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Rip, Michael Russell, Ph.D.

Michigan State University, 1991

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**DEMOGRAPHIC CHARACTERISTICS AND THE
GEOGRAPHICAL VARIABILITY BY ZIP CODE OF
COMMUNITY HOSPITAL UTILIZATION IN MICHIGAN**

by

Michael Russell Rip

A DISSERTATION

Submitted to
Michigan State University
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ABSTRACT

DEMOGRAPHIC CHARACTERISTICS AND THE GEOGRAPHICAL VARIABILITY BY ZIP CODE OF COMMUNITY HOSPITAL UTILIZATION IN MICHIGAN

By

Michael Russell Rip

The phenomenon of the increase in use of community hospital inpatient facilities up until the early 1980s has long interested researchers because of markedly rising health care costs and expenditures across the United States. Inpatient hospital care being by far the most expensive has been the target for cost-containment efforts. The methodologies of small-area analysis have shown that hospital admission and discharge rates vary geographically. However, to date, such studies have been unable to explain a large percentage of the variance from multivariate analyses. In addition, small-area analysis techniques, particularly the 'plurality' methodology developed by Wennberg and Gittelsohn, have been widely embraced by health services researchers attempting to elucidate and understand variations in health care utilization and by health care policymakers in their attempts at cost-cointainment.

A critique of small-area analysis draws attention to numerous methodological and conceptual problems and issues relating to the geographical definition of a hospital service area. This descriptive ecologic study analyzes a total of 33,893 aggregated community hospital discharge abstracts of Michigan residents during 1980. Unlike previous small-area

analyses of per capita hospital use, this study does not use the Wennberg and Gittelsohn 'plurality' methodology for defining population-based hospital service areas but rather undertakes a geographical analysis of age-adjusted hospital use rates for medical and surgical diagnoses on a five-digit ZIP-specific basis; a total of 668 postal codes are mapped for spatial variation. The study uses the entire state of Michigan and investigates the following non-clinical population factors which are known to effect the utilization of hospital services: urban-rural residence, socio-economic status (derived via factor analysis), and patient age group. Age-specific rates are calculated for patients within certain age groups and who, upon discharge from a community hospital, had a medical or surgical diagnosis; all obstetric and mental health patients are excluded from the analysis.

The results of both non-spatial and spatial analyses are presented. More surgical discharges occur than medical — the ratio being approximately 1.2:1.0. Rural residence is shown to be an important variable in describing the overall pattern of hospital use in the state of Michigan during 1980. Even though a little more than 10% of medical (13.1%) and surgical (10.4%) discharges originate from rural communities, only rural medical use rates are statistically significantly higher than discharge rates found in urban areas (OR=2.04; CI=1.40–2.93). Detailed mapping at the ZIP-specific level is shown to be a useful product in documenting this pattern of hospital utilization. The rural bias for medical conditions is not only confirmed via the mapping process but spatial clustering is clearly visible. Age of patient is directly related to hospital use. As expected, surgical discharge rates rise almost linearly with advancing age and for medical discharges the age-specific rates are lowest for adult patients (30–44 years) and reach a maximum in the older adult group (65+).

It seems that the spatial location of communities within Michigan is a more important 'predictor' of medical use rates during this period of time than socio-economic status. Whereas communities differ significantly according to medical discharge and socio-economic status, medical use rate differences are more striking when stratified by residence

($p < 0.001$). Medical discharge rates display an inverse relationship with regard to socio-economic status while little differentiation is seen with surgical rates. These findings illustrate the importance of stratifying and spatially analyzing health care utilization data according to geographical location, namely urban or rural residence. Overall, this study avoids the methodological limitations and pitfalls of the traditional 'plurality' approach adopted by most small-area analyses. It is recommended that the ZIP-specific approach to the presentation of hospital utilization rates be used complementary to those of market share and plurality-defined hospital service area analyses.

DEDICATION

All of what this research represents is dedicated to

Bertram William Russell

My maternal grand-father who influenced my life more than I will ever know

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COLOPHON

This entire research was produced on an Apple Macintosh SE computer equipped with a 20 MB internal hard disk drive. The following commercial software programs and packages were used:

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*Denotes software packages implemented on either an IBM PC or mainframe computer.

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CHAPTER I

INTRODUCTION

Background

Health care in the United States has been experiencing acute and fundamental problems for some considerable period of time. Some of the more important underlying issues include: (i) expanding health care costs and an apparent lack of efficiency; (ii) an inadequate health insurance scheme; (iii) a burdensome bureaucracy; (iv) an inadequate Medicaid program; (v) a lack of emphasis on prevention; (vi) increasing litigious activities; (vii) a shortage of physicians and a maldistribution of existing physicians; (viii) differential accessibility to health services (both physical and financial); (ix) differential availability of health services for various segments of the population, particularly the young and old, people in rural areas, the poor, and minority groups; and (x) lack of coordination of health and city and regional planning. In financial terms, the dollar cost of health care in 1990 was \$666 billion — 12.2% of the gross national product — and the US had the highest per capita expenditure in the world (Cleveland 1991).

The level and distribution of hospital services are a matter of continued interest. Utilization of non-Federal short-term community hospitals in the United States has been increasing since World War II. Admissions rose from one for every 10 persons in the population during the late 1940s to one for every 6.7 persons by the early 1970s. Concomitantly, the number of beds available in such hospitals increased dramatically. This increase in hospital utilization — a phenomena that continued up to the early 1980s — is of special interest because hospital costs have been growing rapidly over time. Between 1965

and 1978, per capita expenditures on health services more than tripled, a rate of increase at least 50% higher than that of prices generally.

The present crisis of a geographic maldistribution of medical care in the U.S. concerns both health facilities and personnel. Consequently, the location of hospitals, dentists, nurses, and paramedical personnel is an important consideration in any solution to the complex health care problem. The basic functional aspects of hospital accessibility — time, cost, and distance (Penchansky and Thomas 1981) — can be mapped to show areas of high or low accessibility. Hospital service areas may be delineated through patient-origin studies and health-worker data may be analyzed and displayed to illustrate underserved, scarce, or oversupplied areas.

The utilization of health care services are influenced by four sets of factors. The first set arises from demographic characteristics of the population such as age, gender, and socio-economic variables (National Center for Health Statistics 1969; Chiswick 1976). The second set has to do with ecological factors such as distance (Shannon *et al.* 1969; Weiss *et al.* 1970). Organization of health services comprise the third set, while social-psychological-behavioral factors such as the influence of friends and neighbors make up the remaining set of variables (Suchman 1964). Alternative schemes are used to classify variables related to health services utilization. Andersen (1968) groups demographic and some of the social psychological variables into a category termed *predisposing* factors. Income, insurance, and community health resources are called *enabling* factors; while a third category is termed *need* which includes levels of health as well as the usual response to illness.

Although current interest in controlling hospitalization is primarily related to controlling costs, assuring appropriate hospital use is equally important from the stand-

point of providing good medical care. Hospitalization is not only expensive, it can be harmful. Furthermore, a large proportion of hospitalizations can be viewed as examples of the failure of the preventive, community, or ambulatory components of the medical care system (Twaddle and Sweet 1970).

The cost of medical care depends on two items: the cost per unit of service (a day in a hospital, a diagnostic test, a surgical procedure, an office visit), and the number of services purchased (consumed), or utilization. Inpatient care is by far the largest single item on the national health care bill and is by far the most costly form of care as compared with services rendered in a hospital outpatient setting or physician's office. Most importantly, however, hospital utilization is to a large extent dependent on physician, not patient, decisions (behavior). The impact of these decisions reveal themselves in such figures as the incidence of hospitalization of a population within a given area, the length of stay (measured in days), and the incidence of surgery, to name but a few. The health care costs induced by high rates of hospital utilization are substantial and raise issues of equity and inter-regional subsidization of health care within a state, as originally reported by Wennberg (1982).

In earlier times, the interest in hospital use and geographic differences — and health care delivery in general — tended to reflect a concern with issues of access and equity. In more recent years, especially during the 1980s, the concern among health services research personnel and to a much lesser extent for geographers, has been from the perspective of costs. Given the alarming fiscal picture and steadily rising secular trend, health care cost-containment strategies are one of the central foci in health services research.

Hospital utilization has been the principal target for cost-containment efforts on the part of public and private payers, since it represents the largest proportion of expenditures

for health care. The discharge rate from general hospitals increased until about 1980, then leveled off, and since 1984 there is evidence of a substantial relative decline in hospitalization rates (Andersen *et al.* 1986).

Certain geographic aspects of the health care problem are immediately recognizable. For example, the spatial patterns and variable distribution of health resources are basic issues to the delivery of effective medical care. Decisions about hospital utilization are critical to the health of the patient, as well as to the cost of medical care. When spatial variations in hospital use rates are observed there is a basis for debate and variations in health service use rates by geographic area have long interested researchers and policy makers. Wennberg, in particular, has used epidemiological principles to contrast rates of hospital inpatient utilization among medical service areas. Typically, investigators comparing population-based health care utilization rates among geographic areas have demonstrated substantial variations in use among seemingly similar communities.

A key issue in small area research is the definition of the geographic quantum (area) being used. The large geographic areas (i.e., state or county) investigated have much internal variation that confuses attribution; when the areas are small (i.e., ZIP codes) cross-boundary population movements obscure the matching of population with resources. The most promising small area research has been completed in states like Vermont and Maine which are not broadly representative of the nation, raising questions of generalizability. However, whereas the majority of studies undertaken by geographers prior to the 1980s focussed on issues relating to the description and analysis of spatial variation between population-based geographic units (counties and postal codes), small area research is now firmly established in attempting to discover the explanatory variables responsible for geographical variations in hospital and surgical use rates; the ultimate goal is to effect savings without jeopardizing the public's health status. In order to accomplish such an

objective, small-area analysis methodology has adopted the hospital service area as its unit of analysis, with the Wennberg and Gittelsohn model (1973) becoming the *de facto* standard by which to define it. Unfortunately, the casualty of these recent trends has been the development and initiation of hospital access, equity, and utilization studies that do not rely on the demarcation of hospital service areas as their unit of analysis, such as those using ZIP code-specific areas.

SMALL AREA ANALYSIS

Wilson and Tedeschi (1984) assert that most hospital utilization studies, lacking the availability of patient origin data, are forced to adopt geopolitical/administrative divisions as units of analysis; counties, Standard Metropolitan Statistical Areas (SMSAs), and states are common choices (Harris 1975; Stockwell and Vayda 1979), as well as five-digit postal codes. This statement is not strictly accurate as the vast majority of small area analyses also use ZIP codes as the basic aggregation unit with which to form hospital service areas. The principal reason for requiring patient origin data is that hospitals can be matched with the community (population) using their services. Hence, service areas are demarcated where the medical care resources constitute a system in the sense that the population encounters a uniform set of arrangements for its care. The process of aggregating ZIP codes, while achieving the aims enunciated above, actually dilutes the power of truly small area analyses. Few studies show the geographic (or temporal) variation of hospitalizations at a small geographic level, rather than by hospital service area that contains multiple hospitals in an urban setting and a single hospital in rural regions. ZIP codes are usually the smallest geographic unit available because hospital patient admission/discharge abstracts reveal the ZIP of permanent residential address. To date, no large-scale mapping of hospitalizations has been attempted using ZIP codes for the State of Michigan and the study reported here is intended to fill that gap. As planning of hospital facilities requires predictions as to future

patterns of utilization, this study provides baseline information and patterns of use so that future comparisons can be made.

Small-area analysis relates characteristics of a community back to the population of that community. For example, using information gathered from hospital discharge abstracts, a town is grouped with other communities into a hospital service area for the hospital (or cluster of hospitals) used by a majority of the residents of the town. In other words, population units are developed (to obtain a denominator) and counting all health care utilization by this unit regardless of where it takes place. A denominator counting all individuals residing in an area allows age- and gender-adjustment of the utilization experience of the population, thus removing one of the most important patient-related characteristics to hospitalization variations. Population-based age- and gender-adjusted utilization rates are then computed for these areas and the rates compared. Furthermore, socio-economic, demographic, health care personnel, and health status data can be aggregated for these hospital service areas and used to stratify them for purposes of analyzing levels of utilization. This population-based approach is a significant advance over earlier methods which used hospital-specific data.

Numerous studies of health (i.e., disease) and health care services (i.e., hospitalizations) use other geographic resolutions as their unit of analysis, for example: state, county, hospital districts, minor civil divisions, and census tracts. In other words, all numerator data are related to the population within the geographic area (unit) under consideration. The important difference between these approaches is that, whereas traditional small-area analysis applied to variations in the use of health care services determines hospital service areas (usually) according to the plurality rule¹ and these regions

¹ To be discussed in Chapter 2.

then form the geographic quantum for research, the alternative does not relate all individuals residing in an area to a specific set of health care arrangements. For example, to capture a working health system provided by each cluster of multi-hospitals in the case of urban areas, or a single hospital as in the case of a sole community provider (a sole hospital within a county). It is this latter approach that forms the basis of the present study, because the aim is not to employ multivariate analysis techniques, such as multiple linear regression, to 'explain' the variation in hospital use across Michigan. Rather, this ecological study documents the characteristics of medical and surgical discharge rates, according to age group, socio-economic category, and urban-rural residence, as well as the geographical patterning of hospitalizations — for the first time — at the 5-digit ZIP-specific level. By adopting a ZIP code-specific approach to the analysis of Michigan hospital discharge data, a number of potentially problematical issues fall away. For example, the 'plurality' methodology averages many postal codes to form hospital service areas. Consequently, quite apart from the probable dilution of use rate variations within a hospital service area (through the amalgamation of ZIPs) that differ in socio-economic-demographic character, urban and rural ZIPs are likely to be included within the same hospital service area. An analysis of individual ZIPs circumvents such problems, as well as the modifiable unit area issue. The ZIP code is the smallest geographic unit available by which to analyze hospitalization data in Michigan as each discharge abstract routinely records the ZIP of permanent residence of the patient.

Central to small-area analysis is the concept of hospital service, or market, area (HSA) which is defined by the historical patterns of hospital use by the population within the area. The definition of hospital service area is of importance because it is assumed that from within that delineated boundary are found the hospital resources and patients that use them. The various methodologies for delineating hospital service area boundaries have been developed by non-geographers and 'space' (both definition and size) has not been a

focus for investigating and understanding small-area variations in hospital use rates. One formal attempt by Tedeschi and Martin (1983) compared the plurality method of Wennberg and Gittelsohn with the Relevance Index² approach of Griffith for Michigan. Their findings suggested these methods produced highly intercorrelated use rates. As a result, the small-area analysis community have assumed that the definition of hospital service area is not an important aspect in the variation of use rates. However, Tedeschi and Martin (*Ibid*) studied large aggregations of postal codes (as defined by the 'plurality' and Relevance Index methods) and it is likely that narrowly defined hospital service areas where between 50% and 90% of patients use the same hospital instead of only 15% - 30%, could yield interesting results. Such a definition would include analyzing individual 5-digit postal codes, as well as including ZIP codes where only a high proportion of patients originated. In addition, hospital service areas possibly ought to be delineated according to a 'dynamic' set of criteria, namely diagnosis- and/or procedure-specific use rather than the traditional total admission rate. These traditional approaches of using aggregations of five-digit postal codes are possibly too large and may contain considerable variation in social, demographic, and geographical factors whereby important internal differences may be obscured. It appears that the scientific and policy community need to be informed about the importance and possible effects of delineating hospital service areas. As recently as 1989, DeFriese and Ricketts (1989, p. 945) called for better ways of identifying service areas within which hospital service needs may be determined. Exploring the usefulness and the validity of using data on such factors as commuting patterns (patient flow), natality and mortality data, as well as data on health services utilization were suggested.

The approach adopted in this research, (i) that of using ZIP code-specific data instead of assigning each postal code to a hospital service area, removes a major source of

² To be discussed in the following Chapter.

bias inherent in contemporary small-area analysis methodology. As claimed earlier, the majority of small-area analysis research uses the plurality method proposed by Wennberg and Gittelsohn (1973, 1982) for assigning ZIP codes to hospital service areas. Each ZIP code within the study area is assigned to an hospital service area where the plurality of its total patients historically had received care. However, the two assumptions fundamental to small-area analysis methodology: (i) that of health care resources contained within a hospital service area; and (ii) the allocation of patients to a hospital service area; introduce an undetermined amount of bias. First, health care resources are thought of as comprising a single set of amenities used by a population within a hospital service area, no matter how many hospitals exist within that area. Traditionally, hospital service areas that contain just one hospital have never explicitly been analyzed (see Clark, 1990). Therefore, hospital service areas with more than one hospital are represented as an aggregation into a single use measure, such as patients (admission or discharge use rates) and resources (such as number of beds).

In addition, a number of important aspects of hospitalization and patient characteristics are investigated. The need for increasing the availability of health services to residents in rural areas has been recognized for several decades and is receiving renewed and increasing attention (Bosanac and Hall 1981; DeFriesse and Ricketts 1989). A major focus of this study is the analysis of patients resident in 'rural' postal codes and to consider their socio-economic status, including pediatric, adult, and elderly use of hospital care. This is in response to the paucity of information concerning the effects of poverty, rural residence, transportation, and higher proportion of elderly with regard to hospitalization which have not been specifically analyzed in Michigan, particularly for small geographic areas. In Michigan, rural communities have only previously been studied at the county and non-Metropolitan Statistical Area (MSA) level.

Most small-area variation analyses do not consider or make allowances for patient mobility in and out of hospital catchment areas. This aspect of hospital utilization is necessary for accurate rate determinations, but the characteristics of the migration population may also be of importance. Small-area studies do not analyze socio-economic status at the fine 5-digit postal code level, but rather by hospital service areas. Additionally, Wilson and Tedeschi (1984) show that income is positively associated with surgical admissions/discharges in Michigan, and that poverty level is negatively associated with medical discharge rates. Clearly, this aspect of hospital use is an important variable and is considered in this study.

A number of different hypotheses have been proposed to explain observed variations in population-based medical and surgical discharge rates in communities. First, physicians in different communities may have adopted different practice styles. Put another way, individual physicians practice in a stereotypical manner which translates into the observed population-based variations. An alternative to this assumption, proposed by Griffith *et al.* (1985), is that the community in which the physician practices and not the individual physician is paramount. In this context, the tendency to admit a patient to hospital is associated more with the community than the diagnosis, and the rate of admission tends to expand uniformly across all diagnoses. The third hypothesis deals with differences in the underlying socio-economic and/or clinical needs of different reference populations that accounts for the observed differences in hospital admission/discharge rates. While much attention has been directed to understanding the influence various socio-economic factors have on hospital use rates, little is known about the residence of patients (or communities) — geographical location — and how this affects the risk of hospital admission, as well as its interaction with other non-clinical variables like socio-economic status.

ZIP-specific ecologic mapping has recently been performed to determine geographic clustering of HIV seroprevalence among newborns (Novick *et al.* 1991) and its relation to four socio-economic variables (low birthweight: <2,500g; maternal education; race or ethnicity; and drug abuse leading to hospitalization) in New York City (Morese *et al.* 1991). Knowledge gained from the geographic associations demonstrated by this study are being used to design and focus intervention/prevention efforts in areas at highest risk for future HIV-AIDS activity.

No previous study of hospital utilization in Michigan has presented data at the 5-digit postal code level; usually, frequencies and rates are portrayed for large aggregations of ZIP codes and sometimes by county. No region that contains a sole community provider, that is a single hospital within a hospital service area, has been described in the literature; regions that have been discussed contain more than three hospitals and their data are averaged. This has the net effect of reducing the power of these types of studies and it is possible that subtle geographic variations have been obscured or masked.

Age-adjustment is necessary to remove the bias introduced by somewhat different age composition of the population within each ZIP code, because it is well known that the elderly have a higher than average rate of hospitalization. Furthermore, the figures reported here refer to *all* hospitalizations of residents of a postal code area, whether or not the individuals were actually hospitalized in that area. In other words, the age-adjusted and age-specific rates are not biased by referrals between areas.

THE STUDY AREA

The entire state of Michigan is considered in this study. The time frame adopted centers around the 1980 calendar year. A point of departure from traditional small-area

analysis methodology is the fact that all 5-digit ZIP codes are analyzed geographically, rather than by hospital service areas defined according to various schemes (for example see: Griffith *et al.* 1981; Clark 1990).

OBJECTIVES OF THE STUDY AND HYPOTHESES

This descriptive ecological study considers the entire state of Michigan and investigates the following non-clinical, population factors which are known to effect the utilization of hospital services: urban or rural residence, socio-economic status, and age group of patient. Age-specific rates are calculated for patients within certain age groups and who, upon discharge from a community hospital, had a medical or surgical diagnosis.

The overall goal of this research is to document, analyze, and map patient discharge characteristics for medical and surgical diagnoses during 1980, from community hospitals in Michigan at the five-digit postal code level.

The specific goals of the study are:

- To document and analyze the characteristics of community hospital use (medical and surgical discharge) rates with respect to:
 - (i) Medical and surgical discharges;
 - (ii) Urban-rural location of patient's residence (5-digit postal code);
 - (iii) Socio-economic status; and
 - (iv) Age group of patients.
- To display and analyze the geographical pattern in hospital use rates at the 5-digit ZIP code level; and
- To undertake a comparative analysis between medical and surgical discharges.

Six research questions are identified with respect to medical and surgical discharges in Michigan during 1980:

- (1) Is there a significant difference in medical (or surgical) discharge rates between urban and rural communities?
- (2) Are rural age-specific medical (or surgical) use rates higher when compared to those in urban areas?
- (3) Do medical (or surgical) rates change with age, when controlled for residence?
- (4) Do socio-economic classes differ with respect to the rate of medical (or surgical) discharge?
- (5) Does residence interact with socio-economic status on medical (or surgical) discharge rates?
- (6) Is there a difference in medical (or surgical) use rates between urban and rural residence after matching on socio-economic status?

LIMITATIONS OF THE STUDY

This study uses an extant patient-origin dataset, thus there is no opportunity to validate the accuracy or completeness of the data. The creation of the dataset preceded Medicare's Prospective Payment coding System, better known as Diagnosis Related Groups (DRGs), which greatly effects present hospital utilization patterns. Whereas hospitals are still being used as one of the primary sites of health and medical service delivery, today there is an increased movement to non-hospital dependent service delivery. Nevertheless, the findings of this study can provide useful baseline information for subsequent analyses that seek to assess the impact that the adoption of the DRG system has had within Michigan, for example, on the use rate patterns of urban and rural hospitals, and medical and surgical classification schemes. This study is further limited by the unavailability of severity of illness index and diagnostic-specific data at the five-digit postal

code level. It is thus assumed that the severity of illness is comparable in both urban and rural settings.

SUMMARY

This study falls within one of the major thrusts of contemporary medical geography in North America, namely studies concerned with hospital use and location (Pyle 1983, pp. 94–95). In so doing, this research provides baseline information for 1980, which is prior to the introduction of the Medicare Prospective Payment System during the latter part of 1983, about hospital patient discharge data which have yet to be analyzed at such a fine geographic scale. The effects of poverty and urban-rural residence is explored, in association with age group of patients, on the variation and distribution of discharge rates across 668 discrete ZIP codes. A spatio-epidemiologic approach is used to better represent and more fully appreciate the statewide patterning of hospital utilization in Michigan. Moreover, the results will permit an understanding of the pattern of hospital use prior to the large reduction in hospital beds and closure of community hospitals that has occurred during the decade of the 1980's, as well as the introduction in the fourth quarter of 1983 of the Diagnosis Related Groups. Comparisons can be made in the future using this 1980 baseline and the implications of hospital policies, practice patterns, and cost saving strategies will be better appreciated.

CHAPTER II

SMALL-AREA ANALYSIS AND INPATIENT HOSPITAL UTILIZATION

Purpose and Organization

The purpose of this chapter is to introduce and review the techniques of small-area analysis using primary as well as secondary sources. A critique follows the presentation of small-area analysis methods, which is in turn followed by an overview of results obtained from the application of small-area analysis applied to the United States, Canada, and Michigan.

