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Variation in Michigan hospital use rates: Do physician and hospital characteristics provide the explanation?

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VARIATION IN MICHIGAN HOSPITAL USE RATES: DO PHYSICIAN AND HOSPITAL CHARACTERISTICS PROVIDE THE EXPLANATION?

By

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A DISSERTATION

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ABSTRACT

VARIATION IN MICHIGAN HOSPITAL USE RATES:
DO PHYSICIAN AND HOSPITAL CHARACTERISTICS
PROVIDE THE EXPLANATION?

By

Jane Deane Clark

Previous small area analysis studies have shown that hospital admission rates (total, medical and surgical) vary among hospital service areas. Using 1983 Michigan hospital inpatient data from 53 non-Metropolitan Detroit lower peninsula hospital service areas, one physician characteristic and thirteen hospital characteristics (in the categories of resource supply, services offered and organization) were tested for their association with and explanation of fourteen hospital use rates. Registered nurses per bed and the weighted proportion of board certified physicians to total physicians were inversely related to and offered significant contribution to the explanation of the variation in total use rates and in four medical causes for admission rates (circulatory, respiratory, digestive and genito-urinary). Physician and hospital variables provided significant explanation for six of the seven

surgical procedure rates tested (appendectomy, hemorrhoidectomy, cholecystectomy, inguinal hernia repair, prostatectomy and hysterectomy).

Four causative factors derived from the characteristics studied are postulated to influence the hospital use rates. The first factor was the small rural nature of the average high use hospital service area. High use areas had a lower proportion of board certified physicians and fewer RNs per bed, beds per hospital, and house staff per 10,000 population than did low use areas. Another factor was the inequality in the distribution of high technology diagnostic services. High use hospital service areas had fewer diagnostic services than did low use areas. The third factor was the inequality in the rural hospital environment produced by the designation of some hospitals as rural referral centers. The fourth factor was the impact of the definition and size of a hospital service area. Current small area analysis methodology assigns every small area to a hospital service area, no matter what the probability of the population using the hospital(s) within the service area. This research questions that methodology, and suggests the need for hospital service area definitions based upon the specific diagnosis or procedure being studied and postulates that some rural hospital distance decay curves may turn upward at farther distances when the timing of treatment is too critical to allow patients to return to distant residences.

Dedicated to

Russell G. Clark, Jr.

for shared

moments,

minutes,

months ...

a lifetime.

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In addition to these people, I wish to thank my sister, Mary-Anne Deane Rappole, my mother-in-law, Harriett Harper Clark, my "adopted parents," Joseph J. and Laurentia Irwin, and the many MHA staff members and friends who have offered encouragement throughout this long process. And, in particular, I wish to acknowledge the rooting section in the Research, Data Policy and Services Department led by my staff who really "make the difference," Julie Lester and Hilda Michaels. I wish my parents could have lived to see the successful completion of this research because they are the ones who provided my educational and emotional foundations and insisted that any task undertaken must be completed.

This document has a polished look in large part because of the tremendous skills of Hilda Michaels with the NBI word processing system and Russell G. Clark, Jr. with his innovative use of the graphics capabilities of the IBM AT and his precise editing. My cartographic efforts for Russell's dissertation have been repaid many many times over. My special thanks to Bruce Pigozzi for his advice, counsel, and rigorous editing and to my committee members for their patience.

The inspiration for this work comes from John Wennberg, Phil Caper, Noralou and Leslie Roos, John Griffith, Peter Wilson, and Phil Tedeschi. They are not geographers; one has, in fact, challenged me to tell him what geography is. But they have used an inherently geographic method to influence health policy, and that is inspiring.

Inspiration alone does not get the job done, and I could not have completed this research, nor the requirements for a doctoral degree, without the active support and love of the three dearest people in the world to me: Amy, Ian, and Russell. Without our four-way partnership, I could not have gotten past the household chores and parenting that they willingly accepted as their part of this shared activity.

And finally, to the three men in my life who assured me that I could do it and then insisted that I do -- Bruce Pigozzi, Richard Hamilton, and Russell Clark. Thank you.

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CHAPTER 1

INTRODUCTION

Background

Variations in the use of health services by the population of a geographic area have long interested geographers and other health researchers. Perhaps the first attempt to analyze the geographic variation of the per capita utilization of hospital services was reported in 1856 by William A. Guy, a physician at King's College Hospital, London, and one of the Honorary Secretaries of the Statistical Society. Guy noted that the annual per capita rates for hospitalization in King's Hospital varied from 325 per 1,000 population in the parish of St. Mary-le-Strand to one per 1,000 in the district of Marylebone. Based on these observations Guy hypothesized that charitable medical care was being consumed in parishes such as St. Mary-le-Strand by an

> "increasing class of working men, in receipt of good wages, who are in the habit of applying to hospitals as a matter of course, even for trifling attacks of illness, to say nothing of those which sometimes follow immediately on expensive acts of self-indulgence" (Barnes, 1982).

Guy clearly felt that the explanation for the variation in use rates between the two areas was related to behavioral characteristics of the populations concerned.

The study of variations in hospital use rates has continued to the present. For example, Wennberg (1982) reported that at the then current rates at which local physicians were performing hysterectomies, in one community in Maine seventy percent of the women would have their uteruses removed by the time they reached seventy-five years of age, while in a similar community less than twenty miles away only twenty-five percent of the women would have had their uteruses removed by the same age. Wennberg felt that since the communities were so similar, the explanation for the variation in hospital use rates would not be found among community variables but elsewhere, and he suggested that the explanation was related to the degree of consensus in medical diagnosis and treatment among physicians.

No matter where the final answers to variations in use rates are found, the question that was asked in 1856 is essentially the same question that is asked today: what can explain the large variations in use rates between apparently similar neighboring communities? Are the explanations to be found among community characteristics as suggested by Guy, or among health care provider characteristics as suggested by Wennberg?

This current research attempts to answer these and other questions about hospital utilization in Michigan. First, is there variation in hospital utilization among Michigan communities? If there is variation in hospital use rates, how does the variation compare to the results of previous utilization research? Does Michigan exhibit the same range and patterns of variation found in other geographic areas? Are there any spatial patterns to the variations? And finally, what characteristics of the hospitals and their medical staffs are related to and explain variations in hospital utilization rates? Are the explanations to be found among characteristics of the physicians or among hospital characteristics which describe the supply of personnel, the services offered, the organization of the hospitals themselves, or a combination of these factors?

Conceptual Approach

In order to ask appropriate questions about the explanation of the variation in hospital use rates, it is necessary to define a model including the possible factors which may cause or contribute to the variation in those rates. Researchers have often tried to identify and describe those factors responsible for an individual's seeking medical care and the subsequent care provided. Andersen (1973) provided a model (Figure 1.1) describing the major elements that he believed contributed to variation in the use of health services. The major elements he identified were: the community, the health services system, and the individual. Andersen's model showed community determinants such as socioeconomic variables, the physical environment, and morbidity influencing health services system determinants and the individual. Andersen believed that both the community and the health system determinants influenced the individual and, when added to the individual's own predisposing and enabling determinants, as well as illness level, would influence the individual's utilization of the

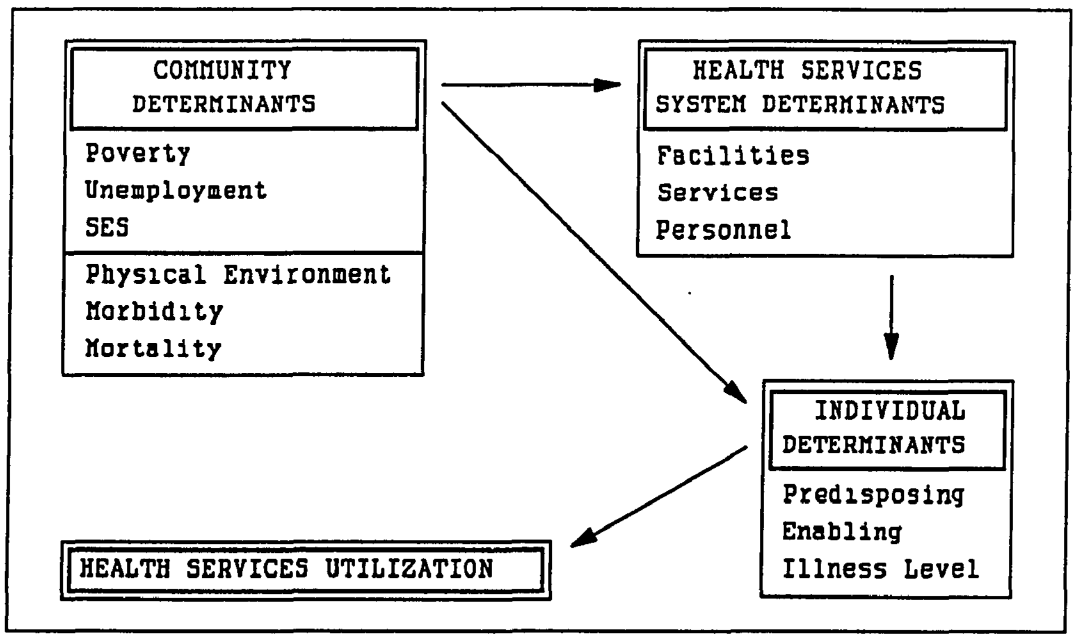


Figure 1.1

The Anderson Model
(adapted from Anderson, 1973)

health services within the community. Andersen did not put his model into a spatial context.

My model (hereafter referred to as the Clark Model), which will be described in detail in the next chapter, is more geographic in nature since it defines the community as an area within which are located all of the participants who determine a community's hospital use rate. These participants include the individual who is the potential patient, the total aggregated individuals who make up the population, the physicians, and the hospitals. Another major difference between this model and Andersen's is the distinction made between the physicians (who act as the gatekeepers to the hospital in this model) and the hospital itself. The distinction is necessary because of the influence or control that physicians have in deciding who shall be hospitalized and therefore shall move from being an "individual" who is part of the population to also being a patient who is hospitalized.

One of the major goals of this research was to identify those factors within the hospital and its medical staff which may influence the hospital use rates and to determine how much of the variation in hospital use rates can be explained by those provider characteristics. A second major goal was to examine spatially the hospital use rates, use rate patterns, and residual use rates unexplained by the multivariate regressions.

Small Area Analysis Methodology

While the explanation for the variation in hospital use rates was sought within the four components of the model (individual, physician, hospital, community), the framework to study them comes from small area analysis methodology. Small area analysis is a method used to analyze the way individuals in a community utilize its health care resources. The approach is analogous to that used in epidemiology. In epidemiology the number of disease occurrences during a defined time period in a specific area is divided by the population at risk for contracting the disease in that area during the same time period. The result is an incidence rate for that disease. In small area analysis the use rate is analogous to the incidence rate for a disease. The number of occurrences of a health care event in an area and within a defined time period is divided by that area's population at risk. The result is a use rate which can be standardized to a given population or subpopulation at risk.

Small area analysis has gained prominence as a tool for health services researchers and policy makers in part because, by defining a geographic area of observation, a resident population at risk is also defined. Therefore, not only can a use rate be calculated, but the health resources available and the population most likely to use those resources can also be defined. Researchers can then search for explanation of the community's health care use within the many physical, structural, cultural, and behavioral variables that exist for the same area.

This current research used small area analysis methodology to determine how much of the variation in hospital use rates can be explained by two components of the Clark Model: the physicians and the hospital. To do this the non-metropolitan Detroit area of the lower peninsula of Michigan was chosen as the study area. Hospital service areas were defined and the characteristics of the hospitals and their medical staffs were determined. Fourteen measures of hospital use were calculated for each hospital service area and then multiple regression analysis was used to determine how much of the variation in hospital use rates could be explained by the characteristics of the hospitals and the physicians that were located within the hospital service area.

CHAPTER 2

A HOSPITAL UTILIZATION MODEL

To better understand and explain why there is variation in hospital use rates, one must first understand what factors influence an individual's decision to be hospitalized. These factors are best described using a model or framework for the conceptualization, hypothesis development and analysis. The previously discussed Anderson Model provided the initial conceptualization for this research problem but had to be adapted to meet my needs. The Clark Model was developed to meet those needs and to provide the framework for a discussion of the previous small area analysis literature and to serve as the basis for preliminary hypotheses about the relationships between components of the models and hospital use rates. The Clark Model also provides the geographic framework for a discussion of the definition of hospital service areas.

Andersen Model

In his model Andersen identified three major components which he believed contributed to health services utilization. The first of Andersen's components was the community. The community determinants were identified as socio-economic characteristics such as poverty and unemployment, the physical environment, and the health of the community's population as measured by morbidity and mortality. The second component in Andersen's model was the health services system which was made up of facilities, services and personnel determinants. The third component in Andersen's model was the individual who was influenced by both the community and the health services system. Andersen identified predisposing, enabling and illness level determinants within the individual. Andersen saw demographic, social structure and personal beliefs as influencing the predisposition (predisposing determinants) of any individual to seek medical care. Family and community characteristics, such as income, health insurance and the price of health care affected the individual's ability to seek medical care (enabling determinants), as did the individual's perceived and diagnosed illness level.

Andersen's model provides a framework for the discussion of what factors affect an individual's decision to seek medical care. It does not provide the spatial structure which would allow the researcher to calculate use rates or to determine whether any of the determinants could help to explain the variation in use rates from one area to another.

Clark Model

The Clark model (Figure 2.1) is different in several respects since it divides the health services determinant into hospital and physician determinants, and adds a spatial dimension. It is more geographic in

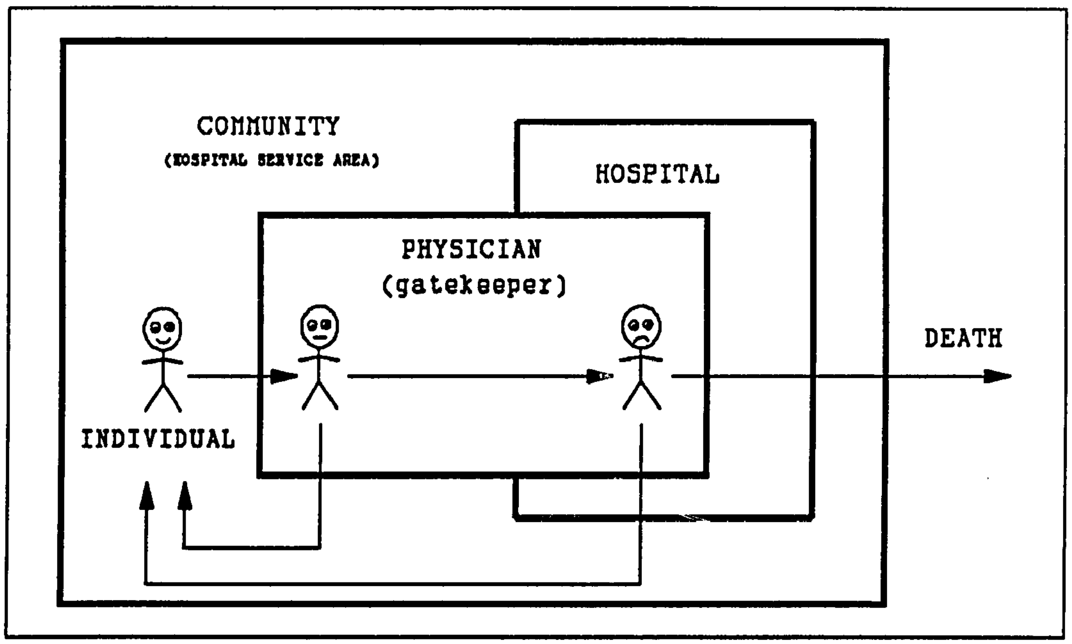


Figure 2.1

The Clark Model

nature because it defines a hospital service area from historical use patterns and then looks at the hospital use within that area. The hospital service area contains all of the participants who determine the hospital use rates: the individual, the population (also called the community), the physicians, and the hospitals.

In addition, the Clark Model acknowledges the influence that different individuals or groups have in the process of hospitalization. When individuals recognize that they are ill, they will usually seek advice from a health care provider such as a physician. The provider then determines if the individual is ill enough to be admitted to a hospital. Individuals admitted to the hospital as patients will be exposed to at least one of a series of possible hospital "events" (admission, medical diagnosis with non-surgical treatment, and/or surgical procedure). Upon completion of a series of events, the patient will either be released from the hospital or will be deceased. In either case, an outcome event has resulted from that hospitalization. Hospital events when standardized to the population at risk, become hospital event-rates, or more simply, hospital use rates.

It is one of the goals of this paper to explain the variation in hospital use rates from one hospital service area to another. The Clark Model indicates that there are four components (the individual, the community, the physician, and the hospital) that may be examined in an attempt to explain such use rate variation. The Clark Model will be used as a basis from which to make that examination. Previous small area analysis literature describing the relationship between each of these components and hospital use rates will be examined and initial hypotheses regarding the relationships between provider (physician and hospital) variables and hospital use rates will be suggested. These hypotheses will be further discussed and summarized in Chapter 3.

Component 1: The Individual

The first component in the Clark Model is the individual within the community. All individuals within the community are potential hospital patients. To become a patient, the individual must recognize a state of disease and then approach a provider for counseling and/or treatment prior to becoming a hospital patient. There are many factors such as age, level of education, socio-economic status, occupation, as well as attitudes about physicians and hospitals that can influence the individual's behavior in seeking health care.

But the individual's characteristics cannot be tested as explanatory variables for variations in use rates because those characteristics exist only in that individual. However, all the individuals in a community contribute to that community's characteristics and the community's characteristics can be tested for their explanatory power as noted below.

Component 2: The Community

The second component of the Clark Model is the community, which actually is the population of the hospital service area and therefore includes all of the individuals (patients and non-patients), physicians, and hospital staff within the area. The community has measurable socio-economic and demographic characteristics such as the level of poverty, unemployment rates, population density and average age. As shown in Tables 2.1 and 2.2 previous research using small area analysis methodology has dealt extensively with the relationships between community characteristics and hospital use rates. Small area analysis researchers have also studied the amount of explanation that community characteristics could provide for the variation in hospital and surgical procedure use rates and results are summarized in Table 2.3.

Several authors have analyzed the relationship between community characteristics and measures of hospital utilization using correlation analysis. The four measures studied were admission or discharge rate (hereafter referred to as admission rate), length of stay (LOS), patient day rate, and mortality rate. A summary of their findings is shown in Table 2.1.

Using multiple regression analyses, previous small area analysis researchers have also tested the power of community characteristics to explain the variation in total hospital admissions rate, LOS and patient day rate use as well as surgery rates. As shown in Table 2.2 Chiswick (1976) was able to explain 73 percent and Deacon et al. (1979) 49 percent of the variation in total admission rates using equations which included demographic and health resource characteristics among others. On the other hand, Knickman & Foltz (1985), working at a standard metropolitan statistical area (SMSA) level, found very low explanatory power from a combination of socio-economic, demographic and health system characteristics.

Wilson et al. (1985) were able to explain 64 percent of white and 55 percent of black patient day rates in Michigan using only community

Table 2.1

CORRELATIONS BETWEEN COMMUNITY CHARACTERISTICS AND HOSPITAL UTILIZATION

Study	Location	Variable Tested	Total Patient Adm/Disch	LOS	Pt Days	Mortality
Anderson, 1973	New Mexico	% labor in agriculture	-.57	-.37	-.37	
"	"	% urban	.55	.55	.49	
"	"	% Spanish American	-.11	-.25	-.22	
"	"	% non-white	.25	-.01	.24	
"	"	Net migration	.16	.30	.20	
"	"	Median age	-.11	.47	.27	
"	"	Median education	.19	.21	.09	
"	"	% unemployed	-.03	-.27	-.14	
"	"	Per capita income	.18	.31	.17	
Brewer & Freedman, 1982	Vermont	Population density factor	-.29			
"	"	Tax base factor	.26			
"	"	Personal income factor	-.40			
"	"	Substandard housing	-.02			
"	"	Poverty	.33			
"	"	Farm population	-.14			
Deacon et al., 1979*	USA Regions	Enrollees over 75	.15	.24	.30	
" *	"	Population density		.38	.26	
Roos, 1984	Manitoba	Income				-0.315

*Partial correlation

Table 2.2

PERCENT OF TOTAL VARIATION EXPLAINED BY COMMUNITY AND PROVIDER CHARACTERISTICS

						Total Patient
Study	Location	N	Variable Tested	Adm/Disch	LOS	Pt Days
Chiswick, 1976	USA States & SMSAs	192	Health sector, demographic, income, January temperature variables	73		
Deacon *et al*., 1979	USA Regions	190	Demographic and health resource variables	49	76	60
Knickman & Foltz, 1985	SMSAs	203	^3 socioeconomic, ^6 demographic and ^6 health system characteristics	02	14	03
Wilson *et al*., 1985	Michigan HSAs	23	Population size, race, beds, and surgeons			60 (White)
"	"	23	Population size, race, beds, and surgeons			32 (Black)

measures of mortality, education, unemployment and poverty. The Wilson group was less successful in explaining patient day rates for whites and blacks when they combined the community variables of population size and race with the provider variables of beds and surgeons.

All of the studies testing the relationships between community characteristics and surgical procedure rates were done in Canada, and all but one study was done by Roos in Manitoba (Table 2.3). Positive relationships were found between total surgery rates and education, Canadian, U.S. or U.K. ancestry (Roos & Roos, 1982), income (Roos, 1984) and high economic status (Vayda et al., 1976). Income was found to be inversely related to cataract surgery rates by Roos & Roos (1982), while Roos (1984) found significant positive correlations between community variables and hysterectomy rates only in high use rate hospital service areas.

While some researchers have looked at a combination of community and provider variables, no small area analysis researcher has looked at only community variables for the sources of explanation for variation in surgical procedure rates. Using data from the National Health Interview Surveys for 1969-1976 that had been organized into 349 - 360 primary sampling units, Mitchell & Cromwell (1982) were able to explain only nine percent of the variation in total surgery rates using a combination of twenty-three demographic, socio-economic and provider characteristics. In summary, researchers have been far more successful in explaining total admissions, LOS and patient days using community and provider variables than they have been in explaining surgical procedure rates.

Table 2.3

CORRELATIONS BETWEEN COMMUNITY CHARACTERISTICS AND SURGERY RATES

Study	Location	Variable Tested	Total Surgery	Cataract	Pros	Hyst
Roos & Roos, 1982	Manitoba	Education	.43			
"	"	Canadian, U.S., UK ancestry	.40			
"	"	Income		-.25		
Roos, N., 1984	"	Women with one or more D&C in 1974				S (high rate areas)
"	"	Women with five or more physicians visits per year				NS (all areas)
"	"	Women with one or more physicians visits for vague psychological diagnoses				NS (all areas)
"	"	Women seeing four or more different physicians				S (high rate areas)
"	"	Income				NS (all areas)
"	"	Mother tongue French, Italian or Polish				S (high rate areas)
Roos, L., 1984	"	Mortality of those >25	-.10			
"	"	Mortality of those >25	.32 S (male)		.32 S	
"	"	Mortality of those >25	-.19 (female)			
"	"	Mortality of those >75	.42 S			
"	"	Mortality of those >75	.45 S (male)			
"	"	Income	.30 S			
Vayda *et al.*, 1976	Canadian Provinces	High Economic Status	.77,.70			

NS=Reported as non-significant
S=Reported as significant

Although the community is a component in the Clark Model, community characteristics are not included within the "independent variables" in this current research design. Instead, the portion of the variation in use rates not explained by either physician or hospital characteristics is assumed to be made up of unidentified physician and hospital influences, community influences and other unexplained influences. Since the residuals following a regression analysis are specific to a hospital service area, geographic analysis of those residuals may be useful in indicating where further research, particularly among community characteristics such as the urban or rural character of an area, could help to decrease the amount of unexplained variation in use rates.

Component 3: The Physician

Physicians are the third component within the Clark Model. They usually have a medical practice outside of the hospital setting at the same time they serve on the medical staff within a hospital. Physicians act as the "gatekeepers" for the hospital, since their decisions control, in most instances, who will be admitted to the hospital and when that admission will occur. Like other individuals, physicians are also an integral part of the community. Their characteristics contribute to the community's characteristics and, as discussed later, the community's characteristics influence the physician.

But a physician is also a health care provider, and therefore the supply of physicians as well as their characteristics are of importance in understanding the variation in hospital use rates. The supply of physicians (total and by specialty group) within a hospital service area will be addressed as one of the health care resources within the hospital component of the model.

In addition to the supply of physicians within a community, the characteristics of the physicians themselves are believed to explain a portion of the variation in hospital use rates. A physician's age, education, residency training, medical specialty, and the length of time in practice within the community all influence patient admitting decisions and practice style and are therefore important provider characteristics. For example, I have reasoned that a physician who did a surgical residency in one institution was taught by mentors not only how to perform surgical procedures, but also the criteria that should be used to decide if and when surgery is necessary. One might therefore assume that those people who did their surgical residency at the same institution under the guidance of the same teachers would have a surgical practice pattern that was more similar to each other's than to those of graduates of other surgical residency programs. This idea of similarity could also be applied to medical specialties, where the physician practice patterns might be expected to have greater similarity within specialties than between specialties.

Practice patterns might also be affected by the length of time individual physicians have practiced in the same community. A young physician arriving in a new community might have practice patterns conditioned largely by his residency program. But, after a length of time in the community, the same physician might be expected to have adopted practice patterns more like the other physicians in the community. One might hypothesize that after a longer length of time practicing in the same community, a physician's practice pattern would be even more like the community practice pattern (community standard) and, given enough time, would probably be indistinguishable from it.

The small area analysis literature rarely deals with these hypotheses. Originally, this study was to have considered questions concerning how variations in use rates might be explained by the dominance of one residency training program, or one medical specialty, or by the length of time a physician had practiced within a community, but the data necessary to address these questions are highly confidential and were impossible to obtain within the time frame of this study.

One previous study, Roos et al. (1977), investigated the explanatory power of several physician characteristics and found that younger physicians trained in the United Kingdom had lower surgical rates and more restrictive criteria for surgery than did older physicians trained in North America. But overall, physician age, specialty, and place of training (United Kingdom or North America) did not account for the observed variation in surgical rates.

Only one measure of the physician component could be obtained for this current research, and that is the proportion of board certified physicians (specialists) to total physicians (specialists and non-specialists) in a hospital service area. One previous study, Connell et al. (1981), had tested the correlation between a specialist to non-specialist ratio and hospital admission rates. A non-significant positive association was found between the ratio of pediatricians to general practitioners and all but one of the seven hospital use measures tested. Additional research results from previous small area analysis literature that concern the supply of specialists will be discussed within the hospital component of the model since those studies address only the supply of specialist physicians and not the dominance of one specialty or non-specialty group of physicians within the hospital service area.

It would appear from previous research that the characteristics of physicians do affect the hospital use rates in their hospital service area. Therefore, I hypothesized that there would be a positive relationship between the proportion of board certified physicians to total physicians and both total admission and total surgery rates.

Component 4: The Hospital

The fourth component of the Clark Model (and the major focus of this research) is the hospital, which is the setting for the health care event. The hospital has its own institutional characteristics and, since it provides a place for the medical staff to practice medicine, has characteristics of its medical staff as well. Three types of hospital characteristics are the focus of this study. They are the supply of health care resources (hospital and staff), the services provided in the hospital, and the organization of the institution. These three types of hospital characteristics are hypothesized to influence the hospital use rates for all hospital events.

Supply of Health Care Resources:

The supply of hospital beds and the supply of physicians (both general practitioners and specialists) have been the most frequently studied health care resources in the small area analysis literature.

1. The Supply of Hospital Beds

Starting with Shain and Roemer (1959), there has been a suspicion that an over-abundance of available hospital beds per capita stimulated increased hospital utilization. This positive relationship between hospital beds and utilization has become known as "Roemer's Law". As shown on Table 2.4, the supply of hospital beds has been positively correlated with total admission, patient day, length of stay, total surgical admission, and non-elective surgery rates. The number of hospital beds has provided significant explanation for the variation in appendectomy, cholecystectomy, total surgery, total admissions, and patient day rates (white and total) in at least one study.

Six studies, shown in Table 2.4, found no significant correlation between hospital beds and use rates and one study reported that the supply of hospital beds provided a non-significant explanation for black patient day rates. From the results shown in Table 2.4, one can hypothesize that the number of hospital beds per capita will be positively related to total admission, medical causes for admission, and surgical procedure rates. One possible exception to the hypothesized positive relationship between hospital beds and use rates is hysterectomy rates.

TABLE 2.4

THE RELATIONSHIP BETWEEN HOSPITAL BED SUPPLY & UTILIZATION*

Positive Relationship

Shain & Roemer (1959)	beds / patient days		.84 correlation
Lewis (1969)	beds / appendectomy	S	contributor to explanation
"	beds / cholecystectomy	S	contributor to explanation
Anderson (1973)	beds / patient days		.94 correlation
"	beds / admissions		.83 correlation
"	beds / length of stay		.86 correlation
Chiswick (1976)	beds / admissions	S	contributor to explanation
Vayda _et al_. (1976)	beds / non-elect. surg. rate	S	+ correlation
Joffee (1979)	beds / admissions		.90 correlation
Mindell _et al_. (1982)	beds / tot. surg. rate	S	correlation in 2 of 5 yrs.
Mitchell & Cromwell (1982)	beds / tot. surg. rate	S	contributor to explanation
Wilson & Tedeschi (1984)	beds / surgical rate		very influential to explanation
"	beds / medical admissions		very influential to explanation
Knickman & Foltz (1985)	beds / admissions	S	contributor to explanation
"	beds / patient days	S	contributor to explanation
Wilson _et al_. (1985)	beds / white patient day rate	S	contributor to explanation

No or Negative Relationship

Vayda & Anderson (1975)	beds / elective surgery	NS	correlation
Deacon _et al_. (1979)	beds / admissions	NS	correlation
Connell _et al_. (1981)	beds / admissions	NS	.28 correlation
"	beds / tot. surgery	NS	.25 correlation
Brewer & Freedman (1982)	available beds / admissions	NS	.22 correlation
Roos, N. (1984)	beds / hysterectomy rate	NS	correlation
Wilson _et al_. (1985)	beds / black patient day rate	NS	contributor to explanation

S = significant   NS = not significant

*The results of the various authors' correlation and regression analyses are reported in this table exactly as given in each original article.

2. The Supply of Physicians

The relationship between the supply of physicians and hospital utilization has interested many researchers in small area analysis. Table 2.5 shows the published relationships between non-specialist physicians and hospital use rates. Non-specialist physicians (medical doctors (MDs), general practitioners (GPs) and physicians) were not consistently related positively or negatively to any of the use rate measures studied. Joffee (1979) found a positive association between physicians and total admission rates, while Deacon et al. (1979) and Brewer and Freedman (1982) found a negative one. Nor was there any consistent relationship between the supply of physicians and total surgery rates. Wennberg and Gittelsohn (1973) found a positive association and Connell et al. (1981) found a significant positive correlation between the supply of direct care physicians or primary care physicians and surgeons with total surgery rates. On the other hand, Detmer and Tyson (1978) found a significant negative relationship between GPs and surgery rate and Mitchell and Cromwell (1982) found that GPs provided a significant (and negative) contribution to the explanation of the variation in total surgery rates.

The relationship between specific surgical procedure rates and the supply of non-specialist physicians (Table 2.5) was found to be unique to the procedure and not always consistent within the articles reporting the results of correlation or regression analyses for each procedure. For example, Roos (1984) found no significant correlation between hysterectomy

TABLE 2.5

RELATIONSHIP BETWEEN NON-SPECIALIST PHYSICIAN SUPPLY & UTILIZATION*

Wennberg & Gittelsohn (1973)	GPs / total surgery		.19 correlation
"	GPs / T & A**		.42 correlation
"	GPs / appendectomy		.14 correlation
"	GPs / cholecystectomy		.24 correlation
"	GPs / varicose veins		.31 correlation
"	GPs / D & C		.38 correlation
"	GPs / hysterectomy		-.21 correlation
"	GPs / mastectomy		-.20 correlation
"	Physicians not practicing / surgical rates		-.44 correlation
Detmer & Tyson (1976)	GPs / T & A	S	+ correlation
"	GPs / appendectomy	S	+ correlation
Roos, N. _et al_. (1977)	Phys./ T & A	Not contributor to explanation	
Detmer & Tyson (1978)	GPs / total surgery	S	- correlation
"	GPs / cholecystectomy	S	- correlation
Deacon _et al_. (1979)	MDs / admissions	S	-.30 correlation
Joffee (1979)	Physicians / admissions		.42 correlation
Connell _et al_. (1981)	Dir. care MDs /tot. surg.	S	.58 correlation
"	Prim. care MDs /tot. surg.	S	.42 correlation
"	Dir. care MDs / ENT surg.	S	.54 correlation
Brewer & Freedman (1982)	MDs / admissions	NS	-.28 correlation
Mitchell & Cromwell (1982)	GPs / tot. surgery	S(-)	contributor to to explanation
Roos, N. (1984)	MDs / hysterectomy	NS	correlation
Wilson & Tedeschi (1984)	Phys./surg. admissions		Very influential in explanation
"	Phys./med. admissions		Low influence in explanation
Wilson _et al_. (1985)	Phys./black or white patient day rate	NS	contributor to explanation

S = significant NS = not significant

*The results of the various authors' correlation and regression analyses are reported in this table exactly as given in each original article.

**T & A = tonsillectomy and adenoidectomy rates and the supply of MDs, while Wennberg and Gittelsohn (1973) and Detmer and Tyson (1976) found a negative correlation between the supply of MDs and hysterectomy rates. Wennberg and Gittelsohn (1973) and Detmer and Tyson (1976) found positive correlations between tonsillectomy with adenoidectomy and the supply of GPs. According to Roos et al. (1977), the supply of physicians offered no significant explanation in the variation in tonsillectomy with adenoidectomy rates. Cholecystectomy rates were also reported as both positively (Wennberg and Gittelsohn, 1973) and negatively (Detmer and Tyson, 1978) related to the supply of non-specialists.

With the exceptions of Detmer and Tyson (1978), who found a negative relationship between the supply of surgeons and appendectomy, tonsillectomy with adenoidectomy (T & A in Tables 2.5 and 2.6), and inguinal hernia repair rates, and Mindell et al. (1982) who found no correlation between total surgery rates and surgeons, all other researchers (shown in Table 2.6) have found positive correlations between the supply of surgeons and total admission, total surgery and specific surgical procedure rates.

The correlations between the supply of surgeons and hospital utilization have been as low as .07 (Wennberg and Gittelsohn, 1973) for varicose vein stripping rates and as high as .70 (Vayda and Morrison, 1976) for total surgical rates. Vayda et al. (1975) found that the supply of surgeons explained sixty-seven percent of the variation in the total elective surgery rate.

TABLE 2.6

RELATIONSHIP BETWEEN SURGEON SUPPLY AND UTILIZATION*

Wennberg & Gittelsohn(1973)	Gen. Surg. / total surgery		.54 correlation
"	Gen. Surg. / T & A**		.46 correlation
"	Gen. Surg. / appen.		.31 correlation
"	Gen. Surg. / cholecystectomy		.48 correlation
"	Gen. Surg. / hysterectomy		.39 correlation
"	Gen. Surg. / mastectomy		.48 correlation
"	Gen. Surg. / varicose veins		.07 correlation
"	Gen. Surg. / D & C		.08 correlation
Vayda & Anderson (1975)	Surg./ tot. elective surgery		.67 R^2
Chiswick (1976)	Surg. / admissions	S	+ correlation
Detmer & Tyson (1976)	Surg. / total surgery	S	+ correlation
"	Surg. / appendectomy	NS	correlation
Vayda *et al*. (1976)	Surg. / total surgery	S	.67, .69, .70 correlation for 3 of 5 years
Detmer & Tyson (1978)	Gen. Surg. / tot. surg.	S	+ correlation
"	Gen. Surg. / hysterectomy	S	+ correlation
"	Gen. Surg. / appendectomy	S	- correlation
"	Gen. Surg. / T & A	S	- correlation
"	Gen. Surg. / hernia	S	- correlation
Connell *et al*. (1981)	Surg. / total surgery	S	.50 correlation
Mindell *et al*. (1982)	Surg. / total surgery	No	correlation
Wilson & Tedeschi (1984)	Surg. / surgical admissions		Very influential in explanation

S = significant
NS = not significant
*The results of the various authors' correlation and regression analyses are reported in this table exactly as given in each original article.
**T & A = tonsillectomy and adenoidectomy

Small area analysis researchers have also investigated the relationship between use rates and the combined supply of non-specialty physicians and surgeons (Table 2.7). Lewis (1969) reported that fifty-two percent of the variation in tonsillectomy with adenoidectomy rates and forty-nine percent of the variation in inguinal hernia repair rates were explained by the supply of non-specialty physicians and surgeons. On the other hand, Knickman and Foltz (1985) found no significant contribution to the explanation of the variation in admission rates when a combined total of non-specialty physicians and surgeons was used in the regression. With the exception of a negative relationship between ear, nose, and throat (ENT) specialists and tonsillectomy with adenoidectomy rates found by Detmer and Tyson (1978), all other specialist to use rate relationships were positive.

Based on the previous small area analysis literature, I hypothesized that the supply of surgeons would be positively related to surgery rates but that the relationship between the supply of non-specialized physicians and specific specialists to procedure-specific use rates would be idiosyncratic. A measure of the supply of physicians within a hospital service area was not available in the database used, so related hypotheses could not be tested.

TABLE 2.7

RELATIONSHIP BETWEEN PHYSICIAN SUPPLY AND UTILIZATION*

	Non-Specialists and Surgeons	
Lewis (1969)	Phys. & Surg. / T & A**	.52 R^2
"	Phys. & Surg. / hernia	.49 R^2
Wennberg & Gittelsohn (1973)	Phys. & Surg. performing surgery / total surgery rate	S .64 correlation
Cageorge et al. (1981)	Operating Phys. / cholecystectomy	NS correlation
Knickman & Foltz (1985)	GPs or Surg. / admissions	NS contributor to explanation
	Specialist Physicians	
Detmer & Tyson (1976)	ENT‡ specialists / T & A	S - correlation
Detmer & Tyson (1978)	ENT specialists / T & A	strong - correlation
"	Internists / total surgery	S + correlation
"	Internists / hysterectomy	S + correlation
Connell et al. (1981)	Pediatricians / total surgery	NS .18 correlation
"	Otolaryngologists / total surgery	NS .33 correlation
Knickman & Foltz (1985)	Non-surgical specialists / adm.	S contributor to explanation

S = significant
NS = not significant
* The results of the various authors' correlation and regression analyses are reported in this table exactly as given in each original article.
** T & A = tonsillectomy and adenoidectomy
‡ ENT = ear, nose, and throat

3. The Supply of Registered Nurses

Only one published small area analysis study has dealt with the role that registered nurses play in explaining use rates. Hammond (1985) investigated the relationship between home health nurses and Medicare home health visits. He found a positive correlation between home health nurses per beneficiary and visits per beneficiary. Although this was not conclusive evidence for hospital use rates, using the same logic, one could hypothesize that the supply of registered nurses in a hospital would have a significant positive impact on the total admission rates and the medical causes for admission rates if the number of nurses per bed was free to move in response to economic pressures. But Michigan in 1983 did not have an unregulated environment. In the regulated hospital environment of 1983 the total number of licensed beds in the state was restricted. The number of beds could not increase but could decrease if the hospital felt it was necessary to temporarily take beds out of service. In an unregulated environment, an increase in the number of patients would require an increase in the number of nurses. But, in fact, Michigan was experiencing a decrease in the number of patients and patient days in 1983. Hospitals were decreasing the number of beds they staffed with nurses while regulations continued to require a specific number of nurses per bed (particularly for specialty beds such as in intensive care units). As a consequence, the nurse to bed ratio would be expected to increase as the number of patients decreased. Therefore, I hypothesized an inverse relationship between registered nurses per bed and total admission and medical admission rates.

Services Provided in the Hospital:

No study within the small area analysis literature has attempted to examine the relationship between the services offered in a hospital and its utilization. One study (Hammond, 1985), determined that a measure of the services offered to medicare home health beneficiaries was the single variable which offered the largest part of the explanation (7.2 percent) of the variation in home health benefits. Using Christaller's central place hierarchy as a model for the hospital industry, I hypothesized that a hospital with a larger number of services would provide care to a larger number of patients and, therefore, the number of services in a hospital would be positively related to use rates.

Organizational Characteristics of the Hospital:

1. Progressive or Conservative Hospital Philosophy

   In this time of increased regulatory and reimbursement pressure on hospitals, the role of the hospital administration is increasingly important and can be critical to the stability and health of the institution. Along with the medical staff and the board of trustees, the hospital administration is responsible for defining the admission policies of the institution. Anderson and Lomas (1985, p. 253) found that the "differences in the patient characteristics and the availability of resources appeared less important in explaining these (cesarean section) rate variations than differences in [administrative] policy." Further, they felt that the variability in the cesarean section rates indicated that new criteria for decision-making which were available in the medical literature were being ignored by obstetricians and/or administrators. This suggested to me that the progressive or conservative attitude of the hospital's administration and medical staff may be important predictors of utilization.

One difficulty was finding a measure or measures for the progressive nature of administration and staff. My intuitive reaction was to use the number of hospital bed (bed size) as the surrogate measure for progressiveness. This intuitive reaction was strengthened by the results of one small area analysis study that reported high diabetes admission rates in small hospitals. Connell *et al*. (1984) had found that the preponderance of hospitals in counties in Washington with high diabetes admission rates were small institutions and that seventy percent of the diabetes admissions in the high-use counties were to small or medium sized hospitals. They also found that hospitals in high-rate counties admitted proportionally more mildly ill patients and made less thorough use of lab tests. If one can generalize from this one study, all of the evidence from Connell *et al*. indicated that small hospitals were less well run and slower to respond with administrative policy changes to changes in technology or care protocols than were larger hospitals.

But, my observation is that the stereotype of small hospitals in backwater communities with out-of-date administrators is not the current state of affairs in Michigan. I decided that a better surrogate measure for progressive or conservative hospital philosophy would be the change in the number of services offered from one time in the past to the present (1981-1983 for this study). A large change, either positive or negative, would indicate that the hospital administration was making a progressive move by either increasing or decreasing the services offered in an attempt to redesign their product to better position the hospital in their current market area.

Outpatient visits per capita were used as a second measure of the progressive or conservative philosophy of the hospital administration because it is to the financial advantage of a hospital to move as much of its surgery to an outpatient setting as possible. Therefore, a high outpatient visit per capita use rate ought to indicate a progressive administration and there should be an inverse relationship between outpatient visits per capita and use rates. Brewer and Freedman (1982) reported a significant negative correlation (-.47) between outpatient visits and admissions in Vermont.

It was hypothesized that a large change (positive or negative) in the number of services offered in a hospital service area would be associated with increasing hospital use rates. It was also hypothesized that as the outpatient visits per capita increased, the total admission (inpatient) use rates would decrease. Since the surgical procedures studied could not be performed in an outpatient setting, the outpatient visits per capita was hypothesized to have no strong relationship to any of the seven surgical procedure rates.

2. Teaching Status

Several small area analysis articles have dealt with the impact of teaching hospitals on an area's use rates. Stockwell and Vayda (1979) found that counties with teaching hospitals had consistently lower surgical procedure rates for tonsillectomy & adenoidectomy, hysterectomy, cholecystectomy, appendectomy and colectomy than counties without teaching hospitals. In a later study Vayda et al. (1984) added prostatectomy and mastectomy to their list of surgical procedure rates that were lower in areas with teaching hospitals. Cesarean section rates were not found to be lower in areas with teaching hospitals. Vayda and his associates also found a positive correlation between health care resources (surgeons and hospital beds) and teaching status. Knickman and Foltz (1985) found that the supply of medical interns and residents was not a significant contributor to the explanation of the variation in admissions.

Anecdotal evidence in Michigan supported the notion that areas with teaching institutions, such as Ann Arbor and Grand Rapids, had lower use rates. This was not consistently observed, since Detroit and Flint both have teaching hospitals but also had higher than average use rates. I hypothesized that areas with teaching hospitals would have lower use rates than areas without teaching hospitals and that there would be an inverse relationship between teaching status and use rates. Teaching status was measured by the total number of interns and residents (house staff) per capita.

Summary

There are four components in the Clark Model and characteristics of each of these components contribute to the explanation of hospital use rate variation. The first, the individual, cannot be tested as a contributor to the explanation of the variation in hospital use rates because characteristics of an individual exist only in that person and cannot be aggregated. The second component, the community, does have testable characteristics. Community characteristics will not be tested for their explanatory powers in this current research, but will be considered when the residuals from the regression equations are examined.

Previous research has tested the explanatory strength of several characteristics of the third component, the physician, but found that age, specialty and place of training (United Kingdom or North America) did not account for the variation in surgical rates (Ross et al., 1977). One measure of the physician component, the weighted proportion of board certified physicians, will be tested in this research and is hypothesized to have a positive relationship with hospital use.

The fourth component of the Clark Model, the hospital, is the major focus of this research. Previous small area analysis research has tested the explanatory power of several characteristics of hospitals. A positive relationship was found between the supply of hospital beds and hospital use. Therefore, I have hypothesized a positive relationship between the two in this research. Previous small area analysis research also found a positive relationship between the supply of physicians and hospital use. Since the supply of physicians could not be measured for this current research, the explanatory power of this variable could not be tested. The supply of registered nurses in a hospital has not been previously tested, but the supply of home health nurses was positively related to the number of nurses' visits per Medicare beneficiary. Due to the regulatory atmosphere in Michigan, I hypothesized an inverse relationship between RNs per bed and hospital use.

Only one previous study tested the relationship between services offered and use rates. Hammond (1985) found that the services offered to home health beneficiaries explained 7.2% of the variation in home health benefits used. I have hypothesized a positive relationship between the availability of hospital services and hospital use.

Two organizational characteristics of hospitals have been previously studied. The first, the progressive or conservative philosophy of the hospital administration was found to be of more importance in explaining Cesarean section rates than either differences in patient characteristics or the supply of resources (Anderson and Lomas, 1985). Two measures of the conservative or progressive philosophy of the hospital administration were designed for this current research to test their power in explaining hospital use rates.

The second organizational characteristic of the hospital component previously tested was teaching status. Several researchers have found a negative relationship between teaching status and many surgical procedure rates. I have hypothesized a negative relationship for all hospital use rates with the exception of Cesarean section rates. The hypotheses used in this current research are further discussed and summarized in Chapter 3.

Definition of Hospital Service Area

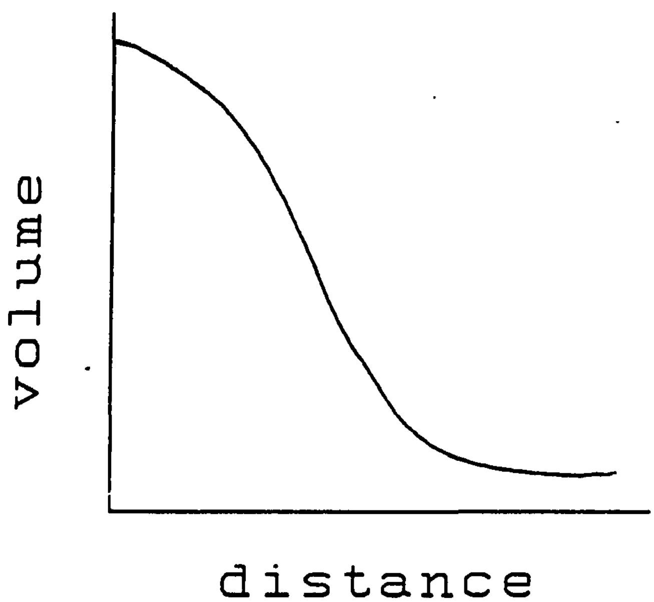
As discussed earlier, one of the additional aspects of the Clark Model is the recognition that all of the influences and activities that produce a hospital admission take place within a defined hospital service area. Medical geographers have long been interested in the definition of hospital service areas, and at least three lines of research support the integrity of the hospital service area. The first line of research is concerned with distance decay. A classic and seminal research paper was published in the Medical and Surgical Journal of Boston (now the New England Journal of Medicine) in 1850 with a following paper in the American Journal of Insanity (now the American Journal of Psychiatry) in 1852. Written by a medical doctor, Jarvis, these two papers form the basis in medical geography literature for Jarvis' Law, which states that the use rate for any medical facility will be greater at a point nearer the facility and less at a point farther away from that facility. In more recent literature geographers have explored the question of access using both spatial and temporal measurements from the location of the patient to the medical facility. In a recent paper, Hunter, Shannon and Sambrook (1985) re-evaluated Jarvis' data and found (as he had) that the state mental asylum of the 1850's was, in reality, a local asylum with almost ninety percent of its patients from within sixty miles of the facility.

