663	1030	26	12
Kalamazoo	660	657	3	0	960	2486	37	23
Kent	979	859	116	4	2260	4374	97	24
Lenawee	96	84	12	0	351	478	19	6
Macomb	1359	730	434	195	1871	5443	146	23
Mason	37	35	2	0	166	172	5	0
Mecosta	23	15	6	2	114	215	5	1
Menominee	35	31	3	1	143	141	4	0
Muskegon	372	305	62	5	853	1079	32	7
Oakland	2378	1750	589	39	2792	10196	211	78
Saginaw	359	301	58	0	887	1613	18	7
Sanilac	21	15	5	1	155	238	11	0
St. Clair	206	199	7	0	623	1028	9	3
Washtenaw	945	924	20	1	865	3649	50	34
Wayne	8385	7400	864	171	6898	15135	334	102
Wexford	29	24	5	0	202	165	6	0

Numbers of Licensees by County

County	Opt.	PT	Psych	MD	DO	Dent	Hyg.	Pod.	Pharm.
Alpena	7	6	1	51	6	19	10	1	25
Bay	10	17	1	133	30	58	57	6	106
Berrien	24	33	11	260	20	94	54	5	109
Branch	5	7	3	47	9	14	11	2	25
Calhoun	24	22	19	211	38	82	100	9	100
Cheboygan	3	1	0	22	8	14	7	0	20
Chippewa	3	5	3	46	8	19	8	0	23
Genessee	61	65	27	737	243	266	345	20	361
Grand Traverse	13	26	9	172	45	65	51	2	75
Gratiot	7	2	0	43	12	21	12	1	16
Houghton	7	5	3	49	3	25	14	0	24
Ingham	38	88	128	813	223	221	231	12	235
Iosco	2	4	0	39	4	16	10	2	21
Isabella	4	10	14	62	10	19	17	2	29
Jackson	9	24	10	170	33	80	56	5	98
Kalamazoo	28	53	59	614	18	172	174	10	266
Kent	68	139	80	1043	154	342	351	22	401
Lenawee	16	11	5	86	12	50	44	2	53
Macomb	74	118	28	754	304	516	329	85	624
Mason	2	3	1	43	3	10	7	1	20
Mecosta	24	8	1	28	9	16	33	0	49
Menominee	2	2	0	18	4	10	5	2	12
Muskegon	16	29	13	220	63	96	54	6	128
Oakland	195	428	305	3605	743	1156	1022	170	1568
Saginaw	21	35	12	368	59	148	152	7	176
Sanilac	10	13	2	61	10	15	8	2	46
St. Clair	11	3	1	22	9	30	33	0	21
Washtenaw	22	207	191	2191	34	452	242	11	362
Wayne	179	350	181	4738	725	1398	798	168	1322
Wexford	7	4	1	33	8	15	12	1	26

APPENDIX III

Ranks of Occupation : Population Ratios, Lowest to Highest

County	STAFDOC	LPN	RN	Chiro	PA	Opt	PT	Mean
Rural Counties								
Alpena	13	29	10	26	11	26	21	15.7
Branch	6	25	7	27	7	13	18	12.9
Cheboygan	16	8	3	9	17	19	2	11.6
Chippewa	3	17	19	2	13	16	17	13.8
Grand Traverse	27	30	30	30	1	27	29	25.3
Gratiot	11	27	2	24	24	22	3	11.8
Houghton	7	5	17	4	18	24	7	11.6
Iosco	2	10	6	14	14	2	8	10.4
Isabella	5	20	1	5	20	3	20	10.6
Lenawee	10	13	4	22	23	23	6	12.0
Mason	15	26	12	17	2	4	5	10.7
Mecosta	4	6	8	7	8	30	23	12.5
Menominee	14	24	5	10	3	5	4	8.5
Sanilac	1	11	9	29	4	28	26	17.6
Wexford	12	28	13	25	5	29	15	17.0
Urban Counties								
Bay	9	22	21	6	27	9	9	15.6
Berrien	19	1	20	28	22	18	22	14.6
Calhoun	21	15	24	11	21	21	13	18.2
Genessee	23	14	23	18	9	15	10	17.8
Ingham	26	7	25	15	30	17	27	22.9
Jackson	8	16	14	12	26	1	14	12.4
Kalamazoo	28	19	28	13	28	14	24	22.0
Kent	22	21	26	23	19	20	25	23.0
Macomb	20	2	22	21	12	12	16	15.4
Muskegon	25	23	15	19	16	11	19	18.0
Oakland	24	3	27	20	25	25	28	25.4
Saginaw	18	12	16	3	10	10	12	13.9
St. Clair	17	18	18	1	6	7	1	5.9
Washtenaw	29	9	29	16	29	8	30	22.9
Wayne	30	4	11	8	15	6	11	14.0