Introduction

Variations in per person use of medical and surgical services and costs seems to be a phenomenon common to the developed countries, have long been present in the United States and are of interest to health care researchers. Such variations are in large part due to the amount of inpatient hospital care. Here, the public funding of health programs is increasingly strained or in jeopardy, with the poor, the uninsured, the underinsured, children, and elderly particularly at risk. In the 1980s, health care policy-makers were confronted with the dilemma of maintaining a reasonable level of health care services despite increasingly limited societal resources. The fiscal crisis in the Medicare Trust Fund with a deficit exceeding \$11 billion in 1984 provided the major impetus for the passage of the prospective payment system based on diagnostic-related groups. Similarly, private insurers began implementing a number of cost-containment programs aimed at reducing their health benefit costs.

The major assumption behind these programs was that inefficiency in health care delivery systems could be identified and that cost-containment efforts could induce administrators and physicians to eliminate, or at least reduce, these inefficiencies. However, these assumptions have not been based on direct measures of inefficiency but rather on indirect measures such as regional differences in admission/discharge rates, length of stay, and patient day rates. Differences exist whether 'region' is defined as a state, city, health planning area, or census division. Yet despite extensive efforts to identify the causes of the differences, they remain largely unexplained.

Forty percent of total health expenditures for the nation in 1979 was contributed by inpatient hospital costs (Freeland and Schendler 1981). Overall health care expenditures accounted for 11% of the gross national product in 1984 and were 8.1% higher than the expenditure during the previous year and continues to rise (The Robert Wood Johnson Foundation 1985). In fact, it is estimated that by the year 2000 health care will consume fully 17% of the gross national product (Davies and Felder 1990). Since populations that use more inpatient care per capita expend more health care dollars than those populations with lower utilization rates, knowledge as to their whereabouts, general characteristics, and an understanding why these services are utilized in different amounts hopefully will provide insights into ways of controlling the present spiral of health care expenditures.

It was not until the mid-1970s that physicians and scientists appreciated just how serious a problem an unregulated surgical profession might be. It had been recognized for a long time that the numbers of surgical procedures conducted in different countries varied widely. There are, for example, twice as many operations per capita in America as in England. This used to be attributed to the mediocre resources of Britain's National Health Service rather than to excessive surgical practice in the United States. However, in the early 1960s, after an investigation into the potential side-effects of an anaesthetic, it was

noted that the levels of surgery also varied widely within America. A decade later Wennberg and Gittelsohn (1973) published a comparative study of surgery and hospitalization rates in different states of America. Only 20% of women in Maine who had reached 70 years of age were likely to have had a hysterectomy; elsewhere the rate was 70%. In Iowa the chances that a man of 85 years or older had undergone a prostatectomy ranged from 15% to more than 60%, depending on which hospital area he found himself in. In Vermont the chances of a child having had a tonsillectomy ranged from 8% to 70%. In 1977, Wennberg demonstrated a 13-fold difference in tonsillectomy admission rates in Vermont. His group and others have shown population-based variation in the use of hospitals in such diverse settings as Manitoba (Roos and Roos 1981; Roos 1983), Ontario (Stockwell and Vayda 1979), Kansas (Lewis 1969), Vermont (Wennberg 1982), Maine (Wennberg *et al.* 1984), Michigan (Wilson and Tedeschi 1984), and Rhode Island (Wennberg 1985a). Significant variations in the use of medical and surgical services by the Medicare population in 13 different locations in the United States has also been documented (Chassin *et al.* 1986).

The early (1977–1982) attempts by Wennberg and Gittelsohn (and co-workers) to explain their findings that common surgical procedures (hysterectomy, prostatectomy, and tonsillectomy) varied markedly in New England with the highest rate six times the lowest — by reference to varying socio-economic conditions, different insurance policies, or ‘provider behavior’ — have led to the formation of an area of research which uses various methodologies for partitioning geographic space into hospital service areas. So-called “small-area analysis” or “small-area variation” studies have come to depend on Wennberg’s population-based ‘plurality’ approach for the assignment of patients to areal units associated with a hospital, or cluster of hospitals, where the majority of the population received care.

Population-based planning and regionalization are inextricably intertwined concepts of hospital planning in the United States. Nevertheless, most hospitals and Federal agencies have great difficulty in relating their planning processes to a population base, as contrasted with a patient base. With the availability of 'patient-origin' usage data from all (or virtually all) hospitals serving specific areas, as well as the presence of methodologies for demarcating, and apportioning resources to, population-based small geographic areas, often referred to as hospital services areas (Roemer and Shain 1959), the application of Wennberg's small-area analysis has gained popularity. Major planning and utilization control decisions have already been made in a number of states based on the findings of small-area analysis by McCracken and Bognanni (1986).

SMALL AREA ANALYSIS METHODOLOGY

The methodology of small-area analysis is becoming a common tool for identifying situations of possible excess medical services utilization. Not only health services research personnel, but also health insurers and the Health Care Financing Administration have acquired the capability to apply the small-area analysis methodology, first applied by Wennberg and Gittelsohn (1973 and 1980), to their own respective datasets. Hospitalization data that are unique to specific communities are being used in an attempt to improve the efficiency of utilization review for both purchaser and providers of health care.

Even though research on geographical variations in health now spans half a century, it is only in the last 20 years that a major effort has been made to map and seek explanations for these variations in health care delivery; particularly the use of services. One of the earliest studies of small-area variations was the analysis of the incidence of surgery among 11 aggregations of counties in the state of Kansas (Lewis 1969).

Seminal research by Wennberg and Gittelsohn (1973) in Vermont pioneered studies that developed the central methodology of small-area analysis as a means of ascertaining the amount of inpatient care used by clusters of communities and the individuals living in those communities. Substantial variations in patterns of inpatient utilization have been demonstrated by such studies and Wennberg *et al.* received national attention.

Various methodologies are available for the analysis of small areas to elucidate the health care needs of the population. Each technique has specific approaches to the problem of how to define the population (the denominator) from which hospital admissions are drawn. Numerator data, that is data derived from a hospital's experience, indicate little about the population on which that hospital's experience is based.

One of the most difficult aspects of small-area analysis is identifying the appropriate denominator to use in the rate calculation, that is, determining the medical service area of each hospital(s). An alternate approach used by Greene (1984), for example, is to calculate county-specific utilization rates based on the population's county of residence. However, such a technique is restricted to rural areas where most counties have only a sole community hospital and where the county unit is considered to be the medical service area.

Geographic area, and methods used to define it, is but one of four factors of small-area analysis which require attention when evaluating studies that use the technique. The other three are, the population at risk and/or subpopulations which may be included within that population; the hospital(s) being evaluated; and the admission category, disease type or procedure being analyzed.

A number of quite distinct approaches for partitioning large regions, such as hospital service areas, have been described in the literature. Generally, regions to be

delineated are composed of numerous small areal units such as postal ZIP codes or census tracts. Three basic solutions to defining population-based district boundaries have been attempted: (i) the equal likelihood method pioneered by Lembcke used all of the population where the market penetration is 50% or more (Poland and Lembcke 1962); (ii) the weighted market penetration (share) approach where a weighted population sum is used, also referred to as the Relevance Index or product moment method; the product of the small area population and the market penetration of the hospital(s) taken over a set of small areas where market penetration is significant (Griffith 1978; Thomas *et al.* 1981); and (iii) the ‘plurality’ method of Wennberg that uses a rule assigning each small area’s population and patients to the hospital service area where the largest number of patients from that area (i.e., ZIP code) received care historically (Wennberg and Gittelsohn 1973, 1975a, 1975b). Sometimes this type of analysis is referred to as “based on census population”, in contrast to the Relevance Index method which is “based on hospital service population” (Barnes 1982).

Adhering to the plurality approach entails a two-step process for the identification and demarcation of hospital service areas (Wennberg and Gittelsohn 1980, p. 18). ZIP-specific areas are grouped into market communities according to the hospital location historically preferred by the residents and is measured by actual use. First, hospitals in the same town or city, or nearby locations, are grouped together on the basis of significant market overlap. Second, each ZIP code area is assigned to that hospital, or more usually a group of hospitals, having the largest single fraction (plurality) of its total use. It is the resulting aggregations of contiguous ZIP code areas that form the communities or hospital service areas.

The geographic area defined as representing a hospital service area is based on historical patient origin information usually geocoded at the postal ZIP code level.

Techniques for the assignment of ZIP codes to a hospital service area are generally arbitrary, but endeavor to accomplish the assignment process in such a manner that each ZIP code is attached to that hospital providing most of the care received by residents within that ZIP. The plurality measure is most often used to achieve ZIP assignments to hospital service areas, that is to say the hospital with the most patients within a given ZIP receives the population for that ZIP code. Located within a service area is a hospital or multiple hospitals — which define a multi-hospital cluster. If this is the case, no attempt is made to divide the service area into individual hospital-specific areas, but rather a single hospital service area emerges for the cluster of hospitals, and the hospital service areas is treated as if it contained a single hospital. Hence, the geographic area describing a hospital service area may contain a single hospital or a set of two or more hospitals.

The max-relevance algorithm used by Griffith (1978; also refer to Thomas *et al.* 1981) to demarcate hospital service boundaries on the basis of hospital clusters, is a more complex method than the plurality model for assigning patients and population to hospital service areas. No map showing service areas has ever been published by Griffith because ZIP codes were split according to the proportion of patients assigned to separate hospital service areas. Because of serious technical and methodological problems experienced with the Relevance Index (see Hulka 1981), almost all small-area analysis studies which aggregate ZIP codes *post* 1978 have used the plurality definition based on historical patterns of total admissions (Clark 1990).

The importance of adjusting population and health variates for statistical cartography/mapping was enunciated by Tukey (1976) early in the 1970s. Age-adjustment is important because, once past infancy, people tend to use more hospital care as they get older, and on average in the United States, people 65 years and older use about three and a half times as many hospital days as those under 65 years (Vladeck 1985). Adjusting

hospital use rates according to the age profile of the population of small areas is necessary to permit reliable comparisons between communities. For example, Wilson and Tedeschi (1984) discovered that 30% of the overall intercommunity variation in the patient day rate in Michigan was explained by different age distributions within community populations. However obvious to the epidemiologist and medical geographer, age-adjustment is frequently overlooked in planning and policy discussions. The very strong dependence of hospital use upon age makes it unwise to compare crude rates.

Regardless of the method used to assign ZIPs to geographic areas, a statistic often used in small area analysis to ascertain variability of hospital use rates is the extremal quotient (EQ); the maximum rate observed from among the hospital service areas divided by the minimum rate. Three other statistical techniques are alternatively used, namely, the Chi-Square $2 \times n$ contingency table; the weighted coefficient of variation (CV); and the systematic coefficient of variation (SCV). A simple way to test for differences in the use rate among n areal units is to separate the people in each unit into two groups (i.e., admitted, not admitted), construct a $2 \times n$ contingency table, and calculate the usual chi-square statistic with $(n - 1)$ degrees of freedom. The weighted coefficient of variation has been used as a descriptive statistic for small-area analysis (Chassin *et al.* 1986), and is the ratio of the standard deviation of the rates (among areas) to the mean rate (among areas) weighted by the population in each area. McPherson *et al.* (1982) developed the SCV (see formula (1)) which is a descriptive statistic that estimates the variance among areas that cannot be accounted for by the variability within each areal unit, and it has been extensively applied to the analysis of small areas. The SCV calculation produces a single value which is not related to the magnitudes of the use rates. A recent example within Michigan is that of Clark (1990). The SCV equation (multiplied by 1,000) is given by:

$$SCV = [\text{Variance (O/E)} - \text{Mean (1/E)}] \quad (1)$$

where:

O = the age- and gender-adjusted observed use rate for each hospital service area;

E = the age- and gender-adjusted expected use rate for each hospital service area; and

Variance and Mean are calculated over all hospital service areas under investigation.

Recently, small-area analysis was applied to test one physician and 13 hospital characteristics for their association with and explanation of 14 hospital use rates among 53 hospital service areas in the non-metropolitan Detroit portion of the lower peninsula of Michigan (Clark 1990). Apart from documenting a number of significant contributions to the explanation of the variation in admission rates, the study concluded that current small-area analysis methodology — the definition and size of a hospital service area — influenced both the magnitude and variation in hospital use rates. Thus, it is evident that the limitations of small-area analysis are now increasingly being recognized. Moreover, given that studies of small-area variation in hospital use rates have policy implications, there are indications that the findings of these studies may not always have been appropriately tested for statistical significance — presenting the danger of making policy decisions based upon potentially inappropriate research findings.

A CRITIQUE OF SMALL AREA ANALYSIS

Despite the very real problem that hospitalized patients are not a random sample of the total population, and that they do not represent a complete sample of the population affected by any condition, it is maintained that much can be learned from area-wide analyses of hospital data and statistics. While it appears that the application of small-area analysis has proven to be a valuable approach to health data examination by hospital planners, marketers, health policy, and regulators, problems are evident due to a singular

lack of critical evaluation of the methodology. For example, within the geographic dimension a number of questions have been posed and await appropriate investigation: What constitutes a service area? Do service areas vary geographically depending on what service is being evaluated? Should standardized service areas be established or should areas be permitted to change with the service being evaluated? If so, how? What kind of arbitrary measures should be used to assist establishing service areas? (after Clark and Hamilton 1986). These questions relating to geographic veracity stand in contrast to those of Dever who suggests that the service area is not important in a geographic sense, but only in a population sense (1980, p. 230).

Geographical Considerations:

A comprehensive review of the North American literature on small-area analysis was published by Paul-Shaheen *et al.* (1987). Among their recommendations for further research, assessing the impact of hospital service area definition is considered an important objective. The authors reiterate that the definition of a hospital service area has not been consistently applied in previous research, nor has its accuracy or potential bias been ascertained (*Ibid.*, p. 766).

With the focus on net supply, small-area analysis neglects important demand factors. Moore (1977; 1985) has correctly identified a number of such serious shortcomings in the application of small-area analysis, but ignores fundamental methodological considerations pertaining to the geographical definition and construction of hospital service areas. In spite of this, however, failure to consider fundamental limitations arising from the geographical dimension of small-area analysis continues. Kazandjian *et al.* (1989) have recently focused attention on the inappropriate statistical testing of area variations, but yet do not mention definitional problems with hospital service areas.

Wennberg's plurality method computes an allocation of resources of all hospitals to an area (i.e., ZIP) under the assumption that its utilization of each hospital's resources is directly proportional to the number of discharges from the hospital to the area divided by the total discharges from the same hospital to all areas. This assumption is not strictly correct because a hospital does not generally provide identical services to patients referred from different areas (Barnes 1982). One ZIP code may send most of its pediatric patients to a hospital that in turn provides staff and facilities for tonsillectomies, and another area may send to the same hospital a disproportionate number of adult cases with degenerative diseases requiring staff and facilities for custodial and terminal care. Thus the resources utilized by a given ZIP code area depend on patterns of patient referral, as well as on numbers of discharges. An imaginary allocation of resources is actually calculated. This amount of resources is then related to an area population known within the accuracy of the decennial census data.

Population-based discharge rates for each hospital service area (referred to as 'community' in the literature) are determined by dividing hospital use (admissions, discharges, or patient days) of patients defined by their ZIP code of origin, *regardless of the hospital that provided the care (service)* by their ZIP code-specific population on an age-specific basis. In other words, calculations of community use rates using the plurality measure, involve the assignment of all short-term general hospital discharges for a year to the *residence* of the patient in a geographic unit, such as postal ZIP code. 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. For example, even if a hysterectomy was performed at a referral center 100 miles from the patients residence, the procedure is considered to have occurred at a hospital in the same hospital service area where the patient resided. Small-area analysis methodology returns each migrating patient back to their place of residence so that the numerator (patient) is indeed taken from within

the denominator (population). Hence, a “closed system” assumption is implicit in small-area studies; it is assumed that patients do not obtain care and that providers do not deliver care outside the service area under study (Paul Shaheen *et al.* 1987). Because a closed system does not exist in reality, small area studies ought to take note of the effects of care received and provided elsewhere if the observed per-capita use rates are to correctly reflect the community’s use of health care services. In studies of the determinants of hospital use, adjustments for patient mobility and/or migration to utilization and resource data is important (Joffe 1979). In contrast, it has been found that a migration adjustment was unnecessary in Michigan (Griffith, cited in Paul Shaheen *et al.* 1987, p. 769).

Small area analysis studies are difficult, if not impossible, to undertake in major metropolitan areas and highly urbanized states. Further, while small-area analysis has identified comparatively high use rates, it has not explained them. Whether high rates reflect excessive and medically inappropriate utilization is a significant, unresolved problem. In addition, small-area analysis generally has not considered possible variations within areas or explored differences in provider practices within communities.

When applied to the lower peninsula of Michigan in 1980 — using a similar dataset as reported here — the plurality methodology led to the formation of 60 hospital service areas containing a total population of 8.9 million people (McMahon *et al.* 1989). These areas range from 11,000 to 861,000 population and range from one to 18 hospitals. The average hospital service area has 148,000 population and contains 3.75 hospitals (Wolfe *et al.* 1989). Ranges this large cast doubt on the homogeneity of the hospital service areas relative to themselves and each other. Supporting evidence comes from Wolfe *et al.* (1989) who studied hospital discharge rates among 60 plurality-derived hospital service areas (“communities”) in Michigan between 1980 and 1984. They reported that community-specific discharge rates typically are 24% above or below the age-adjusted expected rates

for nonsurgical discharges and 13% above or below the expected rates for surgical discharges. This indicates that substantial small-area variation is the norm rather than the exception — that it is not a phenomenon isolated in a few hospital service areas. They concluded that the fact that substantial variability exists among communities even when averages across very broad diagnostic groups indicated that there are community factors — not diagnosis-specific — that have a large effect on hospital discharge rates (*Ibid.*, p. 80). Could it not be that the plurality methodology underlying small-area analysis which defines ZIP code membership and the geographic extent of hospital service areas is contributing to the observed variability and not solely community factors?

Using the same 60 hospital market share areas for 1980 in Michigan defined by the plurality rule of market penetration, as well as individual ZIP codes, referred to a “micro” areas in the study, Tedeschi *et al.* (1985) have shown in a multivariate (non-spatial) analysis that substantial variability exists in use rates by ZIP code within hospital service areas. The amount of variation documented within service areas ranges from 10% of the mean for surgical rates (70.5 ± 9.5) and over 20% for medical rates (77.4 ± 16.3). It is suggested that small-area studies that have failed to demonstrate a significant relationship between socio-economic and demographic factors and hospital utilization may have done so because the small areas were too heterogeneous (socio-economic and demographic differences being masked by aggregation).

In rural areas, plurality-defined hospital service areas usually contain just one hospital, whereas in urban areas where hospital catchments overlap to a considerable degree, the plurality methodology creates a multihospital cluster. Averaging of both the numerator (patients) and denominator (population) occurs and the net result is to markedly dilute variations in inpatient and population characteristics, and socio-economic status across member ZIP codes. In some rural areas, it has been shown that the plurality

approach breaks down as no hospital service area is readily definable; witness the recent analysis of rural hospital utilization in Washington state (Hart *et al.* 1989). Moreover, plurality-defined hospital service areas are not always contiguous and consequently all of the population in a given area will not be included. Some of the population of an area will never be used in any calculation of utilization rate. For example, it is possible for a ZIP code to be excluded from two adjacent service areas as if falls between the two of them.

It seems that the often-used technique for so-called small-area analysis of ascribing the membership of ZIP codes demarcating the boundary of hospital service areas, namely the population-based 'plurality' methodology devised by Wennberg and Gittelsohn, is really a misnomer. From a geographical standpoint, the plurality methodology is in many ways flawed and small-area analysis does not really analyze nor present results at a small geographical level. Most often, particularly in urban and peri-urban areas, the plurality strategy aggregates large numbers of ZIPs and hospitals as well, and assigns them into discrete hospital service areas (market communities). Small area data analyses and results are usually not presented in a map form; a histogram showing the frequency distribution of ZIP codes and use rates is sometimes substituted (see for example Griffith *et al.* 1981). Consequently, small-area analysis presently undertaken within the realm of health services research is, geographically speaking, not small area at all. The only common feature with small spatial resolution is that the ZIP code is the geocoding unit for data collection. Instead of maintaining this high degree of (micro-scale) geographical resolution (actually large-scale mapping covers a small area), the plurality technique aggregates postal codes and moves the level of spatial analysis upward to that of "mesoscale" — despite of the use of the word "micro areas" to characterize the process in the literature. In addition, important issues of cartography and mapping are rarely considered. For example: how to best present postal code areas on a map; how to collapse postbox addresses; what mapping scale to use; what computer mapping strategies to adopt; and how best to present maps

without distortion. An example of the latter problem is found in Clark (1990) where studentized residuals from multiple regression are mapped according to plurality-defined hospital service areas in Michigan. Unfortunately, due to an inappropriate aspect-ratio the problem of foreshortening is acute and the state of Michigan is depicted in a severely distorted manner.

For Michigan, the county has been identified by health services researchers as a legitimate small area unit on the basis that most hospitals, or groups of hospitals, are located in the county seat which tends to be in the center of the county and therefore, the county is thought to approximate a hospital service area (McLaughlin *et al.* 1989). The notion that an area the size of a county can be equated with a hospital service area is, geographically-speaking, untenable. Firstly, few counties have at their center a major urban area where hospitals are located. Secondly, the intra-county variation of population age structure, socio-economic characteristics, and urban-rural residents most likely exceeds the inter-county variation for these same variables.

A fundamental issue not yet confronted in small-area analysis literature has to do with boundary shifts. Many small-area analysis studies make use of data collected over a period of years and a recurring problem is that the boundaries of recording units may change from one time period to the next. These boundary movements may simply reflect administrative convenience or they may be related to more significant events such as marked changes in the population size of an area. Failure to adjust for boundary movements will invalidate inter-area comparisons (Cliff and Haggett 1988, pp. 84–92). Furthermore, when using time-series data spatial continuity and temporal continuity represent irreconcilable goals. If one is to preserve a consistent time series, then a great deal of spatial detail will be sacrificed. Conversely, if the maximum amount of spatial detail is to be retained, then one can only have very short and broken time series. When

using historical time series, shifts in diagnostic and procedure coding (from HICDA-2 to ICD-9-CM) and associated class definitions have been shown to have substantial implications on the values recorded for such measures as length of stay of nonoperated cases (Tedeschi and Griffith 1984). Changes in coding between 1978 and 1980 probably affected both estimates and surgical/nonsurgical use rates in Michigan and expected lengths of stay of operated versus nonoperated patients. With potentially large shifts in average cost per case resulting from the classification to surgery, small-area analysis researchers and administrative personnel must exercise caution to ensure either a stable classification system or a reliable estimate of the impact of coding changes.

The assignment of every small (ZIP) area to a hospital service area, no matter what the probability of the population using the hospital(s) within the service area has also been called into question (Clark 1990).

It is postulated that different geographic quanta used in typical small-area analysis studies which undertake multiple linear regression analyses, be it ZIP code, or county for example, may account for some of the variation observed.

Since utilization rates are calculated for populations divided among areal units, the visual display of such data is most commonly achieved with choropleth maps, and the usual problems of choice of scale and data classes emerge. The inappropriate choice of scales and boundaries, however, make maps more susceptible to misinterpretation than tabular material. Counties, state economic areas, states, and even national units probably have little relevance for the distribution of disease and represent a few of the infinite number of ways of aggregating morbidity, the use of health services, and the denominator population over space (King 1979).