Drosness *et al*. (1965), Lubin *et al*. (1965), and Drosness and Lubin (1966) used distance decay curves of either hospital market share or percent of total inpatient population to determine that the largest portion of a hospital's inpatients came from within fifteen minutes travel time from the facility. The researchers were able to create hospital service areas which were service or disease specific. In every instance the distance decay curve looked very similar to the curve shown in Figure 2.2. Morrill and Earickson (1968; and subsequent papers), DeVise (1966) and Cherniack and Schneider (1967) used patient travel patterns in Chicago and Cincinnati to define hospital spheres of influence or trade areas. The difficulty with spheres of influence is that the defined areas are not unique and therefore have less usefulness for planning and regulation. A unique population at risk is necessary for the denominator in any use rate equation or for age and sex standardization of use rates. Pigozzi (1969; see also other references cited therein) used a modification of Christaller's central place theory to produce Thiessen polygons which defined hospital service areas.

A second line of study used by researchers to establish independent hospital service areas has been to map trips to hospital facilities and delineate the natural catchment areas where there was little, if any, "border crossing" by patients. Using this method, Mountin et al. (1945) not only stressed the need for independent geographic units for comparison and planning, but also delineated a functional hierarchy of 125 regional areas for health care in the United States. Working in western Pennsylvania, Ciocco and Altman (1954) established independent hospital service areas which had almost no patient travel across boundaries for either physician or hospital care. In a similar study in Kansas and Missouri, Poland and Lembcke (1962) delineated 130 hospital service areas that differed in size and population, but had distinctive "population divides" that patients seemed not to cross for medical care. Using physician questionnaires, Dickinson et al. (1949, 1951,

Figure 2.2

Distance Decay Curve



1954, 1954) established 757 geographically defined service areas and assessed their stability over a period of time, making comparisons on such characteristics as size, population, hospital bed to population ratios and physician to population ratios.

The third line of study followed by medical geographers has been to delineate hospital service areas using one of the family of gravity models. The use of gravity models has not been as widespread as one might assume among medical geographers. Shannon et al. (1969) used a modified gravity model to explain the relationship between the distance from a patient's residence to the hospital where that patient received care. Morrill et al. (1970) developed a simulation model in Chicago to account for distance, size of hospital, and several potential intervening opportunities based on racial and religious characteristics of the patients. Morrill and Earickson (1968) reached the conclusion that a gravity model was more successful in defining the hospital service areas of medium to small hospitals than for larger, urban hospitals.

There are two difficulties in using a gravity model to define hospital service areas. The first is that there is overlap in the catchment areas, so that the service areas are not unique. The second problem is that in urban areas where hospitals cluster it is extremely difficult to define individual hospital service areas. Pyle (1979) graphically displayed the shape, size, and extent of each of sixteen hospital service areas in six counties of northeastern Ohio. After constructing an isoline map with overlapping lines surrounding each of the sixteen hospitals, he then drew demand cones for each hospital, showing their overlap and relative size. Pyle's work demonstrated the need to aggregate individual hospital service areas into larger, community-level hospital service areas when doing population-based research such as small area analysis.

Designed by geographers interested in market research, the multiplicative competitive interaction (MCI) model is a new addition to the family of gravity models that has recently appeared in the medical geography literature. Folland (1983) used a MCI model to predict hospital market shares for inter-city hospital trade in a predominantly rural area. Distance alone accounted for over half of the variance in the market shares. Cohen and Lee (1985) produced separate models for several socio-economic and age groups as well as for several medical services, because they felt that the use rates in hospital service areas might be different for subgroups of the population. The model allowed them to relate the probability of hospital selection to such hospital and environmental factors as travel time between residence and hospital, hospital and physician characteristics, and patient characteristics. Cohen and Lee were able to explain eighty percent of the variation in use rates. Erickson and Finkler (1985) used the MCI model to focus on the physician characteristics within individual hospital service areas rather than across an aggregated cluster of hospitals. They found that the number of physician affiliations with a hospital had a significant impact on the market share of that hospital.

Small Area Analysis Definitions

Small area analysis researchers understood that the definition of the geographic area was very important because the area must contain the patients, the community (population), and its health care resources. Previous small area analysis studies used a range of geographic boundaries from those based on pre-existing administrative or political units to those, such as hospital market and service areas, defined by the researcher. States, standard metropolitan statistical areas (SMSAs), counties and minor civil divisions (MCDs) are common choices for pre-existing political boundaries.

> Counties have the advantage of being relatively small but the disadvantage of being suspect as a basis upon which to match populations and medical care resources. SMSAs and states have fewer boundary problems, allowing the matching of population and resources, but are so large that internal variations, both of population characteristics and of the level and organization of medical care resources, can result. In consequence, the governing assumption -- that the population faces a defined set of medical care resources and that the characteristics of both explain the resulting hospital use -- is suspect" (Wilson & Tedeschi, 1984, p. 335).

In response to the problems identified in utilizing political boundaries, a number of researchers moved to create geographic areas for analysis which were defined by the population's use of its medical resources. By defining a small geographic area the researcher has the best opportunity to examine the relationships between the health resources present and the community's use of those resources. Whereas in previous research the geographic scale of the study was usually a nation, state, province or region, now with the advent of computer data bases and the application of small area analysis methods, the smaller geographic area of observation allows the researcher to better match the population with the health care resources they use.

Two definitions of hospital service areas appeared early in the small area analysis literature: the plurality definition of Wennberg and Gittelsohn (1973) and the Relevance Index definition of Griffith (1978). Each was based on the assumption that the population (and therefore the patients) were equally distributed across the "small area" being studied.

Wennberg and Gittelsohn (1973) defined a hospital service area using a patient origin plurality measure. To create a hospital service area using this definition, a zip code's or MCD's population and patients were assigned to the hospital service area where the greatest number of patients from that zip code received care historically. Four zip codes are shown in Figure 2.3. Three of them have a hospital located within them and are assumed, for the purposes of this illustration, to have a plurality of the patients within their own zip code receiving care at the hospital within that zip code. It is the allocation of zip code X, which does not have a hospital within it, that is at question. As shown in Figure 2.3, 40 percent of the patients from zip code X received medical care at hospital A, 35 percent at hospital B and 25 percent at hospital C. Using Wennberg's plurality definition of a hospital service area, all of the patients and population from zip code X would be included in hospital A's service area since that is where the plurality of patients historically received care. Zip code X would then be mapped as lying within hospital A's service area.

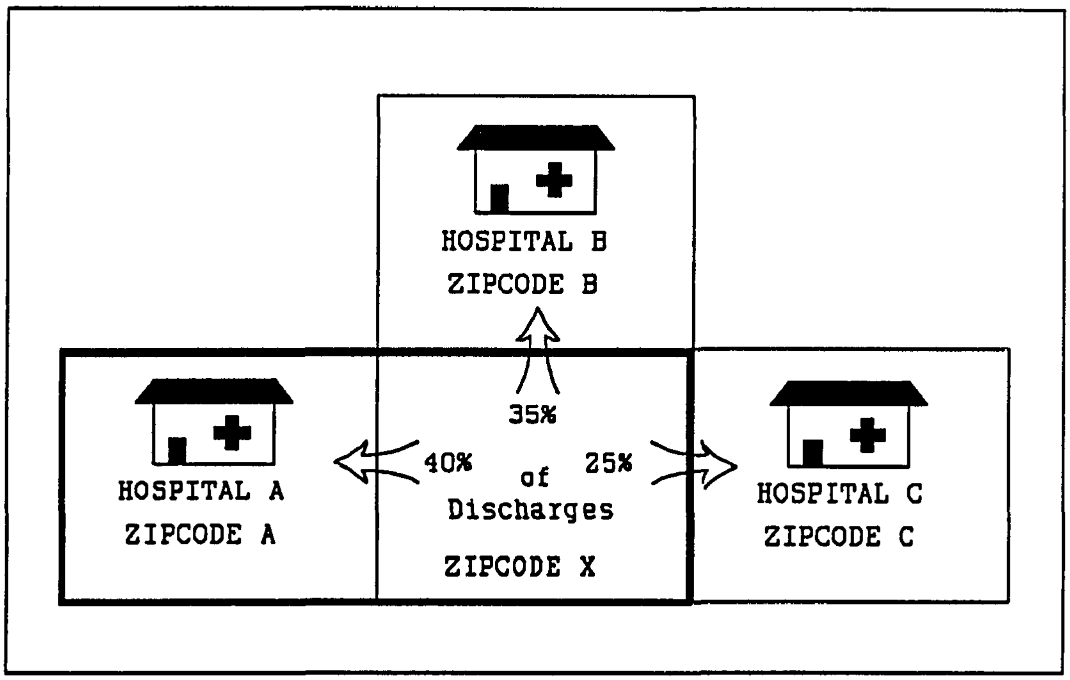


Figure 2.3

Wennberg's Plurality Definition
of a Hospital Service Area

The aggregation of individual hospitals and their service areas into a larger hospital service area can also be illustrated using Figure 2.3. In the example above, the allocation of zip code X's patients and population was in question. The same criteria for allocation (the plurality of historical patient use) can be used for zip codes B and C. The patients and population of zip code B and/or C will be allocated to hospital A's service area if a plurality of zip code B's or C's patients received care at hospital A historically, even if there are hospitals present in zip code B and/or C. For example, using Wennberg's plurality measure in South Central Michigan, even though Eaton Rapids, Mason and St. Johns each has a hospital, the zip codes in each community are allocated to Lansing's hospital service area because historically a plurality of patients from each of the three communities has received care in Lansing hospitals.

In contrast to the plurality model previously described, Griffith's (1978) Relevance Index used a more complex method of assigning patients and population to hospital service areas. Within each zip code, the proportion of patients who received care at each competing hospital was determined. Each competing hospital service area was then assigned its proportion of the zip code's patients and population. For zip code X shown in Figure 2.4, 40 percent of the population would be assigned to hospital A's service area, 35 percent to hospital B's and 25 percent to hospital C's. Since each of the hospitals in the example was located in a separate community, the zip code would be split into three pieces, with each piece proportional to its patient volume and assigned to a

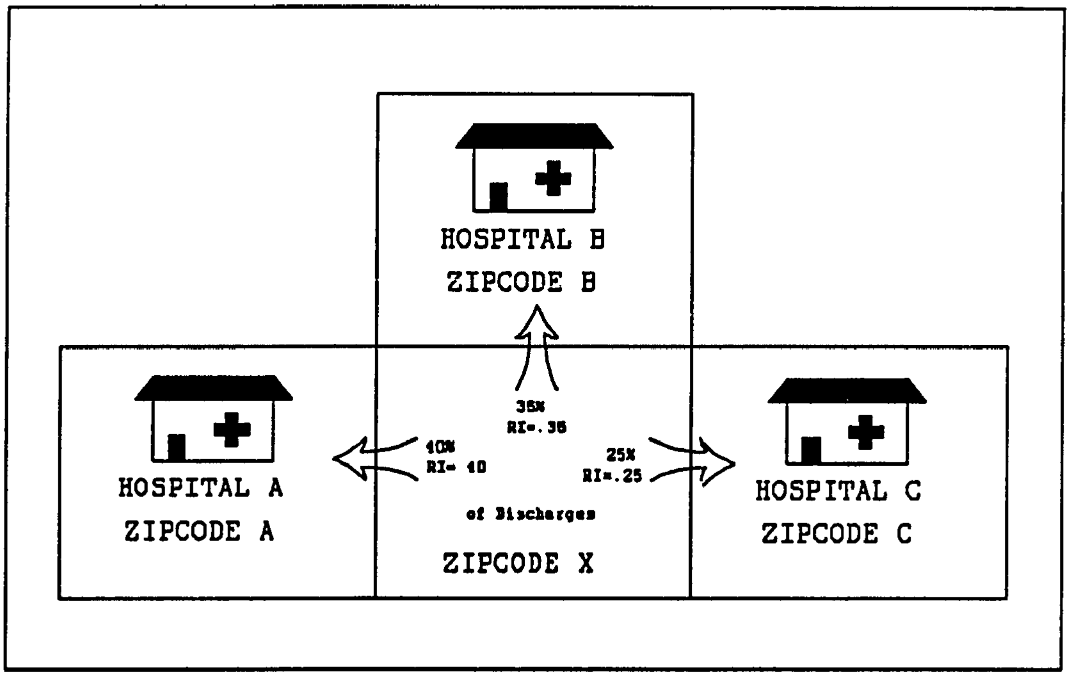


Figure 2.4

Griffith's Relevance Index Definition
of a Hospital Service Area

separate hospital service area. The zip codes were never actually split graphically because Griffith never mapped any hospital service area.

Only one paper has reported the results of a comparison of the impact that changes in the areal definition of a service area had upon utilization rates. Tedeschi and Martin (1983) tested Wennberg's plurality model and Griffith's Relevance Indices (using both a straight assignment based on proportion and a 12.5 percent market penetration measure) and found the overall use rates from the three definitions of hospital service area (one from Wennberg and two from Griffith) to be highly intercorrelated and that an approximate linear relationship existed between each pair of variables. Shaughnessy (1982) felt that the Relevance Index more accurately described a hospital's service area, while Sigmond et al. (1981) felt that Griffith's method systematically underestimated use rates of small rural areas. Because of serious technical problems experienced with the Relevance Index, almost all small area analysis studies which have aggregated zip codes or MCDs and were written after 1978 have used the plurality definition based on historical patterns of total admissions. The plurality definition of hospital service area was also used in this current research, where the hospital service area defines the geographic limits of the "community" component of the Clark Model.

CHAPTER 3

METHODS AND GENERAL HYPOTHESES

Focus of the Study

Review of the small area analysis literature (in Chapter 2) established that small area analysis research has attempted to do three things: 1) document the variation in utilization rates from one small area to another; 2) determine what patterns were apparent in the variation; and 3) determine what independent variables explained that variation. Although a few previous researchers in small area analysis have tested the explanatory power of a small number of health care resource supply characteristics (physicians, specialists, hospital beds, and empty hospital beds), the major focus of the previous research has been the explanatory power of community characteristics.

My research determined the amount of variation found in fourteen measures of hospital utilization among fifty-three non-metropolitan Detroit communities in the southern peninsula of Michigan. The research answered several questions: Was there variation in hospital use rates, and how did the variability in Michigan hospital use rates compare to previous results in Michigan and elsewhere? Were the use rate patterns reported in the small area analysis literature found also in Michigan and were there spatial patterns among the use rates? What relationships were found between different hospital use rates and between use rates and the provider characteristics? How much of the variation in hospital use rates was explained by the supply of health resources within a community and how much was explained by the hospital services offered and the organizational characteristics of the hospitals themselves?

Study Area and Time Frame

The study area for this research included all of the southern peninsula of Michigan with the exception of metropolitan Detroit. Detroit was excluded from this research for two reasons. First, small area analysis is most successful in defining hospital service areas in regions where there is some distance between one cluster of hospitals and another cluster. Second, since approximately one-half of all of Michigan's hospital inpatients are cared for in the Detroit metropolitan area hospitals, the cost of using the data base, if the Detroit metropolitan area had been included, would have been prohibitively expensive. Figure 3.1 shows the hospital service areas included in the research. The hospital inpatient records for all patients from the study area for the calendar year 1983 were analyzed; the data for 1983 was the most recent data available at the time this study was initiated.

Consistent with small area analysis methodology and for reasons of comparability, this study used the 1983 Michigan hospital service areas as defined by John Griffith and his associates at the University of Michigan. They used John Wennberg's plurality method for assignment of

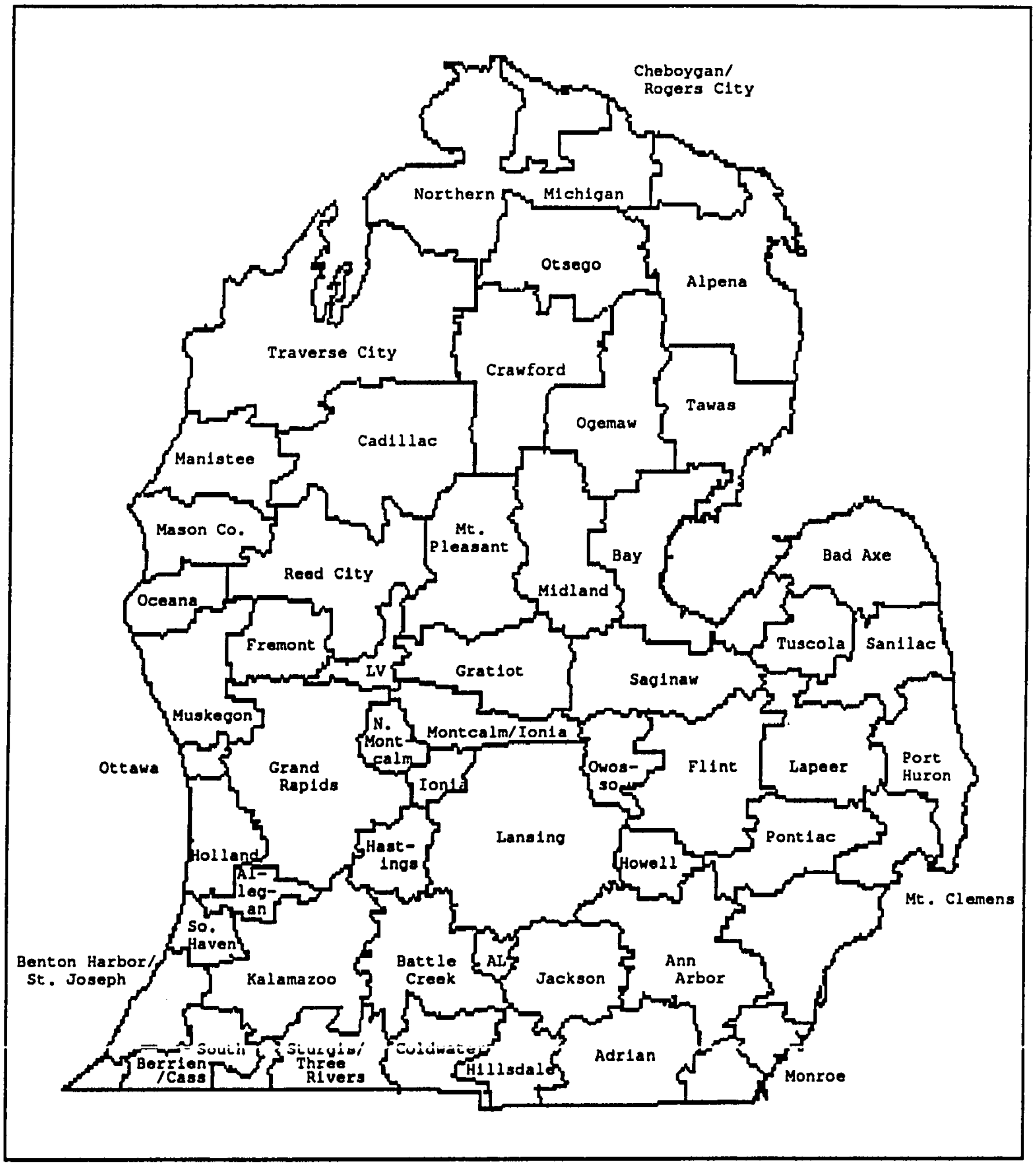


Figure 3.1

Michigan Hospital Service Areas Included in Study Area.

(Abbreviations used: LV = Lake View; AL = Albion) zip codes to hospital service areas. Every zip code in the study area was assigned to the hospital service area where the plurality of its total patients historically had received care. Every zip code in the study area has, therefore, been assigned to one hospital service area.

As illustrated in the Clark Model, two assumptions underlie small area analysis methodology. The first assumption deals with the health care resources a community contains while the second assumption has to do with the allocation of patients to a hospital service area.

1) The population of a hospital service area uses a single set of health care resources within the community, no matter how many hospitals exist within that community. This means that for hospital service areas that contain more than one hospital, the individual hospital characteristics, such as the number of beds, are aggregated into a single hospital measure for that hospital service area. Therefore, for the Clark Model and for the purposes of this research, the term "hospital" may refer to a single hospital or a hospital cluster of two or more hospitals, depending on whether one or several hospitals exist within a hospital service area ("community").

2) The patients residing in a defined hospital service area (the "community" in the Clark Model) go to the hospital(s) within that service area. The utilization rate for a hospital service area, then, is the number of patients in the service area divided by the total population. No matter where hospital care is received by a patient, the occurrence of that health care event is assumed to have taken place in the hospital service area of the patient's residence. Even if a hysterectomy was performed at a referral center a hundred miles from the patient's residence, the hysterectomy was counted as having occurred at

a hospital in the same hospital service area where the patient resided.

This assumption is problematic because of the number of individuals who could potentially leave any hospital service area to receive care in another hospital service area. Migration is both in and out of any given service area. But because it would not be possible to adjust the population at risk for every patient removed from or added to a hospital service area, small area analysis methodology returns each migrating patient back to his place of residence so that the numerator (patient) is indeed taken from within the denominator (population). The procedure-specific and diagnosis-specific use rates included in this current research were chosen to minimize the migration problem.

The extent of the migration problem was checked by determining the migration from "outstate" zip codes into the metropolitan Detroit area. Since Detroit is the largest referral center in the state, it was used as a case study to test if migration was a problem. To do this, the number of patients who were cared for in metropolitan Detroit was determined. As shown in Table 3.1, the total number of patients who went to Southeast Michigan for hospital care was less than eight percent for all but three of the outstate hospital service areas. It was decided that, with the additional safeguards described later in this chapter, this percent was small enough that not being able to adjust for migration should not affect the results of this study. This methodological problem was discussed with a prominent small area analysis researcher (Tedeschi, personal communication, 1987) who agreed

Table 3.1

Patient Migration

Cluster #	Hospital Service Area	Total Pts.	Cared for in SE Hospitals Total Pts.	% of Total
1	Port Huron	22,012	NA	NA
2	Pontiac	63,020	NA	NA
3	Howell	4,549	NA	NA
4	Ann Arbor	41,310	NA	NA
5	Mt. Clemens	39,693	NA	NA
6	Monroe	13,123	NA	NA
14	Lansing	56,709	NA	NA
15	Hillsdale	5,684	NA	NA
16	Adrian	55,022	NA	NA
17	Jackson	23,842	NA	NA
18	Battle Creek	22,414	NA	NA
19	Albion	3,131	NA	NA
20	Benton Harbor/St. Joe	20,041	419	02
21	Kalamazoo	33,641	702	02
22	South Haven Comm.	3,965	88	02
23	Hastings	4,626	82	02
24	Coldwater	6,877	356	05
25	Three Rivers/Sturgis	8,101	233	03
26	S. Berrien/Cass	13,766	250	02
27	N. Montcalm	5,140	87	02
28	Freemont	3,578	96	03
29	Lakeview	2,088	30	01
30	Reed City	7,805	205	03
31	Ottawa	4,695	69	01
32	Kent Co./Grand Rapids	61,594	921	01
33	Muskegon	23,953	414	02
34	Montcalm/Ionia	5,348	77	01
35	Allegan	2,763	39	01
36	Mason County	4,302	95	02
37	Holland	12,316	184	01
38	Oceana County	2,552	17	01
39	Ionia	3,110	43	01
40	Flint	77,433	0	00
41	Lapeer Co.	12,193	0	00
42	Owosso	7,639	323	04
43	Bay	24,951	904	04
44	Saginaw	38,197	1,180	03
45	Tuscola	5,037	309	06
46	Bad Axe	7,412	604	08
47	Sanilac	4,857	778	16
48	Midland	12,413	576	05
49	Mt. Pleasant	11,170	493	04
50	Tawas	5,047	393	08
51	Ogemaw	5,826	391	07
52	Gratiot	9,460	190	02
53	Petoskey	10,034	290	03
54	Cheboygan/Rogers City	4,979	161	03
55	Otsego	3,449	221	06
56	Crawford	5,071	319	06
57	Traverse City	16,988	545	03
58	Cadillac	7,683	233	03
59	Manistee	3,680	89	02
60	Alpena	7,186	362	05

Pts. = Patients
NA = Data not available

with my decision and recommended that I use the current small area analysis methodology, which returns the patient to the hospital service area of residence.

The fourteen hospital use rates (specific diagnoses and procedures) used in the current study were chosen to minimize the number of patients migrating from one hospital service area to another. These fourteen included three types of use rates (see also Figure 3.3, p. 59). The first type included three measures of total admissions (male, female, total), the second included seven specific surgical procedures (appendectomy, hemorrhoidectomy, cholecystectomy, inguinal hernia repair, prostatectomy, hysterectomy, cesarean section), and the third included four broad classes of medical diagnoses (circulatory, respiratory, digestive, genito-urinary). The surgical procedures and medical causes for admissions were chosen in part because they were not technically difficult for the hospital to perform or to care for, nor were the patients who were admitted, or who received the surgical procedure, extremely ill. As a consequence, all the procedures and diagnoses could be handled in any general acute care hospital within each hospital service area as shown in the model. It was felt that the choice of pre-existing hospital service areas and specific diagnoses and procedures maximized the comparability of the results and minimized the problems of patient migration.

Sources of the Data

Procedure and Diagnosis Occurrences

The fourteen hospital use rates were calculated for each hospital service area from data obtained from the Michigan Health Data Corporation (MHDC) through the Michigan Hospital Association's (MHA) Interactive Data System (IDS). The MHDC is a consortium of twelve Michigan institutions that are interested in health care data. One purpose of the MHDC is to produce a data base that has been politically agreed upon by all members and can, therefore, be used as a single data source for all discussions among the membership. The MHDC membership includes, among others: the MHA, the Michigan State Medical Society, the Michigan Department of Public Health, the Blue Cross and Blue Shield Corporation of Michigan and the three largest publicly funded universities (Michigan State University, Wayne State University and the University of Michigan). This data base is called the Michigan Inpatient Data Base (MIDB) and is now available for the calendar years 1980 - 1986, although only 1980 - 1983 data were available at the time this research was initiated. Each annual data base contains almost 1.5 million records and approximately fifty-six variables for every inpatient admission to acute care hospitals in Michigan for that year. Included in the variables are the international codes (ICD-9-CM codes) for each diagnosis and procedure, the zip code of the patient's residence, the sex and the age of each patient.

Access to this data base was granted after review by the Research Subcommittee of the MHA's Data Management Committee, the Data Management

Committee, the Executive Board of the Hospital Research and Educational Reserve of Michigan, Inc., and the Access and Oversight Committee of the Michigan Health Data Corporation. Since eighteen of the fifty-three hospital service areas included in the study area are "sole community providers" (a hospital service area with a single hospital within it), access to the Michigan Inpatient Data Base was granted with the understanding that the data from the sole community provider hospital service areas could be analyzed, but that the data from these eighteen areas would never be identified by hospital service area in a table or on a map. Figure 3.2 shows the location of the eighteen sole community provider hospital service areas. The regions within which they are located will be used to give their general location in later chapters. The regions are shown in Figure 5.4.

Population

The 1980 age and sex-specific population figures by zip code were obtained from the MHDC's population data base, POPZIP, which is available on the IDS and was produced from the official population figures of the Michigan State Demographer. The 1980 population figures were chosen to standardize the 1983 hospital data because the 1980 census data were based on actual census counts whereas the 1983 population data were estimates.

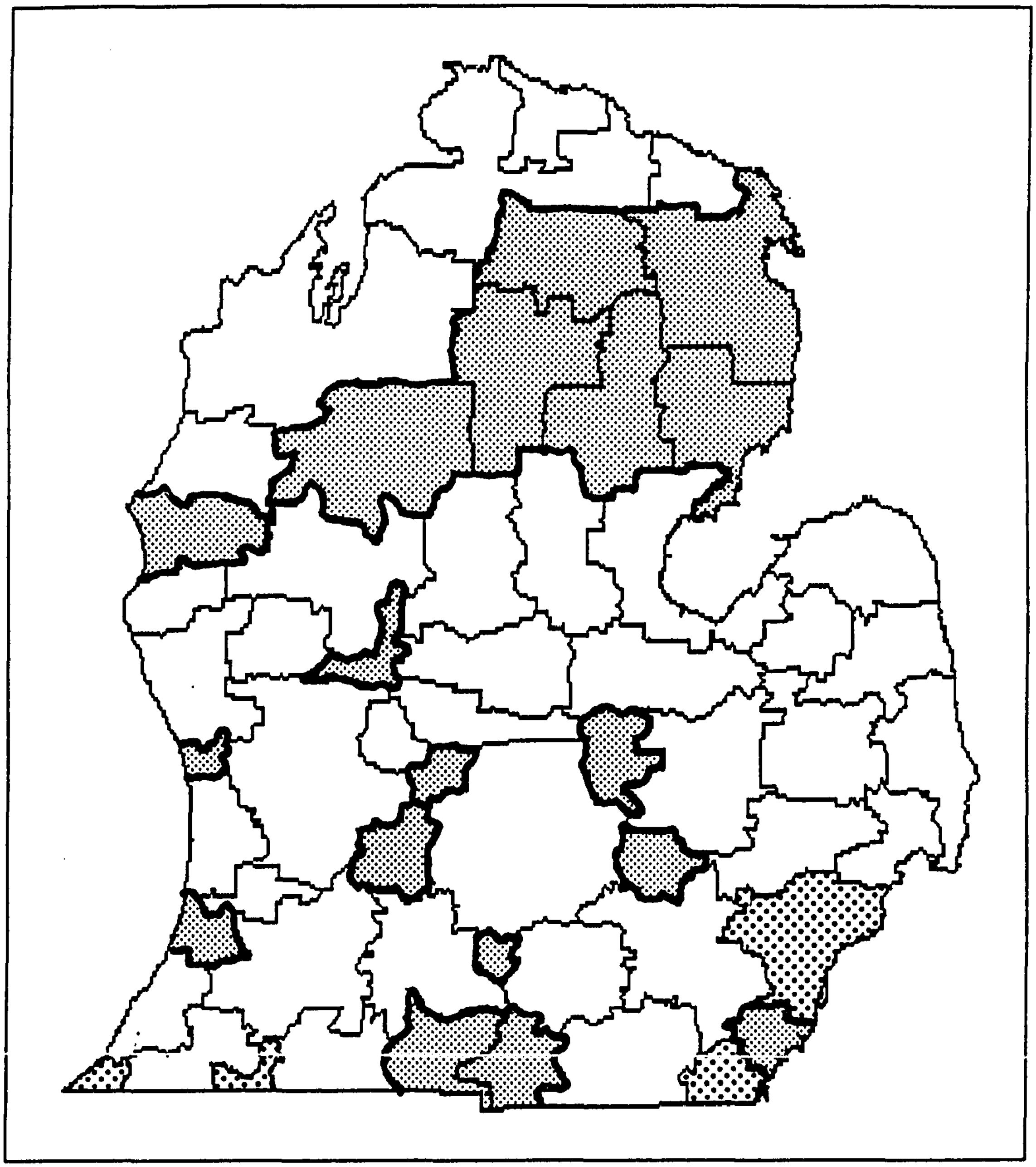


Figure 3.2

Sole Community Provider Hospital Service Areas

Sole Community Provider Hospital Service Areas

Areas Not Included within the Study Area

Physician and Hospital Characteristics

The physician and hospital measures were obtained and calculated from variables obtained from the Department of Research, Data Policy & Services at the MHA and from the American Hospital Association's (AHA) Annual Survey of Hospitals for the years 1981 and 1983. This survey of American hospitals is collected annually and contains information relating to each contributing hospital's personnel, facilities, services, and financial status. Permission to use the non-confidential portions of these data bases was given by the Group Vice President of Research, Data Policy & Services at the MHA. Where data were missing, direct contact was made with hospital personnel.

Research Design

This research had four goals and each had a separate research design. The four goals are discussed below; the results of the research for each goal will be discussed in Chapters 4, 5, 6, and 7, respectively.

Goal 1: Document Variation in Use Rates and Compare Results to Previous Results from Michigan and Elsewhere

Fourteen measures of hospital use have been calculated for each of the hospital service areas in the study area of Michigan. As shown in Figure 3.3, there were three types of use rates studied.

Figure 3.3

Measures of Hospital Use

	Abbreviation
Three Total Hospital Use Rates:	
Total Male Admission Rate	Tot Male Adm
Total Female Admission Rate	Tot Female Adm
Total Admission Rate	Tot Adm
Seven Surgical Procedure Rates:	
Appendectomy Rate	Appen
Hemorrhoidectomy Rate	Hemorr
Cholecystectomy Rate	Chole
Inguinal Hernia Repair Rate	Hernia
Prostatectomy Rate	Prost
Hysterectomy Rate	Hyster
Cesarean Section Rate	C-sect
Four Medical Causes for Admission Rates:	
Circulatory Admission Rate	Circ
Respiratory Admission Rate	Resp
Digestive Admission Rate	Digest
Genito-Urinary Admission Rate	Gen-U

Each of the fourteen use rates was age and sex adjusted to the 1980 total Michigan population using the direct method of standardization as described by Mausner and Kramer (1985). These age and sex standardized use rates for each hospital service area are shown in Appendix A. An age and sex adjusted use rate was calculated for each of the fourteen hospital use rates for each hospital service area.

$$\text{Standardized Rate} = \frac{\sum_{i=1}^{6} \left[\frac{TA_i}{TP_i} * SP_i \right]}{\sum_{i=1}^{6} (SP_i)} * 1000$$

where:

i = a specific age and sex category
SP_i = State Population for i
TA_i = Total Admissions for i
TP_i = Total Population for i

Total Admissions

Three measures of total admissions were used for this research: total male admissions; total female admissions; and total admissions.

Surgical Procedures

The seven surgical procedures were chosen for several reasons. First, the surgical procedures chosen are ones that are well documented in the small area analysis literature. Since previous research has documented procedure-specific use rates, the procedures chosen for this study represent a range from previously determined low variation (inguinal hernia repair) to high variation (hysterectomy). Second, the procedures chosen can be performed at even the smallest general acute care hospital, since the procedures are not technically difficult to perform, nor are they generally performed on patients who are severely ill. Third, the procedures chosen require inpatient, rather than ambulatory surgery. This criterion was used to assure that the number of procedures included in the study was comparable from one hospital service area to another. Michigan does not have an ambulatory surgery data base, so by limiting the research to inpatient procedures, the accuracy of the number of procedures is greater. Outpatients or ambulatory patients can be cared for in non-hospital settings, such as physician-owned "surgi-centers", and data are not collected from those medical facilities. For example, tonsillectomy (with or without adenoidectomy) was excluded from this research, although usually analyzed by small area analysis researchers, because tonsillectomy is now performed far more often on an outpatient rather than an inpatient basis. Fourth, an effort was made to choose procedures where the physician doing the surgery would also be most likely to be the physician who made the diagnosis. This was done to minimize the potential impact of the physician referral patterns within or between communities. Finally, cesarean section was added to the list of surgical procedures to be included in the study because cesarean section met the criteria mentioned above and because cesarean section rates are rising very rapidly all over the United States.

Once the seven surgical procedures were chosen, their ICD-9-CM codes were defined as precisely as possible. Once determined for each procedure, the codes were sent to an informal review panel made up of five Directors of Medical Records within the study area. Each of the five Directors returned a critique of the groups of codes. Where there was a discrepancy in the coding the most senior of the Directors was contacted and that person's decision was accepted. At the advice of this review panel, all oncology codes were excluded from the research. This was done because there is a low degree of medical consensus on hospitalization and treatment of cancer patients and because malignancy patients are often hospitalized in referral centers, not in general acute care hospitals. Hospitalization in referral centers would increase the problem of migration, so by removing oncology procedures, migration from one hospital service area to another was minimized. The ICD-9-CM codes for the seven surgical procedures are given in Figure 3.4.

Figure 3.4

Surgical Procedure Codes

Procedure	ICD-9-CM Procedure Codes
Appendectomy	470, 471
Hemorrhoidectomy	4943 - 4946
Cholecystectomy	5121, 5122
Inguinal Hernia Repair	5300 - 5317
Prostatectomy	602 - 604, 6061, 6062, 6069
Hysterectomy	683 - 688
Cesarean Section	740 - 744, 7491, 7499

Medical Causes for Admission

The medical causes for admission were chosen quite differently. Rather than to determine very small precise definitions of a hospital event, as was used for the surgical procedures, the medical causes for admission were purposely designed to be very large, inclusive, definitions. The aggregation of ICD-9-CM codes into circulatory, respiratory, digestive, and genito-urinary medical diagnoses accounts for the greatest portion of all medical admissions to general acute care hospitals. These four broad categories were established to reduce the chance of bias due to the unique character of any one hospital. The medical records review panel reviewed and approved the medical cause for admission coding shown in Figure 3.5. Oncology diagnoses were excluded from the study.

Figure 3.5

Medical Causes for Admission

Medical Cause for Admission	ICD-9-CM Diagnosis Codes
Circulatory Causes for Admission	390 - 438
Respiratory Causes for Admission	466 - 518.8
Digestive Causes for Admission	530 - 578.9
Genito-Urinary Causes for Admission	580 - 599.9

Analysis for Goal 1: Document and Compare Use Rates

Comparisons were made of these fourteen standardized use rates to previously recorded rates for Michigan and elsewhere. First, the ranges were compared. Then the maximum to minimum ratio (the maximum range divided by the minimum range), the coefficient of variation (the standard deviation divided by the mean), and the systematic component of variation (SCV) for each use rate were compared to previously recorded results.

The systematic component of variation was used by McPherson et al. (1981 and the references cited therein) to facilitate comparisons of the variability of procedure or diagnosis-specific use rates. The SCV calculation produces a single number which is not related to the magnitudes of the use rates. Therefore, using the SCV, the variability of an infrequently occurring procedure or diagnosis can more easily be compared to the variability of a more commonly occurring procedure or diagnosis. A separate SCV was calculated for each use rate (total admission, surgical procedure, and medical cause for admission) using the following equation.

Systematic Component of Variation

$$SCV = 1000 * \left| \left[\text{variance } (o/e) - \text{mean } (1/e) \right] \right|$$

where o = age and sex adjusted observed use rate for each hospital service area

e = age and sex adjusted expected use rate for each hospital service area

and the variance and mean are calculated over all 53 hospital service areas

Goal 2: Analyze the Use Rates

Use Rate Pattern Analysis

In a review of the small area analysis literature, Paul-Shaheen et al. (1987) identified four use rate patterns among the results of previous researchers. The four use rate patterns were: 1) there is consistency in procedure specific variation ranking; 2) the variation in rates for admission due to medical causes is consistently greater than the variation in surgical procedure rates; 3) hospital service areas have unique surgical procedure rate patterns; and 4) hospital service areas may show consistently high or low use across several measures of use. Using those four use rate patterns as a framework, the results from this research were analyzed and compared to the results reported in earlier research.

The variations in the fourteen hospital use rates were mapped and the analysis of their spatial patterns was included as part of the analysis of the fourth use rate pattern, the consistency within hospital service areas of high or low use across several procedures or diagnoses. A classification system based on standard deviation was chosen so that comparisons of hospital service areas could be made across all of the use rates. It was more important to this research to know if a hospital service area had consistently high or low use rates across several measures than to know the actual use rate distribution and range for a specific procedure or diagnosis.

Due to the confidentiality constraints placed upon the display of the results of this research, much of the geographic analysis was done on a regional basis. The hospital service areas shown in Figure 3.1

were aggregated into six regions (Figure 5.4, p. 123) for the purposes of this current study. These six regions represent slight modifications of the regions which have been defined by the Michigan Hospital Association for their Hospital District Councils. Each regional boundary in this current research was established to assure that at least two sole community provider hospital service areas were included within the region. As shown in Figure 3.2 four areas were not included in any hospital service area used in this research. The non-included areas shown on the southern border of Michigan are aggregated zip codes where the plurality of the population received hospital care in a contiguous state (Indiana and Ohio). The metropolitan Detroit area was not included within this research because of reasons described earlier in this chapter.

Goal 3: Determine the Relationships Between Different Hospital Use Rates and Between Use Rates and Provider Characteristics

After a review of the small area analysis literature and the 1983 data available, one measure of physician characteristics, four measures of the supply of health service personnel in hospitals, four measures of the services available in hospitals, and five measures of the organization of the hospitals were designed, collected, and aggregated across all hospitals in each hospital service area. The physician and hospital characteristics for each hospital service area are shown in Appendix B. The fourteen measures are shown on Figure 3.6 and described below.

Figure 3.6

Physician and Hospital Characteristics Studied

I. Physician Component
    1. Weighted Proportion of Board Certified Physicians in 1983 (Wgt Prop Bed Cert)
II. Hospital Component
    A. Supply of Health Care Resources in 1983
        1. Licensed Hospital Beds per 10,000 Population (Beds)
        2. Full Time Equivalent Hospital Employees per 10,000 Population (FTEs)
        3. Registered Hospital Pharmacists per 10,000 Population (Pharm)
        4. Registered Nurses per Licensed Hospital Bed (RNs/Bed)
    B. Services Available in the Hospital in 1983
        1. Average Number of Hospital-Based Services per Hospital (Avg Hosp Serv)
        2. Average Number of Services per Hospital Provided by Another Facility (Avg Other Fac Serv)
        3. Service Level per Hospital Service Area (Serv Level per HSA)
        4. Total Number of Services (out of 66 possible) Available in the Hospital Service Area (Tot # Serv per HSA)
    C. Hospital Characteristics in 1983
        1. Change in Number of Services Offered in the Hospital Service Area from 1981 to 1983 (Change in Serv)
        2. Outpatient Visits per 10,000 Population (OPV)
        3. Proportion of Corporate Owned Beds (Corp Beds)
        4. Salaried House Staff per 10,000 Population (House Staff)
        5. Proportion of Osteopathic Hospital Beds (Osteo Beds)

Physician Component

1. Weighted Proportion of Board Certified Physicians in 1983 (Wgt Prop Bd Cert)

The AHA data base counts a physician in every institution where he admits patients. If a physician was counted in every hospital where he had privileges, the physician count would be inflated for those hospital service areas where more than one hospital exists. Therefore, a new measure was developed. The proportion of board certified physicians to all physicians in each hospital was calculated and then weighted by the number of beds in each institution in order to measure that institution's contribution to the specialist to non-specialist ratio within the hospital service area. This total was then divided by the total number of beds in the hospital service area to allow for comparability. The individual hospital contributions were then summed to create a weighted total for the hospital service area. This weighted proportion of board certified physicians for each hospital service area was calculated as follows:

$$\begin{bmatrix} \text{Weighted} \\ \text{Proportion} \\ \text{of} \\ \text{Board} \\ \text{Certified} \\ \text{Physicians} \end{bmatrix} = \sum_{i=1}^{n} \left[\frac{(\#\text{ beds in hosp}_i) * \left[\dfrac{\#\text{ board certified phys in hosp}_i}{\text{total }\#\text{ phys in hosp}_i} \right]}{(\text{ total }\#\text{ beds in all hospitals in area })} \right]$$

<u>Hospital Component</u>

Supply of Health Care Resources in 1983

1. Licensed Hospital Beds per 10,000 population (Beds)

   The number of licensed beds per 10,000 population is a measure of the historical size of the hospital and provides an indication of the capital investment made by a community in its hospital. When that measure was not available (six hospitals), the total number of "set up and staffed" beds was substituted.

2. Full Time Equivalent Hospital Employees per 10,000 Population (FTEs)

The number of non-professional hospital personnel (FTE's) was determined and standardized to the population of the hospital service area. This measure indicates the level of staffing a community provided for its own health care.

3. Registered Hospital Pharmacists per 10,000 Population (Pharm)

The number of full-time equivalent registered pharmacists was determined and standardized to the hospital service area population. This is a measure of the size and technical sophistication of the hospital, particularly in the area of circulatory admissions because, of the four medical causes for admission included within this study, circulatory diagnoses require the greatest amount of drug use and therefore the greatest number of pharmacists on staff.

4. Registered Nurses per Licensed Hospital Bed (RNs/Bed)

The number of full-time equivalent registered nurses was determined and standardized to the number of licensed hospital beds. This measure is an indication of the "interpersonal" quality of care provided within a community and was thought to be of more importance in the explanation of the variation in the total admission rates and medical diagnosis rates than in the explanation of the variation in surgical procedure rates.

Services Available in the Hospital in 1983

The 1983 AHA Annual Survey of Hospitals tabulated for each hospital sixty-six comparable services that might have been provided during that year. AHA classified the provision of each service into three categories: Code 1 = hospital-based; Code 2 = provided by another hospital or provider; and Code 4 = service was not provided. Using these codes four measures were devised to estimate the provision of services within a hospital service area, and to make it possible to compare the level of services offered in hospital service areas. The first measure calculated was the average number of hospital-based services (code 1) per hospital. The second measure was the average number of services per hospital provided by another facility (code 2). The third measure was the service level per hospital service area for all of the services provided within the service area (codes 1, 2, and 4). In each of these three measures a lower score meant that more services were offered by the hospitals in the service area (coded 1), and that fewer services were offered by contract (coded 2), or were not available (coded 4). The fourth measure was the total number of services (out of 66) which were offered by at least one hospital (code 1s) in the hospital service area. A higher score on this measure meant that more services were offered in the hospital service area.

Hospital Characteristics

1. Change in Services Offered from 1981 to 1983 (Change in Serv)

Because of the change in the hospital environment in recent years, it was important that some measure be devised that would estimate a change in a hospital administration's management philosophy toward a more progressive approach. The change (either positive or negative) in the number of services available from 1981 to 1983 was used as a measure of the change in the administration's management philosophy, since the change would indicate a purposeful shift in the number of services offered to better meet the demands of the market place. In 1981 the AHA used four codes to classify the provision of services by a hospital rather than the three it used in 1983. In 1981 services were classified as: Code 1 = hospital-based and staffed; Code 2 = hospital-based, contracted; Code 3 = provided by another hospital or provider; and Code 4 = service not available. For purposes of comparing 1981 and 1983 data, the first two categories were collapsed into one, hospital-based services. The number of services (out of 66) provided by at least one hospital within the service area was counted. The total number of services offered in each hospital service area in 1981 was subtracted from the 1983 total.

2. Outpatient Visits per 10,000 Population (OPV)

The total number of outpatient visits (clinic and surgery) was determined and standardized to the hospital service area population. This is another measure of the progressive or conservative management philosophy of the community's hospital administration because, under the current cost containment pressures, more progressive hospitals are shifting an increasing amount of their business to the outpatient setting.

3. Proportion of Corporate Owned Hospital Beds in Each Service Area (Corp Beds)

The proportion of corporate owned beds was calculated for each hospital cluster. This was a measure of the structure of the industry in the hospital service area. There are no for-profit hospitals in Michigan at this time, but there is an increasing environment of competition and with it has come corporate and quasi-corporate alliances. The type of organization (corporate vs. independent) could potentially influence the admission practices of the physicians and hence the utilization rates for the hospital service areas.

4. Salaried House Staff per 10,000 Population (House Staff)

The number of medical staff who were given a salary or stipend by the hospital was determined and standardized by the population of the hospital service area. This measures the importance of the teaching institutions within a hospital service area.

5. Proportion of Osteopathic Hospital Beds in Each Hospital Service Area (Osteo Beds)

   The proportion of hospital beds in osteopathic hospitals was calculated for each hospital service area. There is a difference in the medical philosophy between osteopathic and allopathic physicians which could have an influence on the admission practices of the hospitals and therefore on the utilization rates. Michigan is one of the few areas in the nation where this measure could be included in small area analysis research, and therefore it was felt to be important that a measure of the osteopathic influence on utilization rates be tested. The hypothesized impact of osteopathic philosophy will be discussed further in the section of this chapter devoted to general hypotheses.

Analyses for Goal 3: Determine the Relationships Between Different Hospital Use Rates and Between Use Rates and Provider Characteristics

Using the SPSS-X System (Release 2.1), Spearman Rho correlations among the physician and hospital descriptive measures were calculated to determine the relationships between the variables. Correlations were also run to help the researcher develop specific hypotheses and to determine if some of the physician and hospital variables were so closely correlated that they should not be simultaneously entered into the subsequent regression equations.

Goal 4: Use Rates as a Function of Physician and Hospital Characteristics

In an effort to explain the variation in hospital use rates, each of the total hospital admission, sex-specific admission, surgical procedure and medical cause for admission use rates was entered into a multiple regression as a dependent variable. The independent variables were the physician characteristics and the hospital resource supply, service and organization characteristics described in Figure 3.6.