Ranks of Occupation : Population Ratios, Lowest to Highest

County	Psych	MD	DO	Dent	Hyg	Pod	Pharm
Rural Counties							
Alpena	7	19	12	14	7	10	15
Branch	17	11	14	2	4	23	7
Cheboygan	1	6	25	22	10	1	23
Chippewa	22	20	21	20	5	2	16
Grand Traverse	24	28	30	29	29	12	28
Gratiot	2	5	22	8	6	7	2
Houghton	19	12	2	21	15	3	8
Iosco	3	14	9	12	13	26	12
Isabella	26	10	11	3	8	13	4
Lenawee	13	4	8	11	19	6	6
Mason	8	22	5	4	3	14	13
Mecosta	6	3	16	6	27	4	27
Menominee	4	2	10	5	2	28	3
Sanilac	11	17	17	23	24	21	25
Wexford	9	13	15	16	18	16	24
Urban Counties							
Bay	21	8	18	7	17	24	20
Berrien	15	18	6	10	9	8	9
Calhoun	23	16	20	13	21	25	11
Genessee	14	23	27	15	22	19	17
Ingham	29	27	29	26	26	18	19
Jackson	16	9	13	9	14	11	10
Kalamazoo	27	26	3	27	25	20	26
Kent	25	25	24	25	23	22	22
Macomb	10	7	4	24	16	29	21
Muskegon	20	15	26	18	12	15	18
Oakland	28	29	28	28	30	30	30
Saginaw	12	21	19	19	20	9	14
St. Clair	5	1	1	1	1	5	1
Washtenaw	30	30	7	30	28	17	29
Wayne	9	13	15	16	18	16	24

APPENDIX IV

County Ratios

Medical Workers per 10,000 Population

County	STAFDOC	LPN	RN	Chiro	PA	Optom	PT
Alpena	12.69	84.17	63.13	2.48	0.31	2.17	1.86
Bay	10.26	51.72	75.91	1.25	0.83	0.83	1.42
Berrien	16.70	25.57	75.53	2.69	0.64	1.40	1.93
Branch	7.96	55.49	55.49	2.49	0.25	1.24	1.74
Calhoun	21.33	43.52	84.21	1.70	0.64	1.70	1.77
Cheboygan	14.04	31.48	51.82	1.45	0.48	1.45	0.48
Chippewa	5.86	44.78	75.44	0.69	0.34	1.38	1.72
Genessee	23.15	43.20	78.48	1.93	0.29	1.35	1.44
Grand Traverse	28.23	88.53	149.00	3.64	0.00	2.37	4.74
Gratiot	10.88	70.96	51.18	2.22	0.74	1.73	0.49
Houghton	8.98	30.37	73.93	1.06	0.53	1.85	1.32
Ingham	25.99	31.36	95.75	1.89	1.34	1.38	3.19
Iosco	5.64	33.51	54.32	1.76	0.35	0.70	1.41
Isabella	7.21	48.24	46.20	1.11	0.55	0.74	1.85
Jackson	10.17	43.76	67.99	1.72	0.79	0.59	1.58
Kalamazoo	31.08	45.20	117.06	1.74	1.08	1.32	2.50
Kent	22.02	50.84	98.40	2.18	0.54	1.53	3.13
Lenawee	10.67	39.02	53.14	2.11	0.67	1.78	1.22
Macomb	19.57	26.94	78.36	2.10	0.33	1.07	1.70
Mason	14.03	62.96	65.24	1.90	0.00	0.76	1.14
Mecosta	6.22	30.84	58.17	1.35	0.27	6.49	2.16
Menominee	13.36	54.58	53.81	1.53	0.00	0.76	0.76
Muskegon	23.61	54.13	68.47	2.03	0.44	1.01	1.84
Oakland	23.50	27.59	100.77	2.09	0.77	1.93	4.23
Saginaw	15.74	38.89	70.73	0.79	0.31	0.92	1.53
Sanilac	5.15	38.00	58.35	2.70	0.00	2.45	3.19
St. Clair	14.84	44.88	74.06	0.65	0.22	0.79	0.22
Washtenaw	35.69	32.67	137.83	1.89	1.28	0.83	7.82
Wayne	35.87	29.51	64.74	1.43	0.44	0.77	1.50
Wexford	11.55	80.47	65.73	2.39	0.00	2.79	1.59