Among the questions that need to be addressed in analyzing geographic data is: What is the appropriate level of aggregation of the geographic units? The modifiable areal unit problem, referred to as MAUP, has been recognized as one of the most important unresolved problems left in spatial analysis (Openshaw 1984). The modifiable units problem arises because data may be aggregated spatially for different sized areal units. The geographical units employed in a particular analysis can often have substantial effects on the results obtained. Different results are found at different scales and for different aggregations; as areal units are modified so observed patterns change. The modifiable areal unit problem is comprised of a *scale* problem and an *aggregation* problem, both of which are inextricably linked (Openshaw and Taylor 1979, 1981; Openshaw 1984). The scale problem may be defined as the variation in results that can be obtained when the same areal data are combined into sets of increasingly larger areal units of analysis. However, at any given scale or level of resolution (i.e., a particular number of areal units), there are a very large number of ways in which these areal units can be arranged. Any variation in results due to alternative units of analysis where the number of units is constant is termed the aggregation problem (Openshaw and Taylor 1979, p. 128; Stimson 1983; Arbia 1989, Chapter 2). Areas which are too large may contain considerable variation in social, demographic and geographical factors and important internal differences may be obscured. When dealing with small areas, however, small numbers of events may make it difficult to decide whether differences between areas are real or due to random fluctuations.

Questions of scale of analysis or the fineness of spatial units have received minimal attention in the small-area analysis literature. This is despite the fact that the identification of health care utilization patterns is dependent on the scale which is selected, for the selection of one scale may mask or ignore spatial variations at another scale (Mayer 1983). Utilization rates can be expected to decrease as the areal extent of a hospital service area increases. Moreover, 'ecological correlations' may be artifacts of the scale which is

selected. As Cleek (1979) observes, a high correlation between disease frequency and independent variables suggests that they vary respectively at the same scale — the frequencies of cyclic variations are therefore the same. With some exceptions, health services research scientists are, by and large, ignorant of the spatial analytic techniques and methods that are standard tools of geography.

The MAUP is closely related to the ecological fallacy problem (Robinson 1950). An ecological fallacy involves transferring findings about properties of an aggregate of people (i.e., ZIP code or a census tract) to an individual, which, as Robinson (1950) clearly demonstrates, often produces wildly erroneous conclusions. The MAUP is usually concerned with the further aggregation of already aggregated data, although the initial aggregation of individual data can be viewed as a special case of the MAUP (Dudley 1990). In addition, the existence and problems associated with the MAUP is not exclusive to human geography and medical geography in particular. The implementation of social welfare programs based upon decisions made using aggregated areal data are also subject to the confounding effects of MAUP (see, for example, Coombes *et al.* 1982). Consequently, MAUP is a central issue and possible confounder in the plurality methodology used in population-based small-area analysis today. Geographers are often faced with the problem that boundaries of areas used as the basic units of observation can be changed. Units may be put together to make larger units, or unit boundaries may be shifted in some other way — both of these possibilities plague small-area analysis. The former is central to the plurality technique which aggregates ZIPs according to largest hospital market share, while the latter impinges in an, as yet, unquantified extent because the boundaries of ZIP code areas are in many ways not static and certainly modifiable from year to year without the researcher being aware of such alterations and even deletions. The absolute impact that the plurality aggregation process has on changing use rates is unknown, but in certain instances is likely to be substantial.

The basic problem with most morbidity (and vital statistics) data concerns the data not being available at a sufficiently disaggregated level of scale to identify the areas of concentration of a phenomenon. Spatial distributions are typically positively skewed, and the level of skewness increases with increased geographic disaggregation. Thus, with large, heterogeneous hospital service areas, regression towards the mean becomes an important issue and one ought to question whether within area variance is as great as between area variance, particularly where service areas are highly aggregated (Stimson 1983). Small area analysis methodology does not allow for an assessment of homogeneity when designating its ecological hospital service areas. The aggregation problem is inevitable, in most instances, but it is imperative that all medical cartography studies adopt some form of stochastic adjustment procedure.

There is also the question of outpatient usage — the component of hospital use that has risen markedly since the introduction of a prospective payment system. Should a hospital define a separate service area according to outpatient origins as opposed to the inpatient population, or are the two use groups to be considered as one when assigning ZIPs to the service area? The service area will certainly vary in size, shape, and composition for inpatients and outpatients, by bed use, and for different services and facilities.

Although the examples used by Wennberg and Gittelsohn were often characterized by capture rates¹ in excess of 80%, for their whole sample of 193 small areas in New England the median capture rate was approximately 62% (1980, p. 62). Median capture rates obtained in Minneapolis, Minnesota, using small area methodology vary between 30% and 70% (Zellner and McClure 1990, p. 13). It would not be surprising to find the

¹ Capture rate: The percent of all admissions in a hospital's service area that are to that hospital.

contribution to the service area's admissions/discharges in some inner city hospitals to be as low as 10% or 20%. Unfortunately, comparative values have not been reported for Michigan. Hence, particular caution seems advisable when using the plurality algorithm to assess individual provider practice style for services in a multi-provider (multi-hospital) cluster. At a minimum, this suggests that hospital service area boundaries ought to be recomputed each year. However, mixing of patients, even within a ZIP code area, across several hospitals seems increasingly likely. This may result from less dominant 'majority' hospitals becoming increasingly common in the future if health insurers or employers take steps to give patients incentives to choose more efficient providers. The old pattern of neighborhood patients clustering in the nearest hospital is likely to give way. Hence, it is unlikely that redrawing hospital service areas will solve the problem of keeping the plurality hospital dominant in its service area. Thus the algorithm and methodological integrity of small-area analysis may fail increasingly in the future.

Statistical Considerations:

Spatial autocorrelation is a serious hindrance to spatial analysis and has yet to be adequately assessed in relation to small-area analysis research. Spatial autocorrelation means that observations from places adjacent to each other (i.e., ZIP code areas) are influenced by each other. Hence, the assumption of independent observation, required for certain statistical procedures like multiple stepwise regression and correlation, may be violated. The fact that measures of association vary with changing scale is, in part, attributable to spatial autocorrelation. Essentially autocorrelation in independent variables can reduce the power of inferential tests and increase the standard errors of estimated parameters. The effect of autocorrelation in the dependent variable, hospital use rates, is less clear. Some of the effects of spatial autocorrelation have been identified in the context of least squares regression models and in the distribution of residuals (Cliff and Ord 1973).

The influences of spatial autocorrelation on all areas of spatial analysis have serious implications for geographical epidemiology.

Furthermore, the question of using datasets containing multiple admissions of the same patient within the period under study has been highlighted by Diehr *et al.* (1990) who show that readmissions can have a large effect on the variability of small area statistics under the null hypothesis. One assumption underlying most statistics used to examine the variability of use rates is that a patient can be in the numerator once at the most. This is probably true for “ectomies” (or organ removal), since an organ can be removed at most once, but a person can still be enumerated more than once if they are readmitted for complications, if multiple bills are submitted for the same surgical procedure, or in the case of medical diagnoses where the patient can be readmitted often for the same condition. This assumption is violated when hospital admission/discharge rates for a particular diagnosis are analyzed. Readmission rates for many diagnoses run as high as 50%, and the average number of admissions of all types per person hospitalized is 1.5 in a year (U.S. Dept. of Human Services 1983).

Diagnosis (treatment code)-specific hospital service areas may be more appropriate than that usually described using all admissions/discharges and has been suggested by more than one author (Paul-Shaheen *et al.* 1987; Clark 1990). That is to say, many hospital service areas could be delineated, each according to a different DRG category, and not one for the entire state that is produced via the plurality methodology. However, an important issue to be resolved then concerns the reliability of the recorded diagnostic information. At the level of the DRG with multiple diagnoses included in one specific DRG, the impact of variability and bias in the recording of any one diagnosis is unclear. If variations in reported hospital discharges were to be analyzed using service areas defined

by diagnosis-specific criteria — and even more importantly at the ZIP-specific level — coding variability as a potential source of error deserves further study.

A further methodological problem with small-area analysis has to do with how much variation is too much. Often applied to surgery rates for small areas, small-area analysis compares the largest rate to the smallest, notes that the difference is large, and attempts to explain this discrepancy as a function of service availability, physician practice style, or other factors such as population characteristics. Small-area analyses are often difficult to interpret because there is little theoretical basis for determining how much variation would be expected under the null hypothesis that all of the small areas have similar underlying surgical rates and that the observed variation is due to chance (Diehr *et al.* 1990). Of importance is the fact that the expected variability when the null hypothesis is true is surprisingly large, and becomes worse for procedures (or episodes) with low incidence, for smaller populations, when there is variability among the populations of the areas, and when readmissions are possible. Since contemporary small-area analysis research is tending to focus on low-incidence events, smaller populations, and measures where readmissions are possible, more fundamental study is required on the distribution of small-area statistics under the null hypothesis.

Assumed to be missing from multivariate regression models are differences in (i) disease rates, (ii) patient preferences, (iii) underuse of the procedure, (iv) underdetection of the disease, and (v) many types of random variation. The basic question to be considered in small-area analysis is whether adjusted discharge or surgery rates ought to be similar in all geographic areas. Inappropriate utilization is often the implied culprit for the observed variation in use rates. It is not known what the sensitivity and specificity is of using small area-derived use rates to detect inappropriate use of procedures or hospitals.

Small-area analysis is a well-accepted methodology that is now being adopted by the health services research community and used in a manner not foreseen by its formulators. As applied by Wennberg *et al.*, small-area analysis embraced relatively large areal units in which it was assumed that detected variations in use rates were meaningful (Diehr *et al.* 1990). The popularity of the technique and availability of microcomputers encouraged investigators to apply this technique to geographic areas which are very small in extent (i.e., census tract). Earlier applications of small-area analysis focussed on procedures such as "ectomies" where a patient forms part of the numerator at most once. In a statistical sense, this means that the computed surgical rate is a proportion which has known statistical properties. Current research, however, is extending the small-area analysis technique to procedures where readmissions are certain to occur (i.e., the same person can be counted more than once in the numerator). Hospital use rates derived in these situations are not proportions and do not have known theoretical distributions.

Small area variation analysis has not only been faulted on spatial grounds, but Diehr *et al.* (1990) have recently drawn attention to the fact that many of the descriptive statistics used to facilitate comparisons of the variability of procedure or diagnosis-specific use rates are inappropriate because of violations of the underlying assumptions to the theoretical basis of the statistics. Few statistical methods exist that permit assessment of such variability. Some tables are available on the order statistics of the standard normal distribution (Sarhan and Greenberg 1962). In theory, if the populations are large enough, the observed use rate in each small areal unit has a normal distribution, and the order statistic tables can be used. In practice, however, the order statistics are not useful for a number of reasons. First, they are tabled only up to $N=20$. Second, they require that each observation be drawn from the same distribution. The variance can only be the same for all areal units if they have approximately the same populations. This is usually not the case. The often used extremal quotient statistic has not been tabled (primarily because its

expected value is infinity), although tables that deal with some cases of interest — large, similar-sized counties — have recently appeared (Kazandjian *et al.* 1989). Such geographical conditions, namely large similar-sized counties, rarely apply. Except for when the conditions of “ectomies”, large similar-sized areas, and high expected values are met, the extremal quotient can be misleading, as apparently large values are not significantly different from what would be expected by chance alone. In addition, no tables are available for two other small-area analysis statistics, the coefficient of variation and the systematic component of variation. Without such tables, these descriptive statistics cannot be used to test the null hypothesis (Diehr *et al.* 1990, p. 743). The chi-square test is appropriate when a patient can be counted in the numerator at most once, if all the people resident within the area have the same probability of admission, and if the expected number of admissions/discharges is at least five. The method is not appropriate when readmissions are possible — an inherent problem with most patient-origin databases — or for diagnoses with low incidence. Similarly with the weighted coefficient of variation and the systematic component of variation, no tables are available to permit the determination of what is “too large.” The systematic component of variation behaves similarly to the extremal quotient and the coefficient of variation; it is sensitive to the underlying use rate, to the population sizes, and to the variability in the population sizes, and is markedly sensitive to readmissions. The systematic component of variation was developed as a measure for comparing several types of surgical procedures and diagnoses, or the same surgery (diagnosis) in two different regions. Its sensitivity to many factors other than the true variability among small areas suggests that it does not fulfill this purpose (Diehr *et al.* 1990, p. 755). A final issue yet to be addressed concerns the power of these tests and this area remains to be explored.

A cautionary note on the use of small-area analysis has recently been sounded by Zellner and McClure (1990). Such critical appraisal of the small area methodology is

relatively new. In much of the health care policy literature concerned with the application of small-area analysis there appears to be an implicit assumption that, when other relevant factors are appropriately controlled for, variation in small area population utilization rates can be used to infer the practice styles (behavior) of individual providers. The original algorithm employed by Wennberg and Gittelsohn (1973) can be described by the following two rules and paraphrased by Zellner and McClure: (1) A hospital's service area is defined by investigating "....the relative frequencies of use of hospitals in each [sub area unit] and assigning each unit to 'membership' in the area served by the hospital with the plurality of (or most) discharges [or admissions] from the unit" (Wennberg and Gittelsohn 1980, p. 18); and (2) Having constructed hospital service areas so that each hospital is the major supplier of hospital discharges or admissions in its service area, the population-based utilization rates for inpatient services in each area may be assumed to result from the practice style of that area's hospital (Wennberg and Gittelsohn 1980, p. 181). The use of rule 2 in policy proscriptions is never explicitly stated by Wennberg and Gittelsohn. An almost identical interpretation of Zellner and McClure's understanding of Wennberg and Gittelsohn's small-area analysis algorithm is made by Caper (1984) — the technique partitions a geographic region (state or metropolitan area) with multiple hospitals into individual hospital service areas according to rule 1, and then associates the practice style of the hospital with the utilization rate of its service area population by rule 2. It is demonstrated that if a service area's hospital admission rate is high, the hospital that accounts for the largest proportion of that area's admissions is responsible for that area's high admission rate, while intuitively appealing, is not necessarily the case even in instances where the capture rate of the plurality hospitals is high (Zellner and McClure 1990).

The small-area methodology possesses an inherently unrealistic or at least a strained assumption about the underlying distribution of episodes (of each hospital's associated

physicians) among service areas. The analytically correct denominator for measuring a hospital's practice style is in fact episodes which reflect the underlying epidemiology of a population (Hornbrook and Berki 1985). Using small-area analysis populations as the denominator appears to be a questionable procedure for judging the relative practice styles of individual providers when residents of each small area receive a considerable amount of medical care from providers not in their small area. Put another way, discharges in a service area are being averaged over other hospitals and may be distorted away from the practice style of the plurality hospital itself.

Finally, concern over the indiscriminate and inappropriate use of the techniques of small-area analysis within the field of health services research is demonstrated by the recent award by the Health Care Financing Administration in 1987. The American Medical Review Research Center received a two and a half year project, "Small-area analysis of variation in utilization and outcomes of hospital care among Medicare beneficiaries for 1984-1986." One of the central objectives of the project are to develop an understanding of the tools of small-area analysis.

HOSPITAL UTILIZATION

Four kinds of factors contributing to differential availability and utilization of medical services have been identified by Davies (1971): (i) factors intrinsic to the patient, such as socio-economic status, educational level, urban-rural residence, and beliefs and attitudes toward health; (ii) factors associated with the socio-economic environment; (iii) factors associated with education, communication, and transportation, as well as the distribution of resources; and (iv) factors associated with hospitals and clinic care, among them equal availability of clinics and hospitals to all patients, which may be limited by geographic accessibility (*Ibid.*, pp. 26—33).

United States and Canada:

From these factors several hypotheses have been advanced to account for the difference in observed patterns of hospital utilization in the United States and Canada:

- (a) *Health status* — Populations that are less healthy may require more medical care and may consume health care services at higher levels.
- (b) *The availability and accessibility of hospital care* — Populations with easier access to hospital services may use those services more than areas that have less access. In addition, Roemer's Law (Roemer 1961) which states that "If there is a hospital bed available it will be filled," may be true. In other words, regions with higher per capita bed availability may display elevated utilization patterns.
- (c) *The utilization of ambulatory care services* — Hospitalizations may be necessary less often if populations receive more care in physicians' offices.
- (d) *Socio-economic-demographic characteristics* — The social, cultural, and economic composition of a population may effect its use of hospital services.

Early studies (Andersen and Anderson 1967) have shown that variations in the relationship of hospital admission rates to family income over time. While no apparent association existed in 1953, by 1958 some differentiation was apparent. The lowest income group had a slightly higher use rate than higher income groups. Data from 1963 indicates the same general pattern. Richardson (1969) found an even more pronounced relationship between hospital utilization in 1967 and income. The discharge rate per 1,000 population among families with incomes below the poverty line (under \$3,000 per year) was 157 as compared to a rate of 107 for persons from families with incomes three times or more (above \$10,000). Consequently, income is an important predictor of utilization of community hospitals. In addition, Feldstein and German (1965) found income, specifically median household income, to be an important predictor of hospital use rates.

In summary, it is predictable that socio-economic status would be significantly correlated with hospital use.

One of the few studies of hospital discharges where the analyses are conducted at the 5-digit ZIP code-specific level is that reported by Vladeck (1985) among communities in New York City. Their initial result for 1982 show that every one of the 10 communities (ZIP code areas) that have total unadjusted discharge rates for all causes over 200 per 1,000 residents have a median household income in the 1980 Census of less than \$10,000 per year. The low utilization ZIP codes (rates below 115/1,000) are characterized by median household incomes of \$15,700 or more per year. Overall, the pattern is one where most white, middle-class neighborhoods of New York compare favorably with similar neighborhoods elsewhere in the United States, while those in the city's poorer, heavily minority communities have high hospital utilization rates. The marked inverse relationship between median household income and hospital use rates are perhaps the most striking feature. The ZIP area with the highest discharge rate (253.2/1,000) has the lowest income (\$5,688) of all ZIPs within the study area. Unfortunately, as level of illness within each area is unknown, the degree of "need" cannot be controlled for. The poor are certainly using more hospital services, but one cannot say whether they are receiving as much when the amount of illness is taken into account. Nevertheless, one of the principal reasons why hospital utilization in New York appears to be so high when compared to national norms no doubt has something to do with the socio-economic character of the city's population. Such an interpretation is supported by Wennberg's early work which showed that variations in the health care experience of different Vermont populations is explained more by behavioral and distributional differences than by differences in illness patterns (Wennberg and Gittelsohn 1973).

Education level of a community was early on shown to be positively associated with both hospital admission rates and the length of stay (Rosenthal 1964). Education is also associated with other variables, such as income and unemployment. Income and employment opportunities increase markedly with education. Also hospitals are more likely to be located in areas where the population is better educated and resources are available to support various health services. The distribution of community hospitals in the south eastern region of Michigan, particularly in and around the city of Detroit, is a classic example of this geographic reality.

Most recent multivariate analyses tend to use a single variable, such as income (in dollars) to characterize the economic status of a community (Roos and Roos 1981; Roos and Roos 1982; Roos 1984), and/or median household income (Wilson and Tedeschi 1984; Vladeck 1985), and/or the percent Medicaid recipients (used as an indicator of the size of the lower end of the income distribution).

Similarly, measures of poverty also tend to be related to a single variable, the most common being the percent of population below the poverty level (Wennberg and Fowler 1977; Roos and Roos 1981; Roos and Roos 1982; Wennberg *et al.* 1982).

Quite apart from socio-economic factors, age of patients is a fundamental determinant of the need for hospital care. Hospital admission rates, excluding maternity care, are usually lowest for children (pediatric: under 15 years of age), and then rise with age. Historical data support this interpretation. During the decade 1953—1963, admission rates rose appreciably for persons 55 years and over; while during the same period they declined among children (Anderson 1973). Discharge data from 1965 (Andersen and Hull 1967) and from 1967 (Richardson 1969) also support these earlier findings. Age is one of

the most important influencing factors and is highly associated with the use of short-term hospitals, apart from socio-economic factors and gender (Rosenthal 1964).

Education is another variable often used to characterize the social status of a community (Wennberg and Fowler 1977; Roos and Roos 1981; Roos and Roos 1982; Wennberg *et al.* 1982; Roos *et al.* 1982; Roos 1984; Wilson and Tedeschi 1984), as is percent unemployment (Wilson and Tedeschi 1984).

However, only one study uses principal component analysis to create a broader composite socio-economic score than that used in other investigations to enter as independent variables into a multivariate regression model (Wilson *et al.* 1985). The data used for entry into the principal component analysis was the average of member ZIP code areas within each hospital service area, and not on a ZIP-specific basis.

Differences in discharge rates are also apparent between rural and urban areas. As early as the decade between 1953 and 1963, the lowest age-adjusted rates of hospital use were recorded for persons residing in urban areas (Andersen and Anderson 1967). However, Rosenthal (1964) indicates that percent urbanized had little or no effect on admission rates. Urbanization certainly influences education, income, and unemployment rates. Moreover, urban populations tend to be younger and have a greater diversity of health services available to them in addition to hospitalization. An interesting finding of Andersen and Anderson (1967) is that admission rates were highest among rural non-farming communities and lowest among urban residents. Contrary to this are results presented by Anderson (1973) which document slightly increased admission rates among the urbanized population of New Mexico in 1960. No studies are present in the serial literature that use carefully considered definitions of urban-rural residence by small area (i.e., ZIP code) by which to stratify community hospital use rates. County-specific

analyses have been performed where urban or rural residence is considered, but none at a high geographic resolution.

The seminal 1959 study by Shain and Roemer presented data indicating that hospital utilization within a state as well as costs are strongly associated with the supply of beds available to the population served. The authors contend that a new supply of beds in a community leads to a change in demand until an equilibrium is attained with the new occupancy rate at about the same level as the old. This prediction has been confirmed many times (i.e., Anderson 1973).

As detailed above, Wennberg and Gittelsohn drew attention to small-area variations in health care delivery in Vermont by performing a population-based analysis of discharges from hospitals during 1969, including such variables as manpower, bed use, and expenditures. Their methodology — now referred to as the plurality model — grouped minor civil divisions (townships) into hospital service areas; minor civil divisions surrounding the hospital used most frequently by the residents of that area. Hospital discharge rates for all causes, adjusted for age composition, varied from a low of 122 to a high of 197 per 1,000 persons. Importantly, discharge rates tend to be generally higher for those areas with less than 10,000 population, ranging from 40.7 to 115.4 per 1,000; the highest recorded (Wennberg and Gittelsohn 1975a).

When evaluating the uses made of hospitals, it is important to take the case-mix and severity of illness of patients admitted to hospitals into account (Wennberg and Gittelsohn 1975b). This stands in contrast to the model of 'need' health care planners commonly use when evaluating the need for facilities — the assumption that need for institutionalization is dependent largely on the natural incidence of illness.

Roos and Roos' (1981) undertook a population-based analysis of surgical discharges in 1972 from 56 rural hospital service areas across Manitoba, Canada. Only the elderly patients (over 65 years of age) are considered. Unfortunately, no residence comparisons are possible as urban areas are excluded from the analysis. However, their findings suggest that place of [rural] residence — with comparable case-mix — strongly influences exposure to major surgical procedures. One and a half times as much surgery was performed in high rate regions as in low rate regions (115.2 versus 74.7 per 1,000). Interestingly, specialists do not perform a higher proportion of surgery in high rate areas. If anything, general practitioners may be more likely to perform complex elective surgery in high rate, as compared with low rate areas.

Surgical discharge rates for New York by county in 1981 are described by Pasley *et al* (1987). Outmigration was not accounted for by the within-county aggregation process. Of the 2,801,180 hospital abstracts analyzed, 24.5% were discharges of patients aged 65 years and over. The overall mean age-adjusted older adult discharge rate was 353 per 1,000, with an all ages discharge rate of 163 per 1,000. The total age-adjusted surgical rate was 80 per 1,000 and for the 65+ group, 137/1,000.

In a study conducted in 25 hospitals in four Professional Standards Review Organization (PSRO) regions of the United States during 1980, whose aim it was to determine differences in a direct measure of efficiency of hospital utilization — appropriateness of hospital use for adult medical and surgical patients — the following results are of interest (Restuccia *et al.* 1984). Inappropriate admission is measured through application of the Appropriateness Evaluation Protocol. The overall rate of inappropriate admissions is 19%; regional averages range from 11.9% to 28.0%. Of the four regions analyzed, the East-Rural region displayed the largest percentage of inappropriate admissions (28%), East-Urban and West-Urban next (20%), and lastly West-Rural (12%).