Analysis for Goal 4: Use Rates as a Function of Physician and Hospital Characteristics

A stepwise multiple regression technique was used with Version 6.02 of the SAS System (operating under PC DOS). The minimum significance level for entry into the model and for staying in the model was $\alpha = .10$. The Kolmogorov-Smirnov (K-S) test of the residuals was used to determine if they were normally distributed. The residuals from the multivariate regressions were variation unexplained by the provider and community variables in the equation. Since the residuals from each equation were specific to a geographic location, they were mapped and examined for spatial patterns.

General Hypotheses

General research hypotheses were developed by reevaluating the results of previous small area analysis research in light of my logic and my experience within the hospital industry. Since the current research looks for explanation of hospital use rates among provider characteristics, both the physician and hospital components of the model were hypothesized to contribute to that explanation. A review of the previous literature showed that the relationships between seven provider characteristics and hospital use rates had been reported. Five of the seven variables relate to the supply of physicians or their characteristics and two relate to hospital characteristics (bed supply and teaching status).

To facilitate this discussion, Tables 2.4 - 2.7 were consolidated into a single new figure (3.7) that shows the variety of relationships between hospital use rates and provider characteristics reported in the literature. Correlations are reported as "C" with appropriate superscripts to indicate positive (+), negative (-), significant (S), and non-significant (NS) associations. Regression results (R) are shown simply as being significant (S) or non-significant (NS). The results of each study are not shown, but rather each different result is shown, no matter how many researchers had similar findings. As shown in Figure 3.7, there is a good deal of conflicting evidence in the literature about the direction (positive or negative) of the relationships and the strength of the provider characteristics in providing explanation for the variation in use rates.

Figure 3.7

VARIETY OF RELATIONSHIPS REPORTED IN THE LITERATURE

	PHYSICIAN COMPONENT					HOSPITAL COMPONENT	
	Non-Special-ist Supply	Surgeon Supply	Special-ist Supply	Non-Spe-cial + Surg Supply	Prop Bd Cert to NonPhy	Bed Supply	Teach ing Status
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7
Tot Male Adm							
Tot Female Adm							
Total Adm	$C^+C^-C^sC^{ns}$	C^+ C^s	R^s	R^{ns}	C^+ C^{ns}	$C^+R^sC^sC^{ns}$	R^{ns}
Appendectomy	C^+ C^s	$C^+C^{ns}C^-C^s$				R^s	*
Hemorrhoidectomy							
Cholecyctectomy	$C^+C^-C^s$	C^+		C^{ns}		R^s	*
Inguinal Hernia		C^- C^s		R^s			
Prostatectomy							*
Hysterectomy	C^- C^{ns}	C^+ C^s	C^+ C^s			C^{ns}	*
C-Section							
Tot Surgery	$C^+C^-C^sR^s$	$C^+R^sC^sC^{ns}$	$C^+C^sC^{ns}$	C^+C^s		$C^sR^sC^{ns}$	
Circ Admissions							
Resp Admissions							
Digest Adms							
Gen-U Admissions	R^{ns}					R^s	

Correlation Results
- C^+ = positive correlation
- C^- = negative correlation
- C^s = significant correlation (without sign)
- C^{ns} = non-significant or no correlation

Regression Results
- R^s = significant or very influential contributor to explanation
- R^{ns} = non-significant or low influence as contributor to explanation

*Negative relationship reported as untested conclusion of author

Physician Component

There is only one measure of the physician component of the Clark Model used in this research. Based on my analysis of the previous literature and my observations and experience in the hospital industry, I have hypothesized that the weighted proportion of board certified physicians to total physicians will have a positive relationship with all types of use rates. I have hypothesized a positive relationship because of the following information. The weighted proportion of board certified physicians is a measure of the dominance of specialists within a hospital service area, and, as such, is related to columns two through five on Figure 3.7. Columns two through five report the relationships between the supply of specialists and use rates. With the exception of inguinal hernia repair rates, all other previous research has shown a positive relationship between hospital use rates and the supply of surgeons, specialists, non-specialists plus surgeons and the proportion of board certified physicians. The strength of the relationship between the supply of specialists and hospital use rates suggests to me that there will also be a positive relationship between the dominance of specialists in a hospital service area and use rates. The relationship is hypothesized to be stronger for surgery than for total admissions because the surgical procedures being studied must be performed in a hospital setting rather than in a physician's office, thereby reducing the possible effect of non-surgeons doing the surgical procedures.

Hospital Component

Supply of Resources

Variables related to the hospital component of the Clark Model were divided into three categories: the supply of resources; the availability of services; and organizational characteristics (see Figure 3.6). Previous small area analysis research has only tested the relationship between use rates and one variable from each of two of these categories: the supply of hospital beds and the effect of teaching status. As shown in Figure 3.7, a clear positive relationship between hospital beds and use rates has been established. Therefore, without any evidence to the contrary, I have hypothesized a positive relationship between each of the fourteen use rates tested and hospital beds per population.

I also have hypothesized that FTEs and pharmacists per population will behave the same way as beds (have a positive relationship with use rates), since FTEs and pharmacists are also measures of the supply of health care resources and will increase or decrease with the number of hospital beds. I have hypothesized, with more certainty, the positive relationship between pharmacists and circulatory causes for admission rates than for any of the other use rates, since cardiac care is very medicine-intensive, requiring the services of more pharmacists in those hospitals where there is a high volume of circulatory admissions.

The relationship between RNs per bed and hospital use rates is more complex, largely because of the regulatory environment in Michigan. Although the Department of Public Health's Licensing and Registration Bureau does not mandate a minimum number of nurses that a hospital must employ to remain open for patient care, the licensing process does include review of the level of registered nurse staffing in each unit of the hospital. If the number of registered nurses falls below a threshhold level, then hospital beds will have to be withdrawn from service. If there were to be an increase in the number of patients who needed care in that hospital, the economies of scale would go into effect, and the administration would use the same number of nurses to care for many more patients. As a result of this minimum level of staffing I have hypothesized that there would be a negative relationship between registered nurses per bed and total admission rates as well as between registered nurses per bed and medical causes for admission rates. The relationship between surgical procedure rates and registered nurses is less certain, but felt to be negative as well. There may be a threshhold effect with surgical patients, but it would be difficult to hypothesize about each individual procedure use rate.

Availability of Services

Four measures of the availability of hospital services were used in this research. These four were: average number of services provided by the hospitals within a hospital service area in 1983; the average number of services provided by other facilities within a hospital service area in 1983; the average number of services per hospital in a hospital service area in 1983; and the total number of services (out of 66) available in each hospital service area in 1983. I hypothesized that as hospital services were increased in hospital service areas, that hospital use rates would increase. My reasoning was based on the observed increase in hospital use when a new instrument, facility, or procedure is introduced. For example, when ultra-sound or magnetic resonance imagers (new instruments) became available, patients came to a facility to use the diagnostic equipment. The same is true when a new facility is opened or a new procedure introduced, because these new health care resources fulfill a previously unmet need. When heart bypass surgery was introduced, surgical procedure rates rose dramatically in those service areas where the procedure was performed. Assuming that the service was available often enough to meet the patients' needs, it would not matter whether the service was provided by the hospital or some contractual arrangement with another facility as long as the service was available at a hospital within a hospital service area. I have, therefore, hypothesized a positive relationship between all four measures of the provision of services and hospital use rates. I am less certain of the relationship between services provided by a contractual partner and use because those services may be less well known to a community.

Hospital Characteristics

Five measures of a hospital's character and philosophy were included in this study. Two of these, the change in the number of available services from 1981 to 1983 and outpatient visits per population, were used to estimate the progressive or conservative philosophy of a hospital's administration. I hypothesized that the greater the change in absolute value (positive or negative) in the number of available services within a hospital service area, the more progressive was the hospital administration in that area, and therefore the higher the total use rates would be. I am less certain about the strength of the positive relationship between surgical procedure rates and the change in the number of services than I am of the relationship between total use rates and medical causes for admission and the change in availability of services. This is the case because of the potentially ideosyncratic relationship between specific diagnostic and/or therapeutic equipment and individual surgical procedures. As described previously, new instruments encourage increased use, but those instruments are used in the diagnosis or treatment of a very limited number of patients. Without the data to examine specific new instruments, specific hypotheses cannot be generated.

I hypothesized an inverse relationship between outpatient visits and all types of use rates. The reasoning was simply that as more of the health care needs of the community are fulfilled in the outpatient setting inpatient hospital use will decrease. The relationship of outpatient visits to specific surgical procedure rates was less clear, and since the surgical procedures chosen for this study all required hospitalization (inpatient) rather than outpatient surgery, outpatient visits and specific surgical procedure rates were hypothesized to be inversely related, but less strongly so than total and medical causes for admission rates.

No published small area analysis research has dealt with the possible impact that corporate ownership has had on hospital utilization rates. As the hospital environment has changed over the past several years, some hospitals have entered into corporate or quasi-corporate alliances with other hospital facilities. To a degree this might be seen as being another measure of progressive or conservative administrative philosophy, but actually it is different because the initiative for these alliances does not always come from the hospital whose status is changed as a result of the legal move. In other words, one hospital may be encouraged or forced into an alliance with another hospital. The initiative for the alliance may have come from the second hospital's administration and yet the first hospital's status would have changed from non-corporate to a corporate status even though the first hospital's administration might still be considered conservative. As a consequence, the measure should be one of corporate dominance in the hospital service area. Corporate dominance was measured as the proportion of corporate beds in each hospital service area. I have hypothesized that as corporate dominance increases, use rates, particularly total admission and medical cause for admission rates, would also increase as the hospital "worked harder" to stay financially healthy.

As shown in Figure 3.7, the explanatory role of teaching status has been tested in previous small area analysis research. Knickman and Foltz (1985) found that the supply of house staff (interns and residents) was not a significant contributor to the explanation of the variation in total admission rates. Studies by Stockwell and Vayda (1979) and by Vayda and his associates (1984) have found that areas with teaching hospitals have lower surgical procedure rates for appendectomies, cholecystectomies, prostatectomies, and hysterectomies. Griffith (personal communication 1986, 1987) found that some of Michigan's hospital service areas with graduate medical programs (Lansing, Grand Rapids and Ann Arbor) had lower surgical procedure rates, while others (Flint, Saginaw and Detroit) did not. Therefore, I hypothesized that all of the surgical procedure rates except Cesarean section rates would have a negative relationship with house staff per 10,000 population. Cesarean section rates are known to be increasing in the United States and are particularly high in teaching hospitals. Therefore, I have hypothesized a positive relationship between Cesarean section rates and house staff per 10,000 population.

The influence of osteopathic or allopathic philosophy on utilization rates has not been previously discussed in small area analysis literature. Few places offer the opportunity that Michigan does for studying the impact of osteopathic philosophy on hospital use rates. Thirteen Michigan hospital service areas contained osteopathic hospitals in 1983. This is a large enough number to evaluate their impact on use rates.

Osteopathic philosophy emphasizes a more holistic approach to medicine than allopathic philosophy. Osteopathic medicine pays special attention to the musculoskeletal system's relationship to health and disease. One can hypothesize therefore that in areas with osteopathic hospitals the admission and surgery rates would be lower than in areas without osteopathic hospitals. The possible exception to this would be the orthopedic surgical procedure rates which would be hypothesized to be higher in areas with osteopathic hospitals. There are no orthopedic surgical procedures included in this study.

A summary of the general hypotheses is shown in Figure 3.8. The direction of the relationships (positive or negative) are shown with + and - signs. The strength of my certainty in the hypotheses is also indicated: hypotheses that I feel most certain about have a double positive or negative sign, while those of which I am less certain have a single sign.

Figure 3.8

RELATIONSHIPS HYPOTHESIZED IN THE METHODS CHAPTER

	Wgt Prop Bd Cert	Hosp Beds per 10,000	FTEs per 10,000	Pharm per 10,000	RNs per Hosp Bed	Avg Hosp Serv '83	Avg Other Fac Serv '83	Serv Level per HSA '83	Total # Serv per HSA '83	Change in Serv '81-83	Out Pat Visits per 10,000	Corp Beds	House Staff per 10,000	Osteo Beds
Total Male Adm	+ +	+ +	+	+	- -	+ +	+	+ +	+ +	+ +	- -	+ +	- -	- -
Total Female Adm	+ +	+ +	+	+	- -	+ +	+	+ +	+ +	+ +	- -	+ +	- -	- -
Total Adm	+ +	+ +	+	+	- -	+ +	+	+ +	+ +	+ +	- -	+ +	- -	- -
Appendectomy	+ +	+ +	+	+	-	+ +	+	+ +	+ +	+	-	+	- -	- -
Hemhorrhoidectomy	+ +	+ +	+	+	-	+ +	+	+ +	+ +	+	-	+	- -	- -
Cholecystectomy	+ +	+ +	+	+	-	+ +	+	+ +	+ +	+	-	+	- -	- -
Inguinal Hernia	+ +	+ +	+	+	-	+ +	+	+ +	+ +	+	-	+	- -	- -
Prostatectomy	+ +	+ +	+	+	-	+ +	+	+ +	+ +	+	-	+	- -	- -
Hysterectomy	+ +	+ +	+	+	-	+ +	+	+ +	+ +	+	-	+	- -	- -
Cesarean Section	+ +	+ +	+	+	-	+ +	+	+ +	+ +	+	-	+	+ +	- -
Circulatory Adm	+ +	+ +	+	+ +	- -	+ +	+	+ +	+ +	+ +	- -	+ +	- -	- -
Respiratory Adm	+ +	+ +	+	+	- -	+ +	+	+ +	+ +	+ +	- -	+ +	- -	- -
Digestive Adm	+ +	+ +	+	+	- -	+ +	+	+ +	+ +	+ +	- -	+ +	- -	- -
Genito Urinary Adm	+ +	+ +	+	+	- -	+ +	+	+ +	+ +	+ +	- -	+ +	- -	- -

+ + and - - indicate a more certain hypothesis, + and - indicate a less certain hypothesis

CHAPTER 4

MICHIGAN HOSPITAL USE RATES

Documentation of Variation in Hospital Use Rates Found in this Study

Fourteen hospital use rates were calculated for each of the 53 Michigan hospital service areas and then standardized by the direct method using the age and sex of the 1980 Michigan population. Three types of use rates were studied: three total hospital use rates; seven surgical procedure use rates; and four medical causes for admission rates. Each of these use rates was compared to the results from previous small area analyses carried out in Michigan, North America, the United Kingdom, and Norway. A table of all fourteen admission and procedure rates by hospital service area is shown in Appendix A.

In addition to reporting the ranges found, three measures of variation were calculated for each use rate: the maximum use rate divided by the minimum; the standard deviation divided by the mean (the coefficient of variation); and the systematic component of variation.

The amount of variation from one hospital service area to another has been of utmost importance to small area analysis researchers. The first small area analysis studies used the simple measure of the maximum use rate divided by the minimum use rate and discussed "2-fold" or "6-fold" differences from one hospital service area to another. As shown in Table 4.1, using that method for this study, hemorrhoidectomy rates had the greatest variation (18-fold), followed by Cesarean section rates (almost 6-fold), and respiratory causes for admission rates (4-fold). The difficulty with this measure is that only the extreme use rates have been used to calculate the measure, giving undue importance to the use rates which are at the ends of the distribution and hence least representative of it.

Table 4.1

Results of Three Measures of Use Rate Variability

	Max/Min	S.D./Mean	SCV
Total Male Admissions	2.00	0.15	24
Total Female Admissions	1.91	0.14	23
Total Admissions	1.95	0.14	22
Appendectomy	2.98	0.26	58
Hemorrhoidectomy	18.16	0.53	199
Cholecystectomy	2.34	0.19	26
Inguinal Hernia	3.18	0.23	44
Prostatectomy	2.86	0.23	34
Hysterectomy	2.15	0.17	17
Cesarean Section	5.90	0.20	34
Circulatory Diag	2.97	0.19	38
Respiratory Diag	4.03	0.30	115
Digestive Diag	2.45	0.21	50
Genito-Urinary	2.41	0.20	41

The coefficient of variation reduces the effect of the outliers. As shown on Table 4.1, using the coefficient of variation, hemorrhoidectomy rates had the highest variation followed by respiratory causes for admission and appendectomy rates.

The newest measure of variation to be found in the small area analysis literature is the systematic component of variation (SCV) (McPherson et al., 1981 and other references cited therein) which reduces the random sources of variation within the measurement. As shown in Table 4.1, the highest SCV was noted for hemorrhoidectomy rates followed by respiratory causes for admission and appendectomy rates.

As shown in Table 4.2, hemorrhoidectomy rates had the greatest variation no matter which calculation of variation was used. This is in keeping with previous research. Respiratory admission rates ranked second highest in two of the three measures of variation and third when the maximum rate was divided by the minimum rate. This too was expected from previous results. The appearance of the Cesarean section rate as one of the most variable procedure rates was expected, but the high variation in appendectomy rates and inguinal hernia repair rates was unexpected since they have not been considered to have a great deal of medical uncertainty surrounding either their diagnoses or the treatment of choice, surgery. The smallest amount of variation was seen in the total hospital use rate, the sex-specific use rates and the hysterectomy rate. The ranking of the hysterectomy rate as having low variation was unexpected.

Table 4.2

Use Rates Ranked Within Each of Three Measures of Variation

Max/Min	S.D./Mean	SCV
Hemorrhoidectomy	Hemorrhoidectomy	Hemorrhoidectomy
Cesarean Section	Respiratory	Respiratory
Respiratory	Appendectomy	Appendectomy
Inguinal Hernia	Inguinal Hernia	Digestive
Appendectomy	Prostatectomy	Inguinal Hernia
Circulatory	Cesarean Section	Genito-Urinary
Prostatectomy	Genito-Urinary	Circulatory
Digestive	Digestive	Prostatectomy
Genito-Urinary	Cholecystectomy	Cesarean Section
Cholecystectomy	Circulatory	Cholecystectomy
Hysterectomy	Hysterectomy	Male Admissions
Male Admissions	Male Admissions	Female Admissions
Total Admissions	Total Admissions	Total Admissions
Female Admissions	Female Admissions	Hysterectomy

Comparison of the Variation in Use Rates Reported in this Study To Previous Results From Michigan and Elsewhere

Results from previous small area analysis studies have been tabulated by total admissions, surgical procedures, and medical causes for admissions. Comparisons of the results from this current research to earlier work were made. Of particular note were the comparisons made between the results of research by Griffith et al. (1981) calculated from 1978 Michigan data and this current research with its results calculated from 1983 Michigan data. Because so few studies use the SCV, the comparisons using that measure of variation will be discussed separately.

Total Hospital Use Rates

Total admissions per 10,000 age and sex adjusted population ranged from 1146 to 2235 in this study. As shown on Table 4.3, the figures from this current study were generally higher than ones reported previously. The mean of the previous comparable studies' minimum rates was 1041 and the mean of the maximum rates was 1764. When compared to previous Michigan research, the maximum/minimum ratio of 1.95 reported from this study is the same as reported by Griffith et al. (1981) but lower than the ratio reported by either of the OHMA reports (1985). The mean coefficient of variation reported in the literature was .17, only .01 greater than the coefficient of variation found for total admissions in this study. Gender-specific total admission rates were not available from previous small area analysis studies for comparison.

Surgical Procedure Rates

A large number of small area analysis studies have focused on seven surgical procedures. These seven have not formally been recognized as "index" procedures but, because they appear so frequently in the literature, many researchers have studied them and use rate ranges have been published for many geographic areas of the world and at many different times. The seven procedures most frequently studied are: appendectomy, cholecystectomy, hemorrhoidectomy, hysterectomy, inguinal hernia repair, prostatectomy, and tonsillectomy with or without adenoidectomy. Because tonsillectomy is now frequently performed in an outpatient setting, it was not included as one of the surgical

TABLE 4.3

TOTAL HOSPITAL ADMISSION OR DISCHARGE RATES

Study		Location	Ranges in Admissions or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
Clark, 1988		Michigan Hosp Serv Areas	1146 - 2235	1.95	.16*
Clark, 1988	(males)	Michigan Hosp Serv Areas	945 - 1893	2.00	.15*
Clark, 1988	(females)	Michigan Hosp Serv Areas	1338 - 2559	1.91	.14*
Brewer & Freedman, 1982		Vermont Hosp Service Areas	908 - 2007	2.2	.17
Chiswick, 1976		U.S. States & SMSAs	830 - 2480	3.0	.24
Connell, Day & Logerfo, 1981		Washington Hosp Serv Areas	653 - 1617**	2.48	.30*
Deacon et al., 1979		U.S. PSRO Regions (Medicare)	2280 - 4460	1.96	.11*
Deacon et al., 1979		HEW Regions (Medicare)	2960 - 4060	1.37	.10*
Griffith et al., 1981		Michigan Hosp Service Areas	1000 - 1900	1.9	
Knickman, 1982		Los Angeles & NYC	1051 - 1176	1.12	
Knickman & Foltz, 1984		Los Angeles & NYC	1080 - 1113	1.03	
Knickman & Foltz, 1984		SMSAs	1148 - 1195	1.04	
Knickman & Foltz, 1985		Los Angeles & NYC	1050 - 1100	1.05	
Knickman & Foltz, 1985		SMSAs	1130 - 1180	1.04	
OHMA, 1985		Michigan Counties (Med/Surg)	604 - 1556	2.58	.07*
OHMA, 1985		Michigan Counties	668 - 1661	2.49	.16*
Vladeck, 1985		NYC Zip Codes	897 - 2532	2.82	
Wennberg & Gittelsohn, 1973		Vermont Hosp Service Areas	1220 - 1970	1.61	
Wennberg et al., 1975		Maine Hlth Planning Regions	1504 - 2035	1.35	.15
Wennberg et al., 1975		Vt & Maine Hosp Serv Areas	1270 - 2350	2.04	.22*
Wennberg et al., 1977		Vermont Hosp Service Areas	1270 - 2200	1.73	.20*

*Calculated by Clark, 1988
**Per 10,000 person years (Medicaid children)

procedures studied in this current research. Instead, Cesarean section rates were included as the seventh surgical procedure for study.

Appendectomy Rates

Appendectomy rates for the small area analysis studies are shown in Table 4.4. Appendectomy rates ranged from 8 to 22 per 10,000 age and sex adjusted population in this study. The minimum and maximum rates reported for this study are both lower than the mean minimum rate of 12 and the mean maximum rate of 30 calculated from earlier comparable research. The maximum/minimum ratio of 2.75 is slightly higher than the mean (2.45) of previous comparable small area analysis appendectomy research. The only comparable Michigan research (Griffith et al., 1981), shows far more variation using the maximum/minimum ratio than does this study. With the exception of the Lewis (1969) study in Kansas, the coefficient of variation for appendectomy rates lies between .10 and .32 in all previous small area analysis research. The results from this current study (.26) are within that range.

TABLE 4.4

APPENDECTOMY RATES

Study	Location	Ranges in Adms. or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
Clark, 1988	Michigan Hosp. Service Areas	8 - 22	2.75	.26*
Barnes *et al*., 1985	Massachusetts Minor Civil Div	8 - 12**	1.5	
Detmer & Tyson, 1976	Wisconsin Hlth Planning Regions	12 - 26	2.15	.21*
Gittelsohn & Wennberg, 1976	Vermont Hosp Service Areas	14 - 31	2.21	.27*
Griffith *et al*., 1981	Michigan Hosp Service Areas	10 - 48	4.8	
Lembcke, 1952	New York Counties	29 - 71	2.45	.10*
Lewis, 1969	Kansas Hlth Planning Regions	15 - 62	4.23	.52*
McPherson *et al*., 1981	Canadian Provinces	12 - 20	1.67	
"	U.S. Regions	12 - 16	1.33	
McPherson *et al*., 1982	New England Hosp Service Areas	8 - 19	2.38	.26
Stockwell & Vayda, 1979	Ontario Counties	12 - 57	4.8	
Vayda & Anderson, 1975	Canadian Provinces (male)	21 - 31	1.5	
"	" (female)	17 - 29	1.7	
Vayda *et al*., 1976	" (1968)	20 - 30	1.5	
"	" (1972)	16 - 30	1.88	
Vayda *et al*., 1984	Ontario Counties (1973)	13 - 54	4.15	.32*
"	" (1975)	10 - 40	4.02	.27*
"	" (1977)	12 - 34	2.84	.26*
Wennberg & Gittelsohn, 1973	Vermont Hosp Service Areas	10 - 32	3.20	
Wennberg & Gittelsohn, 1975	Maine Hosp Service Areas	11 - 22	2.0	.18*
Wennberg *et al*., 1975	Maine, Vermont Hosp Serv Areas	11 - 23	2.09	.20
Wennberg *et al*., 1982	Rhode Island Hosp Service Areas	7 - 15**	2.14	
"	Maine Hospital Service Areas	10 - 20**	2.0	
"	Vermont Hospital Service Areas	11 - 25**	2.27	
Wennberg et al., 1982	RI, ME, VT Hospital Service Areas		2.0	.21
Wennberg & Gittelsohn, 1982	Rhode Island Hosp Service Areas	7 - 15**	2.14	
"	Maine Hospital Service Areas	10 - 20**	2.0	
"	Vermont Hospital Service Areas	10 - 18**	1.8	
Wennberg, *et al*., 1984	Maine Hospital Service Areas		2.3	.18
McPherson *et al*., 1981	Eng and & Wales Health Districts	13 - 19	1.50	.12*
McPherson *et al*., 1982	Norway Counties	10 - 16**	1.6	.16
"	W.Midlands, U.K. Health Districts	12 - 24**	2.0	.16

*Calculated by Clark, 1988
**Range estimated from graphs

Hemorrhoidectomy Rates

The variation in hemorrhoidectomy rates has been studied less frequently. As shown in Table 4.5, the rates reported by Lewis (1969) were the highest. Prior to the completion of this current research, which reported a 17-fold difference between the lowest rate and the highest rate, the highest maximum/minimum ratio for hemorrhoidectomy rates reported was Griffith's 1981 study in Michigan, which found a 14-fold variation in hemorrhoidectomy rates. The results of this current research showed both maximum and minimum hemorrhoidectomy rates lower than found by Griffith et al. (1981). The coefficient of variation from this current study was .53. Only one previous study, Wennberg and Gittelsohn (1975), reported a coefficient of variation greater than .50. This high variability was expected since hemorrhoidectomies are considered to be elective surgery with low medical consensus.

Cholecystectomy

As shown on Table 4.6, cholecystectomy rates, when analyzed for the total population (both males and females), displayed a relatively consistent pattern of variation from place to place and over time. The mean minimum rate from earlier studies was 18 and the mean maximum rate was 39. The results of this current research are consistent with the previous findings. Griffith et al. (1981) reported a range in cholecystectomy rates from 14 to 53 procedures per 10,000 population, with a maximum/minimum ratio of 3.7. Griffith's maximum rate was considerably higher than my results which show a range from 15 to 36

TABLE 4.5

HEMORRHOIDECTOMY RATES

Study	Location	Ranges in Admissions or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
Clark, 1988	Michigan Hospital Service Areas	.7 - 12	17.14	.53*
Griffith et al. 1981	Michigan Hospital Service Areas	2 - 23	14.1	
Lewis, 1969	Kansas Health Planning Regions	11 - 35	3.04	.34*
McPherson et al., 1981	Canadian Provinces	3 - 14	4.67	
"	U.S. Regions	8 - 11	1.38	
McPherson et al., 1982	VT, ME, R.I. Hosp Service Areas	2 - 11**	4.8	.30
Vayda & Anderson, 1975	Canadian Provinces (male)	7 - 13	1.9	
"	" (female)	5 - 12	2.7	
Vayda et al., 1976	" (1968)	6 - 13	2.19	.22
"	" (1970)	5 - 10	1.98	.17
"	" (1972)	4 - 11	2.57	.21
Wennberg & Gittelsohn, 1973	Vermont Hospital Service Areas	2 - 10	5.0	
Wennberg & Gittelsohn, 1975	Maine Hospital Service Areas	3 - 19	6.33	.55*
McPherson, et al., 1981	England & Wales Health Districts	1 - 3	2.31	.22*
McPherson, et al., 1982	Norway Counties	2 - 7**	2.9	.47
"	W.Midlands, U.K. Health Dist.	1 - 4**	4.6	.35

*Calculated by Clark, 1988
**Range estimated from graphs

TABLE 4.6

CHOLECYSTECTOMY RATES

Study	Location	Ranges in Adms. or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
Clark, 1988	Michigan Hosp Service Areas	15 - 36	2.4	.19*
Barnes et al., 1985	Massachusetts Minor Civil Div	14 - 22**	1.57	
Cageorge et al., 1981	Manitoba Regions	25 - 52	2.1	.09
Detmer & Tyson, 1976	Wisconsin Hlth Plng Regions	21 - 29	1.37	.11*
Gittelsohn & Wennberg, 1976	Vermont Hosp Service Areas	18 - 53	2.94	.29*
Griffith et al., 1981	Michigan Hosp Service Areas	14 - 53	3.7	
Lewis, 1969	Kansas Hlth Plng Regions	12 - 42	3.50	.37*
McPherson, et al., 1981	Canadian Provinces	27 - 46	1.70	
"	U.S. Regions	19 - 26	1.37	
McPherson et al., 1982	Vt, Me, R.I. Hosp Serv Areas	18 - 35**	1.9	.18
Mindell et al., 1982	Canadian Provinces (1968)	16 - 40**	2.5	
"	" (1977)	20 - 28**	1.4	
Roos & Roos, 1981	Manitoba Regions (>66)	36 - 99	2.80	
Stockwell & Vayda, 1979	Ontario Counties	21 - 102	4.9	
Vayda & Anderson, 1975	Canadian Provinces (male)	4 - 18	4.1	
"	" (female)	27 - 63	2.3	
Vayda et al., 1976	" (1968)	16 - 40	2.58	.24*
"	"	18 - 40	2.26	.19*
"	" (1972)	22 - 45	2.05	.17*
Vayda et al., 1984	Ontario Counties (1973)	31 - 68	2.22	.17*
"	" (1975)	27 - 47	1.76	.14*
"	" (1977)	16 - 39	2.49	.17*
Wennberg & Gittelsohn, 1973	Vermont Hosp Service Areas	17 - 57	3.35	
Wennberg & Gittelsohn, 1975	Maine Hosp Service Areas	27 - 55	2.04	.22*
Wennberg et al., 1975	Maine, Vermont Hosp Serv Areas	25 - 55	2.20	.24
Wennberg et al., 1982	Rhode Island Hosp Serv Areas	18 - 33**	1.83	
"	Maine Hosp Service Areas	19 - 29**	1.53	
"	Vermont Hosp Service Areas	17 - 25**	1.47	
Wennberg et al., 1982	Vt, Me, R.I. Hosp Serv Areas		1.8	.18
Wennberg & Gittelsohn, 1982	Rhode Island Hosp Serv Areas	18 - 33**	1.83	
"	Maine Hosp Service Areas	19 - 30**	1.58	
"	Vermont Hosp Service Areas	14 - 26**	1.86	
McPherson, et al., 1981	England & Wales Hlth Districts	6 - 9	1.58	.11*
McPherson, et al., 1982	Norway Counties	6 - 12**	1.5	.18
"	W.Midlands, U.K. Hlth Districts	6 - 12**	1.5	.16

*Calculated by Clark, 1988
**Range estimated from graphs

procedures per 10,000 population, and a maximum/minimum ratio of 2.4. The Vayda and Anderson study (1975) confirmed previous clinical findings that cholecystectomy was predominantly a procedure done on females. Within the Canadian provinces studied, the cholecystectomy rates were from 4 to 18 per 10,000 males and from 27 to 63 per 10,000 females. The coefficient of variation ranged from .09 in Manitoba to .37 in Kansas. The coefficient of variation for cholecystectomy in this current study was .19, the mean for all the comparable previous research results.

Inguinal Hernia Repair

In previous studies, inguinal hernia repair rates showed very little variation (Table 4.7) with most studies reporting less than a two-fold difference between the lowest to the highest rate. McPherson found very little variation in inguinal hernia repair rates in New England, Norway, and the West Midland area of the United Kingdom (McPherson *et al*., 1982), reporting a coefficient of variation of .001 and .002. The results of this current research were dissimilar on two points. First, my minimum inguinal hernia repair rate was lower than that reported in most North American studies and more closely resembled the rates reported by McPherson *et al*. (1981, 1982) in England and Wales. The mean minimum rate reported previously was 22 and the mean maximum rate was 36. The second dissimilarity was that the results of this current research showed a greater amount of variability (3-fold) than any previous study. No previous published Michigan results were available for comparison.

TABLE 4.7

INGUINAL HERNIA REPAIR RATES

Study	Location	Ranges in Adms. or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
Clark, 1988	Michigan Hospital Serv Areas	10 - 31	3.1	.23*
Barnes *et al*., 1985	Massachusetts Minor Civil Div	18 - 35**	1.94	
Detmer & Tyson, 1976	Wisconsin Hlth Plng Regions	28 - 38	1.36	.11*
Gittelsohn & Wennberg, 1976	Vermont Hosp Serv Areas (male)	38 - 54	1.42	.12*
Lewis, 1969	Kansas Hlth Planning Regions	18 - 43	2.39	.26*
McPherson, *et al*., 1981	Canadian Provinces	15 - 26	1.73	
"	U.S. Regions	24 - 32	1.33	
McPherson *et al*., 1982	Vt, Me, R.I. Hosp Serv Areas	22 - 38**	1.7	.001
Roos & Roos, 1981	Manitoba Hosp Service Areas (>66)	31 - 85	2.7	
Vayda & Anderson, 1975	Canadian Provinces (male)	25 - 46	1.8	
"	" (female)	3 - 6	1.9	
Vayda *et al*., 1976	Canadian Provinces (1968)	14 - 26	1.82	.16*
"	" (1970)	14 - 24	1.78	.15*
"	" (1972)	13 - 25	1.94	.16*
Wennberg & Gittelsohn, 1973	Vermont Hosp Service Areas	29 - 48	1.66	
Wennberg & Gittelsohn, 1975	Maine Hosp Service Areas	35 - 60	1.71	.14*
Wennberg *et al*., 1975	Maine, Vermont Hosp Serv Areas	34 - 58	1.71	.16
Wennberg *et al*., 1977,1979	Vermont Hosp Service Areas	39 - 66	1.69	
"	Maine Hosp Service Areas	35 - 60	1.71	
Wennberg *et al*., 1982	Rhode Island Hosp Service Areas	21 - 31**	1.48	
"	Maine Hosp Service Areas	21 - 32**	1.52	
"	Vermont Hosp Service Areas	19 - 34**	1.79	
Wennberg *et al*., 1982	Vt, Me, R.I. Hosp Serv Areas		1.5	.12
Wennberg & Gittelsohn, 1982	Rhode Island Hosp Service Areas	21 - 31**	1.48	
"	Maine Hosp Service Areas	21 - 32**	1.52	
"	Vermont Hosp Service Areas	19 - 34**	1.79	
Wennberg *et al*., 1984	Maine Hosp Service Areas (per 10,000 person years)	19 - 28**	1.7	.12
McPherson, *et al*., 1981	England & Wales Hlth Districts	9 - 15	1.71	.15*
McPherson, *et al*., 1982	Norway Counties	17 - 21**	1.3	.002
"	W.Midlands, U.K. Hlth Districts	8 - 18**	2.0	.002

*Calculated by Clark, 1988
**Range estimated from graphs

Vayda and Anderson (1975) calculated both male and female inguinal hernia repair rates. The results from that study indicated that inguinal hernia repair was a procedure done predominantly on males, but a later study (Vayda et al., 1976) did not confirm higher rates for males.

Prostatectomy

With the exception of one Vermont study (Wennberg and Gittelsohn, 1973), prostatectomy rates (Table 4.8) showed great consistency across all of the Wennberg studies of New England (Gittelsohn and Wennberg, 1976; Wennberg and Gittelsohn, 1982; and Wennberg et al., 1982) with ranges that had a slightly more than two-fold difference between low and high rates. The results of this current study had a slightly higher maximum/minimum ratio than those Wennberg and Gittelsohn reported in New England and had a higher than average minimum (15) and maximum (42) rate. Griffith et al. (1981) found an extremely high variation of over 16-fold between the lowest and highest prostatectomy rates in the 1978 Michigan data. A similar extreme variation result (maximum/minimum ratio of 15) was reported by Vayda et al. (1984) in the prostatectomy rates of the Ontario counties studied. Comparison of the coefficient of variation results showed that they ranged from .19 to .33 in previous studies, with a mean of .25. The coefficient of variation for this current study was .24.

TABLE 4.8

PROSTATECTOMY RATES

Study	Location	Ranges in Adms. or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
Clark, 1988	Michigan Hosp Service Areas	15 - 42	2.8	.24*
Barnes *et al.*, 1985	Massachusetts Minor Civil Div	29 - 33**	1.14	
Gittelsohn & Wennberg, 1976	Vermont Hosp Service Areas	15 - 32	2.13	.19*
Griffith *et al.*, 1981	Michigan Hosp Service Areas	3 - 50	16.7	
McPherson, *et al.*, 1981	Canadian Provinces	6 - 33	5.5	
"	U.S. Regions	21 - 37	1.76	
McPherson *et al.*, 1982	Vt, Me, R.I. Hosp Serv Areas	18 - 44**	2.2	.30
Mindell *et al.*, 1982	Canadian Provinces (1968)	14 - 26**	1.86	
"	" (1977)	16 - 25**	1.56	
Roos & Roos, 1981	Manitoba Regions (>66)	125 - 282	2.3	
Vayda & Anderson, 1975	Canadian Provinces	14 - 25	1.8	
Vayda *et al.*, 1976	" (1968)	14 - 26	1.81	.21*
"	" (1970)	13 - 25	1.88	.20*
"	" (1972)	14 - 27	1.94	.19*
Vayda *et al.*, 1984	Ontario Counties (1973)	3 - 38	15.08	.30*
"	" (1975)	6 - 37	6.08	.27*
"	" (1977)	6 - 34	5.73	.25*
Wennberg & Gittelsohn, 1973	Vermont Hosp Service Areas	11 - 38	3.45	
Wennberg & Gittelsohn, 1975	Maine Hosp Service Areas	18 - 40	2.22	.26*
Wennberg *et al.*, 1982	Rhode Island Hosp Serv Areas	18 - 40**	2.22	
"	Maine Hosp Service Areas	20 - 41**	2.05	
"	Vermont Hosp Service Areas	12 - 33**	2.75	
Wennberg *et al.*, 1982	Vt, Me, R.I. Hosp Serv Areas	-	2.5	.30
Wennberg & Gittelsohn, 1982	Rhode Island Hosp Serv Areas	19 - 39**	2.05	
"	Maine Hosp Service Areas	16 - 41**	2.56	
"	Vermont Hosp Service Areas	13 - 33**	2.54	
McPherson, *et al.*, 1981	England & Wales Hlth Districts	6 - 13	2.28	.20*
McPherson, *et al.*, 1982	Norway Counties	16 - 37**	2.2	.33
"	W.Midlands, U.K. Hlth Districts	7 - 20**	2.1	.24

*Calculated by Clark, 1988
**Range estimated from graphs

Hysterectomy

As shown in Table 4.9, the hysterectomy rates reported in the current research (32 to 69 procedures per 10,000 females) were similar to many of the other reported rates in North America. The mean minimum rate was 32 and the mean maximum rate was 74 for the comparable studies in the literature. The Canadian experience did not appear to be significantly different than that of the United States, although three studies (Dyck et al., 1977; Stockwell and Vayda, 1979; and Vayda et al., 1984) found extraordinarily high upper ranges in their studies in Canada. The hysterectomy rates in England and Wales were considerably lower, as were the rates reported by Barnes et al. (1985) in Massachusetts. Griffith et al. (1981) found a greater than 6-fold difference between the highest and lowest hysterectomy rates in the 1978 Michigan data, while only a 2-fold difference was found in this current study using the 1983 Michigan data. The highest coefficient of variation (.31) was found in Norway, while the mean was .26. The coefficient of variation for hysterectomy in this current study was .17, far lower than expected.

Cesarean Section

Cesarean section procedure rates are of increasing interest to researchers because of the rapid increase in the number of Cesarean sections performed in the United States over the last several years. Anderson and Lomas (1985), Barnes et al. (1985), Mindell et al. (1982), Vayda and Anderson (1975), and Vayda et al. (1984) have all documented

TABLE 4.9
HYSTERECTOMY RATES

Study	Location	Ranges in Adms. or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
Clark, 1988	Michigan Hospital Service Areas	32 - 69	2.16	.17*
Barnes et al., 1985	Massachusetts Minor Civil Div	12 - 23**	1.92	
Detmer & Tyson, 1976	Wisconsin Hlth Planning Regions	20 - 34	1.65	.15*
Dyck et al., 1977	Saskatchewan Cities	50 - 126	2.52	
"	"	36 - 63	1.75	
Gittelsohn & Wennberg, 1976	Vermont Hospital Service Areas	30 - 60	2.0	.22*
Griffith et al., 1981	Michigan Hospital Service Areas	15 - 95	6.5	
McPherson, et al., 1981	Canadian Provinces	42 - 73	1.74	
"	U.S. Regions	58 - 79	1.36	
McPherson et al., 1982	Vt, Me, R.I. Hosp Service Areas	44 - 96**	2.2	.22
Mindell et al., 1982	Canadian Provinces (1968)	33 - 58**	1.76	
"	" (1977)	33 - 68**	2.06	
Roos, N., 1984	Manitoba Regions	41 - 123	2.8	
Stockwell & Vayda, 1979	Ontario Counties	41 - 203	4.9	
Vayda & Anderson 1975	Canadian Provinces	32 - 58	1.81	
Vayda et al., 1976	" (1968)	32 - 58	1.81	.18*
"	" (1970)	47 - 81	1.72	.16*
"	" (1972)	50 - 87	1.73	.18*
Vayda et al., 1984	Ontario Counties (1973)	30 - 109	3.65	.28*
"	" (1975)	29 - 87	2.98	.25*
"	" (1977)	22 - 80	3.69	.24*
Wennberg & Gittelsohn, 1973	Vermont Hospital Service Areas	20 - 60	3.0	
Wennberg & Gittelsohn, 1975	Maine Hlth Planning Regions	39 - 93	2.38	.25*
Wennberg et al., 1975	Me, Vt Hospital Service Areas	40 - 92	2.30	.26
Wennberg et al., 1977,1979	Vermont Hospital Service Areas	30 - 61	2.03	
"	Maine Hospital Service Areas	39 - 93	2.38	
Wennberg et al., 1982	Rhode Island Hosp Service Areas	42 - 73**	1.74	
	Maine Hospital Service Areas	34 - 88**	2.59	
"	Vermont Hospital Service Areas	37 - 65**	1.76	
Wennberg et al., 1982	Vt, Me, RI Hosp Service Areas		2.0	.23
Wennberg & Gittelsohn, 1982	Rhode Island Hosp Service Areas	42 - 74**	1.76	
"	Maine Hospital Service Areas	34 - 89**	2.62	
"	Vermont Hospital Service Areas	25 - 64**	2.5	
Wennberg et al., 1984	Maine Hospital Service Areas (per 10,000 person years)	11 - 33	3.5	.23
McPherson, et al., 1981	England & Wales Hlth Districts	18 - 29	1.59	.12*
McPherson, et al., 1982	Norway Counties	5 - 18**	3.0	.31
"	W.Midlands, U.K. Hlth Districts	13 - 30**	2.1	.20

*Calculated by Clark, 1988

**Range estimated from graphs

variations in the use of Cesarean sections for deliveries, but Anderson and Lomas (1985) and Vayda et al. (1984) calculated their rates as the number of Cesarean sections performed per 1000 births. As shown on Table 4.10, the minimum Cesarean section rate of 13 per 10,000 females reported by Vayda and Anderson (1975) was most similar to the results of this current research. The difference was that Vayda and Anderson (1975) reported a 2.5-fold variation in Cesarean section rates, while this research found a 6-fold difference. Barnes et al. (1985) found very little variability in Massachusetts. No earlier published results for Cesarean section rates were available from Michigan.

Comparison of the Systematic Component of Variation Results

Systematic component of variation results from previous research are available for six of the seven surgical procedure use rates studied. Table 4.11 shows comparable results from Wennberg et al. (1984), McPherson et al., (1981, 1982), and McCracken (personal correspondence). These results allowed comparison of the Michigan surgical procedure SCV's to those in New England, England and Wales, Norway, West Midlands of the U. K., Canada, and Iowa. With the exception of Iowa, there was more variation in the procedure rates for appendectomy, hemorrhoidectomy, cholecystectomy and inguinal hernia repair in Michigan than in any of the other areas for which there are SCV data available. Prostatectomy rates in Michigan had the lowest amount of variation, and only England and Wales had lower variation in hysterectomy use rates than Michigan. Michigan's use rate variation in

TABLE 4.10

CESEAREAN SECTION RATES

Study	Location	Ranges in Adms. or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
Clark, 1988	Michigan Hosp Serv Areas	15 - 90	6.0	.20
Barnes et al., 1985	Massachusetts Minor Civil Div	36 - 50**		
Vayda & Anderson, 1975	Canadian Provinces	13 - 27	2.5	

*Calculated by Clark, 1988
**Range estimated from graphs

Table 4.11

COMPARISON OF SYSTEMATIC COMPONENT OF VARIATION RESULTS

	Clark, 1988	Wennberg *et al.*, 1984	McPherson *et al.*, 1982			McPherson *et al.*, 1981		McCracken, 1985 Personal Correpondence
	Michigan	New England	New England	Norway	West Midlands	England & Wales	Canada	Iowa
Appendectomy	58	22	17	24	29	15	31	76
Hemorrhoidectomy	199		127	147	122	41	104	
Cholecystectomy	26		17	19	21	8	19	33
Inguinal Hernia	44	7	6	2	44	22	19	
Prostactectomy	34		50	93	62	46	96	121
Hysterectomy	17	50	48	104	37	13	33	50
Cesarean-Section	34							

all four comparable procedures was less than that found in Iowa in 1985 by McCracken.

In summary, Michigan showed a greater variation in surgical procedure rates for all tested procedures except prostatectomy and hysterectomy than for all areas except Iowa. Michigan's surgical procedure rates showed less variation than did Iowa in every surgical procedure tested. Clearly, there are differences in the variation in use rates from one place to another, and further investigation of the four components (individual, community, physician, and hospital) that influence use rates is important to find what explains these differences in variability.

Medical Causes for Admission Rates

Variation in surgical procedures is well-documented, but the variations in medical diagnoses that cause hospitalization have not been studied as extensively. A set of specific surgical procedures which range from low to high variability have been used repeatedly by researchers. No such group of specific medical causes for admission has been developed as index "causes". It is far more difficult to compare the medical diagnoses admission rates with previous research because different ICD-9-CM code definitions of the causes for medical admission have been used by different researchers. The comparisons discussed below do not take into consideration the results reported for specific Diagnosis Related Groups (DRGs), the Health Care Financing Administration's (Medicare's) classification of ICD-9-CM codes for prospective payment, or subsets of the four categories (circulatory, respiratory, digestive, or genito-urinary admissions).

As shown in Table 4.12, this study found a range of circulatory admission use rates from 101 to 300 per 10,000 population. That range was reasonably close to the ranges reported by Wennberg and Gittelsohn (1973) and Wennberg et al. (1975) and, although the current study's maximum/minimum ratio was the highest of any of the comparable studies, the coefficient of variation was almost identical to the one reported by Wennberg and Gittelsohn (1975) in Maine.

The respiratory admission rate for Michigan ranged from 50 to 203 per 10,000 population. This study's respiratory rate coefficient of variation (.31) was similar to that reported by Wennberg and Gittelsohn (1973) from Vermont (.35). As reported in this current research, digestive admission rates varied more widely in Michigan than in any of the other reported areas. The rate for the 53 Michigan hospital service areas included in this study ranged from 127 to 310, both higher and lower and with a higher maximum/minimum ratio (2.44) and coefficient of variation (.21) than any other reported comparable results. This research found far lower genito-urinary admission rates than Wennberg and Gittelsohn (1973) and Wennberg et al. (1975) found in New England, although the maximum/minimum ratio (2.37) and coefficient of variation (.21) were higher than shown in all other comparable studies.