County Ratios

County	Psych	MD	DO	Dent	Hyg	Pod	Pharm
Alpena	0.31	15.78	1.86	5.88	3.10	0.31	7.74
Bay	1.00	11.09	2.50	4.84	4.76	0.50	8.84
Berrien	0.64	15.18	1.17	5.49	3.15	0.29	6.36
Branch	0.75	11.69	2.24	3.48	2.74	0.50	6.22
Calhoun	1.34	14.91	2.68	5.79	7.06	0.64	7.06
Cheboygan	0.00	10.65	3.87	6.78	3.39	0.00	9.69
Chippewa	1.03	15.85	2.76	6.55	2.76	0.00	7.92
Genessee	0.60	16.36	5.39	5.91	7.66	0.44	8.01
Grand Traverse	1.64	31.33	8.20	11.94	9.29	0.36	13.66
Gratiot	0.00	10.63	2.97	5.19	2.97	0.25	3.96
Houghton	0.79	12.94	0.79	6.60	3.70	0.00	6.34
Ingham	4.65	29.51	8.09	8.02	8.38	0.44	8.53
Iosco	0.00	13.76	1.41	5.64	3.53	0.70	7.41
Isabella	2.59	11.46	1.85	3.51	3.14	0.37	5.36
Jackson	0.66	11.22	2.18	5.28	3.70	0.33	6.47
Kalamazoo	2.78	28.91	0.85	8.10	8.19	0.47	12.52
Kent	1.80	23.46	3.46	7.69	7.90	0.50	9.02
Lenawee	0.56	9.56	1.33	5.56	4.89	0.22	5.89
Macomb	0.40	10.85	1.14	7.43	4.74	1.22	8.98
Mason	0.38	16.31	1.14	3.79	2.65	0.38	7.59
Mecosta	0.27	7.58	2.43	4.33	8.93	0.00	13.26
Menominee	0.00	6.87	1.53	3.82	1.91	0.76	4.58
Muskegon	0.82	13.96	4.00	6.09	3.43	0.38	8.12
Oakland	3.01	35.63	7.34	11.43	10.10	1.68	15.50
Saginaw	0.53	16.14	2.59	6.49	6.66	0.31	7.72
Sanilac	0.49	14.95	2.45	7.36	8.09	0.49	11.28
St. Clair	0.07	1.59	0.65	1.08	0.58	0.00	1.51
Washtenaw	7.21	82.76	1.28	17.07	9.14	0.41	13.67
Wayne	0.77	20.27	3.27	5.98	3.41	0.72	5.66
Wexford	0.40	13.15	2.39	5.98	4.78	0.40	10.36