The relationship between variations in the characteristics of the elderly population (65+ years of age) and variations in surgical rates across 56 Manitoban hospital service areas have been examined (Roos and Roos 1982). Areas experiencing high rates of surgery are not characterized by an elderly population that is disabled and in ill health. Thus the data do not support a needs model for explaining variations in surgical rates. A non-significant correlation between racial makeup and surgical rates is present, as it is with income, but the association is strong and consistent. This suggests that areas with high surgical rates are also likely to have disproportionately large numbers of elderly Anglo-Saxon (English-Canadian-American) parentage. However, the relationships among income, education (the percentage of elderly respondents with nine years or more education) and surgical rates are not in accord with the literature. The American study of Bombardier *et al.* (1977) found income to be positively associated with surgery, although, other things being equal, the more highly educated tended to have fewer operations. It appears as if, due to the nature of the Canadian health care system, that income is less important given the insured care available under National Health Insurance.

Bunker (1970) was one of the first to suggest that economic factors help explain the

Bunker (1970) was one of the first to suggest that economic factors help explain the existence of variations in surgical rates. Incentives operating in a fee-for-service system might contribute to variations in rates observed between prepaid and for-fee practices in the United States. As set forth in the Bunker-Brown model (1974), supply variables, such as physician-population ratio and hospital bed availability, and population characteristics would seem more likely to influence "demand for surgery" than be related to "need for surgery."

Most racial differences in surgical utilization appear to be attributable to differences in income and not to 'race' *per se*. A similar situation holds for residence: the urban-rural

(SMSA and non-SMSA) differential becomes nonsignificant when adjusted for income (Bombardier *et al.* 1977). The source of data for this study was the 1963 and 1977 Health Interview Survey conducted by the National Center for Health Statistics within a sample of 37,000 households across the nation. Overall, however, individuals in cells with low mean income tend to have fewer surgical procedures. Rutkow and Zuidema (1978) suggest that low surgical rates occur where the population has restricted access to medical care.

Michigan:

Relatively few studies are available that provide detailed information concerning hospital use and reasons for the variations observed at a small geographic level. Most early research used political and/or administrative boundaries to demarcate the geographic units for analysis, for example county, Standard Metropolitan Statistical Areas (SMSAs), and hospital districts (of which there are eight in Michigan).

The correlates of community characteristics and non-obstetrical hospital use were the subject of research using the 1978 Michigan Inpatient Database (Wilson and Tedeschi 1984). The focus of the study was to determine whether a pattern of hospital use is present in high versus low use areas and to determine if that use is associated with characteristics of the population reflecting differences in need. Two hundred and six community hospitals in the lower peninsula were grouped into 60 hospital service areas on the basis of market penetration with common service areas. Due to problems of data reliability, 13 hospitals were discarded and 47 hospitals were ultimately analyzed. Most of the variation in service area hospital use is associated with medical hospitalizations. This variation in medical and hospital use is associated with discharge rate variations. Of the overall inter-community variation in patient day rate, 30% is explained by different age distributions in community populations.

In a follow-up study to their earlier analysis of hospital services, variations in hospital expenditure levels — also by county — within Michigan for the year 1980 are available (Office of Health and Medical Affairs 1985). Of note (not mentioned in the report) is the fact that it is the rural counties which have the highest age-adjusted inpatient hospital use rates. For example, Luce and Ontonagon counties possess total patient day rates per 1,000 that are 210% (1,109 days per 1,000) and 201% (1,160/1,000) of the selected target rate; that being Kent county which has the lowest rate ($799/1,000 = 100\%$). The rate for Michigan as a whole is 1,195 days per 1,000 and is 150% that reported for Kent county. Two rural counties also had the lowest age-adjusted rates, namely Gogebic ($668/1,000 = 91\%$) and Cass ($762/1,000 = 91\%$). However, both of these are border counties and in all likelihood reflect a failure to sufficiently account for out-of-state use. If both the use and the price structure of the Kent County Hospital System (a low use metropolitan county) could be duplicated throughout the state, the savings would have been \$1.2 billion (in 1980 dollars), an overall reduction of one-third.

The effects of race, their characteristics and location upon hospital use were investigated within 23 hospital service areas located in the lower peninsula (Wilson *et al.* 1985). The criteria used to select the 23 regions (out of a total of 60) determined that a range of rural and urban communities were included in the analysis. In addition, over 96% of the total black population resides in the 23 communities studied. Service regions were created by aggregating ZIP codes according to the plurality of hospitalizations for patients. Data pertaining to hospital utilization during 1980 were used and surgical and non-surgical discharge rates calculated. Age-adjusted discharge rates per 1,000 for blacks are 15% above the similarly adjusted white rate (157 vs. 139/1,000). A higher proportion of blacks are found to live in communities with high levels of hospitalization. Importantly, these high levels of hospitalization are experienced by both white and black populations of the service areas. On average, the black population within a community uses 22% more

hospital care than the white population of the same community. Socio-economic differences affect white use rates significantly but do not influence black hospitalizations. The authors were unable to associate either absolute or relative levels of black use to community size, percent black in the community, or supply of physicians or beds. White and black populations with the same morbidity and socio-economic scores did not differ significantly in their use of hospitals. Considering all of the evidence, substantial progress appears to have been made in Michigan in reducing the effect of race as an explanatory variable of hospitalizations.

SUMMARY

Based on the review and critique of the literature dealing with small-area analysis, it is strongly suggested that an alternative conceptualization to the popular plurality methodology of Wennberg *et al* is needed. In particular, a method that can overcome the geographical flaws of the plurality approach. Further, epidemiological concerns, such as age, urban-rural residence, socio-economic status, and large-scale geographic patterning of hospital use needs to be included in the analysis. To this end, Chapter III presents the framework and details for this approach.

CHAPTER III

STUDY METHODOLOGY AND PROCEDURES

The various datasets necessary for this ecological study and their sources are presented in this chapter. In addition, the methodologies adopted for the creation of some variables are discussed.

GEOCODING ACCORDING TO 5-DIGIT POSTAL CODES

The 5-digit postal code (ZIP) forms the spatial quantum of this research. A major survey of ZIP code boundaries in Michigan was undertaken by the U.S. Postal Service in 1975–76. Assistance was provided by the Michigan Acute Care Bed Need Methodology Project, supported by Blue Cross of Michigan, and the Michigan Department of Public Health. Financial support was provided by Federal Hospital Trust Funds. Questionnaires were mailed to all post masters and the routes taken by each mail delivery person were transferred to large-scale maps. This survey represents the most recent attempt to obtain highly accurate ZIP boundaries. Because the boundary of a ZIP code is effectively that region covered by a mail delivery person and has no legal basis, unlike county or MCD boundaries, they change without formal notification. In addition, as development proceeds in an area, so the ZIP code areas become smaller. Consequently, spatial mapping using ZIP codes that are not based on this survey are suspect and illustrate one of the most problematical issues in small area analysis research.

COMPUTER MAPPING

Due to the large number of ZIP codes demarcated in Michigan, the only feasible way of producing maps depicting hospital utilization patterns is to use digital (computer) mapping techniques. ZIP code maps at a scale of 1:168,960 are available and form the basis of all mapping used in this study. A total of 1,743 postal codes with five rubrics were identified by the 1975–76 survey. Before these maps could be digitized, a collapsing process to place all post office boxes and small inner city ZIP code areas into larger ones took place. This procedure effectively reduced the 1,743 ZIPs recognized by the Postal Service to 668 ‘mappable’ ones that could be efficiently portrayed on a map. Every Postal Service map, as described in the section above, showing the accurate postal route for each of the 668 ZIP codes was digitized and stored according to the point-dictionary methodology (Peucker and Chrisman, 1975, pp. 58–59). Conversion to an entity-by-entity structure (*Ibid.*, pp. 57–58) followed for input to the *MapMaker*® (1990) computer mapping package. The digital basemap used throughout the study and shown in Figure 3.1 is geo-rectified to latitude and longitude so that linear distances can be accurately measured. The location of major cities and towns in Michigan are displayed in Figure 3.2 to assist in orienting the ZIP map (Figure 3.1).

SOURCES AND CHARACTERISTICS OF THE DATA

Urban-Rural Residence:

An urban-rural stratification of both patients (discharges) and population by ZIP code is desirable due to the well established understanding that people resident in these two settings are characterized by quite different mortality and morbidity profiles and most importantly, age structure and social class. No well accepted definition of what constitutes urban or rural residence is available, either at the county or postal code level. The most

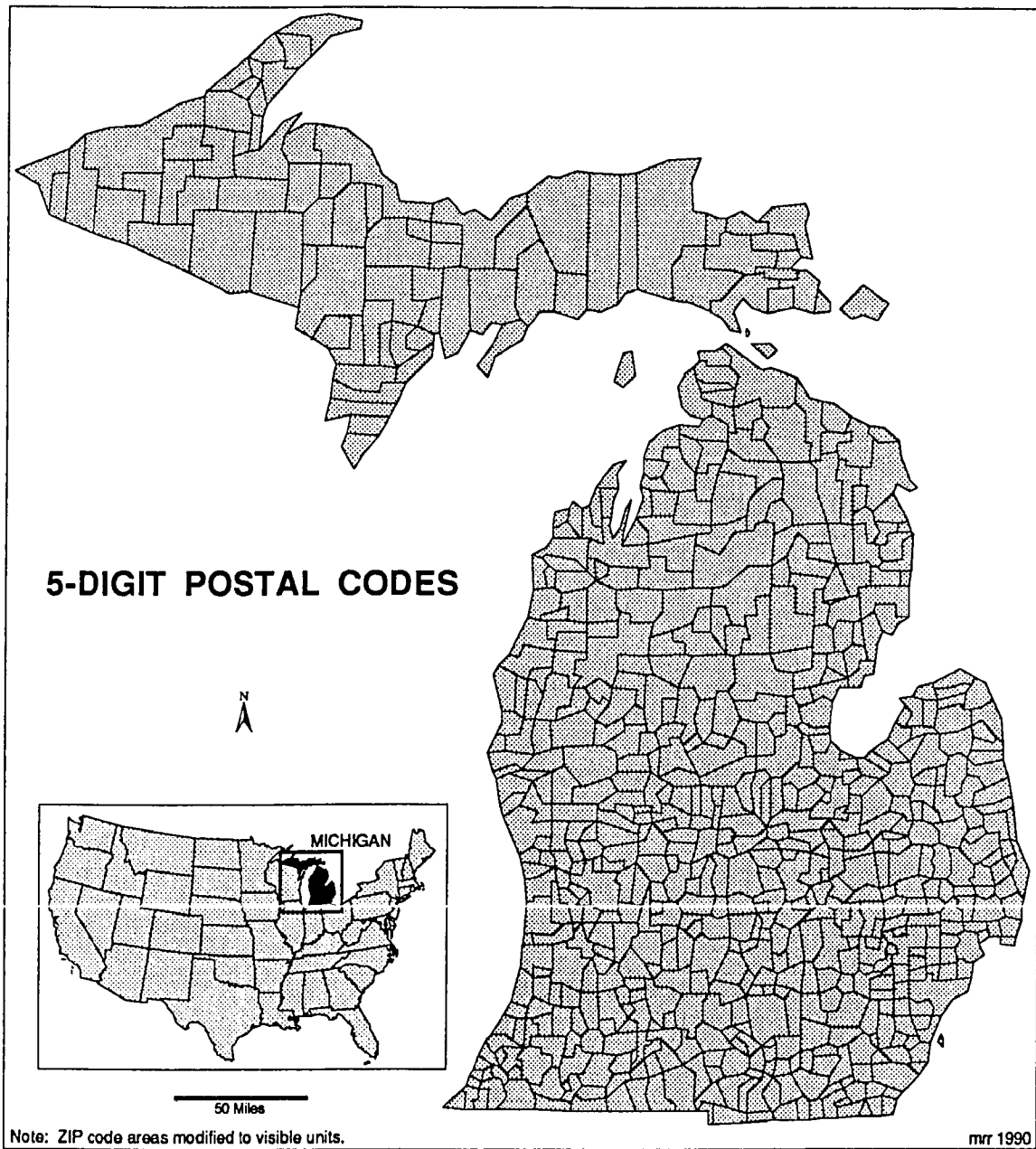


Figure 3.1: Visible 5-Digit ZIP Codes in Michigan.

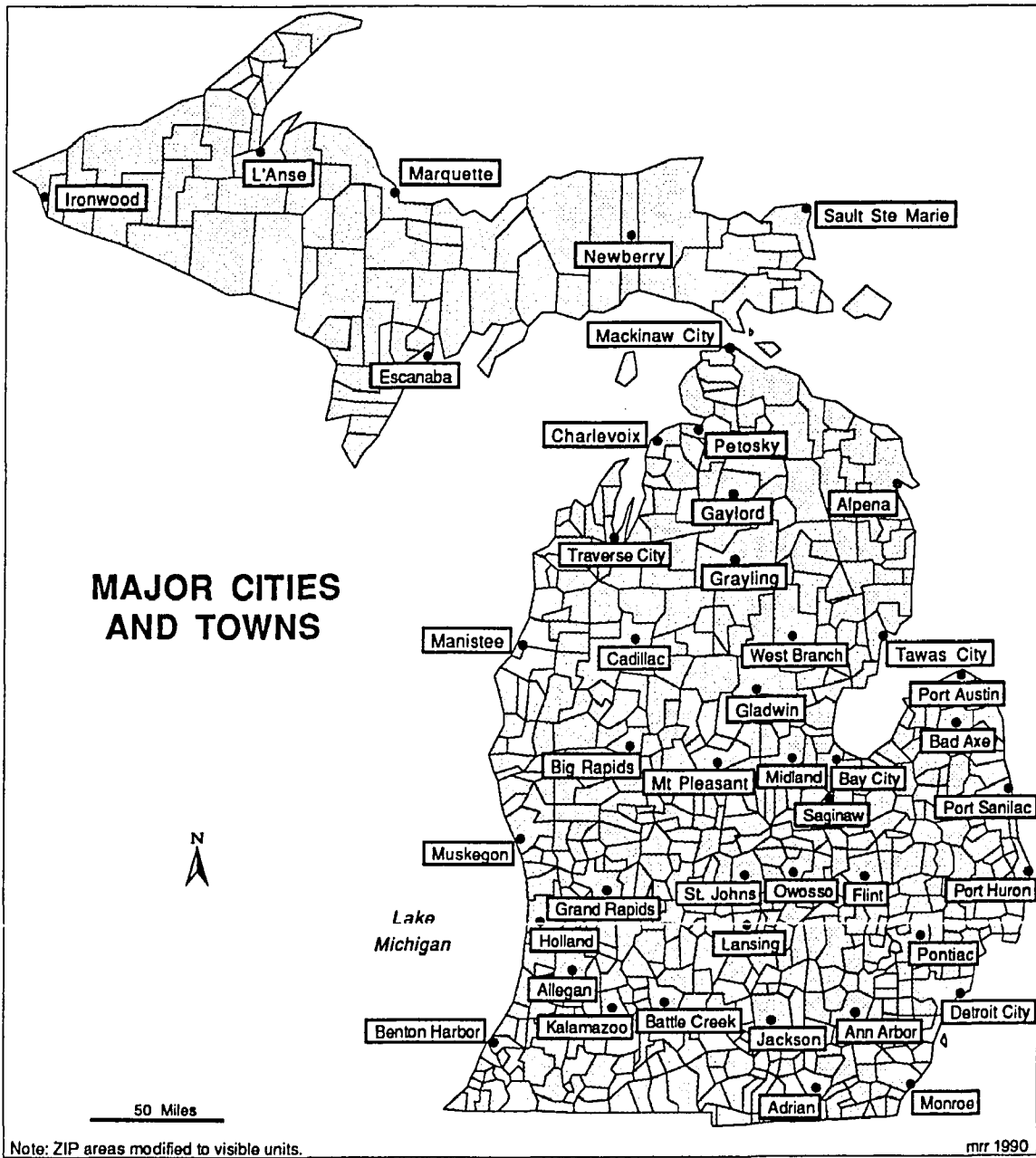


Figure 3.2: Location of Major Cities and Towns Relative to Visible 5-Digit ZIP Codes.

commonly used classification is that based upon the U.S. Bureau of the Census (1980) definition; any area with less than 2,500 persons is defined as rural. Counties are thought of as urban if the population of the county that resides in areas of 2,500 people or more, divided by the total population of the county, exceeds 50%. All other counties are therefore rural. Figure 3.3 maps the distribution of counties that are designated as Standard Metropolitan Statistical Areas (SMSAs) and urban or rural. Over half (N=45; 54.2%) of the 83 counties are defined as rural. The statewide primary health care plan that is based on counties is a recent example of the adoption and use of this definition in Michigan (Michigan Primary Care Association, 1990, pp. 10–11).

The categorization process employed here, however, uses a multi-level decision rule system in an attempt to improve on the Census Bureau's definition. Using an IBM mainframe computer version of the *ARC-Info*® (1987) geographic information system, the digital ZIP code boundary file and total 1980 population figures were overlaid to produce population densities per square mile for each of the 668 mappable postal codes. ZIP codes are classified as either urban or rural on the basis of the eight criteria shown on the following page:

DECISION RULE	CLASSIFICATION
• In SMSA County classified as urban by 1980 Census and population density greater than 54 persons per sq. mile?	Urban
• In SMSA County classified as urban and population density less than 55 persons per sq. mile?	Rural
• In SMSA County classified as Rural and population density greater than 54 persons per sq. mile?	Urban
• In SMSA County classified as Rural and population density <55 persons per sq. mile?	Rural
• In non-SMSA County classified as Urban with a population <5,000 or a population density <55 persons per sq. mile?	Rural
• In non-SMSA County classified as Urban with a population 5,000+ or a population density 55+ persons per sq. mile?	Urban
• In non-SMSA County classified as Rural with a population 5,000+ or a population density 65+ persons per square mile?	Urban
• In non-SMSA County classified as Rural with a population <5,000 or a population density <65 persons per square mile?	Rural

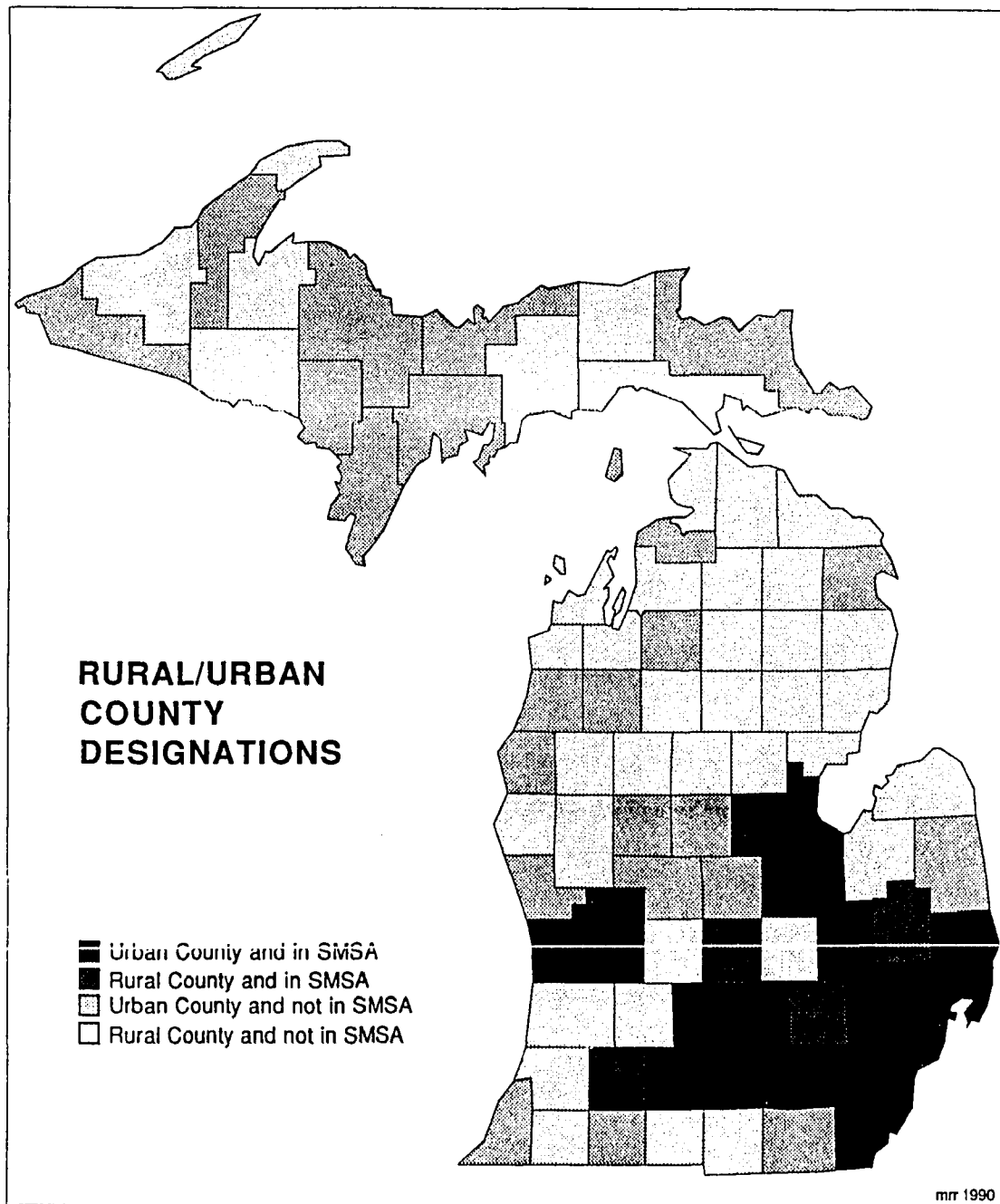


Figure 3.3: Urban and Rural Designations for Counties of Michigan.

The resulting urban-rural map for mappable 5-digit postal codes is shown in Figure 3.4. A total of 303 (45.4%) ZIP codes are classified as having, on average, residents living in an urban setting, while the remaining 365 (54.6%) postal codes are rural in character.

Socio-Economic Status:

In order to stratify the ZIP codes of Michigan according to socio-economic class, six variables from the 1980 census were submitted to principal component analysis so that a composite socio-economic status index could be created. Principle component analysis is a commonly used statistical technique for determining the more important underlying independent dimensions of a multivariate dataset (parsimony). The technique can be used to study the correlation structure of multiple observations by providing clues through the component loadings as to which of the variables best describe the independent trends in correlation. Here, Q-mode factor analysis, where the focus is on the variation of groups, is employed to discern order and regularity in a dataset containing 668 ZIP codes (observations) and six variables describing socio-economic conditions. The following six variables were extracted for each ZIP code:

- Poverty — The percentage of persons with a 1979 income less than 150% of the Federally-defined poverty level;
- Income — Median family income (in dollars);
- Housing — Percentage of housing stock constructed prior to 1940;
- Family Unity — The percentage of families with unrelated children under 18 years of age;
- Education — Percentage of persons 25 years of age and older with less than a 12th grade schooling; and
- Unemployment — The percentage of males 16 years of age and older unemployed within the civilian and military sectors.