Comparison of previous Michigan results is problematic since Griffith et al. (1981) used quartile ranges in an effort to decrease the effect of the minimum and maximum rates. The ranges reported by Griffith et al. (1985) for circulatory and digestive causes for

TABLE 4.12

MEDICAL CAUSES FOR ADMISSION RATES

Study	Location		Ranges in Adms. or Discharges per 10,000 Population	Max/Min Ratio	Coefficient of Variation
CIRCULATORY					
Clark, 1988	Michigan Hosp Serv Areas		101 - 300	2.97	.20*
Wennberg & Gittelsohn, 1973	Vermont Hosp Serv Areas		120 - 250	2.08	
Wennberg et al., 1975	Maine Hlth. Pln. Regions		181 - 296	1.64	.22
Wennberg et al., 1984	Maine Hosp Serv Areas	(DRG 132)	2 - 27**	13.5	
Griffith et al., 1985	Michigan Hosp Serv Areas	(quartile)	168 - 240	1.43	
RESPIRATORY (Including Upper & Lower Respiratory Infections, Pneumonia, Bronchitis, etc.)					
Clark, 1988	Michigan Hosp Serv Areas		50 - 203	4.06	.31*
Connell et al., 1981	Washington Hosp Serv Areas	(URI)	25 - 180**	7.2	
" "	"	(LRI)	20 - 260**	13.0	
Wennberg & Gittelsohn, 1973	Vermont Hosp Serv Areas		100 - 360	3.6	
Wennberg et al., 1975	Maine Hlth. Pln. Regions		151 - 340	2.25	.35
Wennberg et al., 1975	Vt/Maine Hosp Serv Areas	(URI)	0.9 - 25	27.78	.79
Wennberg et al., 1984	Maine Hosp Serv Areas	(DRG 88)	10 - 50**	5.0	
Griffith et al., 1985	Michigan Hosp Serv Areas	(quartile)	116 - 232	2.0	
DIGESTIVE					
Clark, 1988	Michigan Hosp Serv Areas		127 - 310	2.44	.21*
Wennberg & Gittelsohn, 1973	Vermont Hosp Serv Areas		150 - 260	1.73	
Wennberg et al., 1975	Maine Hlth. Pln. Regions		190 - 271	1.43	.16
Wennberg et al., 1984	Maine Hosp Serv Areas	(DRG 183)	15 - 55**	3.67	
Griffith et al., 1985	Michigan Hosp Serv Areas	(quartile)	157 - 246	1.57	
GENITO URINARY					
Clark, 1988	Michigan Hosp Serv Areas		30 - 71	2.37	.21*
Wennberg & Gittelsohn, 1973	Vermont Hosp Serv Areas		80 - 180	2.25	
Wennberg et al., 1975	Maine Hlth. Pln. Regions		145 - 182	1.26	.10
Griffith et al., 1985	Michigan Hosp Serv Areas	(quartile)	123 - 183	1.49	

*Calculated by Clark, 1988
**range estimated from graph

admission lay within those found in this current research. This was as expected since the ranges were reported by quartiles. The highest rate found in this current research for genito-urinary causes for admission (71) was lower than the lower quartile rate (123) reported by Griffith _et al_. (1985), so that even the maximum genito-urinary rate found in this study was lower than the adjusted minimum quartile rate found in the earlier Michigan study.

There are two possible explanations for the differences between my results and Griffith's earlier Michigan results. The first is that Griffith and I used different clusters of ICD-9-CM codes to define the four medical causes for admission categories. My ICD-9-CM definitions were based on previous work by Wennberg, so the differences in variability may lie in the definitions. Secondly, Griffith included metropolitan Detroit in his study area, while I did not. The extreme rates Griffith reported may have been found in Detroit's hospital service areas.

CHAPTER 5

PATTERNS IN MICHIGAN HOSPITAL USE RATES

Four Use Rate Patterns

Paul-Shaheen *et al*. (1987) identified four use rate patterns in the small area analysis literature. The four use rate patterns are: 1) there is a consistency in procedure specific variation ranking; 2) the variation in rates for admission due to medical causes is consistently greater than the variation in surgical procedure rates; 3) hospital service areas have unique surgical procedure rate patterns; and 4) hospital service areas may show consistently high or low use across several measures of use. Each of the use rate patterns was analyzed and the results from this study were described and compared to previous findings by other researchers.

Pattern 1:
Consistency in Procedure Specific Variation Ranking

The first pattern, the consistency in procedure specific variability when ranked by variation in use rates, was initially described by Wennberg and Gittelsohn (1975). They found that some surgical procedures such as hysterectomy and tonsillectomy had greater variation than others such as appendectomy and inguinal hernia repair. This consistency has been documented in many areas over the last thirteen years.

Wennberg and Gittelsohn (1975 and subsequent papers) developed the hypothesis that the differences in use rate variability were related to physician characteristics (the physician component of the Clark Model). They theorized that those surgical procedures that had high variability such as hysterectomy and tonsillectomy had low consensus among physicians. Consensus is based upon certainty of diagnosis, the resulting certainty of the most appropriate treatment, and the timing of that treatment. For example, the diagnosis of appendicitis is straightforward and can be confirmed by an elevated white blood cell count. The most appropriate treatment is an appendectomy performed as soon as possible. Most importantly to this discussion, there is virtually no disagreement among physicians as to the diagnosis, the treatment or the timing of that treatment once the diagnosis is known. Therefore, appendectomy rates should and do have lower variation across small areas.

On the other hand, the diagnosis of tonsillitis is not simple or straightforward. Hypertrophy of the tonsil is a judgment made by comparing the coloring of the organ to the surrounding tissue and the size of the tonsil relative to the opening of the throat. In children the organ is proportionally larger than in adults. There are several accepted treatments for tonsillitis. More conservative physicians usually administer an antibiotic once or several times before, if ever, considering surgery. Less conservative physicians may do a tonsillectomy after the first episode of tonsillitis has run its course. As a consequence, there is little medical consensus on the diagnosis, the most appropriate treatment or its timing. Therefore, according to Wennberg and Gittelsohn's theory, tonsillectomy rates should and do have high variability across small areas.

Using Wennberg and Gittelsohn's theory of medical uncertainty as a starting point, one could hypothesize a relationship between use rate variability and elective or non-elective procedures. Non-elective procedures such as appendectomy should have lower variation in use rates than elective procedures such as hemorrhoidectomy. This is in part explained by the individual component of the Clark model and the tolerance for discomfort that is unique to each individual. It is also, in part, explained by the physician component. The physician is influenced by medical training, specialty or subspecialty associations, the historical practice pattern in the community and possibly desire to maximize income.

In their 1984 New England Journal of Medicine article, Wennberg et al. produced a table ranking many medical causes for admission and surgical procedure rates into categories of variability which ranged from low variation to very high variation. The medical and surgical rankings were done separately using the systematic component of variation as the measure of variation. Wennberg's table is reproduced below as Table 5.1.

As shown in Table 5.2, this current study found that the use rates ranged from a SCV of 199 for hemorrhoidectomy to 17 for hysterectomy. Comparison of this list to the rankings described by Wennberg et al. (1984) and shown in Table 5.1 showed a considerable difference.

Table 5.1

MEDICAL AND SURGICAL CAUSES OF ADMISSIONS RANKED IN ASCENDING ORDER OF VARIATION IN INCIDENCE OF HOSPITALIZATION (1980-1982)

MEDICAL CAUSES OF ADMISSION

Low Variation

None

Moderate Variation

Acute myocardial infarction
Gastro-intestinal hemorrhage
Specific cerebrovascular disorders

High Variation

Nutritional and metabolic diseases
Syncope and collapse
Respiratory neoplasms
Cellulitis
Urinary tract stones
Cardiac arrhythmias
Miscellaneous injuries to extremities
Angina pectoris
Toxic effects of drugs
Psychosis
Heart failure and shock
Seizures and headaches
Adult simple pneumonias
Respiratory signs and symptoms
Depressive neurosis
Medical back problems
Digestive malignancy
G.I. obstruction
Adult gastro-enteritis
Perpheral vascular disorders
Red blood cell disorders
Adult diabetes
Circulatory disorders exc. AMI, with cardiac catheterization

Very High Variation

Deep vein thrombophlebitis
Adult bronchitis and asthma
Organic mental syndromes
Chest pain
Transcient ischemic attacks
Kidney and urinary tract infections
Acute adjustment reaction
Minor skin disorders
Trauma to skin, subct. tissue and breast
Chronic obstructive lung disease
Hypertension
Adult otitis media and URI
Peptic ulcer
Disorders of the biliary tract
Pediatric gastro-enteritis

MEDICAL CAUSES OF ADMISSION (CONT.)

Pediatric bronchitis and asthma
Atherosclerosis
Pediatric otitis media and URI
Pediatric pneumonia
Chemotherapy

SURGICAL CAUSES OF ADMISSION

Low Variation

Inguinal and femoral hernia repair
Hip repair except joint replacement

Moderate Variation

Appendicitis with appendectomy
Major small and large bowel surgery
Gall bladder disease with cholecystectomy
Adult hernia repairs except inguinal and femoral

High Variation

Hysterectomy
Major cardiovascular operations
Pediatric hernia operations
Hand operations except ganglion
Foot operations
Lens operations
Major joint operations
Stomach, esophageal, and duodenal operations
Anal operations
Female reproductive system reconstructive operations
Back and neck operations
Soft tissue operations

Very High Variation

Knee operations
Transurethral operations
Uterus and andenexa operations
Extra-ocular operations
Misc. ear, nose, and throat operations
Breast biopsy and local excision for nonmalignancy
D & C, conization except for malignancy
T & A operations except for tonsillectomy
Tonsillectomy
Female laparoscopic operations except for sterilization
Dental extractions and restorations
Laparoscopic tubal interruptions
Tubal interruption for nonmalignancy

*Causes of hospitalizations are taken from Diagnostic-Related Disease Classification system, but cases have been grouped without regard to presence or absence of significant complication. Obstetrical and neo-natal causes of hospitalization are excluded. Ranking is according to the Systematic Component of Variation. Variations are measured across thirty hospital markets. The exhibit lists individually only those with more than 1,500 cases. More than 50 percent of hospitalizations are represented in the exhibit. Classes of variation are defined such that the variation associated with the first entry in a class is significantly more variable than the first entry in the previous class. For additional information see K. McPherson, J.E. Wennberg, O.B. Hovind, and P. Clifford. The New England Journal of Medicine 307 (1982):1310-4.

Wennberg, J. (1984), Health Affairs (Summer), Vol. 3, No. 2, p.14

Table 5.2

COMPARISON OF VARIATION RANKING BY SYSTEMATIC COMPONENT OF VARIATION

	This Study 1988	Wennberg *et al.*, 1984 *New England Journal of Medicine*	
Cause for Hospitalization	SCV	Classification	SCV
Hemorrhoidectomy	199	High	90*
Respiratory Admissions	115		
Appendectomy	58	Moderate	22
Digestive Admissions	50		
Inguinal Hernia Repair	44	Low	7
Genito Urinary Admissions	41		
Circulatory Admissions	38		
Prostatectomy	34	Very High	190*
Cesarean-Section	34		
Cholecystectomy	26	Moderate	39*
Total Male Admissions	24		
Total Female Admissions	23		
Total Hospital Admissions	22		
Hysterectomy	17	High	50

*SCV from Wennberg's classification system:

low = 17
moderate = 39
high = 90
very high I = 190
very high II = 506

Wennberg's scale characterized low variation as having a SCV of 17; moderate was 39; high was 90; very high I was 190; and very high II was 506. Wennberg placed cholecystectomy and appendectomy in the moderate level of variation, as did the results from this current research in Michigan. Wennberg found that hernia repair had low variation whereas it had moderate variation in my study. Wennberg ranked prostatectomy as having very high variation and hysterectomy as having high variation. Both prostatectomy and hysterectomy ranked as having low or moderate variation in this current study. The reasons for the differences between Wennberg's prostatectomy and hysterectomy rates and the ones from this current study are not immediately apparent, and were unexpected particularly since all oncology ICD-9-CM codes for both prostatectomy and hysterectomy were removed from this study's procedure definitions. The removal of the oncology ICD-9-CM codes was expected to increase the variation in both prostatectomy and hysterectomy rates since there is less medical uncertainty when a malignancy is present and therefore surgery is almost always performed. One must ask what the differences are between New England and Michigan that could explain these differing results. Do the differences relate to the individuals, communities, physicians or hospitals? Further investigation is necessary, and, specifically, further research in the physician practice patterns seems necessary.

Pattern 2: Variation in Medical Causes for Admission Rates Consistently Greater Than Variation in Surgical Procedure Rates

The second pattern identified by Paul-Shaheen et al. (1987) in the previous research was that medical admission rates had greater variability than did surgical procedure rates. Wennberg et al. (1975), Wennberg (1984) and Wilson and Tedeschi (1984) found greater variability among medical causes for admission rates than among surgical procedure rates. As shown previously in Table 5.1, Wennberg et al. (1984) determined that there were no medical diagnoses that fit within his low variation category for medical causes for admission, and most fit within the high or very high categories.

As shown previously in Table 5.2, this current study found that one surgical procedure (hemorrhoidectomy) varied more than any one of the four medical admission rates, and that hemorrhoidectomy and appendectomy rates varied more widely than did digestive, genito-urinary or circulatory admission rates. The results suggested that the practice patterns in Michigan may be different than the ones found in other geographic areas.

Pattern 3:

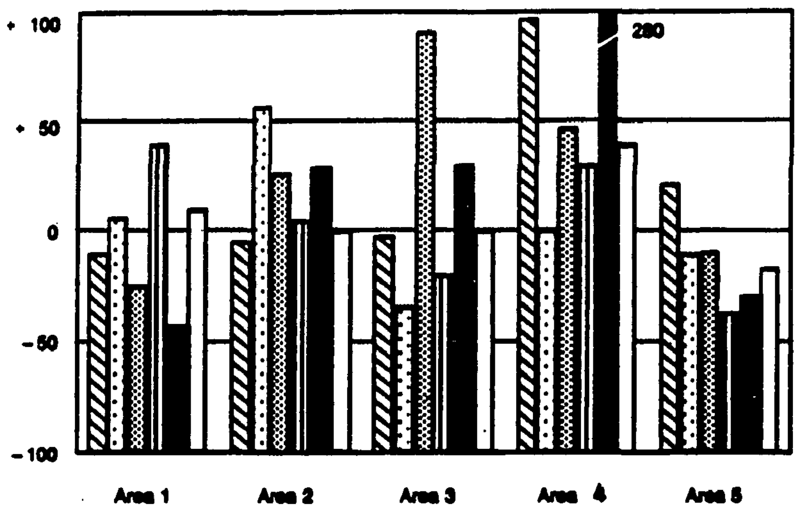
Unique Surgical Procedure Rate Patterns Within a Hospital Service Area

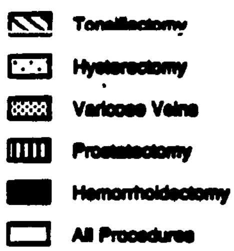
The third pattern was also first identified by Wennberg and Gittelsohn (1975), who hypothesized that surgical procedure rates formed a unique pattern in each hospital service area. They felt that their research had shown that within certain hospital service areas use rate patterns of the practicing physicians created a unique set of higher and lower procedure-specific use rates. They also felt that within a single hospital service area the procedure-specific use rates that were high remained high over time, and those that were low remained low over a number of years. This observation of procedure-specific consistency over time was corroborated by Vayda _et al_. (1984). These research results were part of the reason that I hypothesized in Chapter 2 that hospital service area use rates could, in part, be explained by the dominance of a board certified specialty or the dominance of graduates of a specific residency program within a hospital service area. I felt that a dominance of physicians who either trained in the same specialty or trained in the same graduate medical education program would be more likely to maintain a consistent hospital service area-specific practice pattern over time. Unfortunately, this hypothesis could not be tested in the time frame of this research.

When viewed graphically, with the surgical procedure rates placed side by side, a unique "surgical signature" for a hospital service area was seen. Figure 5.1 is an example of the surgical signatures for five hospital service areas in Maine (Wennberg, 1982).

Figure 5.1

Surgical Signatures
of
Five Hospital Service Areas in Maine





"SURGICAL SIGNATURE" *of a hospital area* reflects the specialties and preferences of the surgeons who practice in the area. Each group of six bars shows the rates of five common surgical procedures and the total surgery rate for one of the five most populous hospital areas in Maine. The rates are expressed in relation to the state average. The total surgery rate in each area is closely correlated with the number of surgeons there. The rates of individual procedures, however, are not determined by the number of surgeons. Areas 2 and 3 have the same total rate, but their signatures are quite different. In area 2 hysterectomy is the commonest procedure; in area 3 it is the least common. A signature is generally consistent over many years.

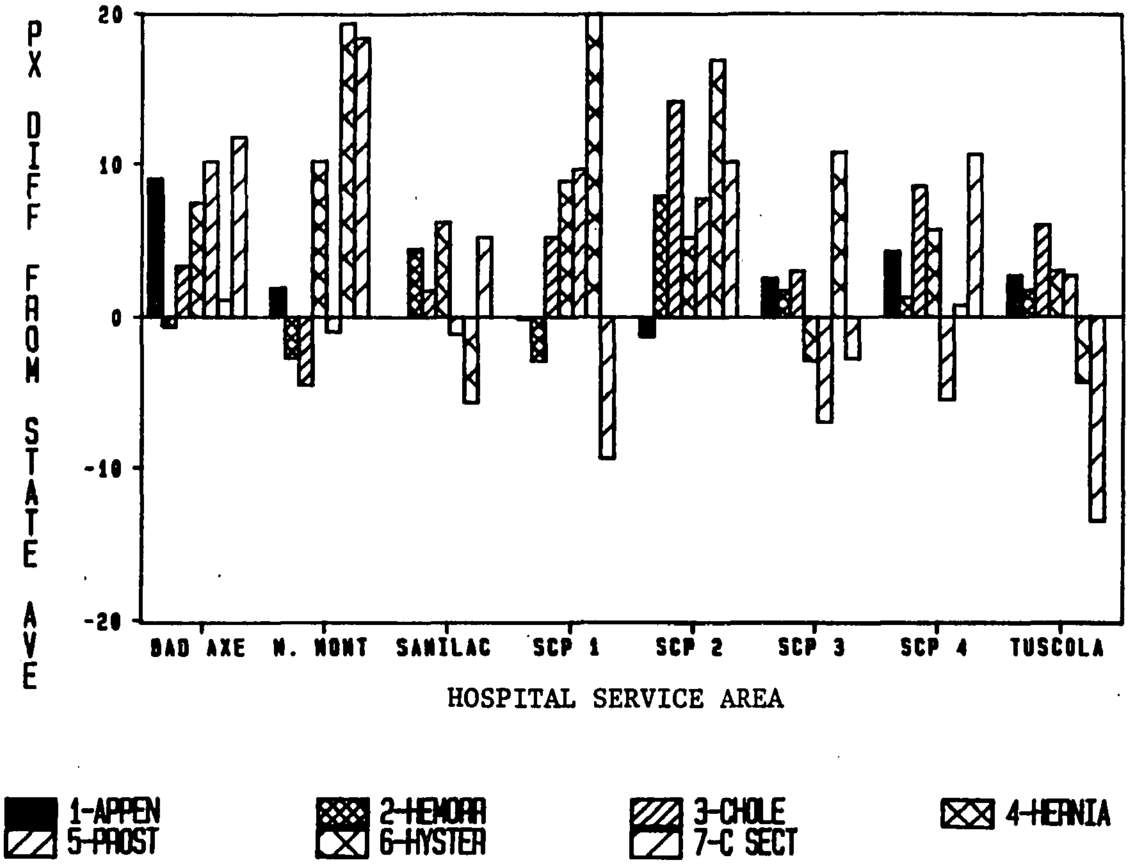
From: "Variations in Medical Care Among Areas," by John Wennberg, The results from this current study in Michigan corroborated Wennberg's observations about unique surgical use rate patterns. Review of the surgical signatures for the 53 hospital service areas in Michigan showed that there was very little similarity among the graphed surgical use rates. Two hospital service areas (Montcalm/Ionia and a sole community provider) had all seven surgical procedure rates above the mean and three hospital service areas (Oceana, Grand Rapids and South Berrien/Cass County) had all seven surgical procedure rates below the mean. All three of these consistently low surgical procedure rate hospital service areas are in the western part of the state.

The surgical signature graphs were also inspected for similarities among the high use hospital service areas and among the low use areas that were identified through analysis of the spatial patterns which will be discussed later in this chapter.

High Use Areas

Three aggregated hospital service areas plus one sole community provider hospital service area were identified as high use areas (a total of eight individual hospital service areas). Inspection of these four areas showed that the surgical signatures were very different in each hospital service area. Surgical use rate graphs for the eight hospital service areas within the four high use areas are shown in Figure 5.2.

Figure 5.2



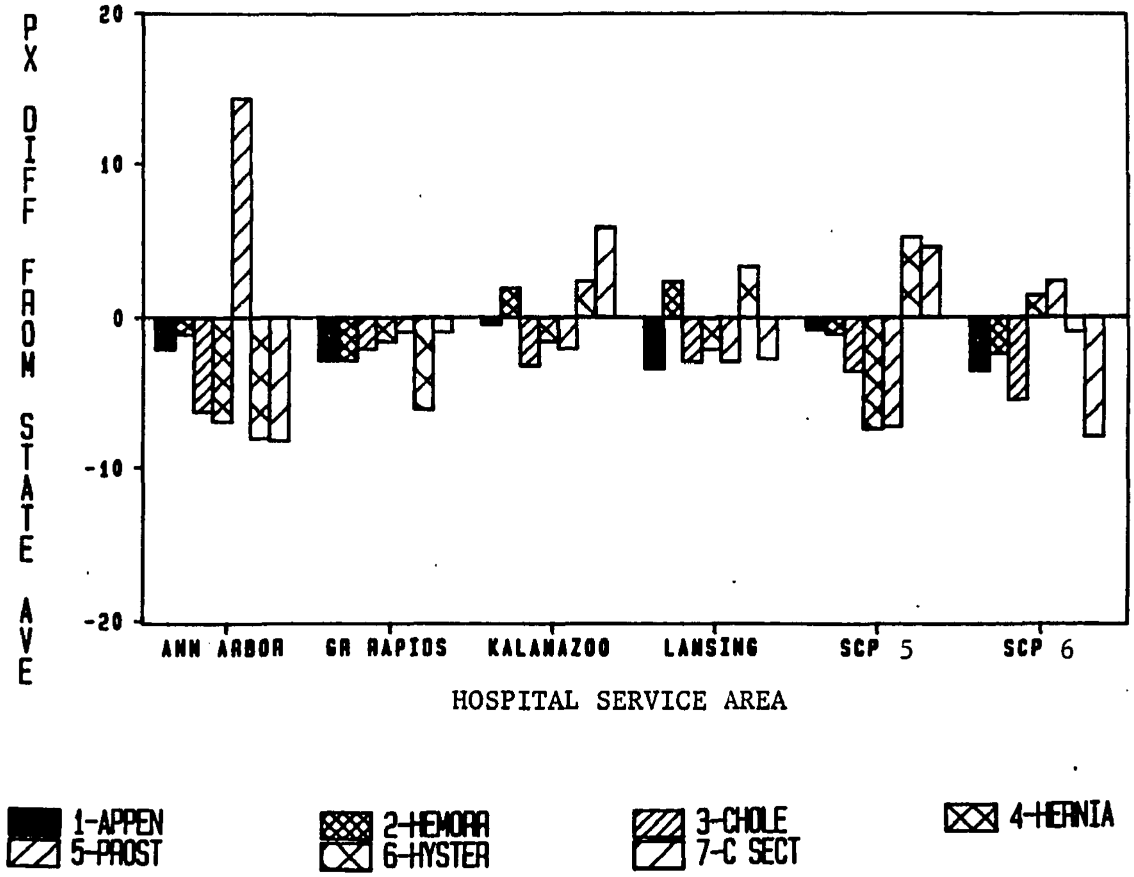
PX = Procedure

SURGICAL SIGNATURES--HIGH USE AREAS

Low Use Areas

Six hospital service areas were identified as low use areas. As shown in Figure 5.3, the surgical signatures for these six areas were dissimilar with one exception. The surgical signatures for Kalamazoo and Lansing were similar in direction (each procedure is higher or lower than the study area average) for six of the seven surgical procedure rates. Only Cesarean section rates were different, with Kalamazoo's rate above the study area's mean and Lansing's rate below. Five of the six remaining surgical procedure rates were very similar in magnitude as well as in direction. Appendectomy rates were lower in Lansing than in Kalamazoo. Grand Rapids had no surgical procedure rates higher than the study area mean, while only the prostatectomy rate was higher than the mean in Ann Arbor.

Figure 5.3



PX = Procedure

SURGICAL SIGNATURES--LOW USE AREAS

Pattern 4:
Consistency Within Hospital Service Areas of High Use or Low Use Across Several Procedures or Diagnoses

Another pattern which appears to have emerged from the small area analysis literature was that of use rate consistency across high or across low use areas. Griffith and his colleagues (1985), using information on hospital admissions in Michigan, analyzed admissions along a number of clinically descriptive dimensions: organ group categories, selected surgical procedures, and characteristics of length of stay and frequency of diagnosis. They found that hospital service areas with high total admission rates also tended to have high medical causes for admission rates, and, specifically, high respiratory admission rates.

To investigate the fourth use rate pattern, the variations in the fourteen hospital use rates were mapped by hospital service area and their distributions described. Their spatial patterns are discussed using the six regions shown on Figure 5.4. A tabulation of the standard deviations for each use rate by hospital service area is shown in Appendix C. The regions are used to give some identification of relative location since the sole community provider areas cannot be described or shown on a map. A standard deviation classification system was chosen so that comparisons of hospital service areas could be made across all of the use rates. It was more important to this research to know if a hospital service area had consistently high or low use rates across several measures than to know the actual use rate distribution

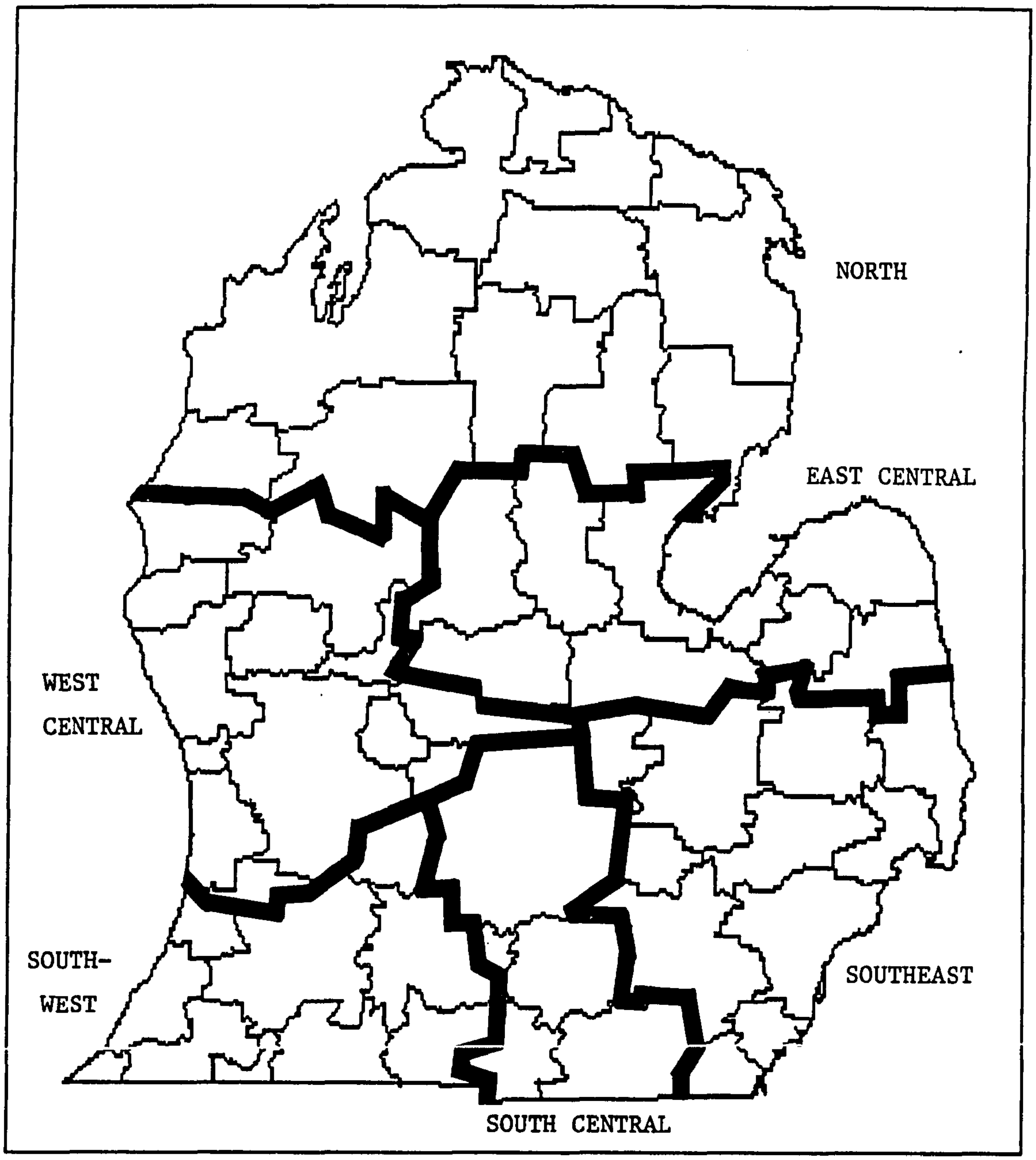


Figure 5.4

Study Area Regions

and range for total admissions, procedure-specific admissions, or medical causes for admission.

Total Hospital Use Rates

When mapped by standard deviations, the spatial patterns for total male admissions, total female admissions, and total admissions were all similar. The areas with higher admission rates were in the northern Thumb area of the East Central Region, the center of the North Region, immediately northwest of Lansing in the West Central Region and one sole community provider hospital service area of the South Central Region. High use (> 1 S.D.) areas were all north of a line drawn from Detroit to Oceana, while, with the exception of one sole community provider area in the South Central Region, the low use areas (< -1 S.D.) were all south of that line. The areas of lower admission rates were the referral centers of the western part of the state, South Central and Southeast Regions, plus two contiguous sole community provider hospital service areas. Figure 5.5, Total Admissions per 10,000 Population, was representative of all three total hospital use rate maps.

Surgical Procedure Rates

Each of the seven surgical procedure rates (Figures 5.6 - 5.12) had a unique spatial pattern of high and low use areas. Most shared one or more of the high use areas identified from the maps of the total admission use rates. One hospital service area in the high use portion of the North Region had high use rates for cholecystectomy, hernia

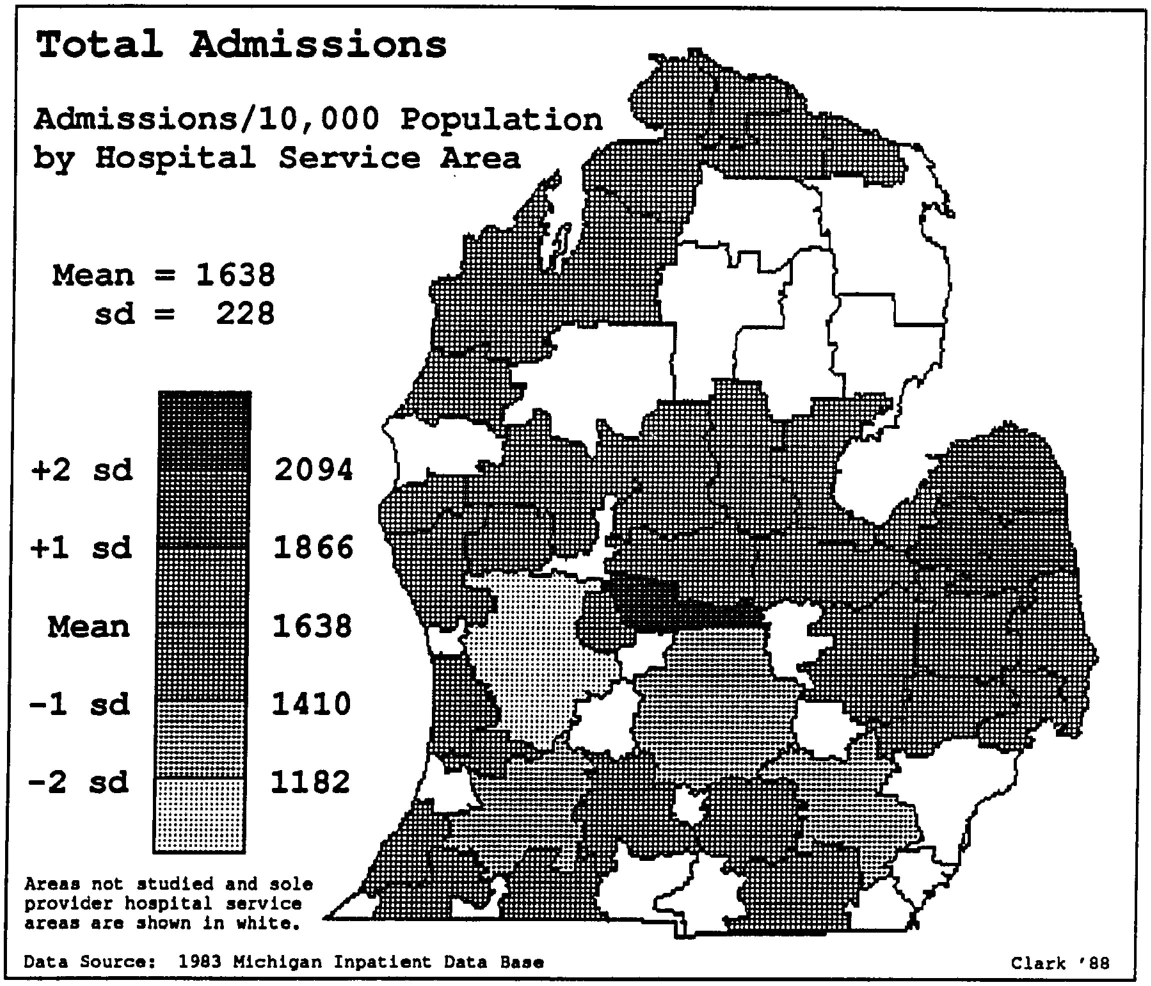


Figure 5.5

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

repair, prostatectomy and hysterectomy. One of the high use hospital service areas in the Thumb area of the East Central Region had high rates for appendectomy, hernia repair, prostatectomy and cesarean section, while both of the hospital service areas in the third high use area northwest of Lansing in the West Central Region had high rates for appendectomy and hernia repair procedures. The fourth high use area, a sole community provider hospital service area in the South Central Region, had high use for only one surgical procedure, prostatectomy.

Appendectomy

Appendectomy rates (Figure 5.6) were very high (>2 standard deviations above the mean) in the Bad Axe and Montcalm/Ionia hospital service areas and in one of the sole community provider areas in the North Region. One sole community provider service area in each of three regions (South Central, North and West Central), and the Holland hospital service area had appendectomy rates between 1 and 2 standard deviations above the mean. A sole community provider service area in the North Region plus one in the South Central Region, one in the West Central Region as well as the Midland, Oceana and Allegan hospital service areas had appendectomy rates between one and two standard deviations below the mean.

Hemorrhoidectomy

As shown in Figure 5.7, only one hospital service area (a North Region sole community provider) had a hemorrhoidectomy rate above 2 standard deviations above the mean. Eight hospital service areas (in a line from Port Huron southwest to Battle Creek) had hemorrhoidectomy

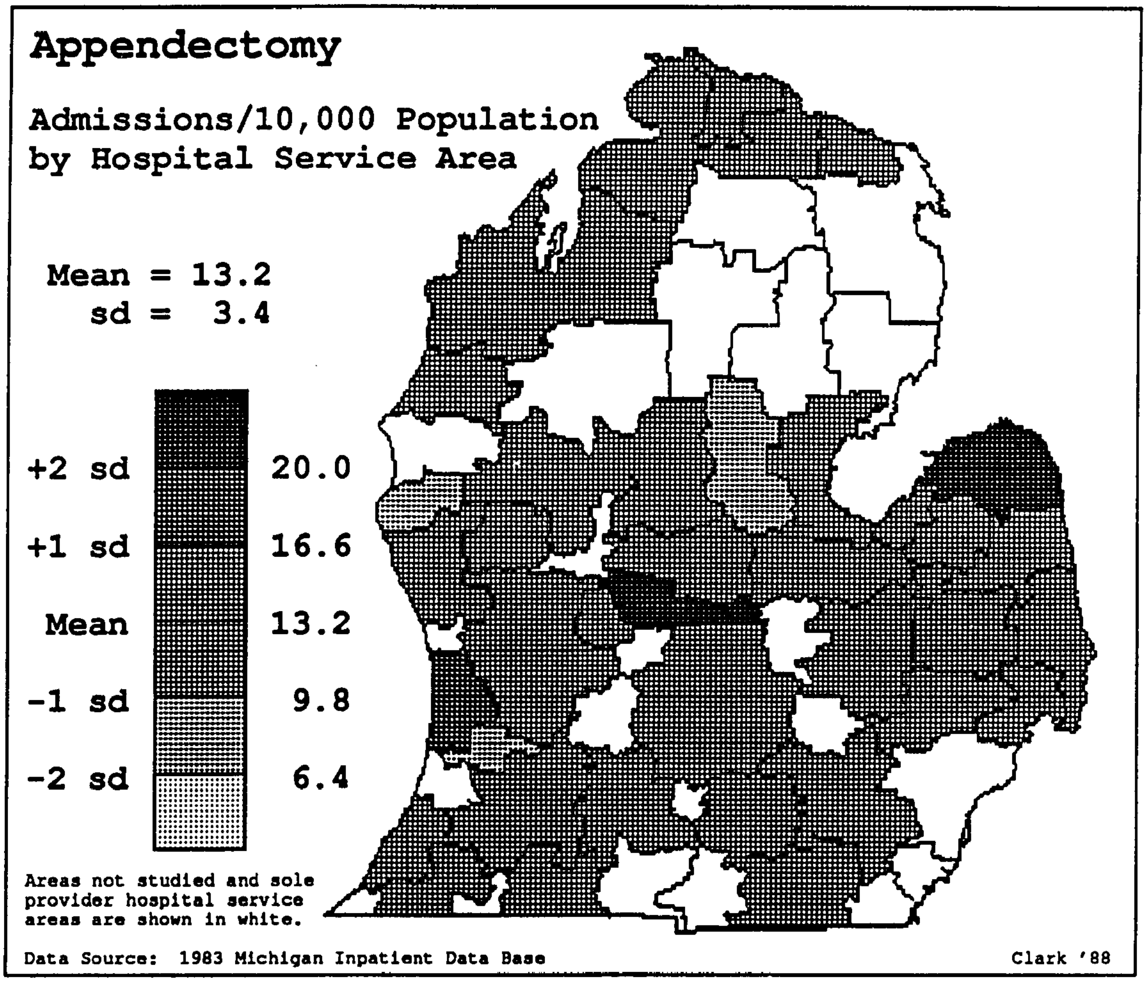


Figure 5.6

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

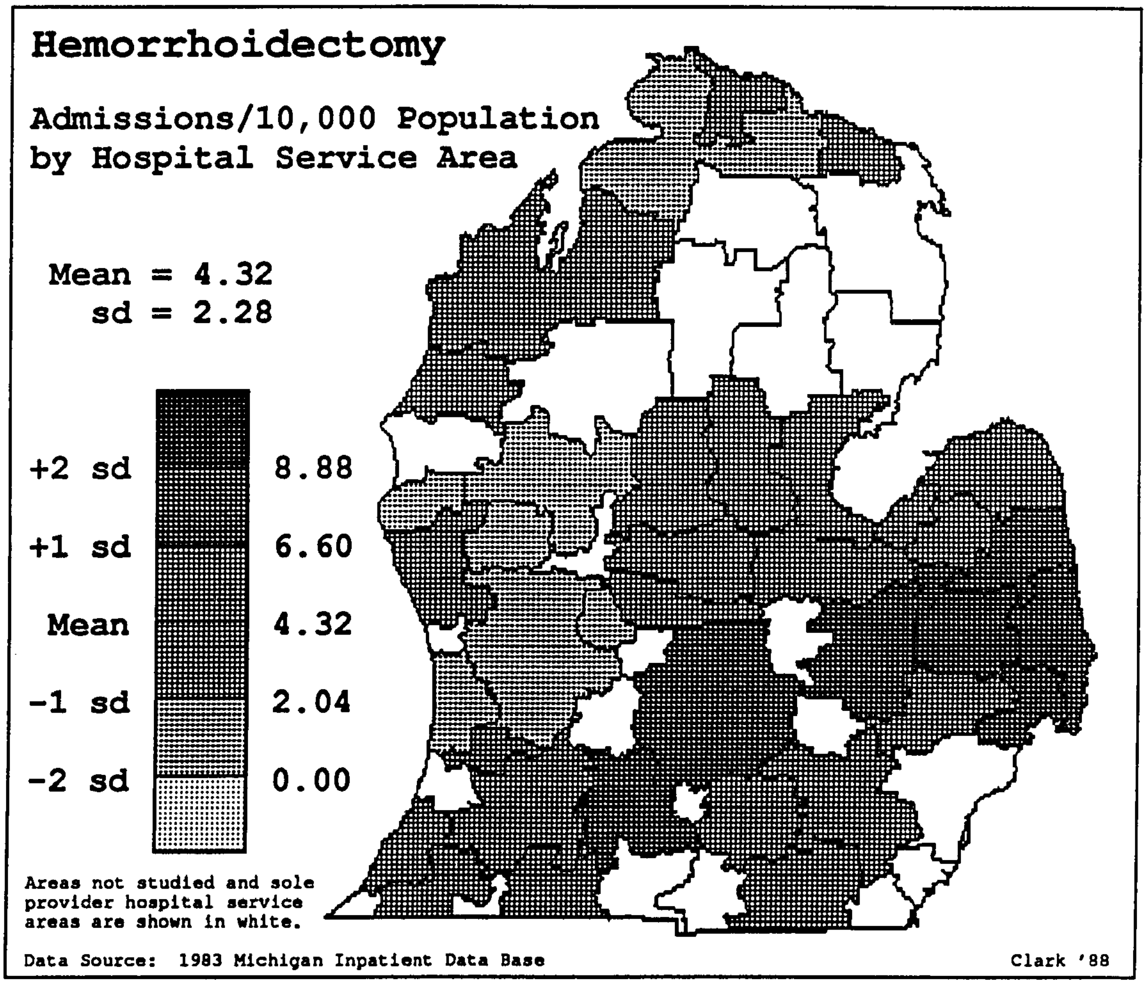


Figure 5.7

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

rates that were between 1 and 2 standard deviations above the mean. Those hospital service areas between -1 and -2 standard deviations below the mean were Petoskey, one of the North Region sole community providers, and a distinct cluster of seven hospital service areas in the West Central Region that included Grand Rapids.

Cholecystectomy

Three hospital service areas (Figure 5.8) had a cholecystectomy rate greater than two standard deviations above the mean. One was a sole community provider in the North region, one was a sole community provider in the West Central Region, and the third was Allegan. Areas of high (1 S.D. - 2 S.D.) cholecystectomy use rates included one hospital service area in the North Region's cluster of sole community providers, one Southwest sole community provider area, plus the Saginaw, Tuscola, and Jackson hospital service areas. Hospital service areas with low cholecystectomy rates (-1 to -2 S.D.) included Ann Arbor, Northern Montcalm, Berrien and Cass counties, two sole community provider areas in the West Central Region of the state, and three contiguous hospital service areas in the East Central Region (Reed City, Mt. Pleasant, and Midland).

Inguinal Hernia Repair

Two hospital service areas, Northern Montcalm and Manistee, had very high (>2 S.D.) inguinal hernia repair rates (Figure 5.9). Two of the six sole community provider areas in the North Region, one sole community provider area in each of the West Central and Southwest Regions, plus the Bad Axe, Sanilac, Montcalm/Ionia and Holland service

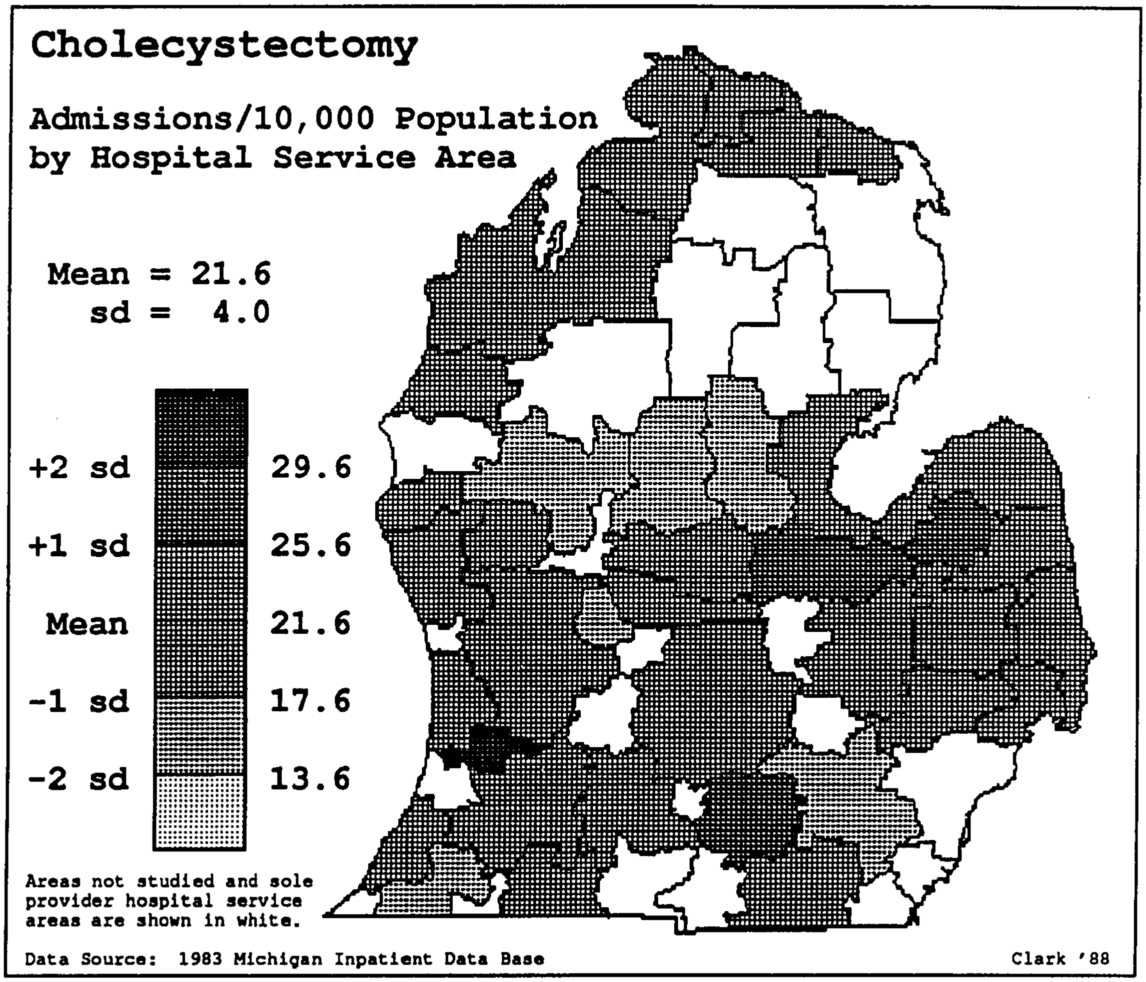


Figure 5.8

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

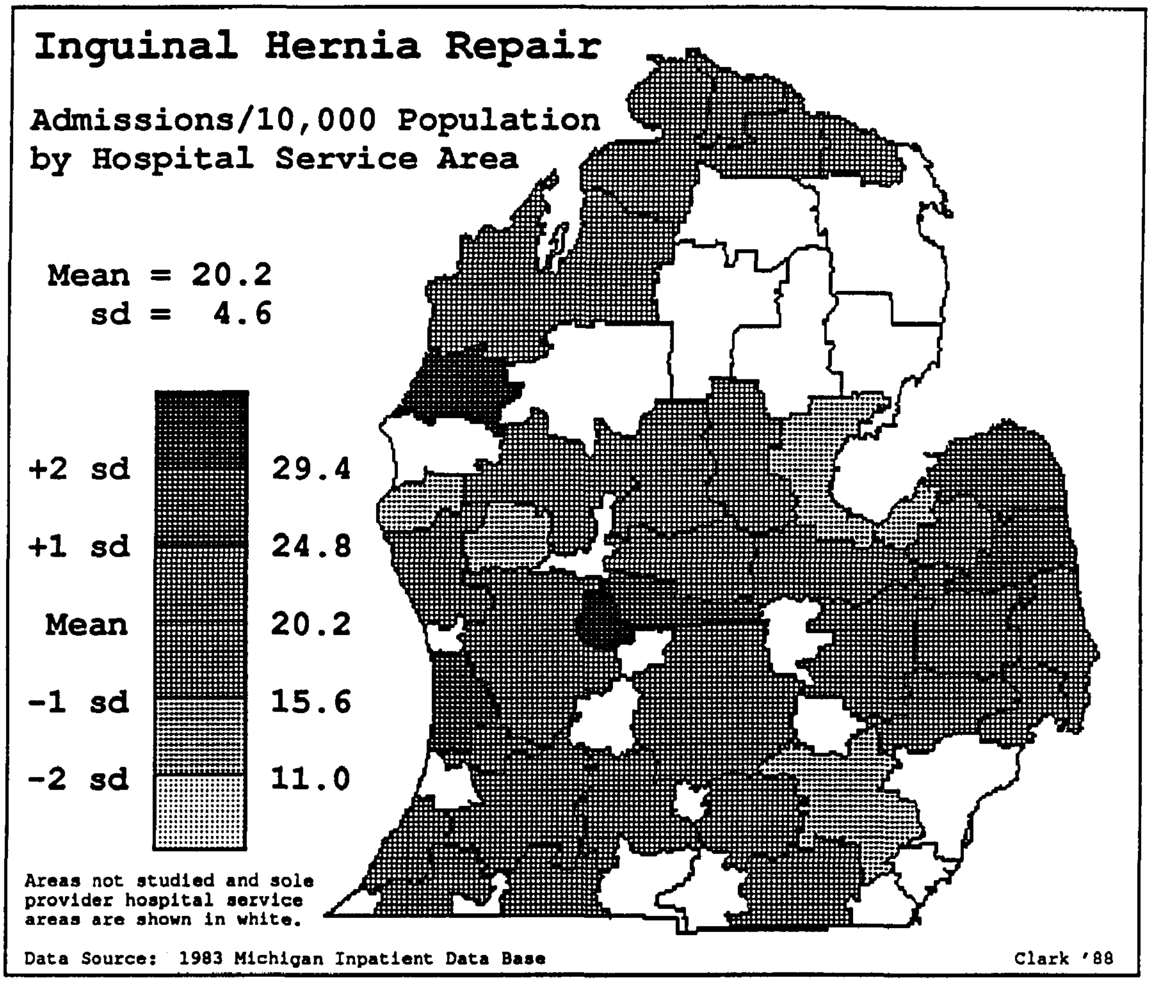


Figure 5.9

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

areas had inguinal hernia repair rates that were between 1 and 2 standard deviations above the mean. Areas with low inguinal hernia repair rates (-1 to -2 S.D.) included Freemont, Oceana, Bay, Ann Arbor and one of the sole community providers in the Southeast Region. Only one hospital service area, a sole community provider in the Southwest Region, had a use rate for inguinal hernia repair which was lower than -2 S.D.