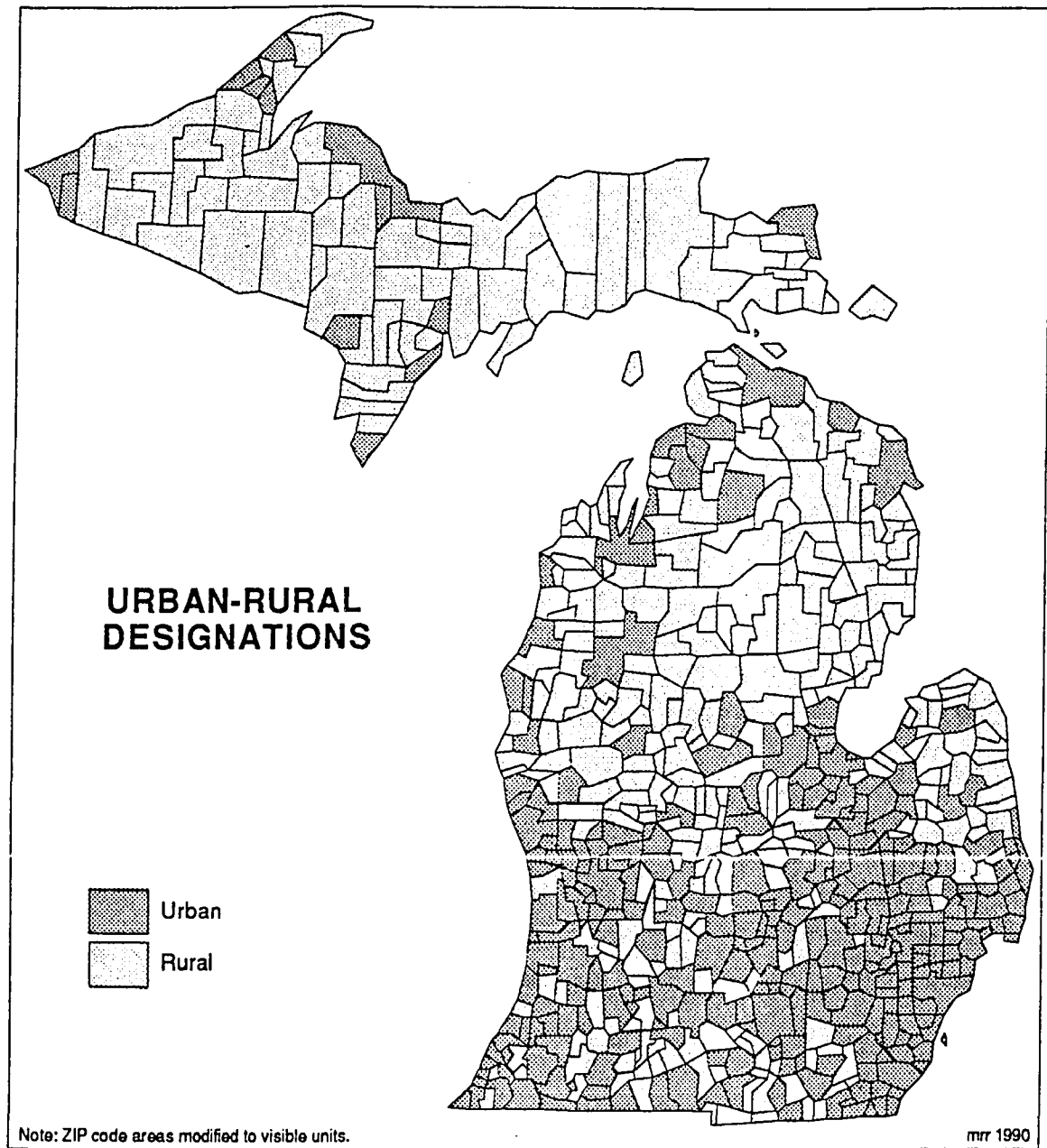


Figure 3.4: Urban and Rural Designations for 5-Digit Postal Codes.

The selection of variables here is more extensive, yet similar to a study conducted between 1966–67 in New Haven, Connecticut, that performed social area analyses for relating health and census data within a health information system framework (Siker *et al.*, 1972, pp. 59–60). Socio-economic status is often defined in terms of some form of income, or lack of it. Here, the selection of variables is broad taking into account the varied character of ‘poverty’ and recognizing that social class is much more than a difference in income.

The entire dataset containing 668 observations and six variables was factor analyzed. A 6 x 6 matrix of Pearson correlations was computed from these data and eigenvalues and eigenvectors of the correlation matrix derived. The eigenvectors are scaled by the square root of the corresponding eigenvalue to produce a matrix of component loadings. Figure 3.5 shows the resulting six factors plotted according to the value of the latent roots. One factor was significant (using the Kaiser (1974) statistic of eigenvalue > 1.0), accounting for a large proportion of the variance, and about three lesser ones of declining importance, with the remainder essentially containing noise. The actual values of these eigenvalues is given in Table 3.1.

The unrotated factors successively define the most general patterns of relationships in the data, whereas the rotated factors delineate the distinct ‘clusters’ of relationships that exist. Orthogonal (varimax) rotation was performed to yield more specific (and interpretable) components. The first component accounts for 35.4% of the total variance ‘explained’ by these six uncorrelated (independent) combinations of the original variables. The remaining components account for a further 18.3%, 18.2%, 17.1%, 8.7%, and 2.4% of the variance, respectively (Table 3.1). The variables are interpreted in terms of the variables that load most heavily on them (i.e., have the highest component loadings, especially above 0.8). The physical meaning of the first component is immediately clear. The component loadings, given in Table 3.1, indicate that ‘socio-economic status’ is well

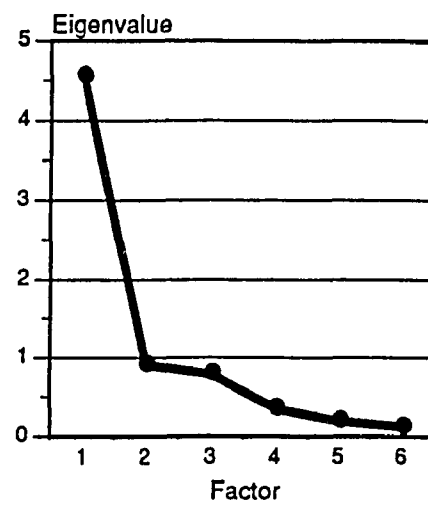


Figure 3.5: Plot of Latent Roots by Factor.

Table 3.1: Latent Roots for Each Factor and
Percent Total Variance Explained.

FACTOR	EIGENVALUE	TOTAL VARIANCE EXPLAINED (%)
1	4.549	35.446
2	0.904	18.255
3	0.785	18.211
4	0.347	17.078
5	0.193	8.658
6	0.118	2.352

represented by component-I. Substantial positive loadings on 'Poverty', 'Unemployment', and 'Housing' are observable on this factor (Table 3.2). 'Income' has a large negative loading (-0.835) because as median household income rises so the Factor score declines. Consequently, component-I is considered to represent an overall composite index of 'socio-economic' well-being — referred to as socio-economic status (SES) throughout this research — for the 668 postal codes.

The 668 factor scores of the first component were standardized, having a mean of zero and a variance of one (minimum= -3.593 ; maximum= 5.042), and divided into four groups according to natural breaks that closely approximated quartiles. According to this scheme, four 'socio-economic status' categories are identified namely, (i) 'High' (N=169, 25.2%); (ii) 'Middle' (N=166, 24.9%); (iii) 'Low-1' (N=173, 25.8%); and (iv) 'Low-2' (N=160, 24.1%). Figure 3.6 maps the distribution of SES for each postal code throughout the State.

Additionally, the two SES variables that loaded most heavily on Factor-I, namely 'Poverty' and 'Income' (refer to Tables 3.3 and 3.4), are tested statistically to ensure the integrity of the urban-rural and statewide stratifications by socio-economic status. Figures 3.7 and 3.8 diagrammatically depict the descriptive statistics (minimum, maximum, mean, standard deviation, and range) for each variable, namely median family income (in dollars) and percent of population under 150% of the Federal poverty level, by residence and SES. The upper and lower quartile intervals for these variables are mapped in Figures 3.9 and 3.10. Residential setting (urban-rural) is statistically very significant ($p < 0.0001$) with regard to SES for both variables (Tables 3.3 and 3.4). Bonferroni Post-Hoc T-test procedures indicate that each socio-economic stratum differs significantly from all other strata at the $\alpha < 0.05$ level, with the exception of the urban Low-1 and Low-2 categories of Median Family Income which are not statistically different. In other words, the Median

Table 3.2: Rotated Factor-I Loadings.

SOCIO- ECONOMIC VARIABLE	DEFINITION	ROTATED LOADINGS
Poverty	Percent under 150% of Federal poverty level	0.918
Income	Median family income (\$).	— 0.835
Unemployment	Percent unemployment.	0.656
Housing	Percent constructed prior to 1940	0.593

Table 3.3: Descriptive Statistics for Median Family Income by Residential Setting and Socio-Economic Status.

SOCIO-ECONOMIC STATUS	NUMBER OF ZIP CODES	DESCRIPTIVE STATISTIC	RESIDENTIAL SETTING		MICHIGAN
			URBAN	RURAL	
Median Family Income (\$):					
High	169	Minimum	18,359	19,375	18,359
		Maximum	54,174	27,755	54,174
		Mean	26,104	22,110	25,267
		St. Dev.	5,357	2,476	5,131
Middle	166	Minimum	15,417	12,961	12,961
		Maximum	28,036	23,990	28,036
		Mean	21,336	19,149	20,354
		St. Dev.	2,642	2,348	2,732
Low-1	173	Minimum	14,092	10,590	10,590
		Maximum	23,348	22,962	23,348
		Mean	18,318	16,237	16,984
		St. Dev.	1,786	2,130	2,440
Low-2	160	Minimum	12,616	5,750	5,750
		Maximum	19,830	19,250	19,830
		Mean	16,145	13,513	13,888
		St. Dev.	2,027	2,158	2,339
Michigan	668	Minimum	12,616	5,750	5,750
		Maximum	54,174	27,755	54,174
		Mean	22,601	16,364	19,135
		St. Dev.	5,202	3,576	5,219
			F=79.51 p<0.0001	F=203.79 p<0.0001	F=374.25 p<0.0001

Note:

Bonferroni post-hoc procedures indicate that each socio-economic stratum differs significantly from all other strata at the $\alpha < 0.05$ level, except for the urban Low-1 and Low-2 categories.

Table 3.4: Descriptive Statistics for Poverty Level by Residential Setting and Socio-Economic Status.

SOCIO-ECONOMIC STATUS	NUMBER OF ZIP CODES	DESCRIPTIVE STATISTIC	RESIDENTIAL SETTING		MICHIGAN
			URBAN	RURAL	
Less Than 150% of Federal Poverty Level (%):					
High	169	Minimum	3.4	6.0	3.4
		Maximum	19.9	25.7	25.7
		Mean	10.3	13.9	11.0
		St. Dev.	3.9	3.6	4.1
Middle	166	Minimum	7.0	8.0	7.0
		Maximum	24.6	32.5	32.5
		Mean	16.1	18.6	17.2
		St. Dev.	3.6	4.2	4.0
Low-1	173	Minimum	16.1	13.2	13.2
		Maximum	29.3	43.8	43.8
		Mean	22.4	25.3	24.2
		St. Dev.	3.4	4.2	4.3
Low-2	160	Minimum	19.2	22.3	19.2
		Maximum	40.0	77.8	77.8
		Mean	29.9	34.0	33.5
		St. Dev.	6.2	7.0	7.0
MICHIGAN	668	Minimum	3.4	6.0	3.4
		Maximum	40.0	77.8	77.8
		Mean	15.6	26.1	21.4
		St. Dev.	7.0	8.9	9.6
			F=213.09 p<0.0001	F=221.68 p<0.0001	F=630.56 p<0.0001

Note:

Bonferroni post-hoc T-test procedures indicate that each socio-economic stratum differs significantly from all other strata at the $\alpha < 0.05$ level.

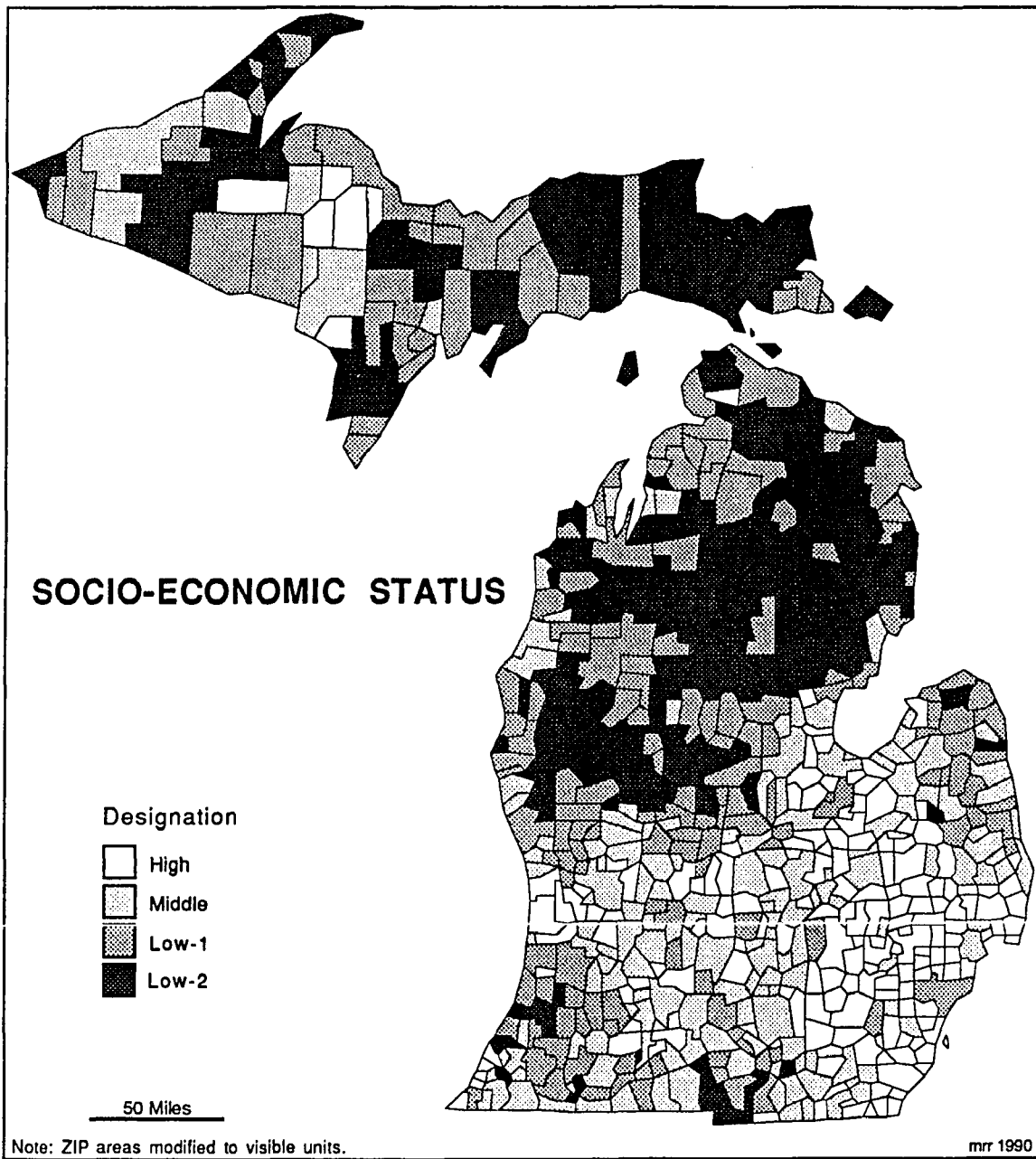


Figure 3.6: Socio-Economic Status Designations for 5-Digit Postal Codes.

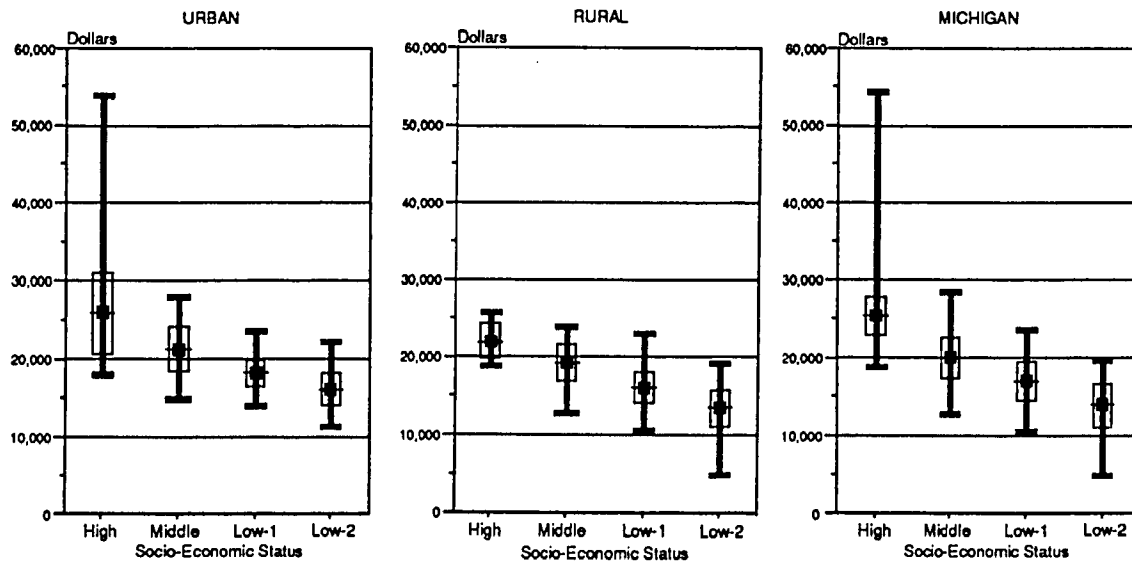


Figure 3.7: Under 150% of Federal Poverty Level.

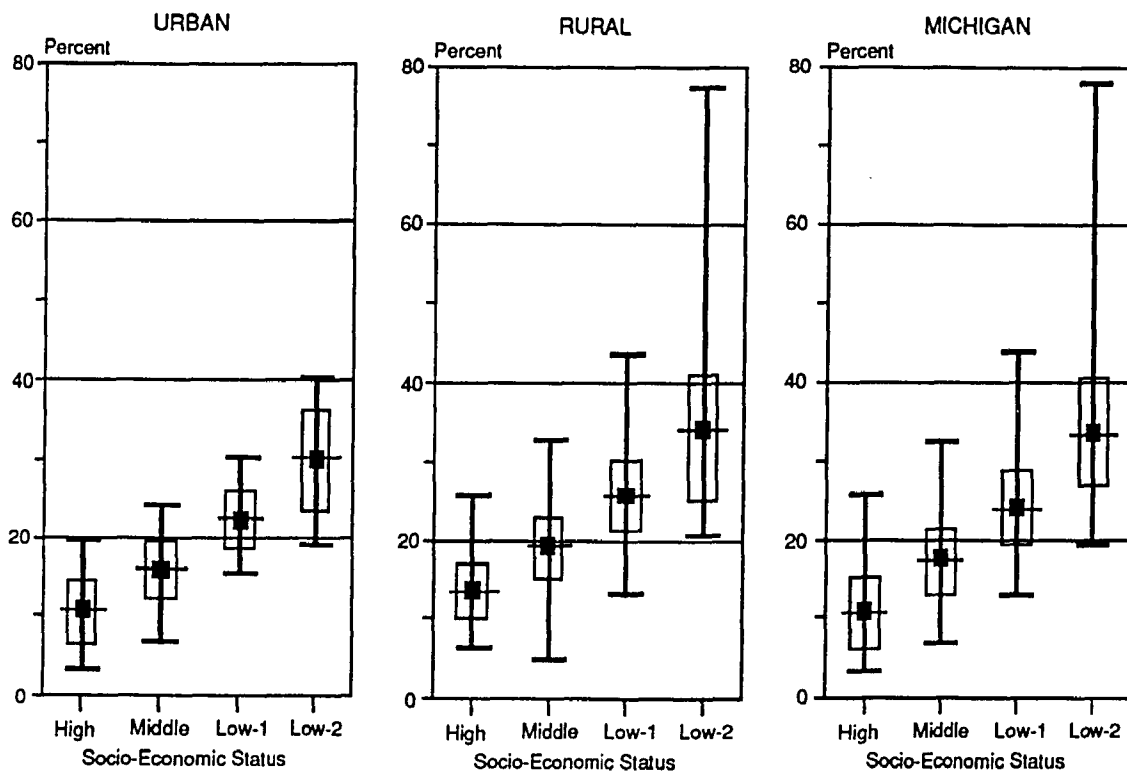


Figure 3.8: Median Family Income.

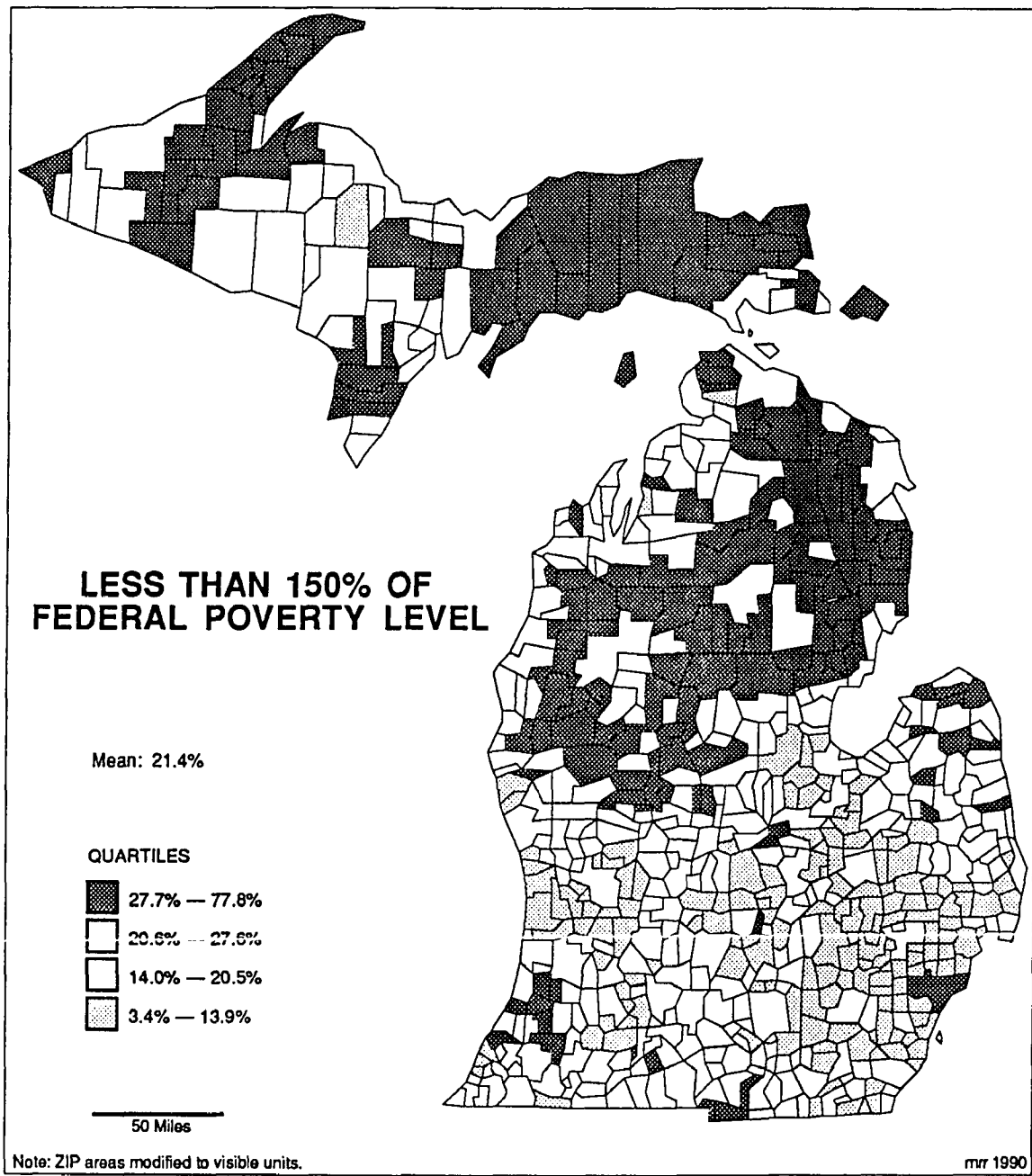


Figure 3.9: Less Than 150% of Federal Poverty Level.

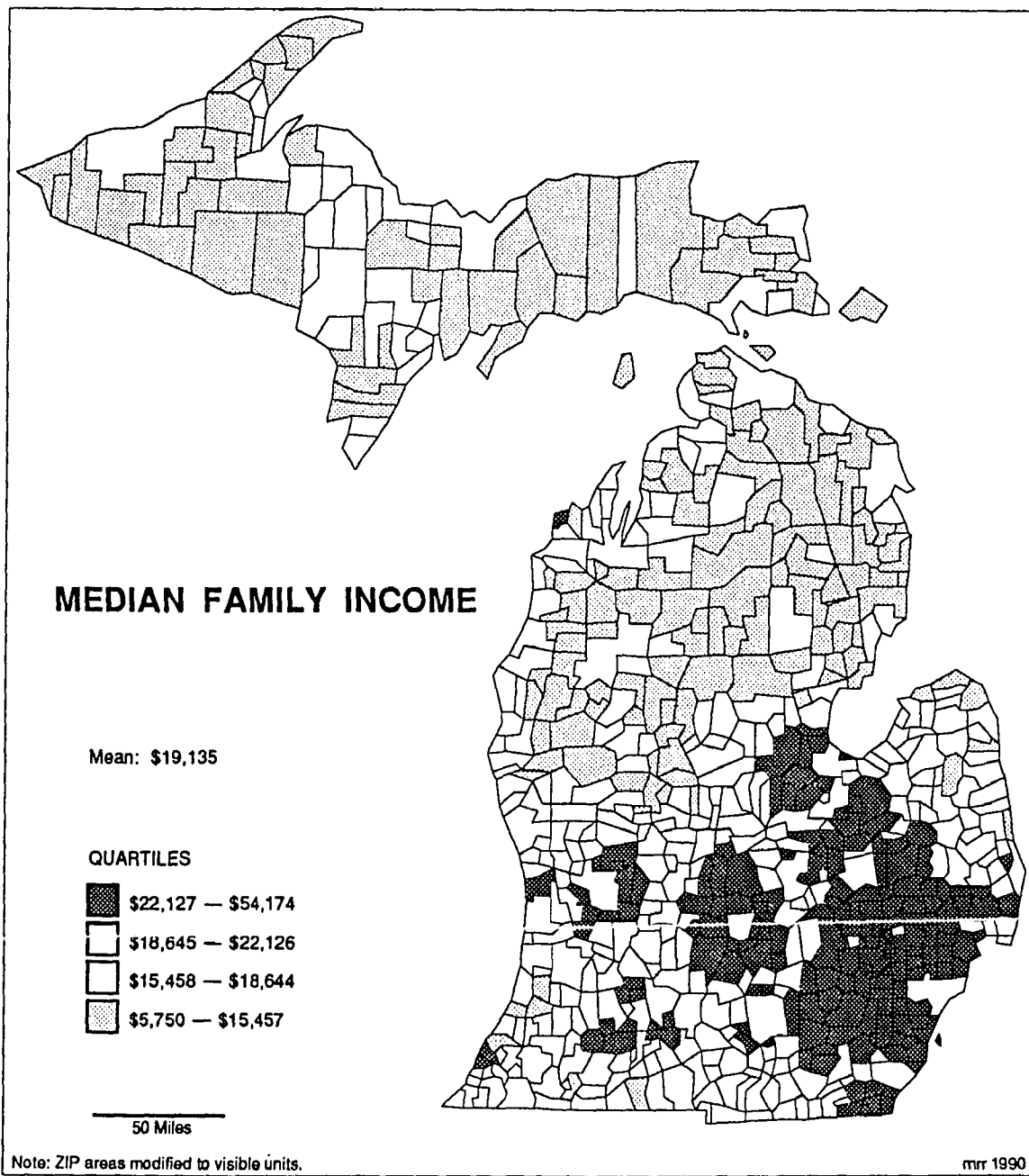


Figure 3.10: Median Family Income by ZIP Code.

Family Income variable differentiates SES appropriately in the sense that High SES has a statistically larger median income than the Middle group; and the Middle has a higher income than Low-1; and Low-1 is higher than Low-2, except in the urban residential setting where Low-1 and Low-2 are not statistically different. Consequently, because the strict ordering of SES by Median Family Income is consistent with the Principal Component Analysis, this provides evidence of the efficiency of the single factor (I) to describe SES. In a similar fashion, the strict ordering of the High, Middle, Low-1, and Low-2 SES groups when stratified on the 'Poverty' variable, provides additional evidence of the efficiency of the single SES factor identified. Thus, the single factor SES is used to control for socio-economic differences and to stratify hospital discharges throughout this study. Figure 3.11 shows the distribution of 5-digit postal codes according to the definitions of urban-rural residence and socio-economic status defined in the preceeding two sections. The majority of the 303 urban postal codes display High socio-economic characteristics (N=132; 43.6%). These 132 urban High socio-economic ZIP codes comprise fully 78.1% of all areas within the High category (N=169). The frequency of urban ZIP codes steadily drops with declining socio-economic status such that only 19 urban ZIP codes (6.3%) are represented within the Low-2 category. The reverse trend is true for rural ZIP codes. Most of the 365 rural ZIPs are Low-2 in socio-economic character (N=141; 38.6%); accounting for 88.1% of all Low-2 areas.

Demography:

The age- and gender-specific population figures for April 1, 1980, by 5-digit postal ZIP code were extracted from the 1980 National Census Summary Tape File-3B dataset available from the Bureau of the Census, U.S. Department of Commerce (1980). Data by race is not available on this ZIP coded file, unlike those at the County, Minor Civil Division, and Census Tract levels. Hence, the denominator figures that are used to produce community hospital use rates are based on actual counts and not on projected

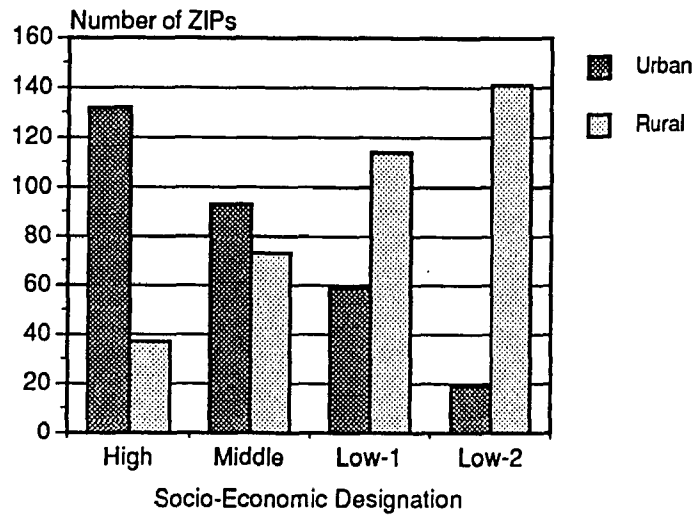


Figure 3.11: Number of 5-Digit Postal Codes According to Residence and Socio-Economic Status.

figures as used in a number of previous studies. Four age groups are analyzed: (i) Pediatric (<15 years), (ii) Adult (30–44), (iii) Older Adult (65+), and (iv) All Ages. Using the definitions of residence and socio-economic status defined above, population counts by these categories and age group are tabulated in Table 3.5 (also see Appendix A). Of the 9,255,008 persons enumerated in the 1980 census, 89.9% (8,322,746) live in an urban environment and 10.1% (N=932,262) in a rural setting. The proportion of people within each socio-economic status category is shown in Figure 3.12. The vast majority of the High socio-economic population are urban residents (N=3,556,749; 97.2%); the remainder being rural (N=98,021; 2.8%). This proportion of urban to rural population declines with decreasing socio-economic status (refer to Figure 3.12). A crossover occurs within the Low-2 socio-economic category where rural residents outnumber their urban counterparts by 1.7:1. Consequently, there are more very poor people of all ages living in a rural setting than in an urban environment (N=325,103 vs. N=212,840). In addition, the number of people within each socio-economic category and residence group as a percent of the total is diagrammatically portrayed in Figure 3.13. The largest number of urban ZIPs (N=132) characterized by High socio-economic status contain 37.4% of the total population. On the other hand, the number of people resident in rural postal codes rises continuously from a low 1.1% (N=98,021) in the High socio-economic status category to 3.5% (N=325,103) in the Low-2 group. Two maps show the distribution of urban and rural ZIP codes (populations) according to socio-economic status (Figures 3.14 and 3.15). The marked concentration of urban ZIPs in the southern half of the lower peninsula is visible, with the obverse for the rural group. In addition, High socio-economic ZIP codes are clustered in the south-eastern portion of the State with few areas in the northern lower peninsula and the Upper Peninsula. In the age groups under 15 years and over 64 years there is a larger number of rural poor (category Low-2) than is the case with the adult population (30–44 years) and All Ages (Figure 3.16).

Table 3.5: Population by Residence, Socio-Economic Status, and Age Group.

URBAN- RURAL RESIDENCE	SOCIO- ECONOMIC STATUS	POPULATION			
		<15	30-44	65+	ALL AGES
Urban	High	801,042	698,604	285,773	3,458,728
	Middle	497,624	386,554	189,653	2,009,026
	Low-1	632,661	454,894	295,233	2,642,152
	Low-2	46,322	31,845	22,963	212,840
	Total	1,977,649	1,571,897	793,622	8,322,746
Rural	High	26,278	24,740	9,237	98,021
	Middle	55,172	54,418	24,569	215,708
	Low-1	71,890	71,221	39,152	293,430
	Low-2	80,118	79,679	44,203	325,103
	Total	233,458	230,058	117,161	932,262
Michigan	High	827,320	1,003,346	295,010	3,556,749
	Middle	552,796	617,939	214,222	2,224,734
	Low-1	704,551	820,671	334,385	2,935,582
	Low-2	126,440	156,926	67,166	537,943
	Total	2,211,107	2,598,882	910,783	9,255,008

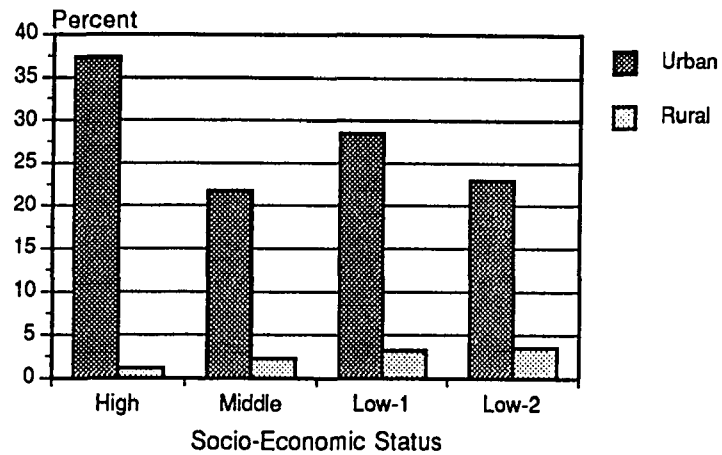


Figure 3.12: Population (All Ages) by Residence Within Each Socio-Economic Category.

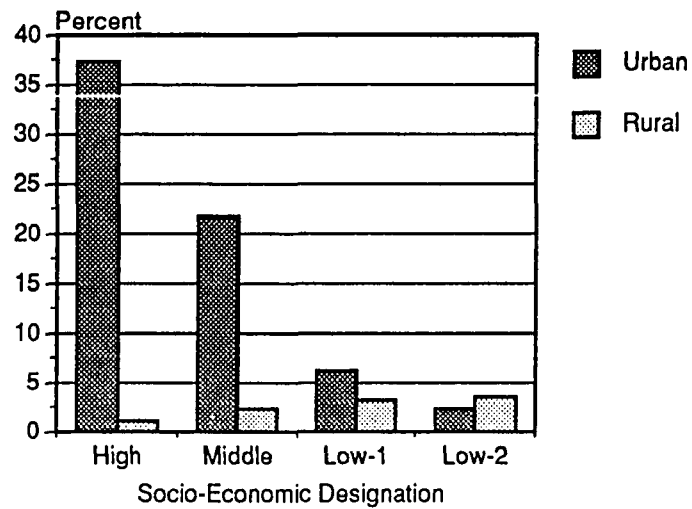


Figure 3.13: Percent Total Population (All Ages) According to Residence and Socio-Economic Status.

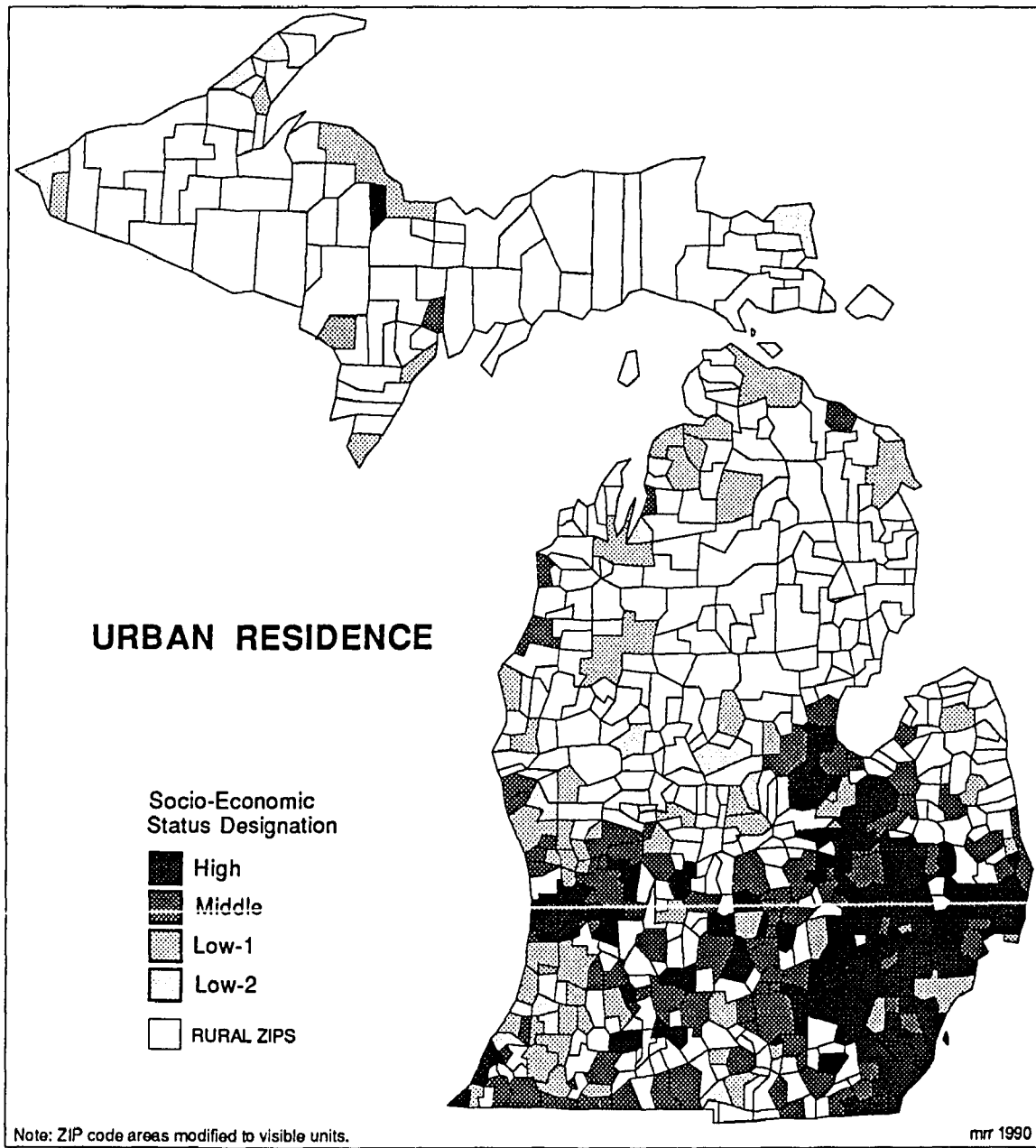


Figure 3.14: Population Residing in Urban ZIP Codes by Socio-Economic Status.

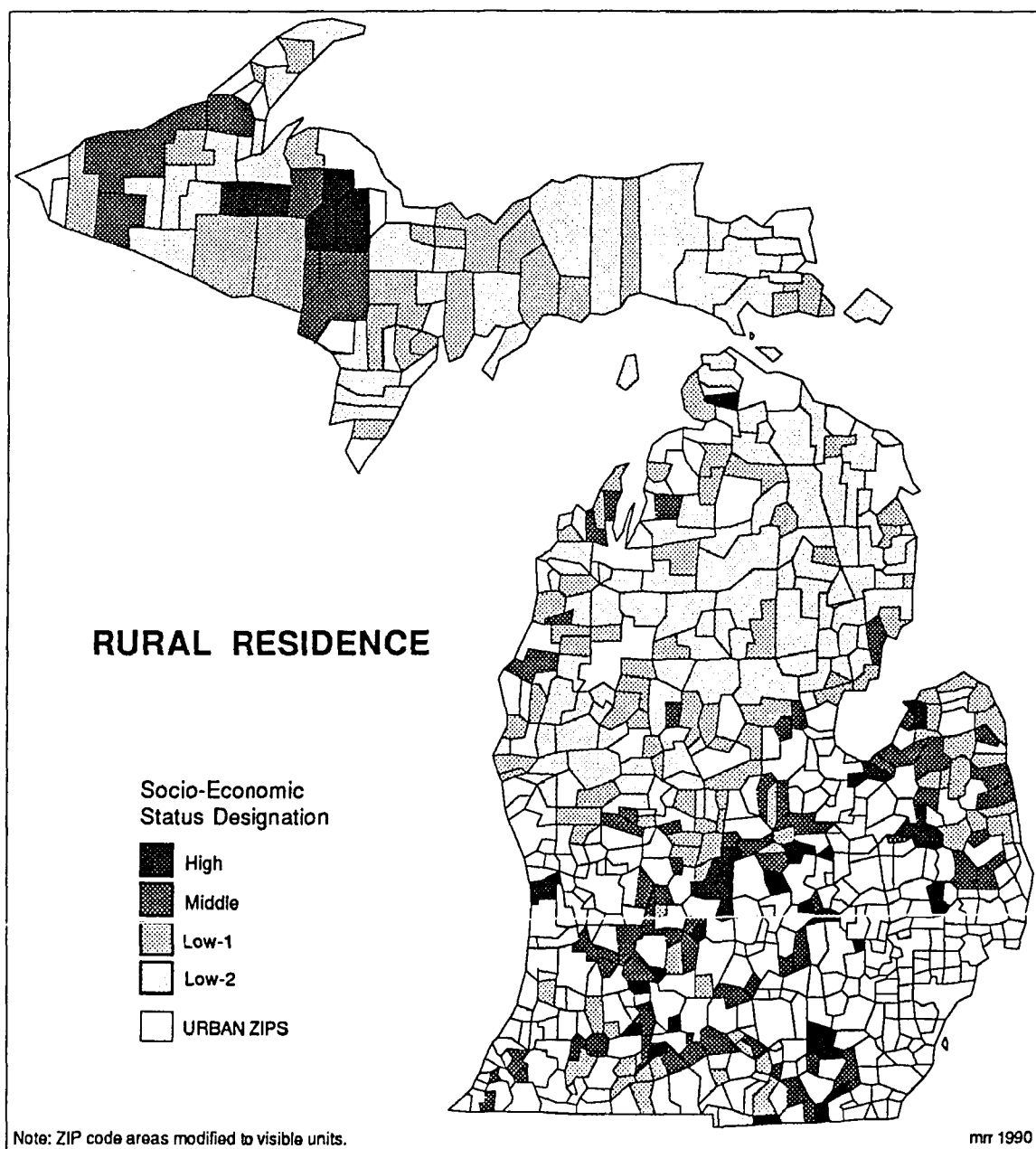


Figure 3.15: Population Residing in Rural ZIP Codes by Socio-Economic Status.

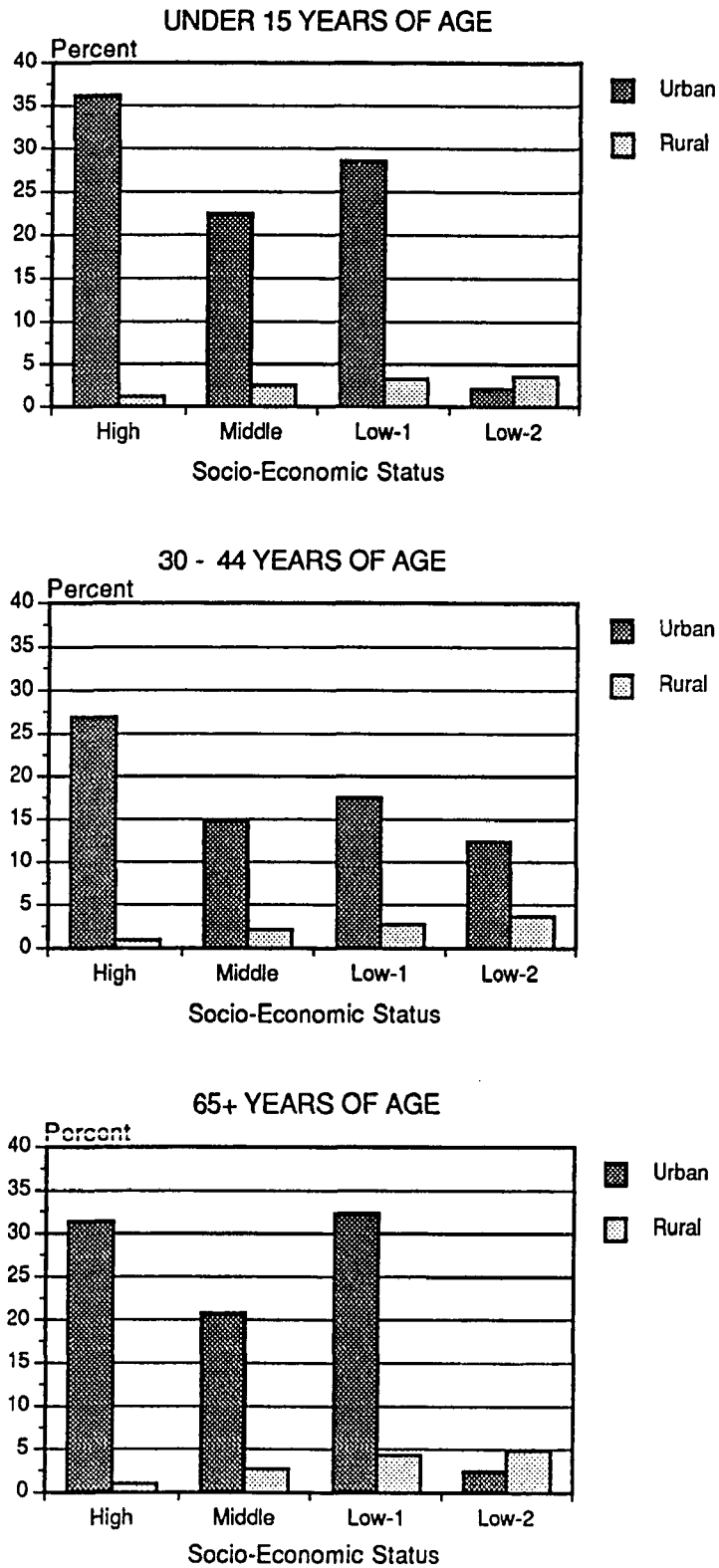


Figure 3.16: Age-Specific Population Groups According to Residence and Socio-Economic Status.

Hospital Patient Discharge Data:

The number of patient discharges¹ for non-obstetrical medical and surgical diagnoses is used as a measure of the use of general hospital facilities. To date, data pertaining to patient admissions² and discharges to community hospitals in Michigan have not been made available other than for aggregations of three or more hospitals. Consequently, no individual hospital has been able to be analyzed or compared with other similar institutions. In addition, ZIP-specific information has likewise not been available. The reasons are purported to be, first and foremost, an attempt to preserve patient confidentiality, and secondarily to protect a hospital from its competition. Whilst this study analyses hospital discharges in terms of five-digit ZIP codes, the aggregated nature of the dataset ensures that any breach of patient confidentiality is not possible.