Prostatectomy

One hospital service area, Ann Arbor, had a very high (>2 S.D.) prostatectomy rate (Figure 5.10). Eleven hospital service areas, scattered around the state, had rates that were between 1 and 2 standard deviations above the mean. One sole community provider area in the Southeast Region of the state had very low prostatectomy use rates (<-2 S.D.) while eleven hospital service areas had rates between -1 and -2 standard deviations from the mean. These eleven hospital service areas with low prostatectomy rates included Traverse City, Reed City, Gratiot, and Jackson as well as five others along the southern border (Three Rivers/Sturgis, Berrien County, Benton Harbor/St. Joseph and two sole community providers) plus one sole community provider hospital service area in each of the North and Southeast Regions. Generally, prostatectomy rates were higher in the eastern part of the state and lower in the western part.

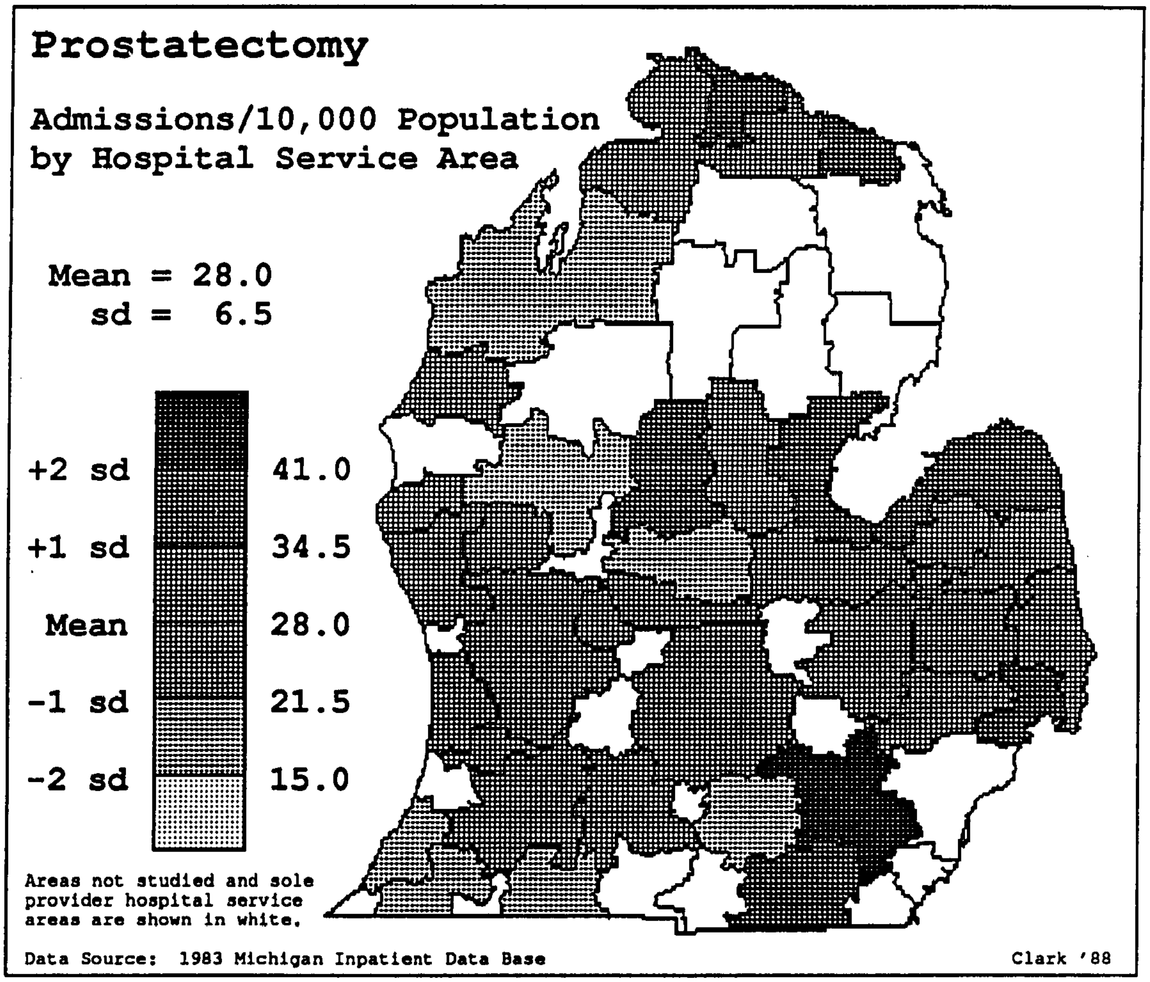


Figure 5.10

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Hysterectomy

Two sole community provider areas in the North Region, as well as the Northern Montcalm hospital service area, had very high (>2 S.D.) hysterectomy use rates (Figure 5.11). Four hospital service areas had hysterectomy rates between 1 and 2 standard deviations from the mean, including two sole community providers in the North Region, as well as Montcalm/Ionia and Port Huron. Eight hospital service areas had hysterectomy rates between -1 and -2 standard deviations. These included Petoskey, Oceana, Mt. Pleasant, Allegan, Benton Harbor/St. Joseph, Ann Arbor, and two sole community providers: one in the West Central Region and one in the North Region.

Cesarean Section

One hospital service area, a sole community provider in the Southwest Region, had Cesarean section use rates (Figure 5.12) greater than 2 standard deviations above the mean. Manistee, Bad Axe, Mt. Clemens, Montcalm/Ionia, Northern Montcalm and one West Central sole community provider hospital service area had Cesarean section rates between 1 and 2 standard deviations above the mean. In addition to the Tuscola hospital service area (-1 to -2 S.D.), lower than average use rates were found in a cluster of three hospital service areas including Mt. Pleasant, Reed City, and one sole community provider in the North Region. Adrian and Oceana were the only hospital service areas with Cesarean section rates which were lower than 2 standard deviations below the mean.

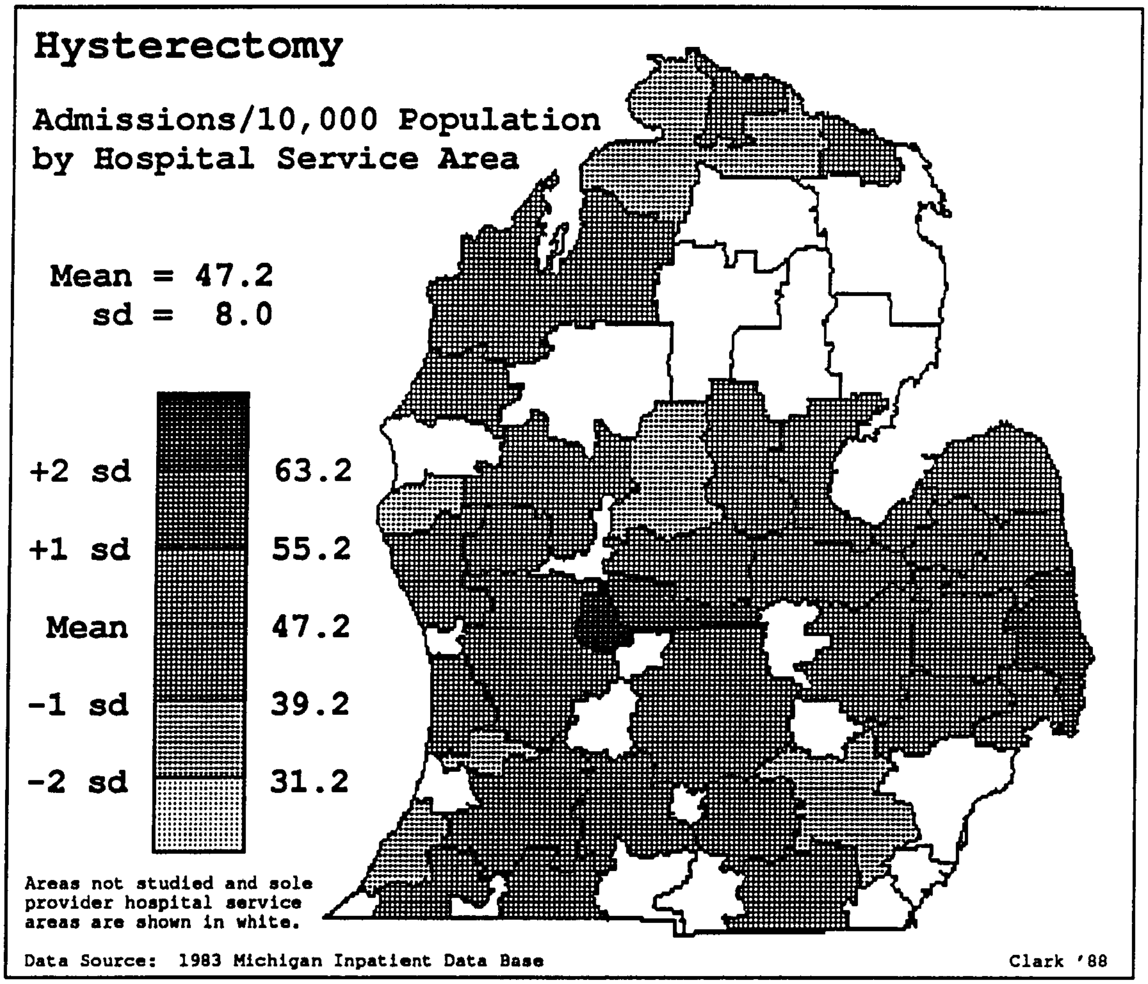


Figure 5.11

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

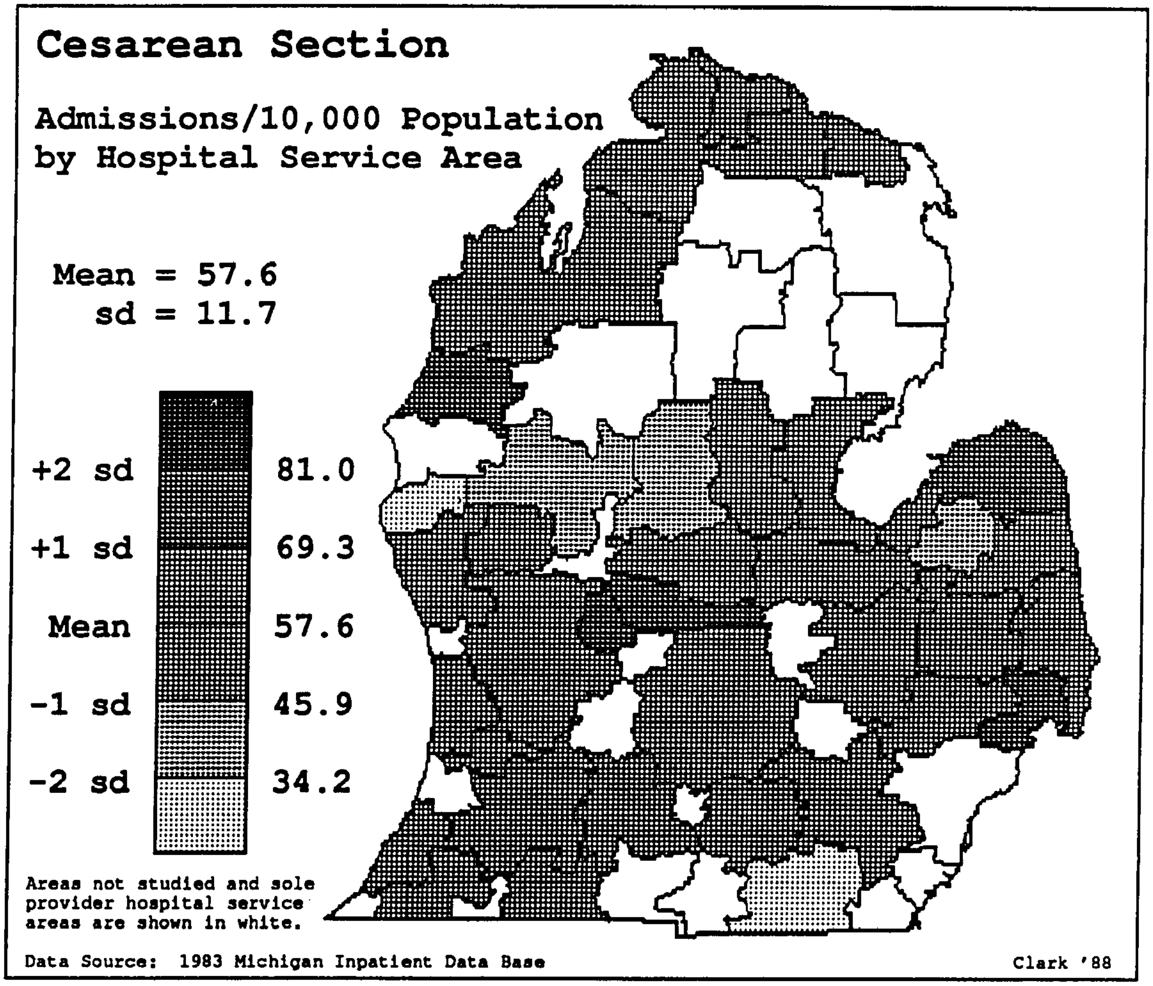


Figure 5.12

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Medical Causes for Admission Rates

Circulatory Diagnoses

Only one sole community provider hospital service area in the North Region had a circulatory admission rate greater than 2 standard deviations above the mean (Figure 5.13). Hospital service areas with circulatory rates between 1 and 2 standard deviations above the mean were Cheboygan/Rogers City, Bay, Bad Axe, Tuscola, Sanilac, Mt. Clemens, Montcalm/Ionia and one sole community provider in each of the South Central and North Regions. Freemont, Holland, Kalamazoo, Lansing and one South Central sole community provider hospital service area had circulatory use rates between -1 and -2 standard deviations below the mean, while the Grand Rapids service area's circulatory admission rate was more than 2 standard deviations below the mean. With the exception of the sole community provider hospital service area in the South Central Region, all of the high use areas for circulatory admission use rates were north of an imaginary line running from Detroit to Oceana and all of the low use hospital service areas were south of that imaginary line.

Respiratory Diagnoses

One sole community provider hospital service area plus the Montcalm/Ionia hospital service area in the West Central Region had respiratory admission rates greater than 2 S.D. above the mean (Figure 5.14). High use (1 - 2 S.D.) areas were clustered around

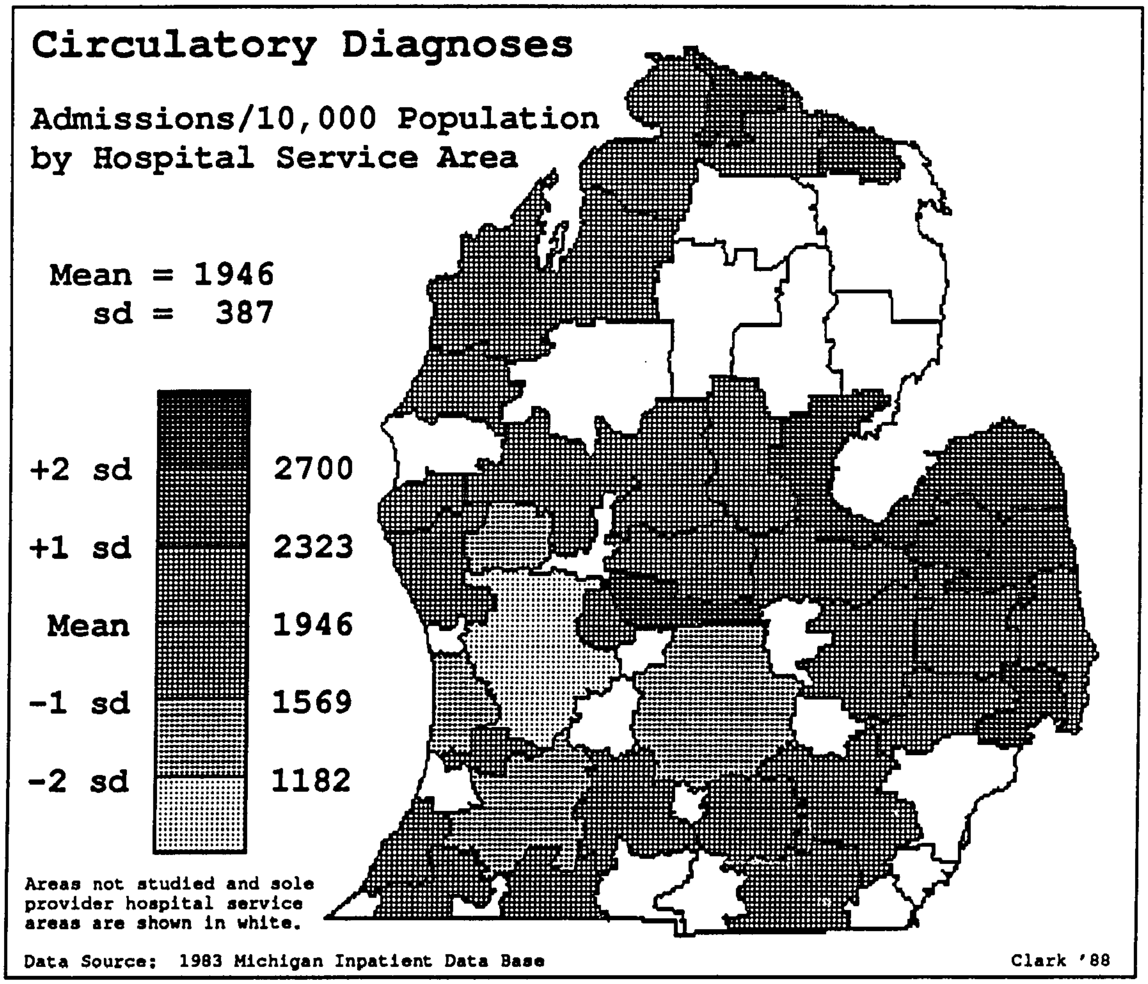


Figure 5.13

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

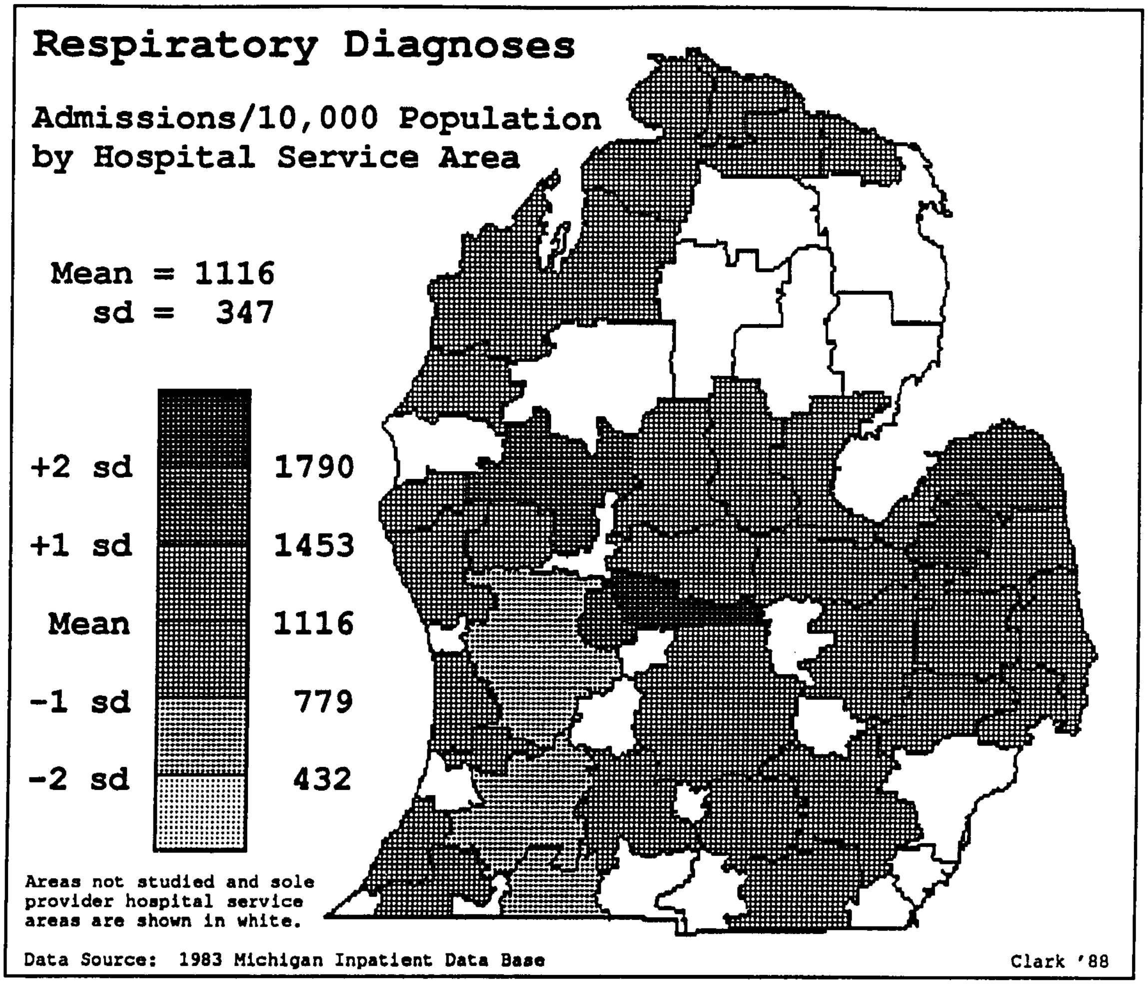


Figure 5.14

Values between -1 sd and +1 sd are mapped with the same shade of grey. See Figure 3.1 for the hospital service area names.

Montcalm/Ionia, the northern Thumb area of the Eastern Region as well as two sole community provider hospital service areas in the South Central Region. Lower than average respiratory causes for admission rates were found in two sole community provider areas in each of the Southeast and West Central Regions as well as Grand Rapids, Kalamazoo and Sturgis/Three Rivers hospital service areas.

Digestive and Genito-urinary Diagnoses

The spatial patterns for the two other medical causes for admission use rates (Figures 5.15 - 5.16) were quite similar to the circulatory admission rate pattern and to the total hospital use rate map discussed above. Areas that were consistent (>1 S.D.) across these two use rate measures were the Thumb in the East Central Region and the Montcalm/Ionia hospital service areas. One sole community provider area in the North Region had higher than average digestive and genito-urinary use rates. The Kalamazoo, Grand Rapids and Lansing hospital service areas had medical causes for admission rates that were consistently lower than most other hospital service areas, while the Ann Arbor hospital service area only had low digestive use rates. With the exception of one sole community provider area, high (> 1 S.D.) digestive cause for admission rates were found north of a line from Detroit to Oceana and low (< -1 S.D.) digestive cause for admission rates were found south of the line. The area with the highest genito-urinary cause

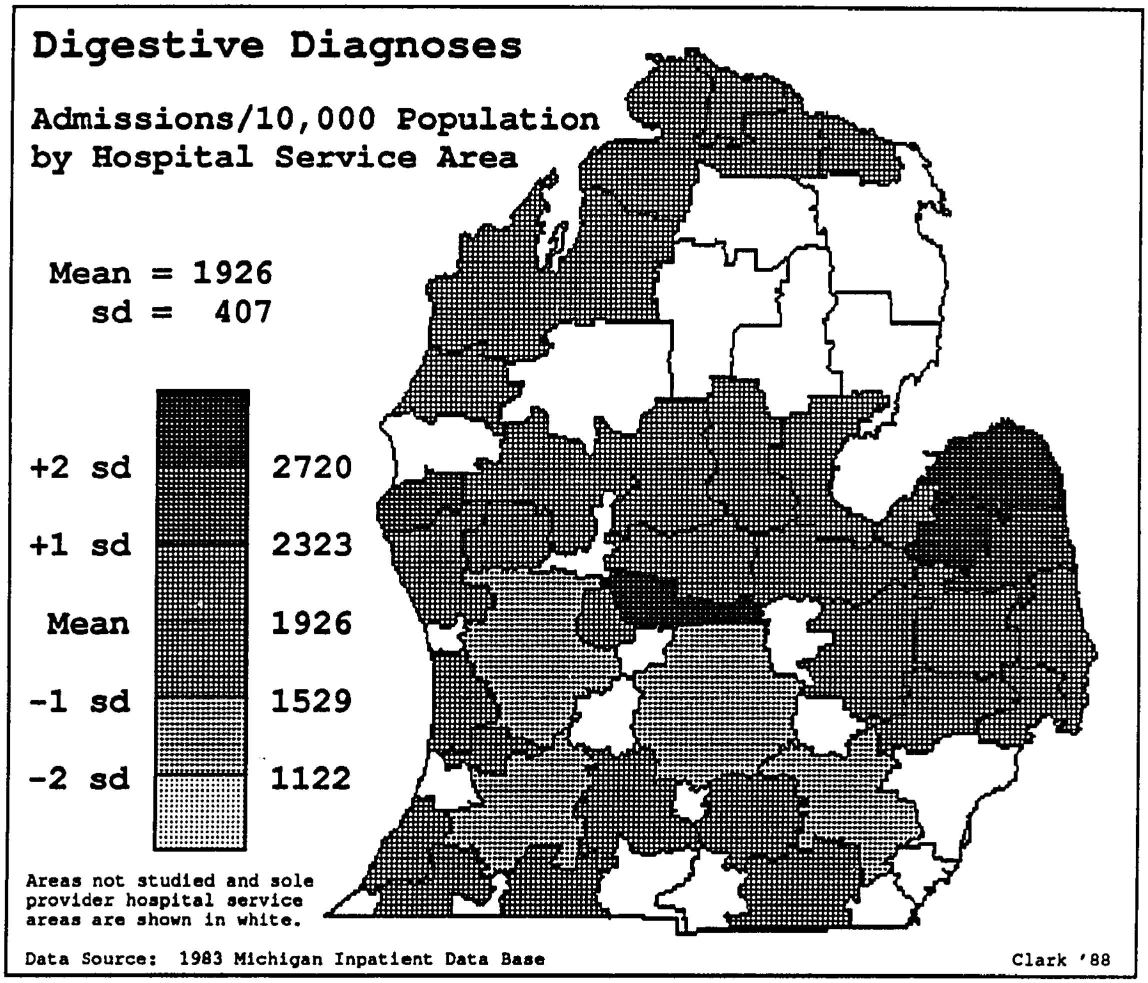


Figure 5.15

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

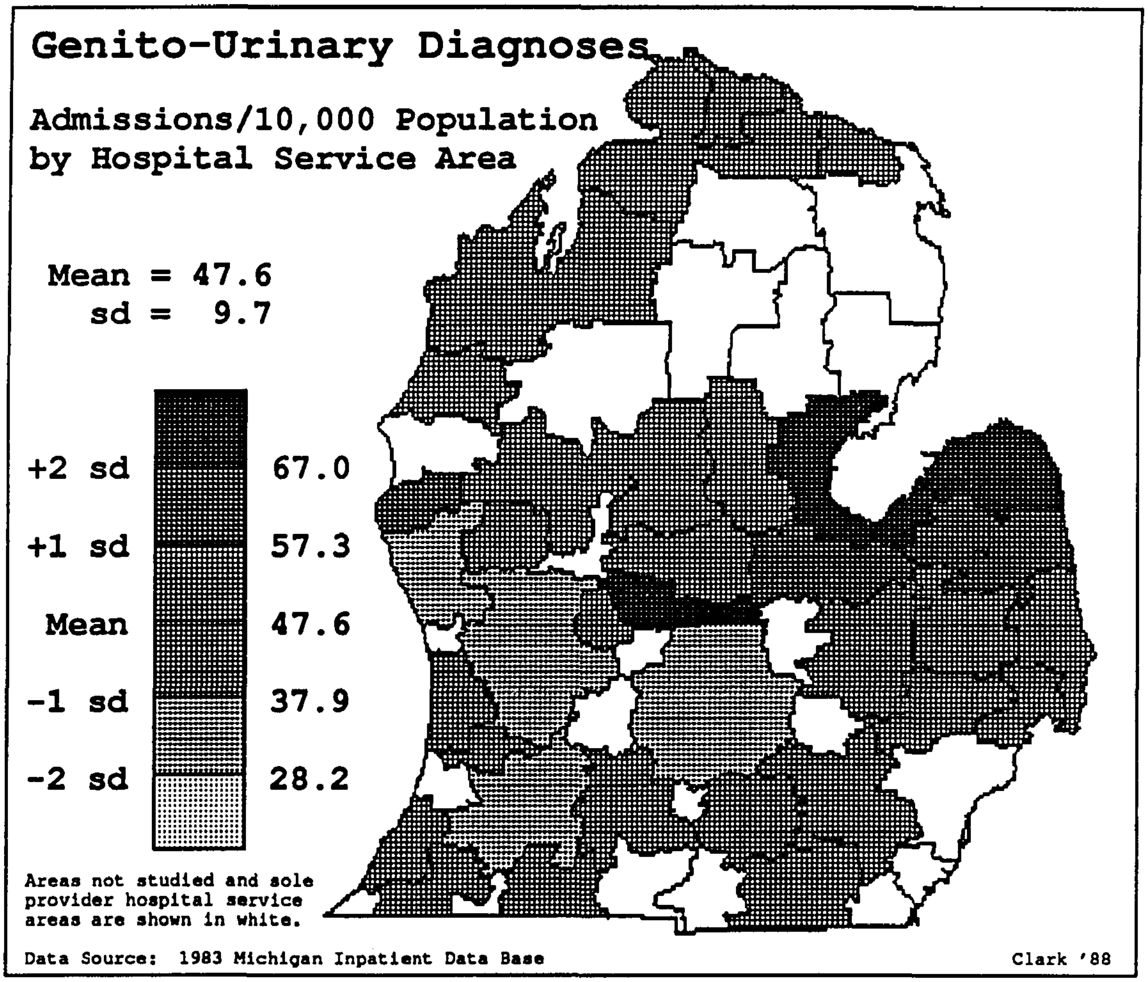


Figure 5.16

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

for admission rates was in the East Central Region, particularly around the Saginaw Bay.

Discussion of Use Rate Pattern #4

Previous small area analysis studies have indicated that for many hospital service areas (or other geographical units) there has been a consistently high or low use pattern across total admissions and several medical causes for admission; particularly respiratory causes for admission. This was the fourth use rate pattern identified by Paul-Shaheen et al. (1987) and was first discussed by Griffith et al. (1985). A tabulation of the standard deviations for each use rate by hospital service area is shown in Appendix C. Four high use areas were identified on the map of total admission use rates (Figure 5.5) and confirmed by inspection of the total male and total female admission rates. Some or all of these same four general areas (two hospital service areas in the North Region, three hospital service areas at the tip of the Thumb in the East Central Region, two hospital service areas northwest of Lansing in the West Central Region and one sole community provider hospital service area in the South Central Region) appeared in many of the maps of medical causes for admission rates (Figures 5.13 - 5.16) with higher than average use rates. Many of the surgical procedures had higher than average use rates within these high use areas as well (Figures 5.6 - 5.12). When at least one hospital service area in a high use area had a use rate of more than one standard deviation above the mean, the area was noted on Table 5.3. As shown in Table 5.3, high appendectomy use rates were present in three of the areas, high

Table 5.3

HIGH USE HOSPITAL SERVICE AREAS
IN MICHIGAN

USE RATE	NORTH REGION REGION (2 hospital service areas)	EAST CENTRAL REGION (3 hospital service areas)	WEST CENTRAL REGION (2 hospital service areas)	SOUTH CENTRAL REGION (1 hospital service area)
Total Male Admissions	X	X	X	X
Total Female Admissions	X	X	X	
Total Admissions	X	X	X	X
Appendectomy		X	X	X
Hemorrhoidectomy	X			
Cholecystectomy	X	X	X	
Inguinal Hernia Repair	X	X	X	
Prostatectomy	X	X		X
Hysterectomy	X		X	
Cesearean Section		X	X	
Circulatory Admissions	X	X	X	X
Respiratory Admissions		X	X	X
Digestive Admissions	X	X	X	
Genito-Urinary Admissions	X	X	X	

X = at least one HSA in region has use rate > 1 SD above mean hemorrhoidectomy rates were present in one, high cholecystectomy and inguinal hernia repair rates were present in three of the four, high prostatectomy rates were present in three, high hysterectomy rates were present in two, and high Cesarean section rates were present in two. One of the four medical causes for admission (circulatory diagnoses) had high rates in all four high use areas. Respiratory, digestive and genito-urinary causes for admission rates were high in three of the four high use areas. From the results of this study, there appeared to be areas of consistently high use for total admissions, several surgical procedures and most medical causes for admission. Respiratory causes for admission rates did not seem to have more consistency in high use than did the other three medical causes for admission rates.

When the low use pattern was analyzed, six specific hospital service areas (rather than more generalized clusters of hospital service areas) had low total male, total female and total hospital admission rates. Four of the low use areas (Ann Arbor, Lansing, Grand Rapids, and Kalamazoo) were urban with tertiary care hospitals located within them while the fifth and sixth were sole community provider areas in the Southeastern and West Central Regions of the state. Each of the low use sole community provider areas was contiguous to one of the low use tertiary care hospital service areas. As shown on Table 5.4, all six low use hospital service areas were consistently low in their useage across all three measures of total admission plus digestive causes for medical admissions. They showed slightly less consistency across the

Table 5.4

LOW USE HOSPITAL SERVICE AREAS IN MICHIGAN

					Sole Community Providers	
USE RATE	Grand Rapids	Kala-mazoo	Lansing	Ann Arbor	West Central	South East
Total Male Admissions	X	X	X	X	X	X
Total Female Admissions	X	X	X	X	X	X
Total Admissions	X	X	X	X	X	X
Appendectomy					X	
Hemorrhoidectomy	X				X	
Cholecystectomy				X	X	
Inguinal Hernia Repair				X		X
Prostatectomy						X
Hysterectomy				X		
Cesearean Section						
Circulatory Admissions	X	X	X			
Respiratory Admissions	X	X			X	X
Digestive Admissions	X	X	X	X	X	X
Genito-Urinary Admissions	X	X	X		X	X

X = at least one HSA has rate < -1 SD below the mean remaining three medical causes for admission and no consistency within the surgical procedures.

In several instances use rates would appear to cluster, taking in more than a single hospital service area. There are a cluster of areas above 1 standard deviation from the mean for hemorrhoidectomies (Figure 5.7). The cluster trends southwest from Sanilac and Port Huron through Flint and Lansing to Battle Creek plus one sole community provider area on the southern border. There is also a cluster of below average hemorrhoidectomy use rate areas in the west central region centered north of Grand Rapids. A cluster of hospital service areas with lower than -1 standard deviation below the mean was found for cholecystectomy use rates. It included three hospital service areas (Reed City, Mt. Pleasant, and Midland) in central Michigan. Two of those three hospital service areas plus one sole community provider in the North Region and Oceana also were in a low use cluster of hospital service areas for Cesarean section rates. It is not surprising that the patterns of use for these two procedures would be similar since cholecystectomy is more often performed on females than males and cesarean sections are only performed on females.

In summary, high use areas appeared to be less localized geographically than low use areas and have more consistently high use across more measures, including surgical procedures. Low use appeared to be most consistent among the three total admission rates and the medical causes for admission rates and less consistent among the surgical procedure rates. This result supported Wennberg's hypothesis of surgical signatures, where specific procedures were either high or low within a hospital service area, and that the "surgical signature" of that hospital service area would remain relatively constant over time. It was not possible to fully test the surgical signature hypothesis without data from several years, but the uniqueness of the surgical use rate pattern in low use areas supported his theory. Further research into the relationships between the dominance of a physician graduate medical education program and/or physician specialty dominance within a hospital service area and the use rates in that area is necessary.

CHAPTER 6

THE RELATIONSHIPS BETWEEN AND AMONG THE HOSPITAL USE RATES AND PROVIDER CHARACTERISTICS

The third research goal was to test the relationships between and among the hospital use rates and the provider characteristics. Three sets of correlations were run using the data from 53 hospital service areas: among the hospital use rates; among the provider (both physician and hospital) characteristics; and between the hospital use rates and the provider characteristics. The correlations were run to test the relationships within the use rates, to test for multicollinearity among the physician and hospital characteristics and to help develop the research hypotheses to be used in the multiple regressions. The correlations were run using the SPSS-X System, Release 2.1 for IBM VM/MTS.

Correlations Among the Hospital Use Rates

As shown in Table 6.1, the Spearman correlations among hospital use rates were all positive with the exception of the relationships between prostatectomy procedure rates and both hemorrhoidectomy and hysterectomy

Table 6.1

SPEARMAN CORRELATIONS OF USE RATES

	Male Adm	Female Adm	Total Adm	Appen	Hemorr	Chole	Hernia	Prost	Hyster	C-Sect	Circ Adm	Resp Adm	Digest Adm	Genito-U Adm
Total Male Adm	1.000	.852*	.946*	.262	.360‡	.463*	.297	.127	.197	.007	.699*	.836*	.793*	.691*
Total Female Adm		1.000	.971*	.256	.285	.507*	.321	.087	.273	.212	.589*	.799*	.857*	.716*
Total Adm			1.000	.245	.323	.486*	.321	.119	.248	.126	.649*	.848*	.861*	.720*
Appendectomy				1.000	.150	.322	.504*	.068	.234	.185	.022	.305	.343	.278
Hemorrhoidectomy					1.000	.358‡	.269	-.022	.275	.227	.208	.198	.275	.179
Cholecystectomy						1.000	.430‡	.218	.240	.220	.304	.347	.589*	.312
Inguinal Hernia							1.000	.251	.291	.258	.114	.256	.465*	.297
Prostatectomy								1.000	-.044	.154	.284	.005	.196	.279
Hysterectomy									1.000	.237	.167	.101	.255	.048
Cesarean Section										1.000	.118	.033	.134	.093
Circulatory Adm											1.000	.513*	.570*	.550*
Respiratory Adm												1.000	.788*	.610*
Digestive Adm													1.000	.762*
Genito Urinary Adm														1.000

* = $\rho < .001$
‡ = $\rho < .01$

rates. In each instance, the correlation was weakly negative and not significantly related.

As expected the three measures of total admissions and the four measures of medical causes for admission were strongly associated. The three measures of total admission rates were significantly ($p<.001$) associated with correlations of greater than .850. The medical causes for admission rates were all significantly ($p<.001$) associated, with correlations greater than .500. All three of the measures of total admission rates were significantly ($p<.001$) correlated with each of the four medical causes for admission rates.

When surgical procedures rate correlations were examined only appendectomy with inguinal hernia repair rates and cholecystectomy with digestive admission rates had significant ($p<.001$) correlations. Cholecystectomy rates were also significantly ($p<.001$) correlated with all three measures of total admissions. The greatest association was between female total admission rates and cholecystectomy rates (.507) which is understandable since cholecystectomy is performed on females more frequently than on males.

As a result of the correlation analysis of use rates, I hypothesized that the total admission rates and medical cause for admission rates would behave the same way when explanations were sought among the provider characteristics and when spatial analyses were done. Indeed, results described in Chapters 4 and 5 showed that areas of high use for total admissions also displayed higher than average use rates for many of the medical causes for admission. The relationships were even more pronounced for areas with both low total hospitalization use rates and areas with low medical causes for admission use rates.

Only two surgical procedure rates had significant (p<.001) correlations with medical causes for admission rates. Digestive admission rates were significantly correlated with cholecystectomy rates (.589) and with inguinal hernia repair rates (.465). Therefore, I hypothesized that there would be similarities in the explanations provided by the independent variables and in the spatial pattern of use among these three measures of use. The results of the regressions will be discussed in the next chapter. A comparison of the maps in Chapter 5 showed that the use patterns for these three measures of use (digestive admission, cholecystectomy, and inguinal repair rates) had very little similarity. Only two hospital service areas, a sole community provider service area in each of the North and West Central high use areas, were consistently between 1 and 2 standard deviations above the mean in all three use measures while Ann Arbor was the only hospital service area which had consistently low use (-1 to -2 S.D.) across all three measures of use.

A significant association (p<.001) was also found between appendectomy and inguinal hernia procedure rates. A comparison of the two maps showed considerable similarity among the high use areas. The appendectomy use rate map (Figure 5.6) showed only three hospital service areas with higher than average use. All three of these hospital service areas also had higher than average inguinal hernia repair rates (Figure 5.9). Only one hospital service area had both lower than average appendectomy and inguinal hernia repair rates.

In summary, the spatial similarities between total admission rates and medical causes for admission rates that have been described earlier in this paper were reconfirmed by the correlation results. With the exception of appendectomy and inguinal hernia repair rates, spatial similarities were not found among surgical procedure rates that were significantly correlated.

Correlations Among the Provider Characteristics

A Spearman correlation was run among the fourteen provider characteristics. As reported on Table 6.2, the results showed that although there were significant associations among some provider characteristics, not one of the provider relationships was strong enough to be considered to show multicollinearity (.800), and therefore, all fourteen provider characteristics were entered into the multiple regressions.

One measure of the physician component of the model, weighted proportion of board certified physicians to total physicians, was positively and significantly related to three measures of the hospital component. The significance level of the relationship between weighted proportion of board certified physicians and RNs per bed, total number of services available (out of 66) and corporate beds was $p<.01$.

Table 6.2

SPEARMAN CORRELATIONS OF PROVIDER CHARACTERISTICS

	Wgt Prop Bd Cert Phys	Hosp Beds/ 10,000	FTEs/ 10,000	Pharm/ 10,000	RNs/ Bed	Hosp Serv '83	Other Fac Serv '83	Serv Level/ HSA '83	Total # Serv per HSA '83	Change in Serv '81-83	OPD Visits per 10,000	Corp Beds	House Staff per 10,000	Osteo Beds
Wgt Prop Bd Cert Phys	1.000	.090	.204	.274	.428‡	.292	.068	-.326	.387‡	-.031	.088	.367‡	.191	.136
Beds		1.000	.367*	.097	-.402‡	-.130	-.052	.157	.066	.054	.286	.085	.257	.103
FTEs			1.000	.563*	.185	.362‡	-.104	-.232	.500*	.184	.083	.268	.602*	.312
Pharm				1.000	.457‡	.347	.136	-.445‡	.320	-.056	-.063	.112	.287	.226
RN/Bed					1.000	.512*	.001	-.440‡	.568*	.089	-.059	.362‡	.367‡	.121
Hosp Serv '83						1.000	-.141	-.765*	.779*	.391‡	-.226	.299	.457‡	.283
Other Fac Serv '83							1.000	-.474*	-.195	-.346	.056	-.170	-.090	.048
Serv Level/Hosp '83								1.000	-.523*	-.069	.120	-.178	-.319	-.293
Tot # Serv out of 66									1.000	.410‡	-.185	.455‡	.584*	.443‡
Serv '81-'83										1.000	-.176	.250	.163	-.049
OPD/Pop											1.000	-.129	.068	-.235
Corp Beds/Pop												1.000	.196	.189
House Staff/Pop													1.000	.387‡
Ostseo Beds/Pop														1.000

* = p <.001
‡ = p <.01

Correlations Between the Hospital Use Rates and the Provider Characteristics

Total Hospital Use Rates and Provider Characteristics

As shown in Table 6.3, there was a significant ($p<.001$) negative relationship between registered nurses per bed and both total female and total admission rates, and at the $p<.01$ level for total male admission rates as well. Significant negative relationships at the $p<.01$ level were found between the weighted proportion of board certified physicians and all three measures of total admission rates. At the $p<.01$ level of significance, negative associations were found between both total female admissions and total admission rates and both the services provided by the hospitals and total number of services available (out of 66) in the hospital service area.

Surgical Procedure Rates and Provider Characteristics

The correlations between the seven surgical procedure rates and the provider characteristics showed no significant relationships. Unlike the consistency in direction shown between the provider characteristics and the total admission rates, the surgical procedure rates had no directional consistency. No provider characteristic was either consistently positively or negatively related to all of the procedure specific use rates, nor did any surgical procedure rate have a consistent pattern of positive or negative relationship to the provider characteristics. This observation reinforces my hypothesis that

Table 6.3

SPEARMAN CORRELATIONS OF USE RATES WITH PROVIDER CHARACTERISTICS

	Wgt Prop Bd Cert Phys	Hosp Beds/ 10,000	FTEs/ 10,000	Pharm/ 10,000	RNs/ Bed	Hosp Serv '83	Other Fac Serv '83	Serv Level/ HSA '83	Total # Serv per HSA '83	Change in Serv '81-83	OPD Visits per 10,000	Corp Beds	House Staff per 10,000	Osteo Beds
Total Male Adm	-.356‡	.231	.053	-.171	-.453‡	-.268	.074	.221	-.277	.105	-.226	-.145	-.181	.007
Total Female Adm	-.382‡	.314	.055	-.206	-.590*	-.439‡	.153	.293	-.428‡	-.033	-.029	-.187	-.237	.012
Total Adm	-.402‡	.281	.049	-.217	-.548*	-.377‡	.113	.279	-.373‡	.029	-.104	-.180	-.230	.002
Appendectomy	-.114	.093	.027	.013	-.301	-.278	-.099	.274	-.292	.135	-.143	.014	-.076	-.098
Hemorrhoidectomy	-.257	-.069	.123	-.003	.051	.066	-.277	.088	.098	.038	-.240	.153	.047	.156
Cholecystectomy	-.256	.294	.217	.046	-.352	-.265	.091	.145	-.294	-.145	-.086	-.209	-.071	-.010
Inguinal Hernia	-.330	.062	.088	.032	-.193	-.103	-.084	.112	-.125	.137	-.054	-.093	-.008	.040
Prostatectomy	.104	.166	.271	.179	.078	-.055	.087	-.086	-.045	-.131	.081	-.143	.053	.009
Hysterectomy	-.331	-.112	.043	-.052	-.153	.080	.057	-.110	-.013	.064	-.258	.081	.008	.325
Cesarean Section	-.131	.038	.092	.125	-.042	-.252	-.044	.167	-.186	-.026	.180	-.163	-.076	.035
Circulatory Adm	-.200	.294	.210	.017	-.293	-.087	-.004	.058	-.087	.257	-.138	-.188	-.069	.054
Respiratory Adm	-.417‡	.172	-.025	-.223	-.458‡	-.424‡	.107	.331	-.366‡	.054	-.043	-.097	-.223	-.041
Digestive Adm	-.359‡	.336	.113	-.139	-.514*	-.472*	-.004	.427‡	-.391‡	-.079	-.077	-.240	-.184	.025
Genito Urinary Adm	-.115	.225	-.046	-.034	-.385‡	-.436‡	.184	.259	-.403‡	-.114	-.044	-.260	-.256	.018

* = p <.001
‡ = p <.01

surgical procedure rates are ideosyncratic, responding to physician characteristics (largely untested in this research) rather than to hospital characteristics.