Hospitals in Michigan voluntarily and routinely submit patient discharge data to the Michigan Health Data Corporation, a consortium of 14 groups from the public and private sectors involved in health care provision, financing and policy. Initial funding to create this database was provided by the W. K. Kellogg Foundation. These data are supplemented through cooperative arrangements with adjacent states enabling the capture of virtually all hospital use by the population — approximately 10 million people.

The Patient Origin and Hospital Use Study (POHUS) undertaken by the Michigan Health Data Corporation collected uniform hospital discharge abstracts of every patient

¹ Patient: is a person who is formally admitted to the inpatient service of the hospital for observation, care, diagnosis, or treatment.

Hospital Discharge: is defined as the completion of any continuous period of stay of one night or more in a hospital as an inpatient, excepting the period of stay of a well newborn infant.

² Admission: The number of patients, excluding newborns, accepted for inpatient service during the reporting period.

from all community hospitals³ in Michigan during the 1980 calendar year. The location of each community hospital is shown in Figure 3.17. In addition, Michigan residents who were discharged from hospitals in adjacent States (Indiana, Illinois, Ohio, and Wisconsin) were also included, as were non-resident patients who were discharged from Michigan hospitals. Only patients discharged from community and non-Federal (that is not owned by the Government, Veterans Administration, or Armed Forces) hospitals are included, while discharges from speciality facilities such as psychiatric nursing homes or long-term care institutions are excluded. However, five community hospitals located in the Upper Peninsula submitted incomplete data and a sample had to be extracted and extended to cover the entire 1980 calendar year. In those cases where patient abstracts were missing according to the hospital's own count of discharges, existing records were replicated to restore the total. Replication reached three-fourths of the year's discharges for some small hospitals not routinely preparing discharge abstracts and for one larger hospital which moved in mid-year. This hospital inpatient utilization dataset represents the most complete patient origin file ever compiled in Michigan. Estimates of accuracy and completeness range between 90% and 95% (Stanley Nash, Michigan Department of Public Health, *pers comm*). The entire file contains approximately 1.49 million individual discharge abstracts and provides a rich source of data for patient origin studies.

The data made available for this study are aggregated and sorted by ZIP code within hospital, thereby reducing the total 1.49 million abstracts to 33,893 agglomerated records. Hence, the dataset is an aggregated one and does not provide patient-specific information.

³ Community hospitals: All non-federal short-term general and other special hospitals, excluding hospital units of institutions, whose facilities and services are available to the public (American Hospital Association, 1981, p. ix). A short-term hospital is one in which the average length of stay is less than 30 days or in which more than 50% of all patients are admitted to units where the average length of stay is less than 30 days.

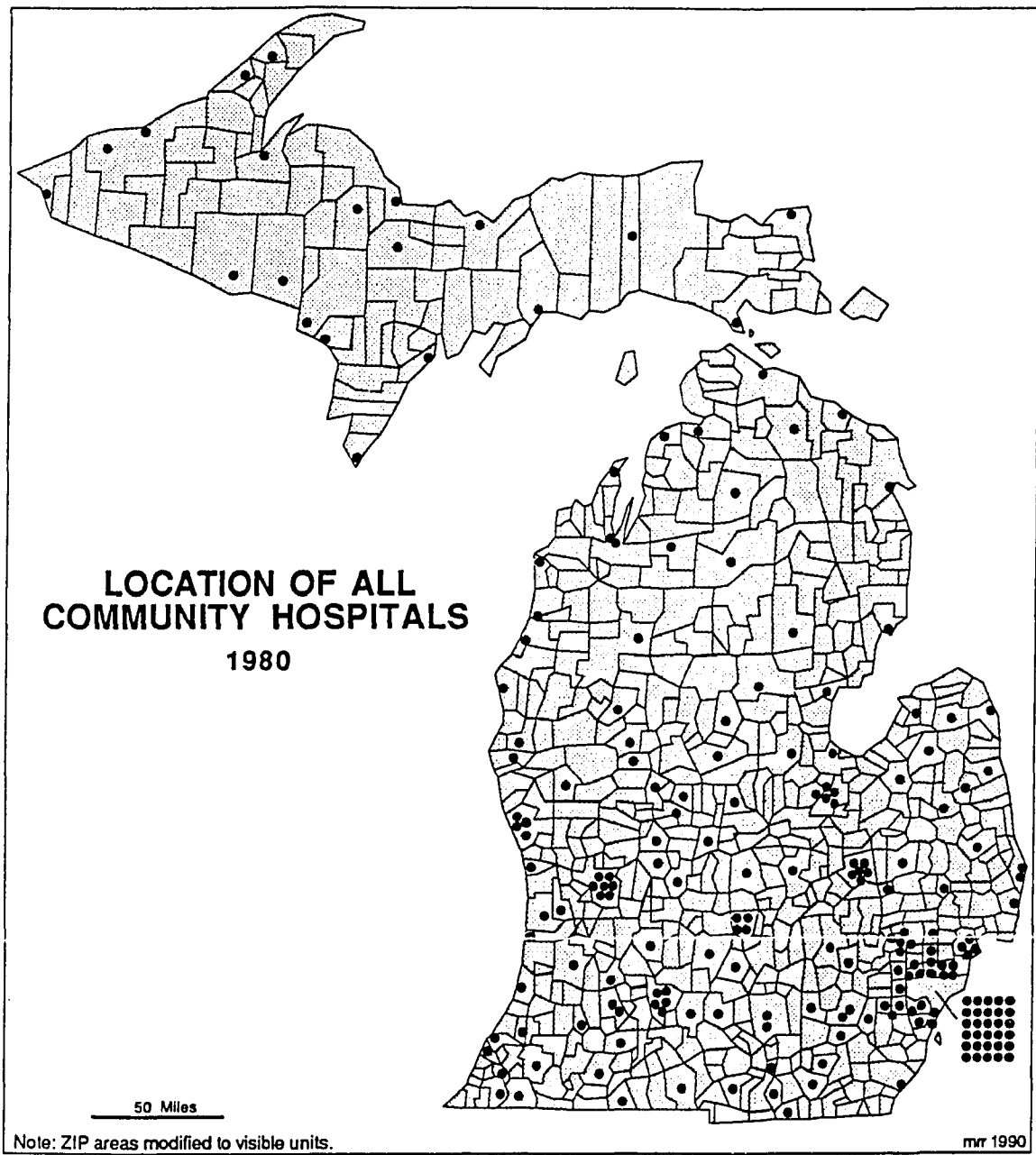


Figure 3.17: Location of Community Hospitals in Michigan, 1980.

Every community hospital is listed individually regardless of the number of patients. This means that the data are specific for each community hospital and all patient discharges from a common ZIP code are aggregated together. For each five-digit postal code the data are broken down by age group and gender within hospital service category, namely, medical, surgical, obstetrical (delivered and not delivered), and psychiatric. The terms 'Surgery' and 'Medical' are Commission on Professional and Hospital Activities (CPHA)-defined categories and surgery is distinguished by the absence of surgery procedure codes on the patient discharge sheet. A surgical operation can involve one or more surgical procedures, but is still considered only one surgical operation. The data used in this research were obtained from the Michigan Department of Public Health on a 9-track IBM-formatted computer tape.

Due to the volume of raw data to be analyzed, the aggregate five-digit ZIP-specific and hospital-specific data were stratified according to three age groups: Pediatric (<15 years), Adult (30-44 years) and Older Adult (65+ years of age). A total of 167 (0.03%) medical and 101 (0.15%) surgical patients were of unknown age, but were included in the 'All Ages' category. Population-based discharge rates are calculated for each ZIP by dividing hospital use (discharges) of patients permanently resident within a ZIP by the ZIP code-specific population on an age-specific basis. Overall community use rates for the total population (All Ages) are also computed and age-adjusted to account for differences in age structure between ZIP codes. Age-standardization of the state population is performed using the indirect method (Fleis 1981) by multiplying the age-specific rates by the statewide age fraction of the population, and summing the product over all ages. Gender is not considered in this study — due simply to logistics — but is recognized as an important variable that may assist in the explanation of patterns of use rate variations in future research. The magnitude and extent of random postal coding errors are unknown. This study is also subject to the usual reliability problems of medical records data.

For the purposes of this study only medical and surgical discharges are analyzed and assessed for geographic variation. The quantity of hospital care used by groups of individuals is calculated as a use rate: discharges form the numerator and the population resident in that ZIP code area, the denominator. Patients not permanently resident in the state of Michigan and who received care in community hospitals outside of the state during 1980 are excluded. Table 3.6 itemizes medical and surgical discharges according to residence of the patient. Hence, a total of 560,856 (96.1%) medical and 665,389 (96.8%) of surgical discharges form the subjects analyzed in this study. A detailed enumeration of medical and surgical discharges by residence, socio-economic status and age group is provided in Appendices B and C. Of note is that nearly identical small numbers of medical and surgical patients seek care out-of-state as do those coming into the state (medical: 1.9% vs. 1.9% and surgical: 1.4% vs. 1.8%). A possible explanation for this is that Michigan, the nation's eighth most populous state, is composed of two peninsulas and has a larger proportion of its borders formed by shoreline than any state other than Florida. The state is characterized by urban centers in the south, and sparsely populated rural areas in the remainder of the lower peninsula and in all of the Upper Peninsula. Thus Michigan is medically more self-contained than most states; the use of hospital facilities outside the state is a realistic option only for residents of the state's southern borders with Ohio and Indiana, and the Upper Peninsula's western border with Wisconsin.

PROTECTING FROM THE ECOLOGICAL FALACY

Because this study makes extensive use of aggregate data, at both the patient and geographic levels, care is taken to avoid complications that may arise through the comparison of statistics across differing scales. In other words, reaching causal inferences about individual phenomena on the basis of group observations (Selvin, 1958). Cognizance will be taken of the fact that ecological associations frequently overestimate the

Table 3.6: Patient Discharges from Michigan Community Hospitals During 1980.

PATIENT CATEGORY	MAJOR DIAGNOSTIC CATEGORY		
	MEDICAL DISCHARGES	SURGICAL DISCHARGES	MEDICAL & SURGICAL COMBINED
Michigan Residents (In-State) [1]	560,856	665,389	1,226,245
Michigan Residents (Out-of-State) [2]	11,273	9,509	20,782
Non-Michigan Residents [3]	11,276	12,454	23,730
Total [4]	583,405	687,352	1,270,757

Notes:

1. Michigan residents who were hospitalized in the State.
2. Michigan residents who were hospitalized in another State.
3. Out-of-state residents who were hospitalized in the State of Michigan.
4. All patients discharged from a Michigan community hospital in 1980.

magnitude of effects at the individual level (Morgenstern, 1982; Piantidosi *et al.*, 1988). A way to minimize inferential problems in ecologic studies is to make the groups — in this case areal units — as small as possible by using smaller units of analysis (Oreglia and Duncan 1977). For example, instead of using counties or hospital service areas, postal ZIP codes are used to determine spatial variation.

STATISTICAL SIGNIFICANCE

All statistical tests are performed at the $\alpha=0.05$ level and confidence intervals (CIs) computed at the 95% level unless otherwise specified. Where appropriate, CIs are presented because a confidence interval conveys much more information to the reader than does the result of a significance test (Thompson 1987).

LIMITATIONS OF THE DATA

Because of the very nature and scope of an ecological study such as this, a number of limitations are inherently present in the data and identifiable. First, the patient discharge data are aggregated by hospital and postal code; hence, individual-specific analyses and cross-tabulations are not possible. Second, no racial breakdown is undertaken. There is a markedly uneven distribution of racial groups between urban and rural communities. As such, no meaningful comparisons are possible. Furthermore, data on racial or ethnic groups are unavailable at the ZIP code level in the 1980 census tapes (STF-3B), and are not recorded for the abstracted patient discharge data. Third, no outpatient utilization information is available. However, such use of hospital services was considerably smaller prior to the 1983 introduction of the DRG system. Fourth, any analysis of severity of illness is thwarted due to a complete absence of data pertaining to case-mix in the aggregated hospital discharge datafile. Fifth, a basic assumption in this study is that patient

admission and discharge are the same; however, in reality there is a small difference due to mortality and has a negligible effect on calculated use rates. Lastly, the patient discharge data represent a unique episode count and it is certain that an unknown number of inpatients have been enumerated more than once due to readmission in a given year. It is assumed that the readmission rate is uniform across the state. Therefore, computed discharge rates do not represent absolute rates, but rather relative ones.

CHAPTER IV

RESULTS

The analyses of the data will be presented in this chapter in the following manner. Results specific to each of the two major discharge categories studied will be presented separately and a comparison of medical and surgical discharges will form the third section. Within each section, results are presented according to the following scheme; first, statewide frequencies and rates then according to urban-rural residence, then age groups by residence, followed lastly by socio-economic status and residence, including residence and socio-economic interactions. Research hypotheses under consideration will be stated, with the individual research questions addressed separately, within each appropriate subsection. The presentation of the research question(s), the necessary statistical analyses, and a discussion of the findings as related to the research question will follow. An overall summary of the findings concludes the chapter.

MEDICAL DISCHARGES

Overall:

Total medical discharges for all ages during 1980 are shown in Table 4.1. Overall, the 214 community hospitals generated a combined utilization of 560,856 discharges from a 1980 population of 9,255,008 (Appendix A). The total age-adjusted discharge rate for all medical diagnoses is 60.6 per 1,000 population (Table 4.2). Place of residence is an important distinction to make as 86.9% of all medical discharges are from urban areas with 13.1% rural.

Table 4.1: Total Medical Discharges. Michigan 1980.

RESIDENCE	[1] S.E.S.	MEDICAL DISCHARGES		
		N	% [2]	% [3]
Urban	High	170,988	35.1	30.5
	Middle	118,164	24.2	21.1
	Low-1	184,274	37.8	32.9
	Low-2	14,013	2.9	2.5
	Total	487,439	100.0	86.9
Rural	High	6,321	8.6	1.1
	Middle	15,989	21.8	2.9
	Low-1	24,043	32.7	4.3
	Low-2	27,064	36.9	4.8
	Total	73,417	100.0	13.1
Michigan	High	177,309		31.6
	Middle	134,153		23.9
	Low-1	208,317		37.1
	Low-2	41,077		7.3
	Total	560,856		100.0

Notes:

1. Socio-economic status designation.
2. Percent of group.
3. Percent of total.

Table 4.2: Total Medical Discharges (All Ages).

RESIDENCE	SOCIO-ECONOMIC STATUS	MEDICAL		
		DISCHARGES	POPULATION	[1]
		N	N	Rate
Urban	High	170,988	3,458,728	49.5
	Middle	118,164	2,009,026	59.2
	Low-1	184,274	2,642,152	70.5
	Low-2	14,013	212,840	71.7
	Total	487,439	8,322,746	59.7
Rural	High	6,321	98,021	61.7
	Middle	15,989	215,708	70.4
	Low-1	24,043	293,430	77.0
	Low-2	27,064	325,103	79.1
	Total	73,417	932,262	69.7
Michigan [2]	High	177,309	3,556,749	49.8
	Middle	134,153	2,224,734	60.3
	Low-1	208,317	2,935,582	70.9
	Low-2	41,077	537,943	76.3
	Total	560,856	9,255,008	60.6

Notes:

1. Age-adjusted rate per 1,000 population.
2. An analysis of Michigan as a whole, shows that the SES categories differ significantly ($F=33.38$; $df=3,667$; $p<0.0001$). Using Bonferroni Post-Hoc procedures at $\alpha=0.05$ suggests that each SES stratum differs from the 'High' category and that the 'Low-2' group differs from the 'Middle' category only.

Table 4.3: Analysis of Variance Results for Medical Discharges (All Ages).

SOURCE	df	MEAN SQUARE	F	p-value
Residence ¥	1	9,454.1	12.79	0.0004
Socio-Economic Status §	3	4,083.6	5.52	0.0001
Residence x SES	3	69.8	0.09	0.9631
Error	667	739.4		

Notes:

- ¥ Rural residence is significantly greater than urban (69.7 vs. 59.7)
- § Using the Bonferroni Post-Hoc procedure shows that the 'High' SES stratum differs significantly from each of the other stratum, and that no other pairwise comparison is significant at the $p=0.05$ level or greater.

Research Question 1: Do urban communities have higher medical use rates than their rural counterparts?

Residence differs significantly with hospital use for medical causes (Table 4.3). The rural age-adjusted rate is significantly higher (14%) than that for urban ZIPs (69.7 vs. 59.7 per 1,000; $p < 0.0004$). For Michigan as a whole, these data indicate that rural communities are using hospital inpatient facilities considerably more per capita than urban areas. If hospital utilization, defined here as medical discharges, is considered a surrogate variable for assessing health status, then it must be concluded that rural ZIPs have poorer health than urban ones.

Age Group:

Persons aged 65 years and over comprise 9.8% (910,783) of the population, yet account for 32.5% (182,033) of total medical discharges; this may reflect their greater health care needs (Table 4.4 and Appendix A). On the other hand, the pediatric population, that is children under 15 years of age, make up 23.9% (2,211,107) of the population and have 18.0% (100,563) hospital discharges, whereas the adult group (30–44 years) show a closer correspondence between proportion of total population and hospital use, 18.8% ($N=1,738,926$ people) and 11.9% ($N=66,588$ discharges), respectively.

The general pattern of discharges according to urban or rural residence for all ages outlined above is apparent within each of the age groups under study, namely pediatric, adult, and older adult (Table 4.5 and diagrammatically summarized in Figure 4.1). Within each of the three age groups under study, the percentage of patients from urban ZIPs ranges between 84.8% to 89.0% for adult patients. Statistical tests of equality of residence by age group in Table 4.5 suggests that the urban and rural differentiation is statistically significantly different for all age groups ($p < 0.001$).

Table 4.4: Numbers of Medical Discharges by Residence and Age Group.

AGE GROUP (Years)	RESIDENCE		MICHIGAN
	URBAN	RURAL	
Pediatric (<15)	87,549	13,014	100,563
Adult (30-44)	59,245	7,343	66,588
Older Adult (65+)	154,315	27,718	182,033
All Ages	487,439	73,417	560,856

Table 4.5: Medical Discharges by Residence and Age Group.

RESIDENCE	AGE GROUP (Years):		
	<15	30-44	65+
Urban:			
Number	87,549	59,245	154,315
Population:	1,977,649	1,571,897	793,622
Rate [1]	44.3 ¥	37.7 #	194.4 §
Rural:			
Number	13,014	7,343	27,718
Population:	233,458	230,058	117,161
Rate [1]	55.7 ¥	44.0 #	236.6 §
Michigan:			
Number	100,563	66,588	182,033
Population:	2,211,107	2,598,882	910,783
Rate [2]	45.5	38.3	199.9

Note:

1. Age-specific rate per 1,000 population.
 2. Age-adjusted rate per 1,000 population.
- ¥ Significantly different, $p=0.0049$.
Significantly different, $p<0.0001$.
§ Significantly different, $p<0.001$.

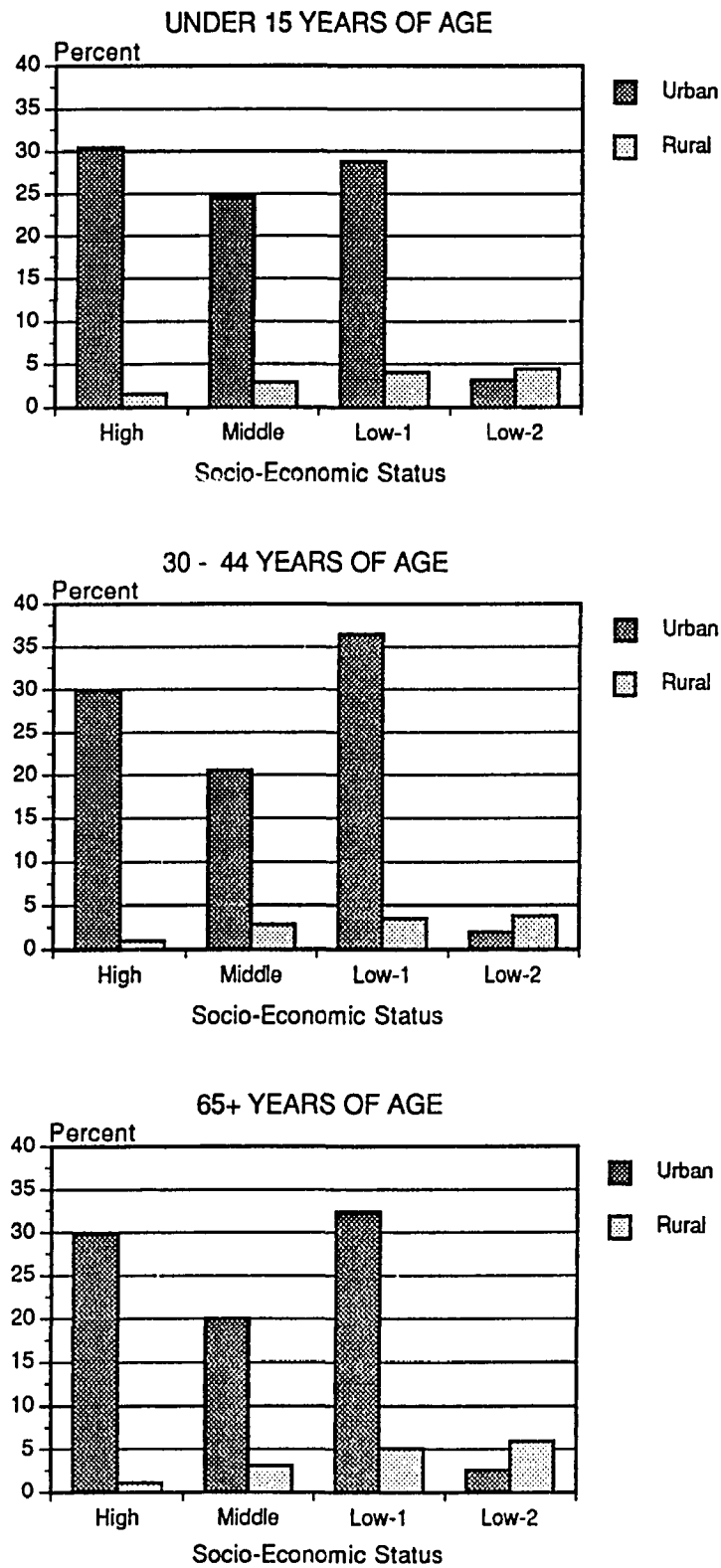


Figure 4.1: Percent of Medical Discharges by Age Group.

Research Question 2: Do rural areas display age-specific medical discharge rates that are lower than those found in urban areas?

It is postulated that medical patients resident in rural ZIPs have less (physical) access to hospital services, as defined in terms of the number of hospitals available and time-distance to those facilities. For each age group, there are significant urban-rural residence differences (Table 4.5). Figure 4.2 shows the higher use rates — consistent in both residence settings — for patients 65 years and older, with the adult discharge rate being slightly less than that for the pediatric group. The older adult discharge rate in urban ZIPs (194.4/1,000) is 18% less than the rural rate (236.6/1,000) a difference that is statistically significant ($p < 0.001$; Table 4.5). Similarly, both pediatric and adult patients exhibit a significant rural increase in hospital utilization; 21% higher for patients under 15 years of age (44.3 vs. 55.7/1,000) and 14% for the adult group (37.7 vs. 44.0/1,000) ($p < 0.001$).

Research Question 3: Do medical discharge rates rise with age, and when controlled for residence?

The age-specific rates for pediatric, adult, and older adult discharges are presented in Tables 4.6; 4.8; and 4.10. As expected, the older adult group seems to display the highest use rate (199.9 per 1,000). However, the pediatric group has the next highest rate (45.5/1,000), followed by 38.3/1,000 for adults. These impressions are statistically verified in Tables 4.7; 4.9; and 4.11 respectively ($p < 0.001$) and shown in Figure 4.2. This pattern is repeated when medical discharges are stratified by residence; medical rates drop slightly from pediatric to adult groups and then rise markedly in the older adult age group, irrespective of urban or rural residence of the population (Table 4.5). All tests for residence by SES interaction are not statistically significant (Tables 4.3; 4.7; 4.9; and 4.11).