Medical Causes for Admission Rates and Provider Characteristics

The digestive admission rate was significantly ($p<.001$) negatively associated with both RNs per bed and services available in the hospital. The other significant associations between medical causes for admission rates and provider characteristics were at the $p<.01$ level and indicated that three of the medical causes for admission (respiratory, digestive and genito-urinary) might exhibit more similar behavior than the fourth, circulatory causes for admission. The only consistent positive relationship (although not significant) was between all four of the medical admission rates and the beds per population. This is in agreement with all previous research.

In summary, the relationships found between the provider characteristics and the surgical procedure rates showed no strong associations and no consistent positive or negative pattern. Therefore, I hypothesized that very little similarity would be found in their explanations. The three total admission rates almost always had the same positive or negative direction in their correlation to each of the provider characteristics, although very few were significant. Therefore, I hypothesized similarities in the variables that would provide explanation for the three total admission rates and for all three of the four medical causes for admission rates.

Comparison of the General Hypotheses with Results of the Correlations

The general hypotheses generated from the review of the small area analysis literature and from personal observation and experience were stated at the end of the Methods Chapter (Figure 3.8). These hypotheses were reviewed following analysis of the correlation results. The directional hypotheses I had generated are shown as the top line in each cell in Table 6.4. The lower symbol, shown in parentheses, is the direction of the correlation for that cell. The correlation results are only shown for significant relationships. In several cells the directional symbols do not agree. For example, I had hypothesized that the relationship between the proportion of board certified physicians to total physicians in each hospital service area and the hospital use rates would be positive. The significant correlations between the proportion of board certified physicians and five measures of use were all negative. Other areas of disagreement between my hypotheses and the correlation results include the relationship between both the mean number of services offered by the hospitals in 1983 and the total number of services (out of 66 possible) available in the hospital service area in 1983 and hospital use. Since the correlations test only a bivariate relationship, I decided, after review of the results of the correlation, to continue with the hypotheses as stated in the multivariate regressions.

Table 6.4

COMPARISON OF HYPOTHESES AND SIGNIFICANT CORRELATION RESULTS

Note: top line = hypotheses derived from literature and observation; bottom line ( ) = significant correlation results	Wgt Prop Bd Cert	Hosp Beds per 10,000	FTEs per 10,000	Pharm per 10,000	RNs per Hosp Bed	Avg Hosp Serv '83	Avg Other Fac Serv '83	Serv Level per HSA '83	Total # Serv per HSA '83	Change in Serv '81-83	Out Pat Visits per 10,000	Corp Beds	House Staff per 10,000	Osteo Beds
Total Male Adm	+ (-)	+	+	+	- (-)	+	+	+	+	+	-	+	-	-
Total Female Adm	+ (-)	+	+	+	- (-)	+ (-)	+	+	+ (-)	+	-	+	-	-
Total Adm	+ (-)	+	+	+	- (-)	+ (-)	+	+	+ (-)	+	-	+	-	-
Appendectomy	+	+	+	+	-	+	+	+	+	+	-	+	-	-
Hemhorrhoidectomy	+	+	+	+	-	+	+	+	+	+	-	+	-	-
Cholecystectomy	+	+	+	+	-	+	+	+	+	+	-	+	-	-
Inguinal Hernia	+	+	+	+	-	+	+	+	+	+	-	+	-	-
Prostatectomy	+	+	+	+	-	+	+	+	+	+	-	+	-	-
Hysterectomy	+	+	+	+	-	+	+	+	+	+	-	+	-	-
Cesarean Section	+	+	+	+	-	+	+	+	+	+	-	+	+	-
Circulatory Adm	+	+	+	+	-	+	+	+	+	+	-	+	-	-
Respiratory Adm	+ (-)	+	+	+	- (-)	+ (-)	+	+	+ (-)	+	-	+	-	-
Digestive Adm	+ (-)	+	+	+	- (-)	+ (-)	+	+	+ (-)	+	-	+	-	-
Genito Urinary Adm	+	+	+	+	- (-)	+ (-)	+	+	+ (-)	+	-	+	-	-

CHAPTER 7

HOSPITAL USE RATES AS A FUNCTION OF PHYSICIAN AND HOSPITAL CHARACTERISTICS

Introduction

The fourth goal of this research was to determine the amount of explanation of the variation in hospital use rates that could be provided by the physician and hospital components of the model. To do this the fourteen hospital use rates were used as dependent variables in fourteen multiple regressions. The independent variables used were the one available measure of the physician component of the model, plus the thirteen measures of the hospital component: four variables measuring hospital resources; four measuring services available within the hospital service area; and five measuring hospital organization and philosophy characteristics. A stepwise multiple regression was run for each use rate using all of the independent variables. The statistical package used was Version 6.02 of the SAS System. The minimum significance level for variable entry and retention in the model was $\alpha = .10$.

The results of each of the regressions are shown below. In each instance the discussion and analysis of the results are presented in four sections (Hypothesis, Equation Results, Variables Entering the

Equation, and Residuals). The hypothesis for the multiple regression is shown first as a matrix. The columns are the use rates being tested and the rows are the independent variables from the model that are being entered into the regression. Each cell in the matrix shows the positive (+) or negative (-) direction hypothesized for the independent variable if it should enter significantly into the equation. The relative certainty of the hypothesis is shown. Double directional signs (++ or --) have more certainty than single directional signs (+ or -).

The second section, Equation Results, deals with the explanatory value of the equation and the third section discusses the significant independent variables that entered the equation. The final section, Residuals, describes the results of the spatial analysis of the residuals from the equation. Since community variables were not among the independent variables tested, any community contribution to the variation in use rates should appear in the residuals. A K-S test of the residuals was used to determine if they were normally distributed.

Regressions of Age and Sex Adjusted Dependent Variables

Total Male, Total Female and Total Admission Rates

Hypothesis

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in total male, total female, and total admission rates. The hypothesized positive or negative entry of each independent variable into the regression equation is shown in Figure 7.1.

Figure 7.1

Hypotheses for Total Male, Total Female, and Total Admission Rate Regressions

	Total Male Admissions	Total Female Admissions	Total Admissions
Physician			
Wgt Prop Bd Cert	+ +	+ +	+ +
Hosp Beds per 10,000	+ +	+ +	+ +
Hospital			
Supply of Resources			
FTEs per 10,000	+	+	+
Pharm per 10,000	+	+	+
RNs per Hosp Bed	- -	- -	- -
Services Available			
Avg Hosp Serv '83	+ +	+ +	+ +
Avg Other Fac Serv '83	+	+	+
Avg Serv per Hosp '83	+ +	+ +	+ +
Total # Serv per HSA '83	+ +	+ +	+ +
Organization			
Change in Serv '81-'83	+ +	+ +	+ +
Out Pat Visits per 10,000	- -	- -	- -
Corp Beds	+ +	+ +	+ +
House Staff per 10,000	- -	- -	- -
Osteo Beds	- -	- -	- -

H_o : $b_i = 0$ for i
H_i : $b_i \neq 0$ for at least one i

Equation Results

Table 7.1

Multiple Regression Equation Results
Separately Run for
Total Male, Total Female, and Total Admission Rates

Dependent Var	R^2	Adj R^2	F Value
Tot Male Adm	0.3892	0.3601	13.383***
Tot Female Adm	0.5077	0.4842	21.656***
Total Adm	0.4827	0.4581	19.598***

***P<.01

For each of the first three hypotheses shown above, the critical F (2,42) for the equation was 2.44; therefore, in each instance (total male admissions, total female admissions, and total admissions), the null hypothesis was rejected and the alternative was accepted. The adjusted R^2 in Table 7.1 shows that 36% of the variation in the total male admission rate, 48% of the variation in the total female admission rate, and 46% of the variation in total admission rate was explained by the independent variables entered into the regression equation. Each equation was significant at the $p<.01$ level.

Variables Entering the Equations

There was a negative relationship between hospital admissions rates (total male, total female, and total) and the number of registered nurses per capita, and the proportion of board certified physicians. As the number of registered nurses per bed and the proportion of board certified physicians decreased, the total use rate and gender-specific use rates increased. The proportion of board certified physicians had been hypothesized to enter the equation with a positive sign.

As Table 7.2 shows, each of the terms in each of the three equations was significant at the $p<.10$ level. The beta weights in each equation showed that the contribution to the explanation of variation made by the registered nurses per bed variable was greater than that of the weighted proportion of board certified physicians variable. The tolerance levels of the two independent variables were above .84 in each of the three equations indicating their mutual independence. A correlation analysis done previously showed that the association between RNs per Bed and Weighted Proportion of Board Certified Physicians was .428.

Table 7.2

Significant Variables for Total Male, Total Female and Total Admission Rate Regressions

Intercept & Ind Var.	Standard Error of B	Coefficient	t statistic	Beta Weights
		Total Male Admissions		
Intercept	10.47	189.6	18.10***	
RNs/Bed	14.47	-50.5	-3.49***	-0.46
Wgt Prop Bd Cert	17.45	-37.1	-2.13**	-0.28
		Total Female Admissions		
Intercept	11.69	253.8	21.71***	
RNs/Bed	16.16	-82.7	-5.12***	-0.61
Wgt Prop Bd Cert	19.48	-34.5	-1.77*	-0.21
		Total Admissions		
Intercept	10.49	222.5	21.22***	
RNs/Bed	14.50	-67.0	-4.63***	-0.56
Wgt Prop Bd Cert	17.48	-35.7	-2.05**	-0.25

*p<.10 **p<.05 ***p<.01

Residuals

The residuals for all three total admission multiple regression equations were analyzed for any spatial pattern (Figures 7.2, 7.3 and 7.4). The three equations all over-predicted the male, female and total admission rates for Port Huron, Reed City, South Berrien/Cass County plus two sole community provider hospital service areas: one in the South Central Region; and one in the West Central Region. The three equations under-predicted the total admission rates for Grand Rapids, Tuscola, Cheboygan/Rogers City, Ann Arbor, N. Montcalm, and Saginaw hospital service areas. One sole community provider service area in the

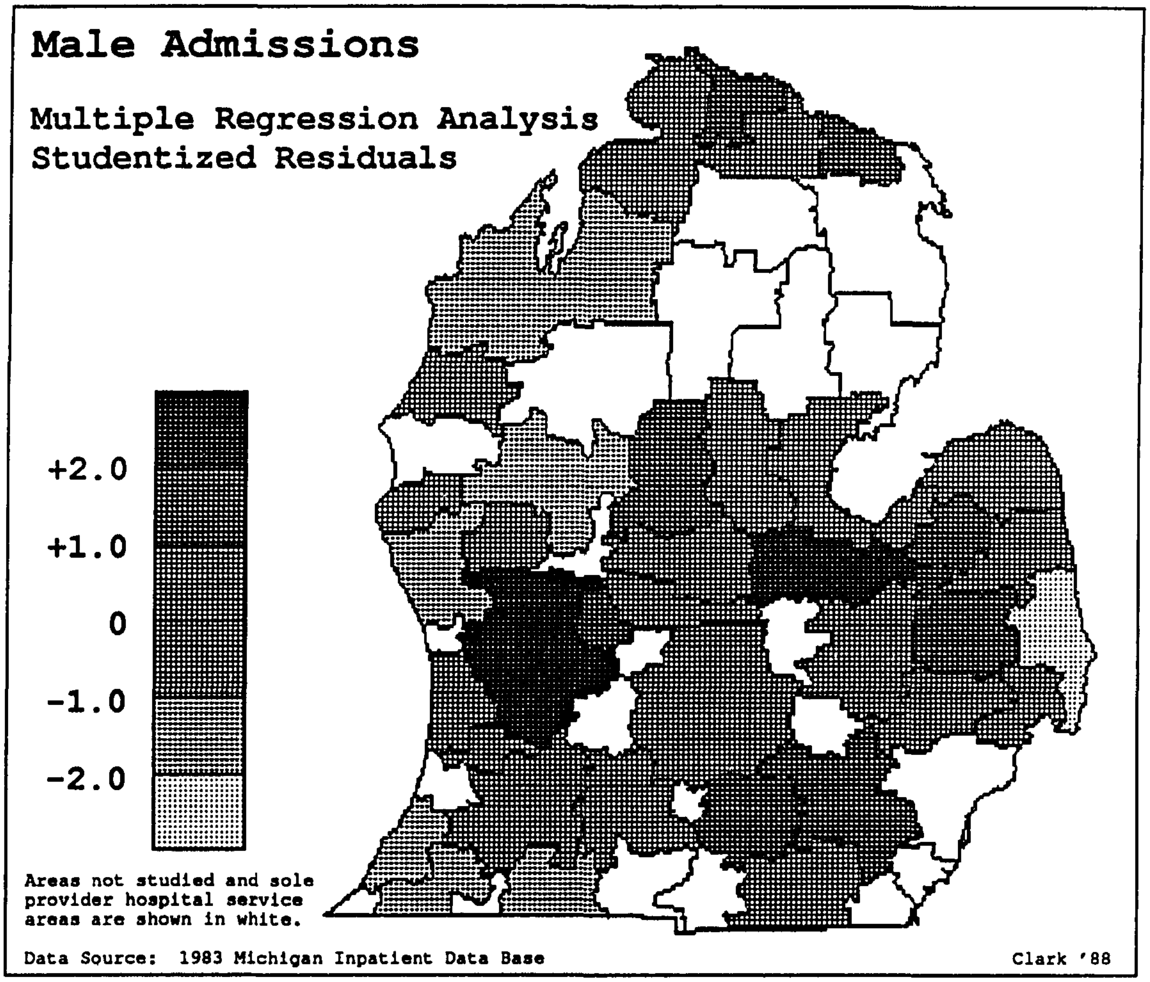


Figure 7.2

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

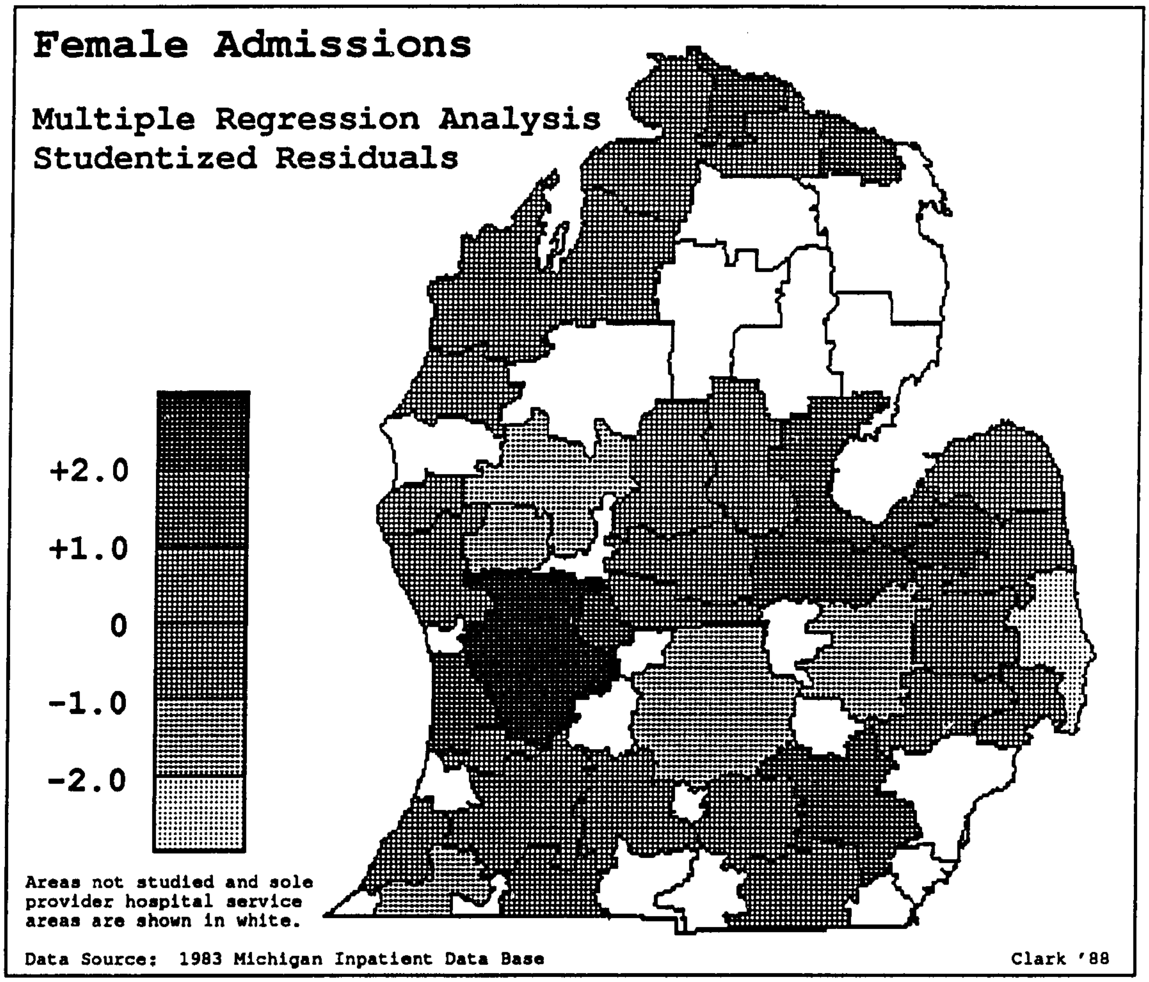


Figure 7.3

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

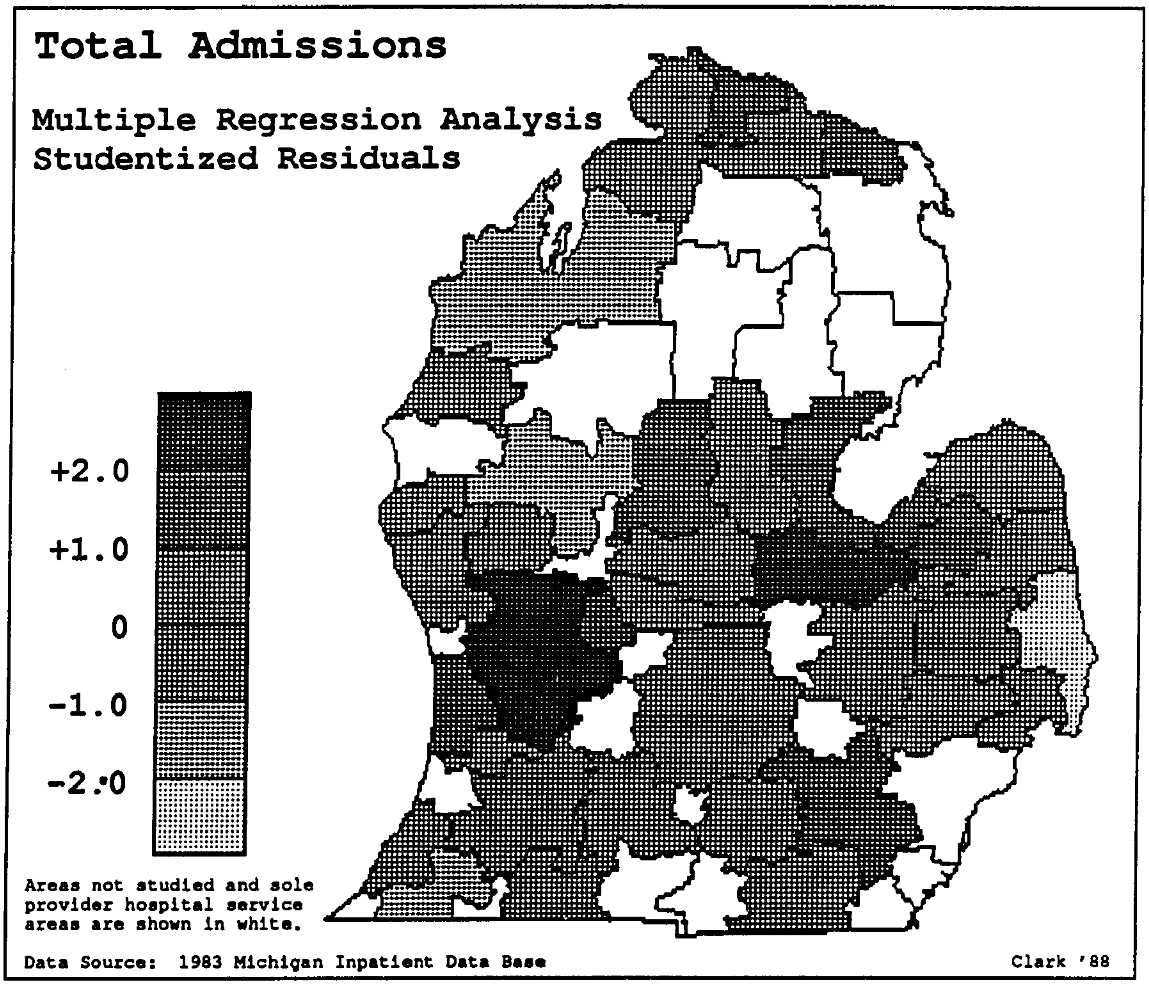


Figure 7.4

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

North Region was under-predicted. There appeared to be no urban-rural or regional component to the residuals from the multiple regressions using the three total admission rates as the dependent variables. A K-S test of the residuals verified their normal distribution.

Appendectomy

Hypothesis

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in appendectomy use rates. The hypothesized positive or negative entry into the regression equation are shown in Figure 7.5.

Figure 7.5

Hypothesis for Appendectomy Use Rate Regression

	Appendectomy
Physician	
Wgt Prop Bd Cert	+ +
Hosp Beds per 10,000	+ +
Hospital	
Supply of Resources	
FTEs per 10,000	+
Pharm per 10,000	+
RNs per Hosp Bed	-
Services Available	
Avg Hosp Serv '83	+ +
Avg Other Fac Serv '83	+
Avg Serv per Hosp '83	+ +
Total # Serv per HSA '83	+ +
Organization	
Change in Serv '81-'83	+
Out Pat Visits per 10,000	-
Corp Beds	+
House Staff per 10,000	- -
Osteo Beds	- -

H_0 : $b_i = 0$ for i
H_i : $b_i \neq 0$ for at least one i

Equation Results

The critical F (3,41) for the equation was 2.23. The calculated value of F was 5.71. Therefore, the null hypothesis was rejected and the alternative was accepted. As shown in Table 7.3, the adjusted R^2 indicated that 24% of the variation in appendectomy rates could be explained by the independent variables that entered into the regression equation. The equation was significant at the p<.01 level.

Table 7.3

Multiple Regression Equation Results for Appendectomy Rates

R^2	=	0.2947
Adjusted R^2	=	0.2431
F Value	=	5.71 p<.01

Variables Entering the Equation

As Table 7.4 shows, all of the terms of the equation were significant at the p<.10 level. There was a positive relationship between the appendectomy rate and the FTE's per capita and a negative relationship between the appendectomy rate and the outpatient visits per capita and the number of services (out of a possible 66) available within the hospital service area. As the number of FTE's per capita increased and the number of outpatient visits and available services decreased, the appendectomy rate increased. The number of available services had been hypothesized to enter the equation with a positive sign. The beta weights showed that the outpatient visits per capita contributed most to the equation, followed by the total number of services available in the hospital service area and the number of FTE's per capita. The tolerance levels were all above .58, indicating their mutual independence. A correlation analysis done previously showed that the highest correlation among the independent variables in this equation was between the number of FTE's per population and the number of services available in the hospital service area. The two independent variables were positively correlated (.500).

Table 7.4

Significant Variables
for Appendectomy Rate Regression

Intercept & Inde Var.	Coeffi-cient	Standard Error of B	t statistic	Beta Weights	Toler-ance
Intercept	1.73	0.16	11.03***		
FTEs/Capita	0.003	0.001	1.75*	0.30	0.58
Tot # Serv per HSA	-0.00003	0.000008	-3.17***	-0.46	0.83
OPD/Capita	-0.01	0.004	-3.41***	-0.57	0.61

*p<.10 ***p<.01

Residuals

The residuals were mapped (Figure 7.6) and showed that the equation under-predicted the appendectomy rates in Midland, Saginaw, Grand Rapids, Flint, Berrien/Cass County, Allegan and two sole community providers (one in the Southeast Region and one in the South Central region). The equation over-predicted the appendectomy rates in Bad Axe, Lapeer, Jackson, Benton Harbor/St. Joseph, Northern Michigan and in five sole community providers; one in the North Region, one in the Southeast

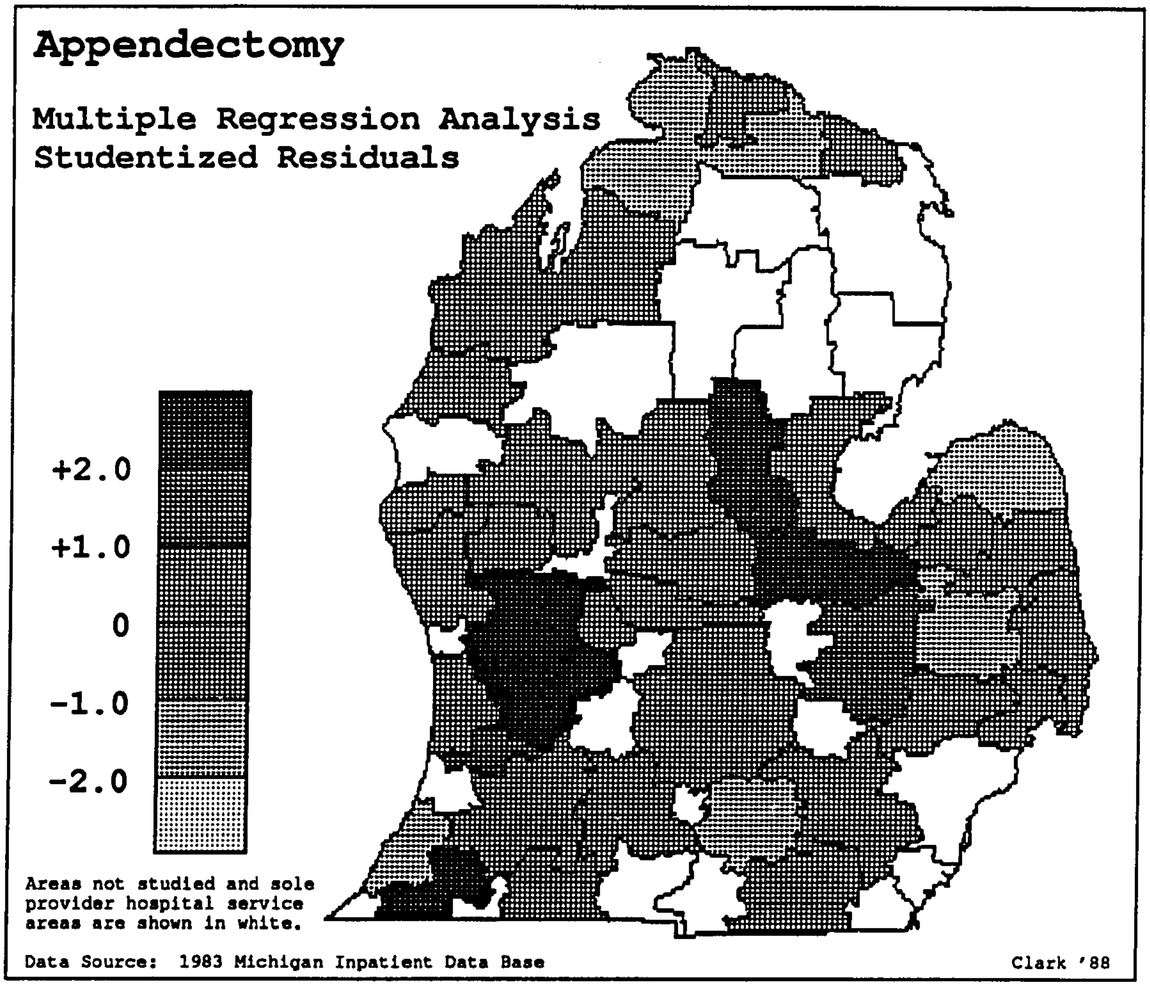


Figure 7.6

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Region, two in the West Central Region and one in the Southwest Region. There does not appear to be any urban/rural or regional component to the residual. The K-S test of the residuals verified their normal distribution.

Hemorrhoidectomy

Hypothesis

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in hemorrhoidectomy use rates. The hypothesized positive or negative entry into the regression equation are shown in Figure 7.7.

Figure 7.7

Hypothesis for Hemorrhoidectomy
Use Rate Regression

	Hemorrhoidectomy
Physician	
Wgt Prop Bd Cert	+ +
Hosp Beds per 10,000	+ +
Hospital	
Supply of Resources	
FTEs per 10,000	+
Pharm per 10,000	+
RNs per Hosp Bed	-
Services Available	
Avg Hosp Serv '83	+ +
Avg Other Fac Serv '83	+
Avg Serv per Hosp '83	+ +
Total # Serv per HSA '83	+ +
Organization	
Change in Serv '81-'83	+
Out Pat Visits per 10,000	-
Corp Beds	+
House Staff per 10,000	- -
Osteo Beds	- -

H_o : $b_i = 0$ for $_i$
H_i : $b_i \neq 0$ for at least one $_i$

Equation Results

The critical F (3,41) for the equation was 2.23. The calculated value of F was 3.4. Therefore, the null hypothesis was rejected and the alternative was accepted. As shown in Table 7.5, the adjusted R^2 indicated that 14% of the hemorrhoidectomy rate could be explained by the independent variables in the equation. The equation was significant at a p<.05 level.

Table 7.5

Multiple Regression Equation Results
for Hemorrhoidectomy Rates

R^2	=	0.2001	
Adjusted R^2	=	0.1416	
F Value	=	3.419	p<.05

Variables Entering the Equation

As Table 7.6 shows, each of the terms of the equation was significant at the p<.10 level. There was a negative relationship between the hemorrhoidectomy rate and three independent variables. As the number of outpatient visits per capita, the proportion of board certified physicians and the number of services provided by a contractual party decreased, the hemorrhoidectomy rate increased. Both the outpatient visits per capita and average number of services provided by another facility had been hypothesized to enter the equation with a positive sign. The beta weights showed that the three independent variables contributed almost equally to the explanation. The tolerance levels for all the independent variables were very high, confirming their orthogonality. A correlation analysis had previously indicated their independence.

Table 7.6

Significant Variables for Hemorrhoidectomy Regression

Intercept & Inde Var.	Coeffi- cient	Standard Error of B	t statistic	Beta Weights	Toler- ance
Intercept	0.84	0.15	5.78***		
OPD/Capita	-0.00001	0.000006	-1.70*	-0.24	0.98
Wgt Prop Bd Cert	-0.37	0.22	-1.70*	-0.24	0.98
Avg Other Fac serv	-0.004	0.002	-1.71*	-0.24	0.99

*p<.10 ***p<.01

Residuals

The residuals were mapped (Figure 7.8) and showed that the equation under-predicted the hemorrhoidectomy rates for Northern Michigan, Tuscola, Ann Arbor, Mt. Clemens, Adrian, Midland, Manistee, Oceana, and one of the sole community provider areas in each of the South Central and West Central Regions. The equation over-predicted the hemorrhoidectomy rates in Port Huron, Mt. Pleasant, Allegan, Three Rivers/Sturgis, Fremont, and Reed City. There was one cluster of three hospital service areas in the West Central Region that were over-predicted by the equation. The K-S test of the residuals verified their normal distribution.

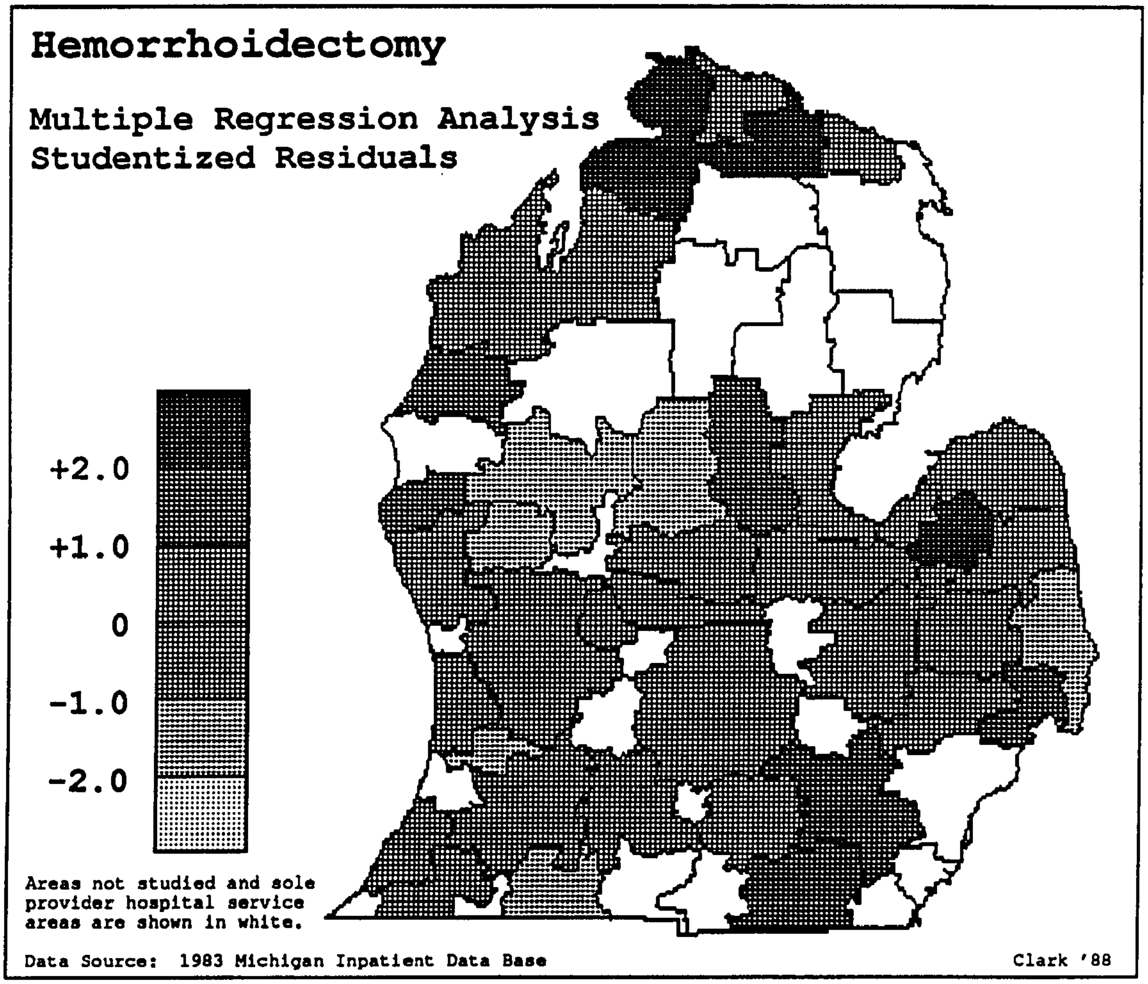


Figure 7.8

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Cholecystectomy

Hypothesis

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in cholecystectomy use rates. The hypothesized positive or negative entry into the regression equation are shown in Figure 7.9.

Figure 7.9

Hypothesis for Cholecystectomy
Use Rate Regression

	Cholecystectomy
Physician	
Wgt Prop Bd Cert	+ +
Hosp Beds per 10,000	+ +
Hospital	
Supply of Resources	
FTEs per 10,000	+
Pharm per 10,000	+
RNs per Hosp Bed	-
Services Available	
Avg Hosp Serv '83	+ +
Avg Other Fac Serv '83	+
Avg Serv per Hosp '83	+ +
Total # Serv per HSA '83	+ +
Organization	
Change in Serv '81-'83	+
Out Pat Visits per 10,000	-
Corp Beds	+
House Staff per 10,000	- -
Osteo Beds	- -

H_0 : $b_i = 0$ for i
H_i : $b_i \neq 0$ for at least one i

Equation Results

The critical F (2,42) for the equation was 2.44. The calculated value of F was 4.9. Therefore, the null hypothesis was rejected and the alternative was accepted. As shown in Table 7.7, the adjusted R^2 indicated that 15% of the variation in cholecystectomy rates could be explained by the two independent variables entered into the regression equation. The equation was significant at a $p<.01$ level.

Table 7.7

Multiple Regression Equation Results for Cholecystectomy Rates

R^2	=	0.1893	
Adjusted R^2	=	0.1507	
F Value	=	4.904	$p<.01$

Variables Entering the Equation

As Table 7.8 shows, each of the terms of the equation was significant at the $p<.10$ level. There was a positive relationship between the cholecystectomy rate and the number of beds per capita, while there was a negative relationship between the cholecystectomy rate and the weighted proportion of board certified physicians. As the number of beds per capita increased and the proportion of board certified physicians decreased, the cholecystectomy rates increased. The weighted proportion of board certified physicians had been hypothesized to enter the equation with a positive sign. The beta weights showed that the proportion of board certified physicians contributed more to the equation than did the variable measuring beds per capita. The tolerance level for each independent variable was extremely high, showing their mutual independence which was previously reported from a correlation analysis (0.090).

Table 7.8

Significant Variables for Cholecystectomy Regression

Intercept & Inde Var.	Coefficient	Standard Error of B	t statistic	Beta Weights	Tolerance
Intercept	2.33	0.31	7.53***		
Beds/Capita	0.01	0.01	1.83*	0.26	0.98
Wgt Prop Bd Cert	-1.08	0.39	-2.75***	-0.38	0.98

*p<.10 ***p<.01

Residuals

When the residuals were mapped (Figure 7.10), the cholecystectomy use rates for Northern Michigan, Midland, Saginaw, North Montcalm, Muskegon, Allegan, Kalamazoo plus one sole community provider in each of the Southeast and South Central Regions were under predicted by the equation. The cholecystectomy rates in Three Rivers/Sturgis, Fremont, Bad Axe, Sanilac, Port Huron, Benton Harbor/St. Joseph, and Pontiac hospital service areas as well as one Southwest Region sole community provider area were over-predicted. There appeared to be no urban/ rural component to the residuals, but three hospital service areas in the eastern edge of the Thumb were all over-predicted by the equation. The K-S test of the residuals verified their normal distribution.

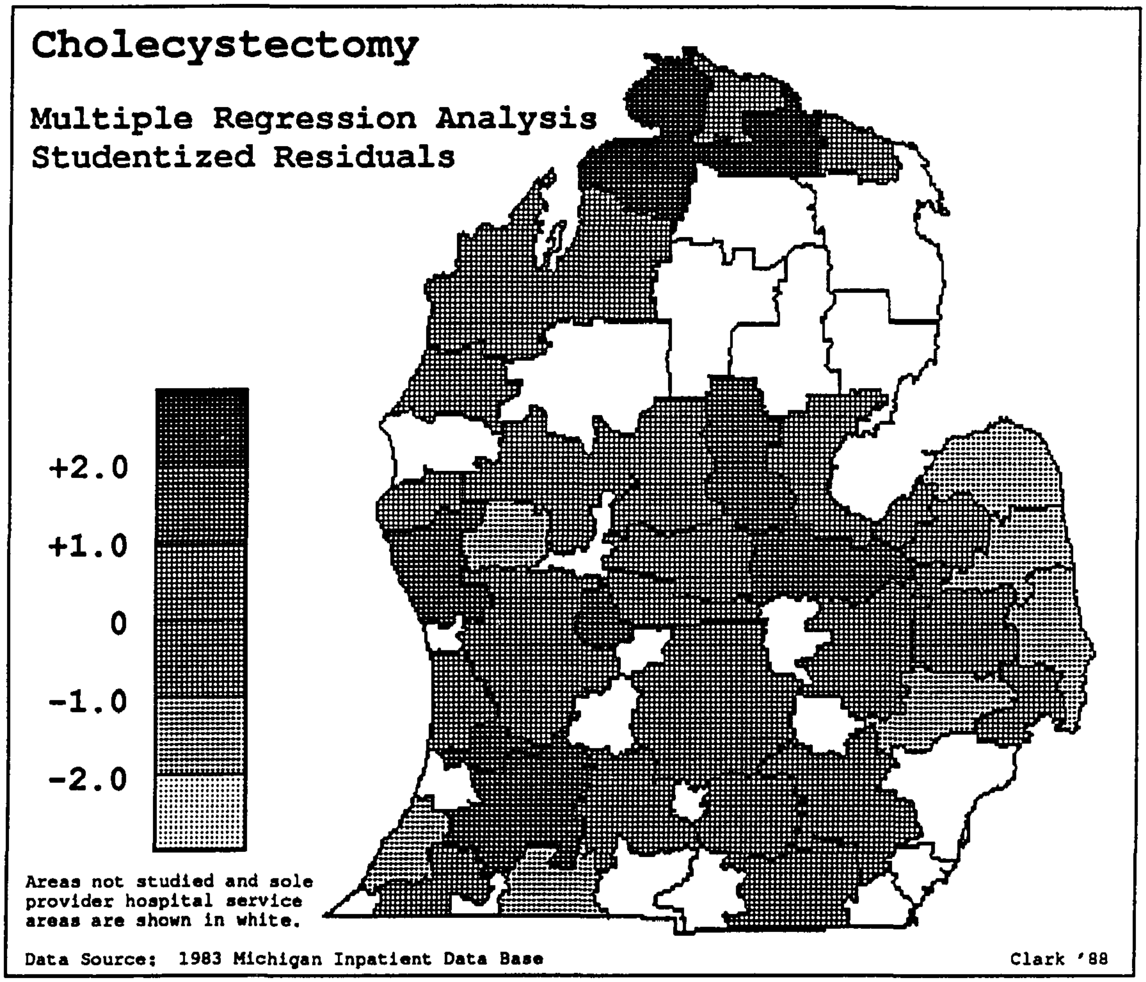


Figure 7.10

Values between -1 sd and +1 sd are mapped with the same shade of grey. See Figure 3.1 for the hospital service area names.

Inguinal Hernia Repair, Hysterectomy and Cesarean Section

Hypotheses

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in inguinal hernia repair, hysterectomy, and Cesarean section use rates. The hypothesized positive or negative entry into the regression equation are shown in Figure 7.11.

Figure 7.11

Hypotheses for Inguinal Hernia Repair, Hysterectomy, and Cesarean Section Use Rate Regressions

	Ing Hernia	Hysterectomy	C-Section
Physician			
Wgt Prop Bd Cert	+ +	+ +	+ +
Hosp Beds per 10,000	+ +	+ +	+ +
Hospital			
Supply of Resources			
FTEs per 10,000	+	+	+
Pharm per 10,000	+	+	+
RNs per Hosp Bed	-	-	-
Services Available			
Avg Hosp Serv '83	+ +	+ +	+ +
Avg Other Fac Serv '83	+	+	+
Avg Serv per Hosp '83	+ +	+ +	+ +
Total # Serv per HSA '83	+ +	+ +	+ +
Organization			
Change in Serv '81-'83	+	+	+
Out Pat Visits per 10,000	-	-	-
Corp Beds	+	+	+
House Staff per 10,000	- -	- -	+ +
Osteo Beds	- -	- -	- -

H_o : $b_i = 0$ for $_i$

H_i : $b_i \neq 0$ for at least one $_i$

Equation Results

Table 7.9

Multiple Regression Equation Results
Separately Run For
Inguinal Hernia Repair, Hysterectomy and Cesarean Section Rates

Dependent Var.	R^2	Adjusted R^2	F Value
Inguinal Hernia	0.1198	0.0993	5.853**
Hysterectomy	0.2005	0.1819	10.784***
Cesarean Sect	0	0	2.250

**p<.05 ***p<.01

The critical F (1,43) for each equation was 2.84. Therefore, the null hypothesis was rejected and the alternative hypothesis was accepted for the inguinal hernia repair regression equation and for the hysterectomy equation. The adjusted R^2 indicated that 9% of the variation in inguinal hernia procedure rates and 18% of the variation in hysterectomy rates were explained by the independent variable entering the equation. These two equations were significant at at least a p<.05 level.

In the multiple regression for the Cesarean section rates, the critical F (1,43) for the equation was 2.84, while the F value was 2.2520; therefore, the null hypothesis was accepted. There was no relationship between the independent variables and the Cesarean section use rate.

Variables Entering in the Equation

As shown in Table 7.10, the weighted proportion of board certified physicians was the only independent variable which was significant in explaining inguinal hernia repair rates and hysterectomy rates. There was a negative relationship between the weighted proportion of board certified physicians and the inguinal hernia procedure rate and also it and the hysterectomy rate. As the proportion of board certified physicians decreased in a hospital service area, the inguinal hernia repair rate and the hysterectomy rate increased. The weighted proportion of board certified physicians had been hypothesized to enter the equations with a positive sign. No physician or hospital characteristic provided significant explanation to the Cesarean section use rate.

Equation Results

Table 7.10

Significant Variables for
Inguinal Hernia Repair Rates and Hysterectomy
Use Rate Regressions

Intercept & Inde Var.	Coeffi- cient	Standard Error of B	t statistic
	Inguinal Hernia Repair		
Intercept	2.54	0.24	10.50***
Wgt Prop Bd Cert	-0.99	0.41	-2.42**
	Hysterectomy		
Intercept	6.01	0.43	14.07***
Wgt Prop Bd Cert	-2.38	0.73	-3.28***

**p<.05 ***p<.01

Residuals

The residuals from the inguinal hernia use rate equation were mapped (Figure 7.12). The regression equation for inguinal hernia repair under-predicted the use rates for nine hospital service areas. These service areas included Tuscola, Saginaw, and Mt. Pleasant in the

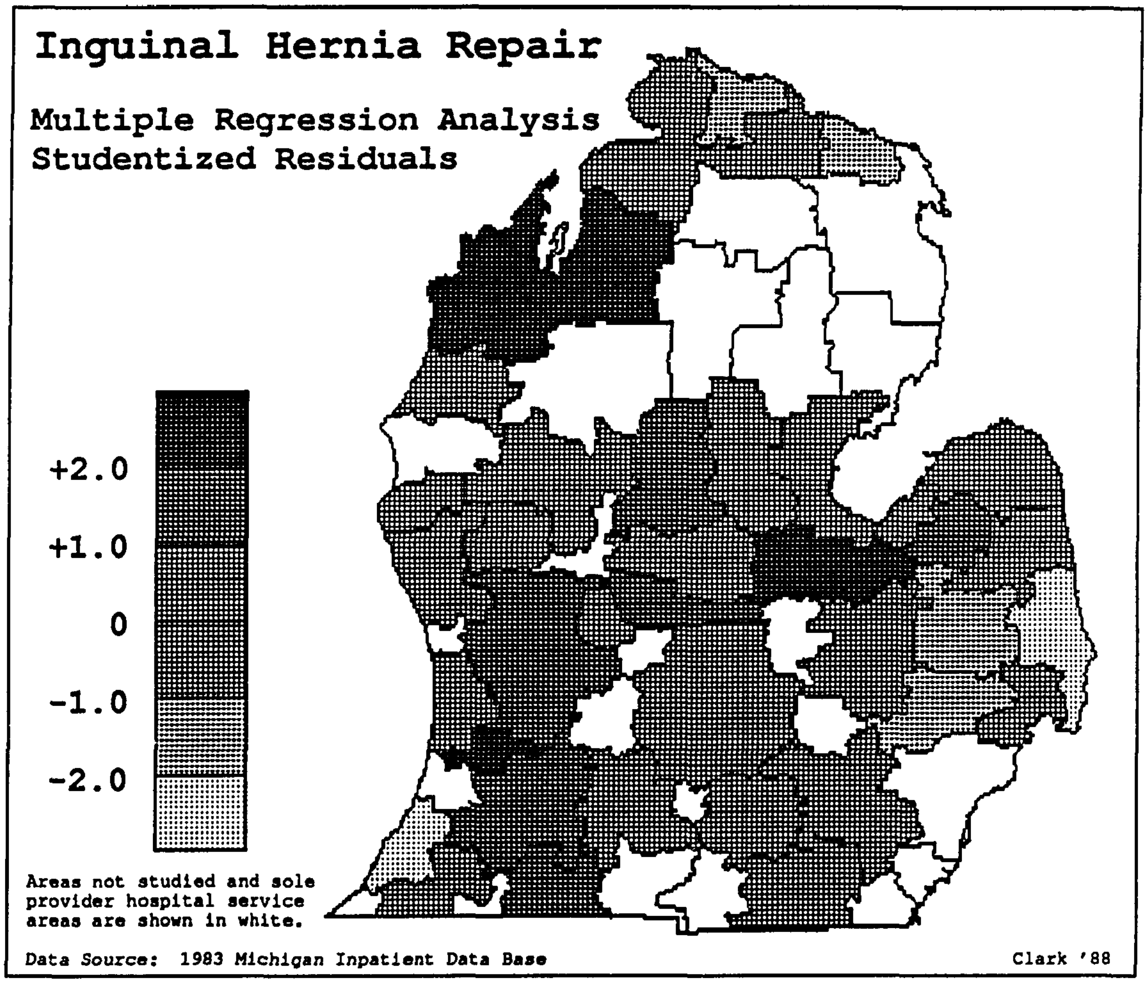


Figure 7.12

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

East Central Region, Grand Rapids, Montcalm/Ionia, and Allegan in the West Central Region, and Kalamazoo and Three Rivers/Sturgis in the Southwest Region. The equation under-predicted the Traverse City hospital service area in the North Region. The regression equation over-predicted the inguinal hernia repair rates for Port Huron, Benton Harbor/St. Joseph, Cheboygan/Rogers City, Pontiac, Lapeer and one sole community provider hospital service area in the West Central Region. There appeared to be no urban/rural or regional pattern to the residuals. The K-S test of the residuals verified their normal distribution.

The residuals from the hysterectomy multiple regression equation were mapped (Figure 7.13) and showed under-prediction by the regression equation for nine hospital service areas. These nine included Northern Michigan, Manistee and two sole community provider areas in the North Region, as well as the Grand Rapids, Kalamazoo, Three Rivers/Sturgis and Mt. Pleasant hospital service areas, plus one sole community provider area in the Southeast Region. Over-prediction of the hysterectomy rates occurred in Muskegon, Sanilac, Bay, Lansing, and Benton Harbor/St. Joseph hospital service areas. There appeared to be no urban/rural or regional component to the residuals. The K-S test of the residuals verified their normal distribution.

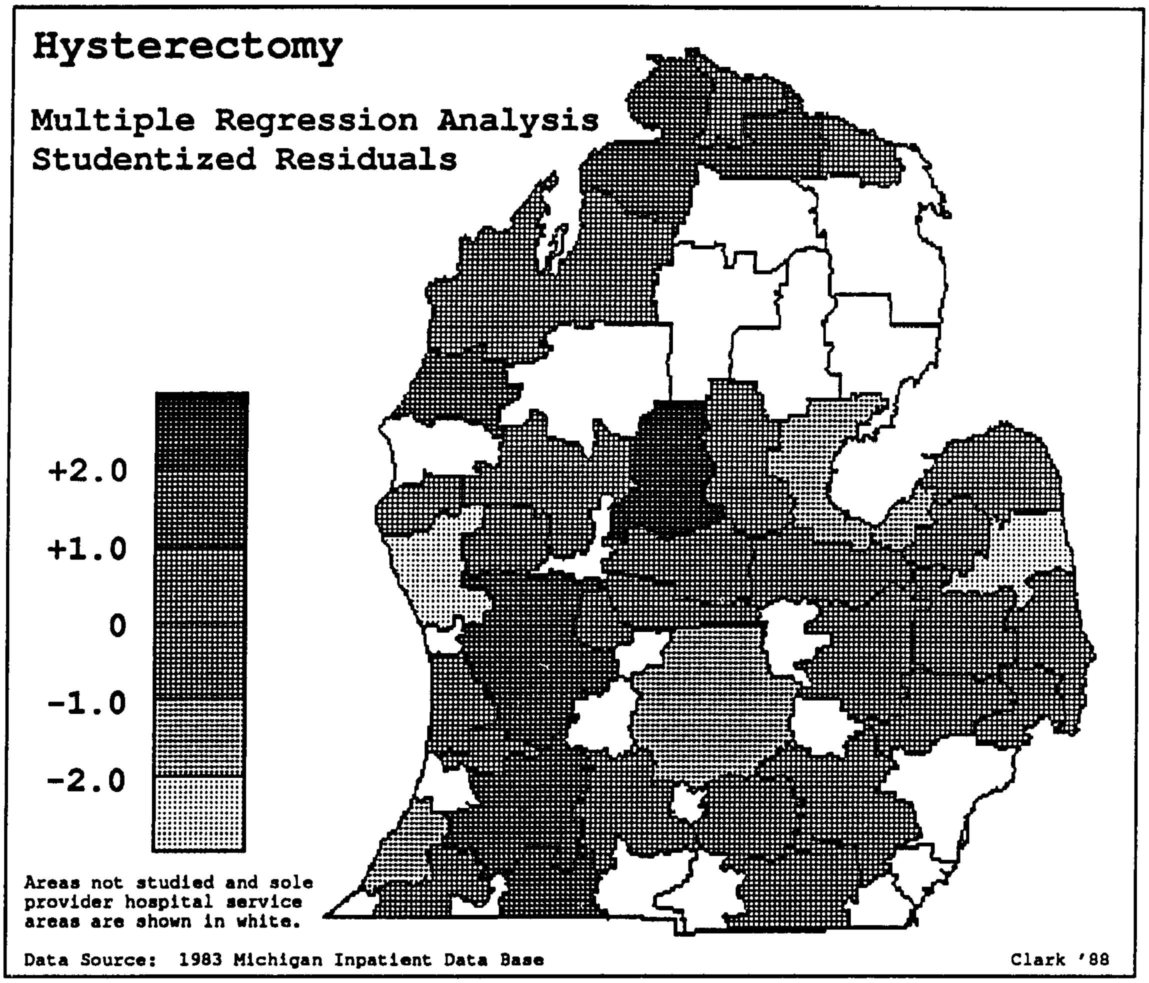


Figure 7.13

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Prostatectomy

Hypothesis

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in prostatectomy use rates. The hypothesized positive or negative entry into the regression equation are shown in Figure 7.14.

Figure 7.14

Hypothesis for Prostatectomy
Use Rate Regression

	Prostatectomy
Physician	
Wgt Prop Bd Cert	+ +
Hosp Beds per 10,000	+ +
Hospital	
Supply of Resources	
FTEs per 10,000	+
Pharm per 10,000	+
RNs per Hosp Bed	-
Services Available	
Avg Hosp Serv '83	+ +
Avg Other Fac Serv '83	+
Avg Serv per Hosp '83	+ +
Total # Serv per HSA '83	+ +
Organization	
Change in Serv '81-'83	+
Out Pat Visits per 10,000	-
Corp Beds	+
House Staff per 10,000	- -
Osteo Beds	- -

H_0 : $b_i = 0$ for i
H_i : $b_i \neq 0$ for at least one i

Equation Results

Table 7.11

Multiple Regression Equation Results
for Prostatectomy Rates

R^2	=	0.1005	
Adjusted R^2	=	0.0796	
F Value	=	4.805	$p<.05$

The critical F (1,43) for the equation was 2.84. The calculated value of F was 4.8. Therefore, the null hypothesis was rejected and the alternative hypothesis was accepted. As shown on Table 7.11, the adjusted R^2 indicated that slightly less that 8% of the variation in prostatectomy rates could be explained by the independent variable. The equation was significant at the $p<.05$ level.

Variables Entering the Equation

As shown on Table 7.12, one term in the equation was significant at the $p<.05$ level. There was a positive relationship between the prostatectomy procedure rate and the number of full time equivalent personnel per population. As the number of FTEs per capita increased, the prostatectomy rate increased.

Table 7.12

Significant Variables for
Prostatectomy Regression

Intercept & Inde Var.	Coefficient	Standard Error of B	t statistic
Intercept	2.08	0.34	6.13***
FTEs/Capita	0.01	0.00	2.19**

**p<.05 ***p<.01

Residuals

When the residuals were mapped (Figure 7.15), the regression equation over-predicted the prostatectomy rates for eleven hospital service areas. These eleven hospital service areas included two in the North Region, two in the West Central Region, four in the Southwest Region, one in the South Central Region and two in the Southeast Region. The prostatectomy use rate equation under-predicted the twelve hospital service areas shown in Figure 7.15, plus one sole community provider hospital service area in the Southeast Region. The pattern did not appear to be regional or urban/rural in nature. The K-S test of the residuals verified their normal distribution.

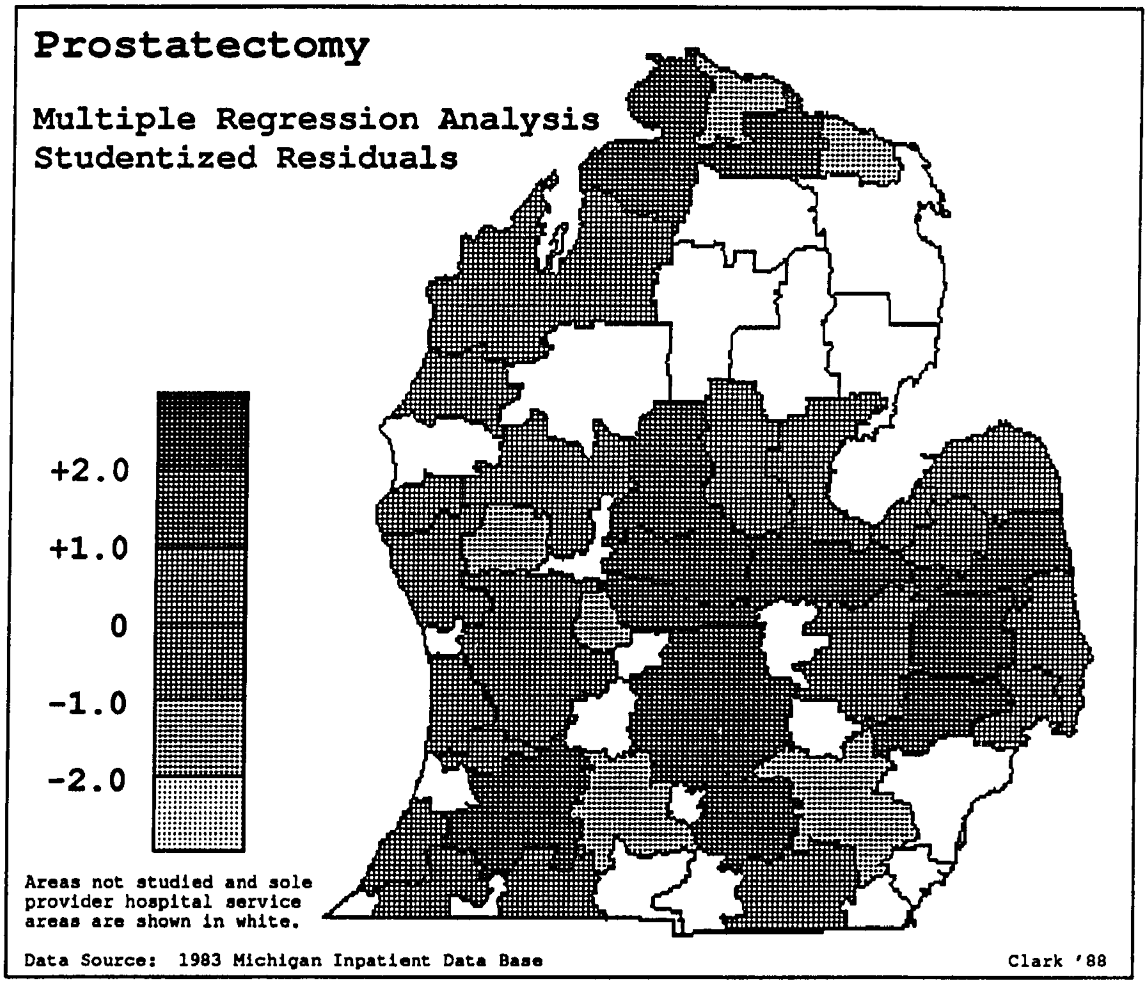


Figure 7.15

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Circulatory Admissions

Hypothesis

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in circulatory causes for admission use rates. The hypothesized positive or negative entry into the regression equation are shown in Figure 7.16.

Figure 7.16

Hypothesis for Circulatory Admission Rate Regression

	Circulatory
Physician	
Wgt Prop Bd Cert	+ +
Hosp Beds per 10,000	+ +
Hospital	
Supply of Resources	
FTEs per 10,000	+
Pharm per 10,000	+ +
RNs per Hosp Bed	- -
Services Available	
Avg Hosp Serv '83	+ +
Avg Other Fac Serv '83	+
Avg Serv per Hosp '83	+ +
Total # Serv per HSA '83	+ +
Organization	
Change in Serv '81-'83	+ +
Out Pat Visits per 10,000	- -
Corp Beds	+ +
House Staff per 10,000	- -
Osteo Beds	- -

$H_0 : b_i = 0$ for i
$H_i : b_i \neq 0$ for at least one i

Equation Results

Table 7.13

Multiple Regression Equation Results for
Circulatory Causes for Admission Rates

R^2	=	0.3231	
Adjusted R^2	=	0.2735	
F Value	=	6.523	$p<.01$

The critical F (3,41) for the equation was 2.23. The calculated value of F was 6.5. Therefore, the null hypothesis was rejected and the alternative was accepted. As shown on Table 7.13, the adjusted R^2 indicated that 27% of the variation in circulatory admission rates could be explained by the three independent variables entered into the regression equation. The equation was significant at a $p<.01$ level.

Variables Entering the Equation

Table 7.14

Significant Variables for
Circulatory Causes for Admission Regression

Intercept & Inde Var.	Coeffi-cient	Standard Error of B	t statistic	Beta Weights	Toler-ance
Intercept	22.72	1.69	13.46***		
Pharm/Capita	2.84	1.22	2.34**	0.35	0.74
RNs/Bed	-11.73	3.11	-3.77***	-0.56	0.75
Change in Serv	0.29	0.11	2.66***	0.35	0.98

**p<.05 ***p<.01

As Table 7.14 shows, each of the terms in the equation was significant at a $p<.05$ level. There was a positive relationship between the circulatory admission rate and two of the three independent variables and a negative relationship between the circulatory admission rate and one of the independent variables. As the supply of pharmacists per population increased, and the change in the number of services offered from 1981 to 1983 increased, the circulatory admission rate increased. As the registered nurses per bed decreased, the circulatory admission rate increased. The beta weights showed that the contribution made by the registered nurses per bed to the equation was slightly larger than that of the pharmacists per population and the change in the services (from 1981 to 1983) available in the hospital service area. The tolerance levels of the three independent variables were all above .73 and confirmed their mutual independence. A correlation analysis previously run had indicated this finding.

Residuals

When the residuals from the circulatory admission equation were mapped (Figure 7.17) the circulatory admission rates for eight hospital service areas were under-predicted. These hospital service areas included Jackson, Mt. Pleasant, Lapeer, Bay, Gratiot, Cheboygan/Rogers City, and two sole community provider areas; one in the West Central Region and one in the Southeast Region. With the exception of Port Huron and one Southeast Region sole community provider area, over-prediction of the circulatory admission rates occurred in the west from Reed City south through Muskegon, Allegan, Berrien/Cass County, Three Rivers/Sturgis and one sole community provider area in the Southwest Region. There did not appear to be any urban/rural component to the residuals. The K-S test of the residuals verified their normal distribution.

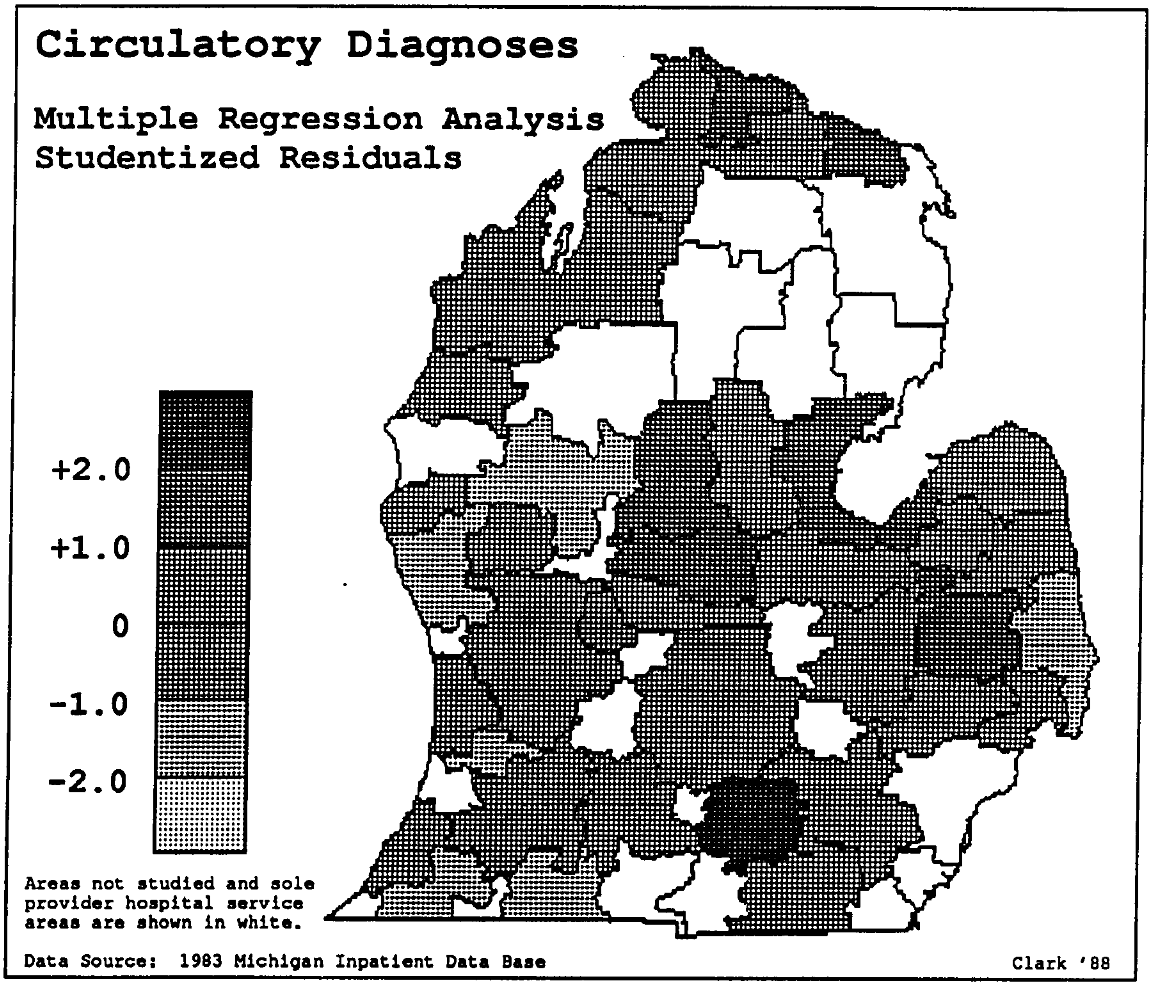


Figure 7.17

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Respiratory Admissions and Digestive Admissions

Hypothesis

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in respiratory and digestive causes for admission rates. The hypothesized positive or negative entries for each independent variable into the regression equation are shown in Figure 7.18.

Figure 7.18

Hypotheses for Respiratory and Digestive Causes for Admission Rate Regressions

	Respiratory	Digestive
Physician		
Wgt Prop Bd Cert	+ +	+ +
Hosp Beds per 10,000	+ +	+ +
Hospital		
Supply of Resources		
FTEs per 10,000	+	+
Pharm per 10,000	+	+
RNs per Hosp Bed	- -	- -
Services Available		
Avg Hosp Serv '83	+ +	+ +
Avg Other Fac Serv '83	+	+
Avg Serv per Hosp '83	+ +	+ +
Total # Serv per HSA '83	+ +	+ +
Organization		
Change in Serv '81-'83	+ +	+ +
Out Pat Visits per 10,000	- -	- -
Corp Beds	+ +	+ +
House Staff per 10,000	- -	- -
Osteo Beds	- -	- -

H_0 : $b_i = 0$ for i

H_1 : $b_i \neq 0$ for at least one i

Equation Results

Table 7.15

Multiple Regression Equation Results
Run Separately For
Respiratory and Digestive Causes for Admission Rates

Dependent Var.	R^2	Adjusted R^2	F Value
Respiratory	0.3768	0.3471	12.695***
Digestive	0.4046	0.3762	14.269***

***p<.01

The critical F (2,42) for each equation was 2.44; therefore, the null hypothesis was rejected and the alternative was accepted in each case. The adjusted R^2 (shown in Table 7.15) indicated that slightly less than 35% of the variation in respiratory admission rates and 37% of the variation in digestive admission rates could be explained by the two independent variables entered into the equation.

Variables Entering the Equation

As shown on Table 7.16, each term in the equation was significant at the p<.10 level. There was a negative relationship between each of the two causes for admission rates and two independent variables (RNs per bed and weighted proportion of board certified physicians). As the supply of registered nurses per hospital bed and the weighted proportion of board certified physicians decreased, the respiratory and digestive admission rates increased. The weighted proportion of board certified physicians had been hypothesized to enter the equations with a positive sign. The beta weights showed that the contribution made by the two independent variables was almost identical in the respiratory regression equation. The registered nurses per bed contributed more than the weighted proportion of board certified physicians did to the digestive admission equation. High tolerance levels (>.84) indicated the mutual independence of the two independent variables. Previously, a correlation of - 0.428 between RNs per bed and weighted proportion of board certified physicians was reported.

Table 7.16

Significant Variables for
Respiratory and Digestive Admission Rate Regressions

Intercept & Ind Var.	Coefficient	Standard Error of B	t statistic	Beta Weights
		Respiratory		
Intercept	19.17	1.67	11.46***	
RNs/Bed	-6.30	2.31	-2.72***	-0.36
Wgt Prop Bd Cert	-7.85	2.79	-2.82***	-0.37
		Digestive		
Intercept	27.67	1.80	15.41***	
RNs/Bed	-9.50	2.48	-3.83***	-0.50
Wgt Prop Bd Cert	-5.72	2.99	-1.91*	-0.25

*p<.10 ***p<.01

Residuals

The residuals were mapped (Figures 7.19 and 7.20) and showed some similarity in their patterns for under-prediction. Both equations under-predicted respiratory and digestive admission rates for the Bay, Saginaw, North Montcalm and Holland hospital service areas. Six other hospital service areas were under-predicted for respiratory use rates and three were under-predicted for digestive use rates. Over-prediction of the respiratory and digestive admission rates occurred in Port Huron, Muskegon, Reed City, and one sole community provider area in the West

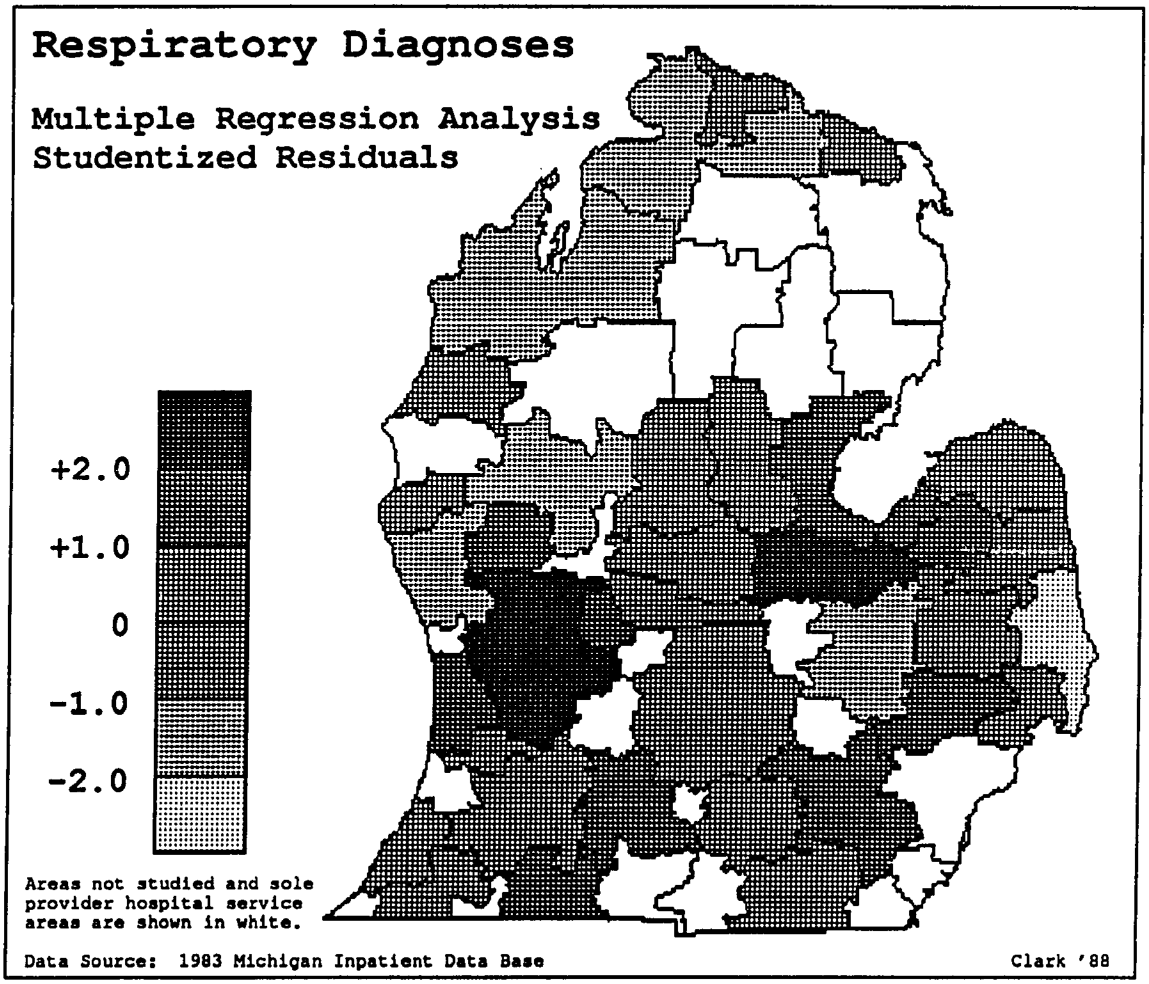


Figure 7.19

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

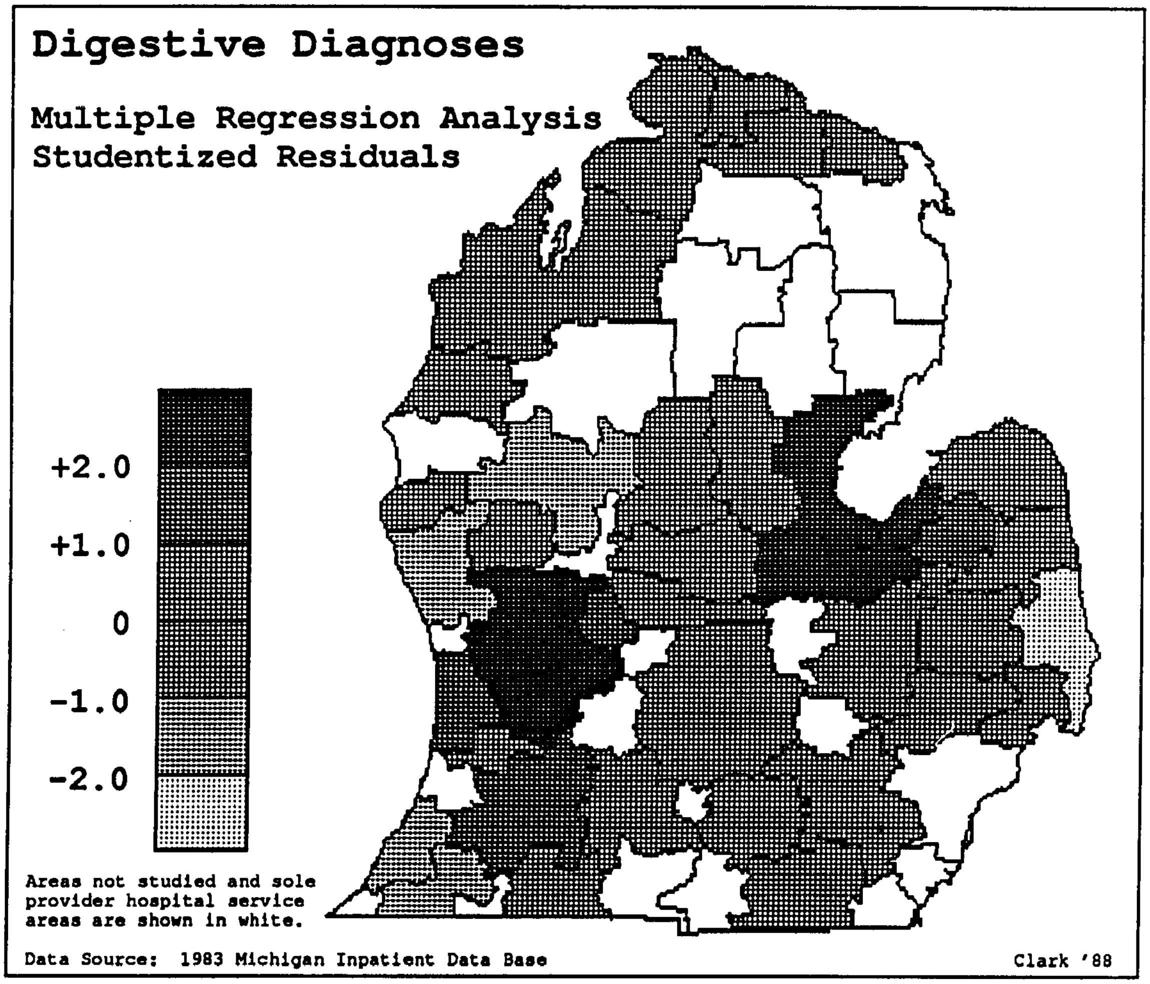


Figure 7.20

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Central Region. Five other hospital service areas were over-predicted by each of the respiratory and digestive equations. There appeared to be no regional or urban/rural pattern to the residuals. The K-S test of the residuals verified their normal distribution.

Genito-Urinary Admissions

Hypothesis

Fourteen measures of the physician and hospital components of the Clark Model were tested for their power in explaining the variation in genito-urinary admission rates. The hypothesized positive or negative entry of each independent variable into the regression equation is shown in Figure 7.21.

Figure 7.21

Hypothesis for Genito-Urinary Admission Rate Regression

	Genito-Urinary
Physician	
Wgt Prop Bd Cert	+ +
Hosp Beds per 10,000	+ +
Hospital	
Supply of Resources	
FTEs per 10,000	+
Pharm per 10,000	+
RNs per Hosp Bed	- -
Services Available	
Avg Hosp Serv '83	+ +
Avg Other Fac Serv '83	+
Avg Serv per Hosp '83	+ +
Total # Serv per HSA '83	+ +
Organization	
Change in Serv '81-'83	+ +
Out Pat Visits per 10,000	- -
Corp Beds	+ +
House Staff per 10,000	- -
Osteo Beds	- -

H_0 : $b_i = 0$ for i
H_i : $b_i \neq 0$ for at least one i

Equation Results

Table 7.17

Multiple Regression Equation Results for
Genito-Urinary Admission Rates

R^2	=	0.2243	
Adjusted R^2	=	0.1874	
F Value	=	6.072	p<.01

The critical F (2,42) for the equation was 2.44. The calculated value of F was 6.0. Therefore, the null hypothesis was rejected and the alternative was accepted. As shown in Table 7.17, the adjusted R^2 indicated that 19% of the variation in genito-urinary admission rates could be explained by the independent variables entering the equation. Each of the terms in the equation was significant at a p<.10 level.

Variables Entering the Equation

As Table 7.18 shows, there was a positive relationship between the genito-urinary admission rate and one of the two independent variables entered into the equation and a negative relationship with the other independent variable. As the number of nurses per bed decreased and the services offered by a contractual party increased, the genito-urinary admission rate increased. The registered nurses per bed contributed more to the explanation than did the services offered by a contractual party. The extremely high tolerance levels show the independent variables' orthogonality that had been previously shown by a correlation coefficient of -0.001.

Table 7.18

Significant Variables for
Genito-Urinary Admission Regression

Intercept & Inde Var.	Coefficient	Standard Error of B	t statistic	Beta Weights	Tolerance
Intercept	5.59	0.46	12.27***		
RNs/Bed	-2.07	0.68	-3.07***	-0.42	0.99
Avg Other Fac Serv	0.02	0.01	1.71*	0.23	0.99

*p<.10 ***p<.01

Residuals

The residuals were mapped (Figure 7.22) and showed a pattern of under-prediction of the genito-urinary admission rates in a band across the state from Holland to Sanilac. The genito-urinary admission rates for Port Huron, Gratiot, Reed City, Berrien/Cass County, and six sole community provider areas (two in the North, two in the West Central, and two in the Southwest Regions) were over-predicted by the regression equation. There appeared to be a regional component to the under-predicted hospital service areas and a rural component to the over-predicted areas. The K-S test of the residuals verified their normal distribution.

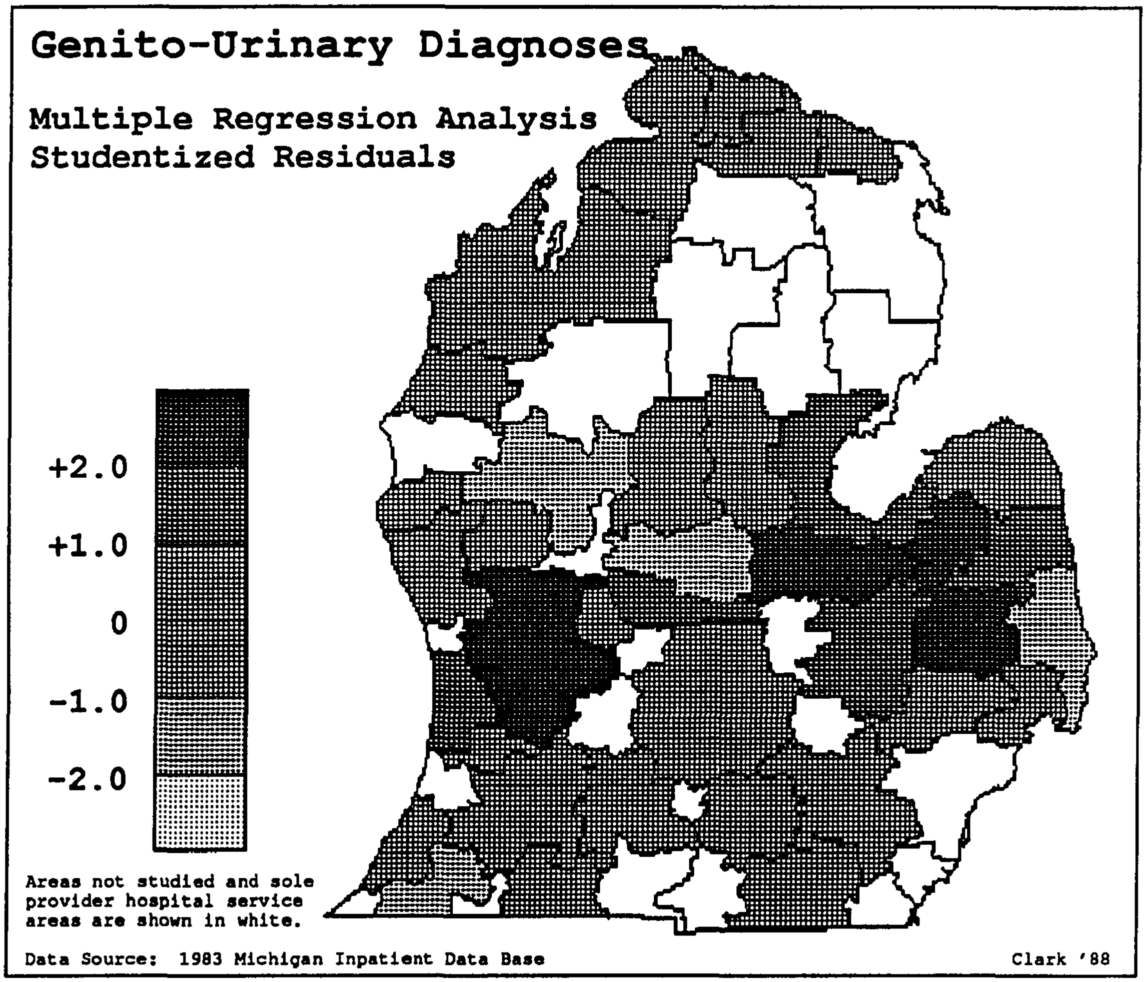


Figure 7.22

Values between -1 sd and +1 sd are mapped with the same shade of grey.
See Figure 3.1 for the hospital service area names.

Summary of Regression Results

The results of the multiple regressions are shown in Table 7.19, with the beta weight rankings shown in superscripts. The provider characteristics used in this analysis best explained the variation in the total female admission rate (48%) followed by the total admission rate (46%). Thirty-eight percent of the variation in the digestive admission rate, 36% of the total male admission rate, and 35% of the respiratory admission rate were explained using these provider characteristics. Far less explanation was found for the variation in surgical procedure rates. Provider characteristics explained 24% of the variation in the appendectomy rates, 18% of the hysterectomy rate, 15% of the cholecystectomy rate, 14% of the hemorrhoidectomy rate, 10% of the inguinal hernia repair rate, 8% of the prostatectomy rate, and none of the Cesarean section rate.

The results of the stepwise multiple regressions for all three measures of total admission rates (male, female and total) were very similar to those of medical causes for admission rates. With the exception of respiratory admission rates where the two significant explanatory variables had almost identical beta weights, RNs per bed was the most important explanatory variable in each equation and its coefficient had a negative sign in every instance. Again, with the exception of the respiratory admission rate equation, the weighted proportion of board-certified physicians was the second most important explanatory variable in the explanation of the three total admission rates and the digestive cause for admission rates.

Table 7.19

MULTIPLE REGRESSION RESULTS*

	Wgt Prop Bd Cert	Hosp Beds per 10,000	FTEs per 10,000	Pharm per 10,000	RNs per Hosp Bed	Avg Hosp Serv '83	Avg Other Fac Serv '83	Serv Level per HSA '83	Total # Serv per HSA '83	Change in Serv '81-83	Out Pat Visits per 10,000	Corp Beds	House Staff per 10,000	Osteo Beds	Adj R^2
Male	-0.28^{2}				-0.46^{1}										.3601
Female	-0.21^{2}				-0.60^{1}										.4842
Total	-0.25^{2}				-0.56^{1}										.4581
Appen			0.30^{3}						-0.46^{2}		-0.57^{1}				.2431
Hem	-0.24^{1}						-0.24^{1}				-0.24^{1}				.1416
Chole	-0.38^{1}	0.26^{2}													.1507
Hernia	-0.34^{1}														.0993
Prost			0.32^{1}												.0796
Hyst	-0.45^{1}														.1819
C-Sect															-0-
Circ				0.35^{2}	-0.56^{1}					0.35^{2}					.2735
Resp	-0.37^{1}				-0.36^{2}										.3471
Digest	-0.25^{2}				-0.50^{1}										.3762
Genito					-0.42^{1}		0.23^{2}								.1874

*The rank of each Beta Weight in each multiple regression equation is shown as a superscript.

The surgical procedure rates tested were less well explained by the provider variables used in the equations, and the variables that provided the explanation were quite dissimilar from procedure to procedure. The weighted proportion of board-certified physicians was the most important variable in the explanation for four surgical procedure rates (hemorrhoidectomy, cholecystectomy, inguinal hernia repair and hysterectomy). Only two other variables entered into more than one equation: FTEs and out patient visits per 10,000 population. Otherwise the explanatory variables that were significant in the procedure-specific regression equations were as idiosyncratic as the hospital service area surgical signatures discussed earlier. The low level explanatory power of the provider (hospital and physician) variables tested leads me to believe that further explanation lies with other untested physician or hospital variables, or with community characteristics. The dominance of specific surgical residency program graduates or specialists within a hospital service areas may, as hypothesized in Chapter 2, offer significant explanation of the variation in procedure-specific use rates.

CHAPTER 8

SUMMARY AND CONCLUSIONS

Summary

This research analyzed the hospital use rates for fourteen types of admissions to hospitals in 53 hospital service areas within the non-metropolitan Detroit portion of the lower peninsula of Michigan. The Clark Model described four components that influence hospital use rates: the individual; the community; the physician; and the hospital. The relationships between fourteen measures of the physician and hospital components and the hospital use rates were tested and multiple regressions were run to investigate what power the fourteen independent variables had in explaining the hospital use rates.

Four goals were established in the research design. These four goals attempted to answer several questions. Is there variation in hospital utilization among Michigan communities? If there is variation in hospital use rates, how does the variation compare to the results of previous utilization research conducted in Michigan and elsewhere? Does Michigan exhibit the same range and variability found in other geographic areas? Are there any use rate or spatial patterns to the variation? Which of the fourteen measures of the physician and hospital component of the Clark Model are related to and explain variations in hospital utilization rates? The conclusions reached as a result of this research will be discussed as they relate to each of these goals.

Research Goal 1:
Documentation of Variation in Hospital Use Rates

Variation was found among the 53 hospital service areas for each of the fourteen hospital use rates studied. Results from the computation of three measures of variation (maximum/minimum rate, coefficient of variation, and systematic component of variation) were examined and all showed variability not unlike results from earlier small area analysis research.

Comparison of the Results of this Study to Previous Results from Michigan and Elsewhere

Total Admission Rates

Comparison to earlier work showed that the total admission rates from this current research were very similar to results reported from New England, Washington, Los Angeles, New York City and other U.S. states and standard metropolitan statistical areas. The minimum total admission rate in all these studies was more consistent than the maximum rate. This indicates to me that there probably is a relatively consistent minimum threshhold of patient need which is being met by hospitals.

Surgical Procedure Rates

Comparison to other small area analysis results showed that the range in appendectomy, hemorrhoidectomy, cholecystectomy, prostatectomy, and hysterectomy rates found in this current research was consistent with earlier results outside of Michigan. The inguinal hernia repair rates found by this current research had lower minimum rates than those reported earlier from North America but were consistent with reported minimum rates from England and Wales. The maximum inguinal hernia repair rates found in this current study were consistent with reported results from North America.

Comparison of the surgical procedure ranges from this current research to Griffith's earlier work in Michigan showed a great number of dissimilarities. In each of the five surgical procedures where comparison was possible, the maximum rate reported by Griffith was higher than the maximum rate found by this current research. There are two possible explanations that occur to me. First, Griffith's work included metropolitan Detroit while this current research did not; therefore, the higher maximum rates may have occurred in Detroit. There may also be differences in the ICD-9-CM coding used by Griffith and myself which could explain the higher rates found by Griffith. Oncology codes were excluded from this research but may have been included in Griffith's previous work.

When the comparison of variation in surgical procedure rates was done using the SCV (rather than the maximum rate divided by the minimum rate), the results were very different. The variability in prostatectomy and hysterectomy rates from this current research in Michigan was considerably less than the variability in those two procedure rates reported by Wennberg from research done outside of Michigan and shown on Table 5.2. Wennberg's categorization system placed both prostatectomy and hysterectomy rate variability at least one category higher than the results from this current research showed. Wennberg categorized prostatectomy rates as being in the "very high" variation category and hysterectomy rates in the "high" variation category. The results from this current research showed prostatectomy rates as being in the "moderate" variation category and hysterectomy rates as being in the "low" variation category, each with lower variation than Wennberg found. The most probable explanation is that Wennberg included oncology patients within his numerator and they were excluded from this study. The removal of surgical patients with malignancies from the study would appear to have decreased the variation in the rates.

The difference in hysterectomy rate variation between the results of this current research and Wennberg's earlier studies is important because the results add information to the discussion on medical consensus and its influence on use rate variability. This notion of variability as it relates to medical consensus will be discussed further in a later section of this chapter.

Medical Causes for Admission Rates

Respiratory causes for admission rates have the highest variability among the four medical causes for admission rates tested in this current research. This was generally the case in earlier small area analysis research results as well, but the lack of a tacitly agreed upon set of medical causes for admissions make these comparisons less certain than comparisons of surgical procedure rates.

Research Goal 2:
Analysis of Use Rate Patterns

Four use rate patterns were analyzed in this research. The first was the consistency in procedure specific variability when ranked by variation in use rates. As shown previously on Table 5.2, the results of this study support Wennberg's earlier findings from New England that cholecystectomy and appendectomy had a moderate level of variation. Dissimilarities in ranking between this study's results and Wennberg's previous results were found in hemorrhoidectomy, inguinal hernia repair, prostatectomy and hysterectomy rates. For two of these, hemorrhoidectomy and inguinal hernia repair, this study showed greater variability in rates than did Wennberg's results from New England. For two others, prostatectomy and hysterectomy, the results of this current study showed lower use rate variability than did Wennberg's results from New England.

Wennberg concluded from his research that all non-elective procedures with high medical consensus (appendectomy, inguinal hernia repair, cholecystectomy) have less use rate variability than elective procedures with low medical consensus (hemorrhoidectomy, non-malignant prostatectomy and non-malignant hysterectomy). The results from this current research did not support Wennberg's conclusions.

The hysterectomy use rate is of particular interest because malignant hysterectomies, which were believed to be the portion of all hysterectomies with low variability, were removed from the hysterectomy category as defined for this study. Hysterectomies performed because of malignancy are believed to have low variability because medical consensus is very high and surgery is agreed to be the appropriate treatment when malignant or pre-malignant cells are present. Therefore, Wennberg's SCV of 50 for all hysterectomies (both malignant and non-malignant) was expected to be lower than the SCV found in this current study since this research looked only at non-malignant and therefore elective and more variable hysterectomies. The hysterectomy SCV was 17 in this current research.

The same relative variability of total prostatectomy rate and non-malignant prostatectomy rate was found. The variation in total prostatectomy rates found by Wennberg (SCV=190) were far higher than the variability in the non-malignancy prostatectomy rates found in this research (SCV=34).

Using the Clark Model as a framework for analysis, are there differences between New England and Michigan individuals, communities, physicians, and hospitals that would cause Michigan to have more consistency in its non-malignant, and therefore elective, hysterectomy and prostatectomy rates? To help answer this question, use rates for total hysterectomies and total prostatectomies should be calculated in the future for Michigan and then compared to Wennberg's results from New England.

The second use rate pattern, the greater variability of medical causes for admission rates than for surgical procedure rates could not be substantiated by this research. As shown previously in Table 5.2, this current study found that hemorrhoidectomy rates varied more than any of the four medical causes for admission tested. Appendectomy rates varied more than did three and inguinal hernia repair rates varied more than did two of the medical causes for admission rates. The results of this study do not support earlier findings by Wennberg in New England and Wilson in Michigan that medical causes for admission have greater variability than surgical procedure rates.

Results from this current research corroborated the third use rate pattern identified in previous small area analysis literature. Previous work by Wennberg and Gittelsohn, as well as by Vayda, demonstrated hospital service area "surgical signatures". As Figures 5.2 and 5.3 show, each hospital service area in this study had its own unique pattern of surgical use rates, no matter whether the hospital service area had a total admission rate that was designated as high or low.

The fourth use rate pattern identified from previous small area analysis literature was the consistency of higher than average or lower than average use over several use rate measures within a hospital service area. Hospital service areas designated as high use areas because of their higher than average total admission rates (Table 5.3) also had higher than average medical causes for admission rates for most, if not all, of the four medical causes for admissions. Griffith had reported that high respiratory admission rates were found in areas of high total admission rates. In this current research, this was found to be true in only three of the four high use areas. Appendectomy, cholecystectomy, inguinal hernia repair and prostatectomy rates were higher than average in three of the four high use areas, while hysterectomy rates were higher than average in two of the four high use areas. This current research supports Griffith's earlier Michigan results. Areas that have high total admission rates tend to have high medical causes for admission rates and several high surgical procedure rates as well.

Areas of low total admission rates (Table 5.4) also had low male, female and digestive admission rates. Low genito-urinary rates were found in five of the six low use areas and low respiratory admission rates were found in four of the six low use areas. Low circulatory admission rates were found in only three of the low use areas, and no surgical procedure was found to have lower than average use in any more than two low use areas. Areas that have low total admission rates do not demonstrate consistency in low use rates across several medical causes for admission or surgical procedures.

In summary, high use areas when compared to low use areas appeared more apt to cluster geographically and more apt to have a consistency of high use across several use rate measures, including surgical procedures. Low use appeared to be most consistent among the three total admission rates, slightly less consistent among the medical causes for admission, and least consistent among the surgical procedure rates. This result supported Wennberg and Vayda's findings that specific procedures were either high or low within a hospital service area, and that the "surgical signature" of that hospital service area would remain relatively constant over time. It was not possible to fully test the surgical signature hypothesis without data from several years, but the uniqueness of the surgical use rate pattern in each hospital service area supported Wennberg's theory.

The explanation for the variation in use rates will be discussed in the portion of this chapter devoted to a summary of the results of the multiple regression analysis and conclusions drawn from the research.

Research Goal 3: Determination of the Relationships Between Different Hospital Use Rates and Between Use Rates and Provider Characteristics

As shown in Table 6.1, significant positive correlations ($p<.001$) were found among the three measures of total admission rates and between the three rates for total admissions and the four measures for medical causes for admission rates. Only three significant ($p<.01$) relationships were found among the surgical procedure rates and only two were found between the surgical procedure rates and the medical causes for admission rates. Cholecystectomy was significantly related ($p<.001$) to all three measures of total use.

The strong correlations between the three rates for total admission rates and the four rates for medical causes for admission rates are in keeping with the spatial patterns of the high use and low use areas described previously. The probable explanation for the high use and low use areas will be discussed later in this chapter.

Although several correlations among the fourteen provider characteristics were significant (Table 6.2), they were all below .800. Therefore, multicollinearity was not a problem and each of the fourteen independent variables could be entered into the multiple regression equations simultaneously.

When correlations were run between the fourteen use rates and the fourteen provider characteristics (Table 6.3), the only significant ($p<.001$) and negative correlations were between RNs per bed and total female, total admissions and digestive causes for admission rates. There was consistency in the sign of the correlations between the total admission and medical causes for admission rates and the provider characteristics. The relationships between the provider characteristics and surgical procedure rates showed no significant associations and no consistent positive or negative pattern.

In summary, the relationships tested by the correlations reconfirmed those noted previously. All three measures of total admission rates were significantly positively related to the four medical causes for admission rates (Table 6.1). With few exceptions, correlations among the surgical procedure rates and between the surgical procedure rates and both the three measures of total admission and medical causes for admission rates were not significant (Table 6.1). There was no consistency in the sign of the correlation between the surgical procedure rates and the provider characteristics (Table 6.3). The correlation results reinforced the conclusion that surgical procedure rates are idiosyncratic. The results of this current research showed that a hospital service area's surgical procedure rates are unique when one considers use rate patterns (surgical signatures), spatial patterns, and their relationships with provider characteristics.

Research Goal 4:
Use Rates as a Function of Physician and Hospital Characteristics

<u>Total Male, Total Female, Total Admission Rates</u>

<u>Digestive and Respiratory Admission Rates</u>

As shown on Table 7.19, the physician and hospital characteristics chosen for this study most successfully explained the variation in total female admission rates (48%), total admission rates (46%), digestive admission rates (38%), total male admission rates (36%) and respiratory admission rates (35%). Two provider variables, RNs per bed and the weighted proportion of board certified physicians, were significant to the explanation and entered negatively into each of these five multiple regression equations. It is difficult to understand why decreasing the number of nurses per bed would cause an increase in use unless you remember that we are working with a proportion. It may not be that there are a smaller number of nurses in all hospital service areas, but rather that there are a larger number of beds. This explanation is more easily understood when one considers that the number of beds used in this current research was the number of licensed beds rather than the number of set up and staffed beds. The number of licensed beds is the historical number of beds in a service area and consequently not the currently used number of beds. The general decline in the occupancy and admission rates in Michigan hospitals means that the number of licensed beds is larger than the number of beds currently being used. If the ratio is, in fact, a reflection of the number of beds, then the explanation for high use returns to Roemer's law which states that increasing the number of available beds encourages higher use.

The second provider variable to negatively enter all five of these equations was the weighted proportion of board certified physicians. The mechanisms for this relationship are clearer to me. Non-board certified physicians are physicians who have had less specialty training. They are, I believe, less likely to use alternative settings for health care and more likely to admit patients to hospitals. They are also less likely to use diagnostic tests, if available, to screen patients for admission. The end product is that as the training and expertise level of the physicians in a hospital service area increase, use rates will decrease.

Circulatory Admission Rates

Twenty-seven percent of the variation in circulatory admission was explained by three provider variables: RNs per bed entered the regression equation negatively, pharmacists per 10,000 population entered positively, and the change in the number of services available in the hospital service area from 1981 to 1983 entered positively. The RNs per bed has been discussed previously. The other two hospital characteristics only entered as significant variables into this one equation. Both are positive relationships, so that as the number of pharmacists and available hospital services increase, the circulatory admission rates will increase. This happens, I believe, because of two important aspects in cardiac care. First, circulatory disease treatments are medication intensive, requiring a large number and amount of prescriptions. A hospital specializing in circulatory (cardiac) care would be more likely to employ more pharmacists than one which did not specialize in cardiac care.

The second aspect of cardiac care is the new technology and new procedures which have become available. Between 1981 and 1983 an increase in the number of services available in a hospital service area almost certainly would have included new cardiac diagnostic and treatment services which would have caused an increase in hospital use just because the services were new and therefore would meet previously unmet needs of the community.

Genito-Urinary Admission Rates

Nineteen percent of the variation in genito-urinary admission rates was explained by two provider characteristics: RNs per bed and the average number of services provided by contractual agreement with other facilities. The explanation for the negative relationship between RNs per bed and use rates was discussed previously. The explanation provided by contractual services is, I believe, related to outpatient, clinical and diagnostic services provided to smaller hospitals by other hospitals or clinics. One of the first specialists to be sought by smaller community hospitals is a urologist. These physicians often work at the hospital on a contractual basis to run periodic clinics. The clinic urologist may or may not have admitting privileges, but by providing a new service will cause the genito-urinary admission rate to increase in the hospital service area.

Surgical Procedure Rates

The percent of explanation provided by the fourteen provider characteristics for the variation in the seven surgical procedure rates ranged from 0 for cesarean section to 24 for appendectomy. The provider characteristics were no more successful in explaining the elective surgery rates (hemorrhoidectomy, non-malignant prostatectomy and non-malignant hysterectomy) than in explaining the non-elective surgery rates (appendectomy, cholecystectomy and inguinal hernia repair). The weighted proportion of board certified physicians entered as a significant variable into four of the surgical procedure multiple regression equations. In each instance the relationship was negative and had the largest beta weight. This result means that as the specialty level of the physicians in a hospital service area decreased, the surgical procedure rates for hemorrhoidectomy, cholecystectomy, inguinal hernia repair and hysterectomy procedures increased. The results from this current study are unlike earlier results reported by Wennberg and Gittelsohn (1973) and Detmer and Tyson (1978) that showed a positive relationship between specialists and total surgery rates. Earlier research suggested it did not matter if the specialists were surgeons or not, simply that they were specialists.

No explanation was found among these provider variables for the cesarean section rates. This means that cesearean section rates are related to individual patient characteristics, community characteristics, physician practice style, or untested hospital characteristics. Several hypotheses to explain the rising cesarean section rates have been suggested to me by hospital administrators and clinicians. In every instance they have suggested that the cesarean section rate is related to : 1) the need (as perceived by the physicians) to practice defensive medicine because of rising malpractice insurance problems; 2) the age of the mothers -- either nearer the end of child-bearing years or very young teens; and 3) physician practice patterns resulting from differences in training, specialties, or historical community norms.

Conclusions and Future Research

The results from this current research suggest to me that four major factors derived from the physician and hospital characteristics studied may influence the hospital use rates. Each of the four factors presented below are preliminary in nature and will require further investigation to prove or disprove their importance in explaining hospital use. These four postulated causative factors for 1983 Michigan hospital use rates are: 1) the small rural nature that characterizes the average of the high use hospital service areas; 2) the inequality of the distribution of high technology diagnostic equipment; 3) the inequality in the rural hospital environment produced by the designation of some hospitals as rural referral centers; and 4) the impact of the size and definition of a hospital service area upon hospital use rates.

Factor 1: The Small Rural Nature of High Use Hospital Service Areas

One aspect of the hospital component of the Clark Model that was not directly studied in this current research appears to be of importance in explanation of the variation in hospital use rates. The factor is the small, rural character of the hospital service areas that have use rates that are consistently higher (>1 S.D) than average. The urban or rural character of a hospital service area is a community variable and therefore was not studied in this research. The rural nature of many of the high use areas indicates that it is an important variable that should be included in future work. Twelve of the fourteen hospitals within the high use areas, and therefore six of the eight hospital service areas, have fewer than 100 beds. As shown in Table 8.1, the average number of licensed hospital beds in the high use hospital service areas was 74, while in the low use areas it was 271.

This is not solely a question of the size of the hospitals, but rather of the whole health care delivery system and the stress that the current industry environment places on small rural hospitals. Recent research I directed at the MHA (Hamilton, Clark and Lester, 1988) showed that the smaller hospitals in Michigan are currently under a great deal of hospital industry environmental stress. That would have been true, although to a lesser degree, in 1983 as well as today.

The hospital industry environmental stress on smaller hospitals has exhibited itself in several ways. First, the small rural hospitals have had difficulty recruiting registered nurses and physicians. As a result of recruitment problems and lay-offs, the number of registered nurses per bed has decreased. This is true of all hospitals, but is particularly critical in smaller hospitals where the margin for change is reduced because of the smaller starting point. The potential impact on hospital use rates of the reduced number of RN's per bed is supported by the comparison shown on Table 8.1. The high use areas had an average of .44 registered nurses per bed, while the low use areas had an average of .85 registered nurses per bed.

Table 8.1

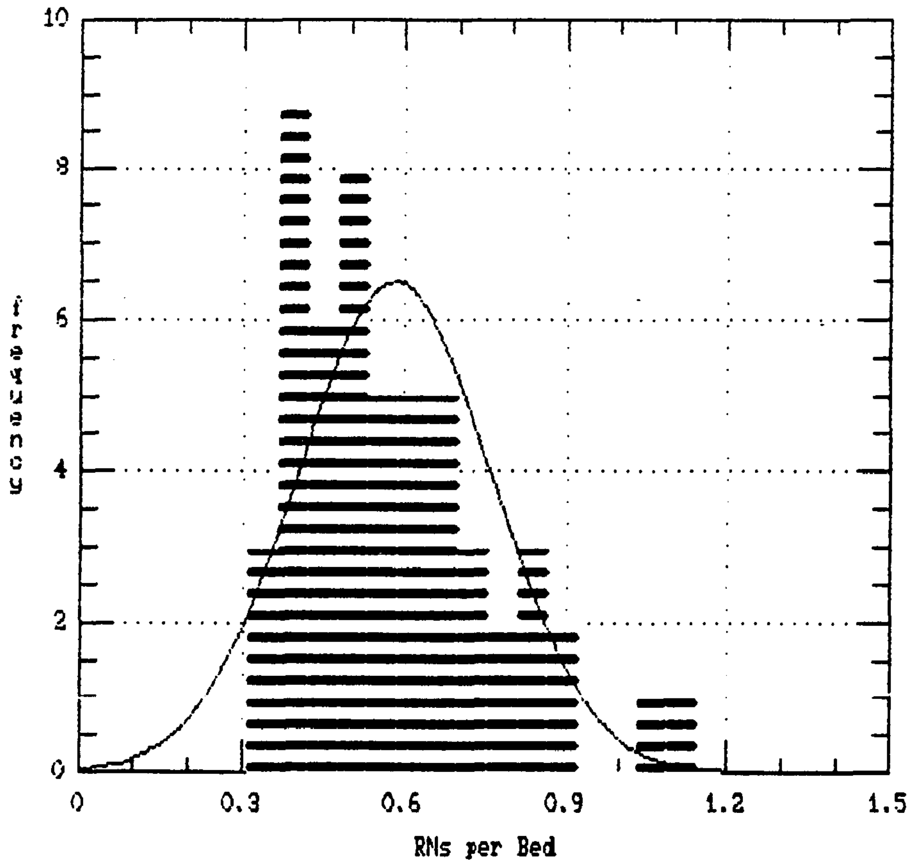
Comparisons of High Use and Low Use Areas identified in Chapter 5

	High Use Area Mean (8 HSAs)	Study Area Mean (53 HSAs)	Low Use Area Mean (6 HSAs)
Licensed Beds per Hospital	74	172	271
Weight Proportion of Board Certified Phys.	.42	.58	.61
Registered Nurses per Bed	.44	.58	.85
House Staff per 10,000 Pop	1.32	1.71	6.80
Diagnostic Services (Out of 7 Possible)	3.00	4.10	5.50

The negative relationship between registered nurses per bed and use rates can be better understood if one considers the histogram (Figure 8.1) of the distribution of registered nurses per bed by hospital service area. There is virtually no tail to the left of this distribution. The sharp rise at .4 RNs per bed indicates a threshhold effect. Clearly one cannot have a hospital bed in operation without nurses on staff to administer care to the patient in that bed. But as hospital industry environmental pressures such as recruitment problems,

Figure 8.1

Frequency Histogram for RNs per Bed
(shown with normal curve)



declining revenues, and occupancy rates make an impact on a hospital, the nurses are asked to provide care to more and more patients in the occupied beds. The number of patients an RN is able to care for can be increased to the threshhold level that the state and the Health Care Financing Administration (Medicare) require.

Also, because of the difficulty in recruiting physicians, the proportion of board certified physicians to total physicians has decreased in the small rural hospitals. As shown on Table 8.1, the high use areas had a weighted average of 42% board certified physicians, while the low use areas had a weighted average of 61% board certified physicians. Anecdotal information provided by the hospital administrators suggests that the physicians in many smaller hospitals are aging and that physicians who are currently initiating practices in smaller hospitals are less apt to be board certified specialists, less apt to be graduates of United States medical schools, and more apt to be graduates of foreign medical schools who are board eligible but not board certified. I think that one way that the decrease in the proportion of board certified physicians affects use is by the following mechanism: as physicians increase their training and expertise in their area of specialty, they are more likely to use more diagnostic tests and to use alternative health care settings outside the hospital. Both the increased use of diagnostic tests and the use of alternative health care settings would cause a reduction in inpatient hospital use.

Factor 2: Inequality of the Distribution of High Technology Diagnostic Equipment

The second factor in the explanation of hospital use rates also is within the hospital component of the model. Because of financial and regulatory constraints, smaller hospitals have had a great deal of difficulty in obtaining the new technology that has become available to larger, urban hospitals. To test the effect that the lack of access to new technology may have upon use, the hospital services available in 1983 were re-examined, and those that were diagnostic services were noted. Seven types of diagnostic services or equipment were included within the list of available services in 1983. These seven diagnostic technologies included cardiac catheterization, CT scanner, diagnostic radioisotope, electrocardiogram, histopathology, ultrasound and nuclearmagnetic resonator equipment. As shown on Table 8.1, the high use areas had an average number of 3.0 diagnostic services per hospital service area while the low use areas had an average number of 5.5 diagnostic services available. I think that the lack of access to new diagnostic technology increases the hospital use rates because physicians cannot be as certain of their diagnoses, nor can the diagnoses be made as rapidly when high technology diagnostic equipment is not present. In these times of defensive medicine due to the difficulties associated with and expense of malpractice insurance, I think physicians in hospital service areas lacking high technology diagnostic equipment are more apt to use the inpatient facilities of the hospital and less apt to delay or avoid hospitalization for their patients.

Factor 3: Rural Referral Centers

The third factor in the explanation of higher use in small rural hospital service areas also lies within the hospital component of the model. Specifically, there is an inequality in the rural hospital environment produced by the designation of some hospitals as rural referral centers. With the advent in 1983 of DRGs and the prospective payment system for Medicare patients, a higher level of reimbursement was given to rural hospitals who met the criteria for being designated a rural referral center. These criteria included being an acute care hospital in a rural area that had either: 1) more than 500 beds or 2) had both 50% of its Medicare patients referred from another hospital or by physicians who did not have admitting privileges at the hospital and had at least 60% of its Medicare patients and services provided to people who lived more than 25 miles from the hospital.

None of the fourteen hospitals in the high use hospital service areas has been designated as a rural referral center. The two high use sole community provider hospital service areas in the North Region are surrounded by four rural referral center hospital service areas. As a consequence of the designation as a rural referral center, those hospitals that are not rural referral centers have lower patient revenues, and less ability to maintain a medical education program or to purchase high technology equipment. As a consequence the rural hospitals that are not referral centers tend to attract fewer board certified physicians and have fewer house staff (interns, residents and salaried physicians). As a consequence, the weighted proportion of board certified physicians in the high use areas was 4.2 and in the low use areas was 6.1. The average number of house staff per 10,000 population in the high use areas was 1.32, while in the low use areas it was 6.80.

The importance of these hypothesized causative factors has yet to be tested, but the differences in the measures between high use and low use areas are striking. Further research will need to be conducted to test the power of other physician and hospital characteristics in explaining hospital use rates. Two hospital characteristics that should be tested are immediately apparent from the previous discussion. They are the number of beds that are currently being used (set up and staffed) per hospital and the number of high technology diagnostic services per hospital service area. An additional hospital characteristic that may have an impact on the hospital use rates is the occupancy rate. By testing the explanatory power of occupancy rate, one would be isolating the unused and available hospital resources from a measure of the total historical resources (beds per population) in the hospital service area.

Further research is necessary in the area of physician characteristics as well. Few physician characteristics have been studied previously, and those studies yielded inconclusive results. As described earlier (Chapter 2), I have hypothesized that physician training, specialty and length of time in a community will be influential in explaining hospital use rates. The results of this research have strengthened this hypothesis for several reasons. First, the percent of explanation found among the physician and hospital characteristics tested in this study was low. There is further explanation of hospital use rates to be determined. Second, results from this current research indicated that Wennberg's classification of procedures and medical causes for admission into low, medium, high, and very high variation groups did not match the classification in Michigan. One possible way to explain this difference is that Wennberg's classification system is not stable. The differences found between Michigan and New England bring into question Wennberg's hypothesis that procedures that have high levels of medical consensus have low variation in use rates and that procedures that have low levels of medical consensus have high variation in use rates. Procedures that were thought to have high medical consensus did not necessarily have lower use rates. This suggests to me that surgical training may be of importance in creating medical consensus and, therefore, in influencing surgical procedure rates. Further work needs to be done in Michigan to determine if the procedure-specific use rates are stable over time and if Michigan perhaps has its own (and different) classification of low, medium, high and very high variation procedures due possibly to a difference in the medical education of its physicians. The influence of medical training, particularly surgical medical education should be studied further.

One word of caution should be introduced here. This research used 1983 data and the hospital industry is not the same today as it was in 1983. The beginning of some very important changes in the hospital industry within Michigan and elsewhere within the United States were initiated in the fourth quarter of 1983 when the DRG system was introduced into some of the hospitals in the United States. The DRG system was phased in at all United States hospitals following 1983. The change to a prospective payment system for Medicare and then Medicaid patients has had an immense impact upon Michigan's hospitals and health care. It has been observed that dramatic decreases in admissions and length of stay had begun prior to the institution of the DRG system and have continued to the present. Although the influence of this revolutionary change in incentives has not been addressed in this paper, the changes that have occurred in the hospital industry since the end of 1983 are continuations of trends that started in 1983 or before. Therefore, this research gives an indication of changes that were to become more extreme over time and longitudinal studies should be undertaken to study the impact of the DRG system and to monitor the use rate patterns over time.

Factor 4: The Impact Upon Hospital Use Rates of the Size and Definition of the Hospital Service Area

Small area analysis methodology is based upon the notion of a hospital service area defined by the historical patterns of hospital use by the population within the area. As explained earlier, the definition of the hospital service area is of great importance because it delineates a boundary and within that boundary are found the hospital resources and the population assumed to use those resources.

Although the delineation of the hospital service area boundary is important, it has been very casually derived by small area analysis researchers who are non-geographers and therefore not as conscious as they might be of its potential importance. Small area analysis methodology has been accepted by many within the health services research and policy community with very little validation. Several questions about the validity of the currently used hospital service area boundary definition methodology (Wennberg's plurality method) have been raised by this current research. To my knowledge, only one previous paper has reported the results of a comparison of the impact that changes in the assignment of small areas (zip codes or minor civil divisions) to a hospital service area have had upon use rates. Tedeschi and Martin (1983) tested Wennberg's plurality model and Griffith's relevance indices (using both a plurality and a 12.5 percent market penetration measure) and found the overall use rates from the three definitions of a hospital service area to be highly intercorrelated, and that an approximate linear relationship existed between each pair of variables. This satisfied the non-geographers, but does not satisfy me.

Preliminary work done by this author indicated that there may be no significant difference between use rates when the hospital service areas are defined using either Wennberg's plurality model or Griffith's majority model. There probably would not be any significant difference because they both assign all small areas to a hospital service area, leaving no small areas unassigned. On the other hand, there may be a very great difference between use rates when a narrowly defined hospital service area is compared to a larger, more inclusive hospital service area. Using a probabilistic gravity model (Taylor, 1977) as the basis for further work, I would hypothesize that use rates and the explanation for those use rates from a hospital service area where 75 - 90 percent of the population used the same hospital would be significantly different than use rates and the explanation for those use rates calculated in a hospital service area where only 20 - 30 percent of the population used the same hospital. I suggest that only those small areas that have a great probability of all or a large percentage of the patients using the same hospital should be assigned to the hospital service area. Small areas that do not meet the high level of probability required would not be assigned to any hospital service area. In this way, the impact of the physician and hospital components of the model would not be "diluted" by patients who had a low probability of using those physicians or that hospital. This notion of a more narrowly defined hospital service area would be particularly important if hospital service areas were defined by historical procedure-specific or medical diagnosis-specific use rates rather than by historical total admission rates. Defining the hospital service area more narrowly and by diagnosis or procedure-specific use would be of particular importance in any attempt to determine the true impact of physician training or specialty.

One of the family of gravity models could be used to define a hospital service area as I have suggested. The criteria could be established so that 75, 80, or any percent of the population had a high probability of using the hospital located within it. Once the new hospital service areas were defined, then testing the explanatory power of a dominant physician residency program or specialty or any physician or hospital characteristic would have more meaningful results. If the results were significant, then re-educating the health services research and policy community to understand the importance of the areal units would have to be undertaken.

The delineation of the boundary of a hospital service area is also of particular importance to this research in yet another way. Most of the high use hospital service areas found in this current research were rural in character and a few were very large in size. I think that this is very important because I think that hospital use rates increase in areas where there is a long distance between the hospital and the hospital service area boundary. This hypothesis is based on earlier work done by Girt (1973) who studied patient visits to physicians' offices in Newfoundland. Girt found that when graphed, distance decay curves were very different for some diseases or complaints. He found that distance had both a positive and negative effect on a patient's decision to initiate contact with a physician. Girt found that a patient increased his sensitivity to the development of a disease as the distance to medical help increased. At the same time, Girt discovered that the increase in distance reduced the likelihood of the patient actually consulting a physician.

If you move this notion from a physician's office in a rural setting to a hospital in a rural setting, there may be pressures not only for the patient to increase his desire for hospitalization but also for a physician to increase his desire to order a hospital stay rather than to observe the patient in the patient's home or to treat the patient in a non-hospital setting. For example, let us look at the hypothetical case of a child with an acute respiratory infection or an elderly person with chest pain. In each instance there is a need for observation of the patient and there is also the need to have immediate availability of care in a medical crisis. Both of these pressures will encourage the physician to order a hospital admission if the distance from the patient's home is considered to be too far to provide the immediacy of treatment necessary. Both of these pressures will also encourage the patient to seek hospitalization. In these two examples the diagnosis-specific distance decay curve could conceivably look like Figure 8.2, with an upturn in admissions at longer distances, rather than looking like Figure 8.3, the normal distance decay curve for total admissions.

The potential importance of the definition of the hospital service area to both of these discussions re-emphasizes the need for a rigorous re-examination of the impact that the definition of the hospital service area can have on the hospital use rates and on the explanation of those use rates.

Figure 8.2
Hypothetical Diagnosis-Specific
Distance Decay Curve

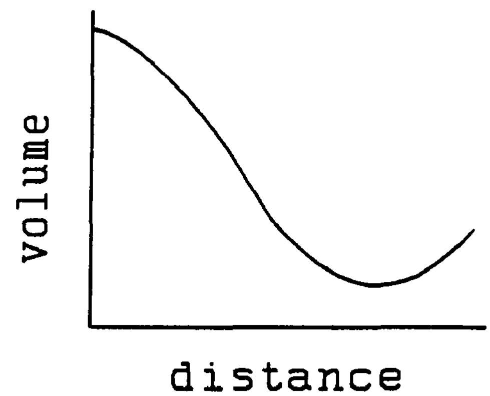
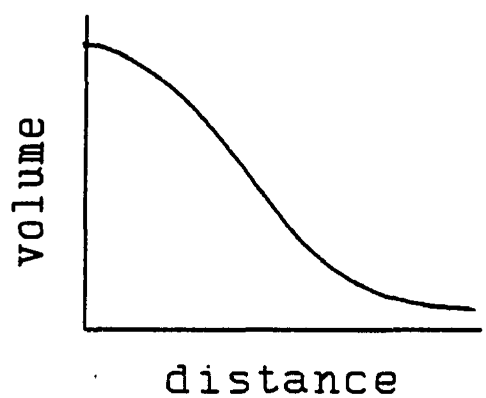


Figure 8.3
Hypothetical Total Admissions
Distance Decay Curve



GLOSSARY

GLOSSARY

appendectomy	surgical removal of the appendix
board eligible physicians	physicians who are qualified to take the examinations for specialty certification
board certified physicians	physicians who have passed specific requirements for specialty certification
cesarean section	surgical delivery of baby through the abdominal wall
cholecystectomy	surgical removal of gall bladder
DRG	Diagnosis Related Group; Medicare's prospective payment coding system
ENT	physician who specializes in diseases of the ear, nose and throat
epidemiology	the study of the incidence, distribution, and control of a disease within a population events (hospital, outcome)
HCFA	Health Care Finance Authority; federal administrators of the Medicare system
hemorrhoidectomy	surgical removal of hemorrhoids
home health	health care delivered in a home
hospital service area	geographic area served by the hospital/s within it
hysterectomy	surgical procedure to remove uterus
ICD-9-CM	international codification of diseases and procedures
IDS	Interactive Data System; interactive computer system produced by the MHA and containing patient level clinical data as well as other data bases
incidence rate	occurrence of a disease per population
inguinal hernia repair	surgical procedure to repair protrusion of tissue through the abdominal wall
inpatient	patient who is admitted to a hospital, i.e., spends at least one night in a hospital bed

licensed beds	hospital beds licensed by the state
market share (hospital)	percent of population within a hospital service area which receives care from the hospital/s within it
MHA	Michigan Hospital Association
MHDC	Michigan Health Data Corporation
MIDB	The Michigan Inpatient Data Base; an annual compilation of all of Michigan's hospital inpatient clinical abstracts
migration	patient movement from hospital service area of residence to hospital service area of the hospital where care was provided
morbidity	occurrence
mortality	death
outpatient	patient who receives hospital care in an outpatient setting, i.e., without being admitted to a hospital
patient origin	geographic area where patient resides
procedure	surgical procedure
prostatectomy	surgical procedure to remove or repair prostate gland
relevance index	Griffith's method of allocating population to a hospital service area
referral center	tertiary care facility providing more highly sophisticated technology and care than other hospitals
rural referral center	hospital that meets the criteria or a larger DRG reimbursement for each Medicare patient treated
set up and staff beds	hospital beds currently being used
small area analysis	method used to study the variation in health care use rates
SMSA	Standard Metropolitan Statistical Area
sole community provider	a single hospital within the hospital service area

surgical signature	unique pattern of procedure-specific use rates seen when each hospital service area's surgical rates are graphed systematic component of variation (SCV) - a measure of variation
T & A	tonsillectomy and adenoidectomy
use rate	hospital use per population

APPENDICES

APPENDIX A

Table 9.1

HOSPITAL USE RATES BY HOSPITAL SERVICE AREA
(Standardized by Age and Sex per 10,000 Population)

	Male Adm	Female Adm	Total Adm	Appen	Hemrr	Chole	Hern	Prost	Hyster	C-Sect	Circ Adm	Resp Adm	Digest Adm	Genito-U Adm
PORT HURON	144.48	181.89	163.65	1.12	0.67	2.06	2.17	2.43	5.76	5.93	21.92	9.54	17.90	4.57
PONTIAC	130.10	180.31	155.84	1.31	0.39	2.13	1.89	2.94	5.11	5.94	22.77	10.21	17.99	4.22
ANN ARBOR	113.43	141.57	127.85	1.11	0.31	1.53	1.33	4.24	3.91	4.94	17.08	8.82	13.45	4.18
MT CLEMENS	146.41	201.33	174.56	1.15	0.67	2.00	2.10	3.53	5.52	7.24	26.04	11.09	18.71	4.74
LANSING	116.39	158.26	137.85	0.98	0.67	1.86	1.81	2.50	5.05	5.47	15.49	8.49	14.81	3.73
ADRIAN	147.48	184.58	166.50	1.33	0.38	2.11	1.79	3.55	3.93	3.08	17.03	12.55	19.51	4.37
JACKSON	130.30	180.93	156.25	1.18	0.38	2.57	1.77	1.94	5.07	4.70	17.83	10.48	17.52	4.46
BATTLE CREEK	130.67	185.82	158.94	1.12	0.72	2.03	1.85	2.64	4.36	5.56	15.77	10.44	18.74	4.65
B HARBOR/ST JOE	135.84	170.32	153.51	1.07	0.23	2.02	2.02	2.01	3.91	6.08	20.00	12.55	17.98	3.90
KALAMAZOO	105.44	136.64	121.43	1.26	0.61	1.83	1.86	2.58	4.95	6.34	13.83	6.74	13.43	3.14
STURGIS/3 RIVERS	118.64	175.30	147.68	1.15	0.29	1.83	1.62	1.78	4.74	6.26	17.27	7.12	16.71	3.82
S BERRIEN/CASS	149.96	205.65	178.50	0.98	0.29	1.72	1.78	1.96	4.12	4.62	16.69	10.23	17.76	4.34
N MONTCALM	143.24	221.80	183.51	1.50	0.16	1.70	3.03	2.69	6.65	7.59	16.79	17.68	23.09	5.18
FREMONT	119.85	166.81	143.92	1.63	0.08	2.31	1.42	2.68	4.49	5.68	13.45	9.11	15.55	3.91
REED CITY	133.65	165.99	150.23	1.43	0.17	1.56	1.91	1.58	4.19	3.77	19.05	14.95	19.22	4.58
GRAND RAPIDS	94.49	133.78	114.63	1.02	0.14	1.94	1.85	2.70	4.10	5.65	10.10	5.03	12.66	2.97
MUSKEGON	126.42	166.24	146.83	1.23	0.45	2.31	2.16	2.47	5.02	4.87	17.44	8.08	17.18	3.60
MONTCALM/IONIA	189.31	255.92	223.45	2.24	0.57	2.45	2.86	3.11	6.31	7.27	23.46	20.28	30.97	7.14
ALLEGAN	124.72	180.02	153.06	0.93	0.33	2.97	2.19	3.00	3.18	6.30	17.92	9.08	16.75	3.92
HOLLAND	115.84	165.50	141.29	1.73	0.13	2.38	2.71	3.18	4.45	5.98	13.26	8.14	17.88	4.40
OCEANA CO	129.92	209.78	170.85	0.75	0.07	2.07	1.26	2.30	3.87	1.52	18.99	11.61	24.06	6.10
FLINT	140.64	181.87	161.77	1.15	0.67	2.15	1.86	3.10	5.06	5.50	20.82	9.93	18.28	4.57
LAPEER CO	150.08	192.89	172.02	1.14	0.84	2.33	1.83	2.88	5.35	6.37	21.91	10.62	20.72	5.19
BAY	160.00	191.49	176.14	1.11	0.38	2.05	1.48	3.55	4.75	5.60	24.24	10.55	19.44	6.85
SAGINAW	151.77	188.31	170.50	0.99	0.51	2.63	2.08	3.15	4.12	5.33	22.20	8.94	21.44	6.09
TUSCOLA	169.59	230.43	200.78	1.58	0.60	2.76	2.32	3.06	4.27	4.41	24.73	17.18	28.55	6.09
BAD AXE	171.42	224.06	198.40	2.22	0.37	2.49	2.77	3.81	4.82	6.94	24.57	17.05	30.14	6.84
SANILAC	166.84	218.33	193.23	1.31	0.87	2.32	2.63	2.68	4.15	6.29	24.21	14.36	23.27	6.46
MIDLAND	120.95	166.64	144.37	0.87	0.22	1.63	1.86	3.21	4.90	5.96	18.75	9.05	15.24	3.82
MT. PLEASANT	148.81	174.20	161.82	1.17	0.49	1.72	1.97	3.54	3.31	4.31	20.81	12.86	21.01	5.48
GRATIOT	150.90	201.77	176.97	1.53	0.58	2.34	1.90	2.13	5.41	6.65	20.18	11.86	21.53	5.24
N.MICHIGAN	128.10	172.42	150.82	1.38	0.20	1.92	1.70	3.03	3.73	6.02	18.54	9.59	17.10	4.31
CHEBOYGAN/ROGERS C	153.18	212.83	183.76	1.55	0.35	2.28	2.08	3.71	4.50	6.18	24.35	12.33	21.12	4.36
TRAVERSE CITY	127.51	169.10	148.83	1.24	0.32	1.86	1.70	2.00	4.92	5.97	18.87	8.55	16.09	3.99
MANISTEE	123.42	190.14	157.62	1.34	0.66	2.33	3.11	2.80	4.65	7.63	19.11	9.51	21.64	4.96

APPENDIX A (Continued)

Table 9.1

HOSPITAL USE RATES BY HOSPITAL SERVICE AREA
(Standardized by Age and Sex per 10,000 Population)

	Male Adm	Female Adm	Total Adm	Appen	Hemrr	Chole	Hern	Prost	Hyster	C-Sect	Circ Adm	Resp Adm	Digest Adm	Genito-U Adm
SCP	126.81	157.03	142.30	0.91	0.23	2.02	1.56	2.92	4.74	5.29	19.60	8.45	14.12	4.01
SCP	148.95	196.56	173.36	0.92	0.52	1.94	1.67	1.48	3.98	5.58	18.66	11.96	17.57	4.75
SCP	127.12	189.40	159.04	1.54	0.46	2.65	2.72	3.62	5.50	8.99	16.51	9.90	20.83	4.71
SCP	151.05	195.53	173.85	1.88	0.74	2.03	2.46	1.78	4.74	5.11	14.75	14.69	18.61	4.90
SCP	111.47	146.95	129.66	1.24	0.32	1.81	1.28	2.07	5.24	6.21	17.92	6.28	13.94	3.64
SCP	176.43	200.41	188.72	0.90	0.56	2.44	1.74	3.69	4.10	6.31	26.53	14.92	21.07	4.65
SCP	130.37	196.58	164.31	1.05	0.25	1.56	0.98	2.73	4.10	7.20	21.58	10.22	15.47	4.75
SCP	136.03	179.32	158.22	1.60	0.54	2.20	2.13	1.82	4.13	5.50	16.05	10.91	16.72	3.87
SCP	178.87	243.16	211.82	1.75	0.55	3.01	2.58	2.24	4.79	6.83	21.26	19.38	26.59	4.88
SCP	120.59	166.73	144.24	1.63	0.34	1.84	2.07	3.70	3.60	6.18	17.77	6.90	17.34	5.72
SCP	149.42	205.94	178.39	1.12	0.21	2.24	1.64	2.71	4.79	6.25	18.96	14.77	22.31	6.48
SCP	130.89	172.98	152.46	2.10	0.55	2.26	1.98	3.12	3.79	6.27	18.41	9.94	16.32	4.73
SCP	188.91	228.25	209.08	1.29	0.13	2.69	2.90	3.76	6.86	4.82	29.95	14.44	23.71	5.88
SCP	114.34	145.48	130.30	0.95	0.19	1.61	2.16	3.03	4.62	4.97	16.02	5.96	13.28	3.56
SCP	135.72	187.69	162.36	1.18	1.23	3.58	2.55	3.57	6.41	6.78	15.85	9.86	21.25	4.24
SCP	137.53	177.39	157.96	1.58	0.32	1.81	2.30	2.90	4.92	5.29	19.84	7.64	17.68	5.58
SCP	163.07	216.35	190.38	1.56	0.60	2.45	1.72	2.11	5.80	5.47	24.17	14.20	21.86	3.94
SCP	157.32	213.46	186.10	1.71	0.39	2.20	2.15	2.93	5.53	4.54	19.10	14.30	21.39	5.73

SCP = Sole Community Provider Hospital Service Area

APPENDIX B

Table 9.2

PHYSICIAN AND HOSPITAL CHARACTERISTICS BY HOSPITAL SERVICE AREA

Hospital Name	Wgt Prop Bd Cert Phys	Hosp Beds/ 10,000	FTEs/ 10,000	Pharm/ 10,000	RNs/ Bed	Hosp Serv '83	Other Fac Serv '83	Serv Level/ HSA '83	Total # Serv per HSA '83	Change in Serv '81-83	OPD Visits per 10,000	Corp Beds	House Staff per 10,000	Osteo Beds
PORT HURON	0.64	36.44	104.97	0.76	0.68	26	26	172	45	.	9,210	0.53	0.53	0.00
PONTIAC	0.76	33.78	120.10	1.18	0.83	41	14	130	57	.	6,679	0.56	3.57	0.21
ANN ARBOR	0.80	52.15	244.00	2.03	1.04	38	10	132	61	-1	16,393	0.38	21.59	0.00
MT CLEMENS	0.55	32.61	118.92	0.93	0.62	33	25	157	62	2	8,036	0.55	0.66	0.34
LANSING	0.68	33.76	124.28	1.15	0.89	26	13	159	52	-4	12,222	0.36	4.11	0.16
ADRIAN	0.43	42.90	109.75	0.56	0.40	21	28	184	39	-1	11,640	0.00	1.45	0.00
JACKSON	0.50	36.36	108.56	0.78	0.39	27	14	158	39	1	9,169	0.00	0.52	0.13
BATTLE CREEK	0.71	45.25	146.37	1.39	0.70	26	22	168	43	.	8,947	0.37	1.25	0.17
BHARBOR/ST JOE	0.65	38.83	129.76	1.17	0.69	27	22	166	48	5	10,781	0.74	0.70	0.00
KALAMAZOO	0.56	37.58	176.68	1.28	1.12	34	18	148	59	1	17,503	0.49	6.23	0.00
STURGIS/3 RIVERS	0.68	31.32	81.50	0.75	0.46	19	39	199	22	-4	11,188	0.00	0.00	0.00
S BERRIEN/CASS	0.59	38.94	102.46	0.67	0.52	24	21	170	35	1	8,399	0.26	0.27	0.00
N MONTCALM	0.32	42.10	93.35	0.73	0.35	19	17	177	24	-2	15,005	0.00	0.73	0.49
FREMONT	0.75	49.14	96.12	0.43	0.47	16	38	205	22	3	23,042	1.00	0.43	0.00
REED CITY	0.49	32.00	92.72	0.96	0.63	22	32	186	29	2	11,402	0.00	0.39	0.00
GRAND RAPIDS	0.71	30.58	110.59	1.11	0.87	34	18	148	56	1	6,790	0.00	7.76	0.15
MUSKEGON	0.66	48.49	130.58	1.30	0.49	33	13	145	48	.	12,896	0.30	1.12	0.18
MONTCALM/IONIA	0.33	65.84	166.70	0.84	0.40	17	22	185	21	.	11,177	0.00	2.95	1.00
ALLEGAN	0.46	69.93	223.99	2.27	0.58	30	17	156	37	0	27,045	0.00	1.71	0.00
HOLLAND	0.70	36.14	93.15	0.80	0.67	21	19	176	30	1	7,062	0.00	0.00	0.00
OCEANA CO	0.66	49.39	109.91	0.00	0.37	15	18	187	20	-3	30,459	0.00	1.39	0.00
FLINT	0.66	41.54	142.75	1.29	0.77	33	14	146	60	6	7,381	0.43	7.37	0.19
LAPEER CO	0.38	32.88	78.50	0.52	0.56	20	8	167	24	0	5,845	0.00	0.78	0.00
BAY	0.61	41.48	132.65	1.57	0.58	26	8	154	41	-3	4,493	0.00	0.21	0.17
SAGINAW	0.74	49.96	146.80	1.47	0.65	30	12	149	45	-2	7,057	0.00	2.78	0.18
TUSCOLA	0.31	46.97	104.14	0.41	0.40	19	22	182	21	-1	11,481	0.00	0.00	0.00
BAD AXE	0.73	43.36	131.53	1.46	0.47	24	8	158	34	.	11,437	0.00	0.88	0.00
SANILAC	0.58	45.57	123.99	0.41	0.48	20	36	194	36	12	15,325	0.00	2.05	0.00
MIDLAND	0.54	33.74	125.32	0.78	0.86	28	20	163	44	5	12,431	0.00	2.02	0.00
MT. PLEASANT	0.50	30.49	86.21	0.83	0.66	25	41	190	32	6	4,993	0.00	0.14	0.00
GRATIOT	0.46	35.54	105.10	1.13	0.56	22	25	180	31	2	8,113	0.00	0.38	0.00
N.MICHIGAN	0.76	61.36	204.87	1.45	0.85	22	20	175	48	8	10,137	0.78	2.42	0.00
CHEBOYGAN	0.68	69.92	142.66	0.00	0.32	26	21	168	31	5	9,954	0.00	0.40	0.00
TRAVERSE CITY	0.74	45.12	128.27	1.19	0.52	26	18	164	52	5	9,217	0.00	2.02	0.16
MANISTEE	0.44	57.05	121.36	1.45	0.39	14	50	220	23	.	10,416	0.00	0.00	0.00

Appendix B (continued)

Table 9.2

PHYSICIAN AND HOSPITAL CHARACTERISTICS BY HOSPITAL SERVICE AREA

Hospital Name	Wgt Prop Bd Cert Phys	Hosp Beds/ 10,000	FTEs/ 10,000	Pharm/ 10,000	RNs/ Bed	Hosp Serv '83	Other Fac Serv '83	Serv Level/ HSA '83	Total # Serv per HSA '83	Change in Serv '81-83	OPD Visits per 10,000	Corp Beds	House Staff per 10,000	Osteo Beds
SCP	0.64	34.44	94.91	0.82	0.50	30	0	138	30	.	5,464	0.00	1.23	0.00
SCP	0.74	30.94	86.48	1.04	0.63	36	0	126	36	5	14,985	0.00	0.00	0.00
SCP	0.63	32.46	129.13	1.41	0.72	26	0	146	26	-1	13,914	0.00	0.71	0.00
SCP	0.42	27.57	84.32	0.64	0.49	23	35	187	23	3	4,113	1.00	0.32	0.00
SCP	0.40	36.21	105.16	1.06	0.47	29	22	162	29	5	7,713	0.00	0.00	0.00
SCP	0.52	51.74	112.78	0.58	0.39	18	42	204	18	-1	19,151	0.00	0.00	0.00
SCP	0.49	35.24	80.80	0.86	0.49	18	0	162	18	0	14,251	0.00	0.00	0.00
SCP	0.48	32.86	81.91	0.95	0.47	25	1	149	25	-2	6,576	0.00	1.19	0.00
SCP	0.29	55.61	149.72	1.07	0.35	26	38	184	26	5	8,492	0.00	2.14	0.00
SCP	0.89	35.72	112.79	1.50	0.59	21	42	198	21	-4	12,502	0.00	0.75	0.00
SCP	0.69	39.75	89.31	1.03	0.57	16	0	166	16	-6	15,080	0.00	0.00	0.00
SCP	0.68	23.25	94.45	1.43	0.80	20	0	158	20	0	12,984	0.00	0.36	0.00
SCP	0.26	37.05	116.80	2.01	0.40	19	0	160	19	2	9,645	0.00	0.40	0.00
SCP	0.51	30.80	93.23	0.82	0.72	31	1	137	31	4	14,804	0.00	1.09	0.00
SCP	0.38	26.39	84.14	0.50	0.51	20	44	202	20	-3	9,634	0.00	0.00	0.00
SCP	0.66	47.49	102.03	0.60	0.41	35	31	159	35	9	13,470	0.00	1.61	0.00
SCP	0.33	38.52	150.22	1.28	0.60	27	36	180	27	2	9,025	0.00	2.14	0.00
SCP	0.74	44.81	128.55	1.02	0.45	27	0	144	27	1	4,361	1.00	0.00	0.00

SCP = Sole Community Provider Hospital Service Area

Appendix C

Table 9.3

COMPARISON OF HOSPITAL USE RATES BY HOSPITAL SERVICE AREA BY STANDARD DEVIATIONS

	Male Adm	Female Adm	Total Adm	Appen	Hemorr	Chole	Hernia	Prost	Hyster	C-Sect	Circ Adm	Resp Adm	Digest Adm	Genito-U Adm
Southeast Region														
Port Huron					1				1					
Pontiac														
Ann Arbor	-1	-1	-1			-1	-1	2	-1				-1	
Mt. Clemens					1			1		1	1			
Lapeer					1									
Flint					1									
SCP												-1		
SCP	-1	-1	-1				-1	-1				-1	-1	-1
SCP				-1				-2						
South Central Region														
Lansing	-1	-1	-1		1						-1	1		
Jackson						1		-1						
Adrian								1		-2				
SCP	1		1	-1				1			1	1		
SCP				1	1			-1			-1	1		
Southwest Region														
Battle Creek					1									
Kalamazoo	-1	-1	-1								-1	-1	-1	-1
Sturgis/3 Rivers	-1							-1				-1		
B Harbor/St. Joe								-1	-1					
S Berrien/Cass						-1		-1						
SCP								-1						
SCP						-1	-2			1				
SCP						1	1	1		2				
West Central Region														
Reed City					-1	-1		-1		-1		1		
Fremont					-1		-1				-1			
Oceana				-1	-1		-1		-1	-3			1	1

SCP = Sole Community Provider

Appendix C (Continued)

Table 9.3

COMPARISON OF HOSPITAL USE RATES BY HOSPITAL SERVICE AREA BY STANDARD DEVIATIONS

	Male Adm	Female Adm	Total Adm	Appen	Hemorr	Chole	Hernia	Prost	Hyster	C-Sect	Circ Adm	Resp Adm	Digest Adm	Genito-U Adm
Muskegon														-1
Grand Rapids	-2	-2	-2		-1						-2	-1	-1	-1
N. Montcalm		1			-1	-1	2		2	1		1		
Montcalm/Ionia	2	2	2	2			1		1	1	1	2	2	2
Holland	-1			1	-1		1				-1			
Allegan				-1		2			-1					
SCP												1		1
SCP	-1	-1	-1	-1	-1	-1						-1	-1	-1
SCP	1	2	2	1		2	1					2	1	
SCP								1	-1			-1		
<u>East Central Region</u>														
Mt. Pleasant						-1		1	-1	-1				
Gratiot								-1						
Midland				-1		-1								
Bay							-1	1			1			2
Saginaw						1								1
Bad Axe	1	1	1	2			1	1		1	1	1	2	2
Tuscola	1	1	1			1				-1	1	1	2	1
Sanilac	1	1	1		1		1				1		1	1
<u>North Region</u>														
Manistee							2			1				
Traverse City								-1						
N. Michigan					-1				-1					
Cheboygan/Rgrs City								1			1			
SCP					3	3	1	1	2					
SCP	2	1	1		-1	1	1	1	2		2		1	1
SCP		-1		-1									-1	
SCP		1		1					1	-1				1
SCP	1	1	1					-1	1		1			
SCP				2					-1					

SCP = Sole Community Provider

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