Table 4.6: Pediatric Medical Discharges (<15 Years).

RESIDENCE	SOCIO-ECONOMIC STATUS	MEDICAL		
		DISCHARGES	POPULATION	[1]
		N	N	Rate
Urban	High	30,609	801,042	38.2
	Middle	24,780	497,624	49.8
	Low-1	29,001	632,661	45.8
	Low-2	3,159	46,322	68.2
	Total	87,549	1,977,649	44.3
Rural	High	1,553	26,278	59.1
	Middle	2,951	55,172	53.5
	Low-1	4,051	71,890	56.3
	Low-2	4,459	80,118	55.7
	Total	13,014	233,458	55.7
Michigan [2]	High	32,162	827,320	38.9
	Middle	27,731	552,796	50.2
	Low-1	33,052	704,551	46.9
	Low-2	7,618	126,440	60.2
	Total	100,563	2,211,107	45.5

Notes:

1. Age-specific discharge rate per 1,000.
2. An analysis of Michigan as a whole, shows that the SES categories differ significantly ($F=11.28$; $df=3,667$; $p<0.0001$).
Using Bonferroni Post-Hoc procedures at $\alpha=0.05$ suggests that each SES stratum differs from the 'High' category only.

Table 4.7: Analysis of Variance Results for Pediatric Medical Discharges (<15 Years).

SOURCE	df	MEAN SQUARE	F	p-value
Residence ¥	1	6,562.8	7.95	0.0049
Socio-Economic Status §	3	2,507.0	3.04	0.0285
Residence x SES	3	1,388.8	1.68	0.1693
Error	667	825.0		

Notes:

- ¥ Rural residence is significantly greater than urban (55.7 vs. 44.3)
 § Using the Bonferroni Post-Hoc procedure shows that the 'High' SES stratum differs significantly from each of the other stratum, and that no other pairwise comparison is significant at the $p=0.05$ level or greater.

Table 4.8: Adult Medical Discharges (30—44 Years).

RESIDENCE	SOCIO-ECONOMIC STATUS	MEDICAL		
		DISCHARGES	POPULATION	[1]
		N	N	Rate
Urban	High	19,906	698,604	28.5
	Middle	13,685	386,554	35.4
	Low-1	24,324	454,894	53.5
	Low-2	1,330	31,845	41.8
	Total	59,245	1,571,897	37.7
Rural	High	641	24,740	33.1
	Middle	1,851	54,418	44.9
	Low-1	2,322	71,221	45.8
	Low-2	2,529	79,679	45.3
	Total	7,343	230,058	44.0
Michigan [2]	High	20,547	1,003,346	28.6
	Middle	15,536	617,939	36.3
	Low-1	26,646	820,671	52.7
	Low-2	3,859	156,926	44.0
	Total	66,588	2,598,882	38.3

Notes:

1. Age-specific discharge rate per 1,000.
2. An analysis of Michigan as a whole, shows that the SES categories differ significantly ($F=16.82$; $df=3,667$; $p<0.0001$).
Using Bonferroni Post-Hoc procedures at $\alpha=0.05$ suggests that each SES stratum differs from the 'High' category and that the 'Middle' SES group is significantly different from the 'Low-2' group.

Table 4.9: Analysis of Variance Results for Adult Medical Discharges (30—44 Years).

SOURCE	df	MEAN SQUARE	F	p-value
Residence ¥	1	4,826.3	7.91	0.0051
Socio-Economic Status §	3	3,937.6	6.45	0.0003
Residence x SES	3	100.9	0.17	0.9198
Error	667	610.3		

Notes:

- ¥ Rural residence is significantly greater than urban (44.0 vs. 37.7)
- § Using the Bonferroni Post-Hoc procedure shows that the 'High' SES stratum differs significantly from each of the other stratum, and that the 'Middle' and 'Low-2' SES groups differ significantly as well.
No other pairwise comparison is significant at the $p=0.05$ level or greater.

Table 4.10: Older Adult Medical Discharges (65+ Years).

RESIDENCE	SOCIO-ECONOMIC STATUS	MEDICAL		
		DISCHARGES	POPULATION	[1]
		N	N	Rate
Urban	High	54,163	285,773	189.5
	Middle	36,428	189,653	192.1
	Low-1	58,936	295,233	199.6
	Low-2	4,788	22,963	208.5
	Total	154,315	793,622	194.4
Rural	High	2,039	9,237	220.7
	Middle	5,618	24,569	228.7
	Low-1	9,272	39,152	236.8
	Low-2	10,789	44,203	244.1
	Total	27,718	117,161	236.6
Michigan [2]	High	56,202	295,010	190.5
	Middle	42,046	214,222	196.3
	Low-1	68,208	334,385	204.0
	Low-2	15,577	67,166	231.9
	Total	182,033	910,783	199.9

Notes:

1. Age-specific discharge rates per 1,000.
2. An analysis of Michigan as a whole, shows that the SES categories differ significantly ($F=6.93$; $df=3,667$; $p<0.0001$). Using Bonferroni Post-Hoc procedures at $\alpha=0.05$ suggests that the 'Low-2' SES strata differs from the 'High' category only.

Table 4.11: Analysis of Variance Results for Older Adult Medical Discharges (65+ Years).

SOURCE	df	MEAN SQUARE	F	p-value
Residence ¥	1	83,979.7	10.83	0.0011
Socio-Economic Status ¢	3	9,151.5	1.18	0.3166
Residence x SES	3	4,868.1	0.63	0.5974
Error	667	7,756.8		

Notes:

- ¥ Rural residence is significantly greater than urban (236.6 vs. 194.4)
- ¢ Using the Bonferroni Post-Hoc procedure shows that the 'High' SES stratum differs significantly from the 'Low-1' and 'Low-2' strata, and that no other pairwise comparison is significant at the $p=0.05$ level or greater.

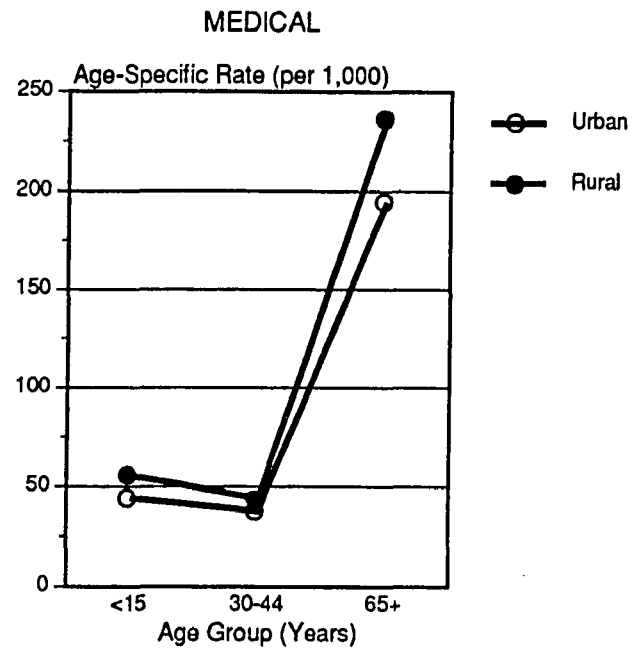


Figure 4.2: Urban-Rural Medical Discharge Rates by Age Group.

Pearson correlation coefficients between discharge rates for each age group and residence are listed in Table 4.12. Age-adjusted and age-specific rates are significantly associated with every other age group as well as by residence ($p < 0.001$).

Socio-Economic Status:

The majority of statewide discharges are from Low-1 socio-economic areas (37.1%), with the High group second (31.6%), Middle category next with 23.9%, and the smallest number of discharges coming from the very poor Low-2 group (7.3%) (Table 4.1). Low-1 and High socio-economic categories dominate urban areas, 32.9% and 30.5%, respectively, while 21.1% is contributed by the Middle SES group and only 2.5% from Low-2 areas. In rural areas, on the other hand, there is a clearer SES gradient from High to Low-2; 1.1% rising steadily to 4.8% (Figure 4.3). However, while urban poor (Low-1 and Low-2) communities contribute 40.7% of all urban discharges, nearly 70% (69.6%) of rural discharges originate from ZIPs with Low SES. With respect to total discharges, the situation is quite different. Here the urban Low areas constitute the largest percentage of discharges (35.4%), whereas similar SES communities in rural areas make up only 9.1%.

Research Question 4: Do socio-economically poorer communities have higher hospital use rates than wealthier areas of the state?

For Michigan as a whole, the socio-economic categories differ significantly ($p < 0.001$; Table 4.3). The rates reveal a marked increase from High to Low socio-economic status. The lowest rate, 49.8 per 1,000 population for the High SES group, is one and a half times lower than that recorded for Low-2 ZIP code areas (76.3/1,000). Bonferonni Post-Hoc procedures (at $\alpha = 0.05$), indicate that each SES stratum differs from the High category and that the Low-2 group differs from the Middle group only. Hence,

Table 4.12: Pearson Correlations Coefficients for Medical Discharges by Age Group.

RESIDENCE	DISCHARGE CATEGORY BY AGE (Years):			
	MEDICAL [1]	MEDICAL [1]		
		<15	30-44	65+
Urban	<15	-		
	30-44	0.74	-	
	65+	0.64	0.78	-
	All [2]	0.84	0.93	0.91
Rural	<15	-		
	30-44	0.51	-	
	65+	0.46	0.57	-
	All	0.73	0.79	0.84
Michigan	<15	-		
	30-44	0.59	-	
	65+	0.53	0.64	-
	All	0.78	0.84	0.86

Note:

1. All pairwise correlation coefficients are significant at the $p < 0.001$ level.
2. Age-adjusted rates (per 1,000). All other rates are age-specific.

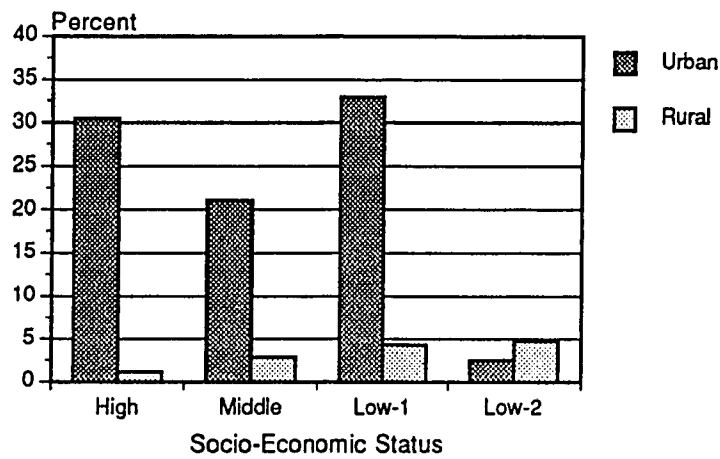


Figure 4.3: Percent Medical Discharges (All Ages).

these data indicate that patients resident in poorer communities do indeed have significantly higher hospital use rates than higher SES postal code areas.

Research Question 5: Does residence interact with socio-economic status on medical discharge rates?

A significant inverse relationship is evident within each residence category, namely rural and urban, where discharge rates rise with declining socio-economic status ($p < 0.001$; Tables 4.2 and 4.3). This trend is shown graphically in Figure 4.4. The highest rates of hospital utilization are found in communities with the lowest SES ranking, a finding consistent for both urban-rural residence and age group (Tables 4.6–4.11). However, urban and rural ZIPs do not differ significantly for all ages combined with respect to SES levels ($F=0.09$, $p=0.9631$; Table 4.3), as well as for pediatric ($p=0.1693$; Table 4.7), adult ($p=0.9198$; Table 4.9), and older adult groups ($p=0.5974$; Table 4.11).

The above findings suggest that High SES areas have the lowest age-adjusted use rates. However, when the population is stratified by age a different pattern emerges. The inverse relationship is well represented by only the older adult (Table 4.10; Figure 4.5). For the pediatric and adult groups the SES categories do not conform to the trend of increasing discharge rate.

Research Question 6: After matching on socio-economic status, will there be a difference in hospital use between urban and rural residential setting?

Urban-rural discharge rate differences by age and socio-economic status are shown with the use of a line chart in Figure 4.6. High use rates for older adult patients (65+ years) are readily observable (Table 4.10); the inverse relationship between hospital

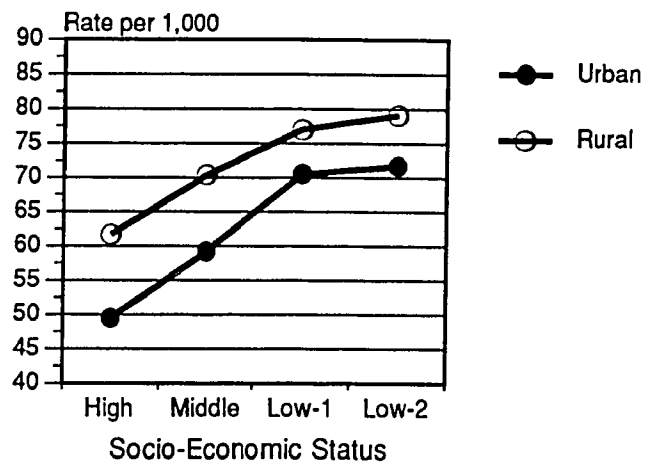


Figure 4.4: Medical Discharge Rates (All Ages) by Residence.

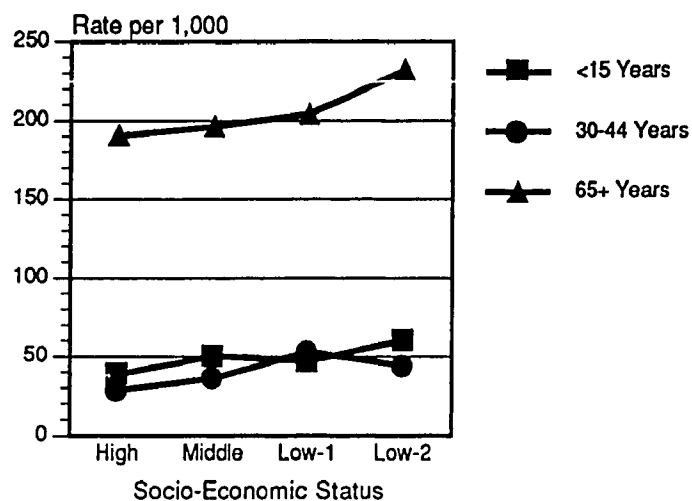
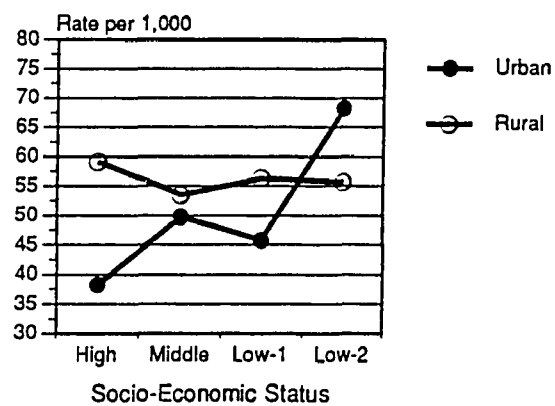
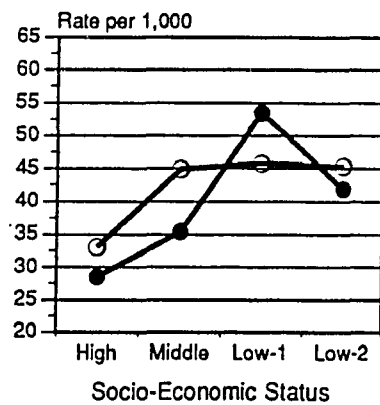


Figure 4.5: Medical Discharge Rates (All Ages) by Age Group and Socio-Economic Status.

Pediatric Medical Discharges (<15 Years)



Adult Medical Discharges (30-44 Years)



Older Adult Medical Discharges (65+)

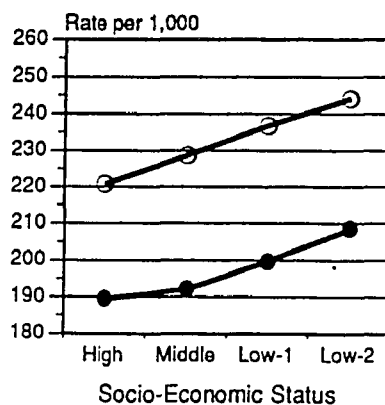


Figure 4.6: Medical Discharge Rates for Each Age Group by Residence.

utilization and socio-economic status by residence is most pronounced, but not significant ($p=0.5974$; Table 4.11). The situation for pediatric discharges (Table 4.7) and adult discharges (Table 4.9) is similar with no significant residence by socio-economic status interaction present (<15 years: $p=0.1693$; 30-44 years: $p=0.9198$). There is also no residence by socio-economic status interaction irrespective of age (Table 4.3; $p=0.9631$).

Geographical Patterns:

Maps have greatly facilitated the presentation of geographical data. Maps can, more effectively than tables, display spatial patterns and illustrate statistical measures of geographical relationships.

Apart from the cross-tabular analyses developed above, medical discharge rates for each of the 668 ZIP codes are analyzed for spatial variation. The frequency distribution of age-adjusted discharge rates illustrates the slightly skewed (mean=60.6/1,000; median=62.1/1,000) utilization pattern of the geographic areas (Figure 4.7). Not only are higher rates in rural ZIPs well portrayed in Figure 4.8, but the urban-rural shift in the ZIP-specific frequency distribution is seen as well.

Statewide median discharge rates for all ages by residence and socio-economic category, as well as upper and quartile ranges, are presented in Table 4.13 and mapped in Figure 4.9. Rural communities are twice as likely to experience a hospital discharge for medical cause(s) as are urban areas (Odds Ratio¹ (OR)=2.04; CI=1.40–2.93). The

¹ An odds ratio greater than 1.00 (unity) indicates a factor which is positively correlated with hospital discharge. An odds ratio lower than 1.00 indicates a factor having a protective effect. That is, a factor having a negative correlation with hospital discharges. Inverting odds ratios less than 1.00 reveals how many times less likely hospital admission/discharge is relative to the protective factor. This allows for an easier interpretation of variables negatively associated with risk of discharge. An odds ratio of exactly 1.00 indicates no difference in risk, or no apparent association.

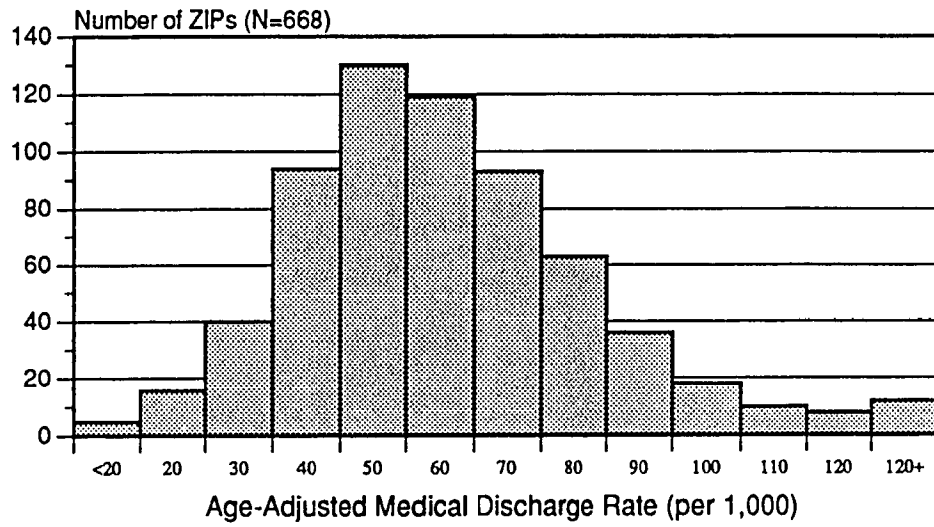


Figure 4.7: Frequency of Occurrence of Medical Discharge Rates (All Ages) by ZIP Code.

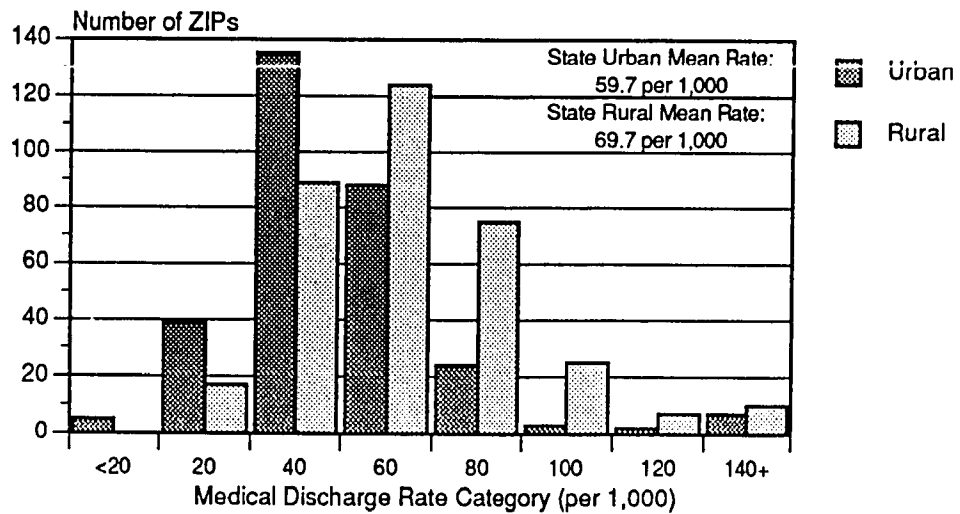


Figure 4.8: Occurrence of Medical Discharge Rates (All Ages) by ZIP Code According to Residence.

Table 4.13: Medical Discharge Rates (All Ages) per 1,000 for all 668 ZIP Codes.

RESIDENCE	NUMBER OF ZIP CODES	SOCIO- ECONOMIC STATUS	MEDIAN ZIP Rate	LOWER QUARTILE	UPPER QUARTILE
				Rate	Rate
Urban #	132	High ¢	51.2	4.1 - 42.2	61.9 - 89.8
	93	Middle	58.1	9.5 - 47.7	70.6 - 303.8
	59	Low-1 §	59.2	22.0 - 49.9	73.6 - 123.1
	19	Low-2 ¥	62.7	39.6 - 57.7	72.8 - 93.9
	303	Total #	56.0	4.1 - 46.5	67.8 - 303.8
Rural #	37	High ¢	67.3	35.9 - 53.0	74.3 - 87.2
	73	Middle	60.9	28.9 - 52.9	83.1 - 188.0
	114	Low-1 §	69.4	22.2 - 56.0	87.8 - 204.8
	141	Low-2 ¥	75.3	23.1 - 62.8	88.2 - 218.8
	365	Total #	70.9	22.2 - 56.0	86.5 - 218.8
Michigan	169	High	54.6	4.1 - 43.9	65.3 - 89.8
	166	Middle	58.7	9.5 - 49.2	74.1 - 303.8
	173	Low-1	68.1	22.0 - 52.9	84.8 - 204.8
	160	Low-2	73.6	23.1 - 60.5	87.8 - 218.8
	668	Total	62.1	19.7 - 50.3	78.0 - 303.8

Notes:

Comparisons between the number of ZIP codes above and below the median are significantly different when stratified by residence at the $\alpha=0.05$ level for :

¢ 'High' SES (OR=3.31, CI=1.42—7.84)

§ 'Low-1' SES (OR=2.01, CI=1.00—4.02)

¥ 'Low-2' SES (OR=2.84, CI=1.00—9.60)

Urban-Rural Residence (OR=2.04, CI=1.40—2.93)

inverse relationship between socio-economic status and discharge rate is again confirmed ($p < 0.0001$).

Comparisons between the number of ZIP codes above and below the median are significantly different when stratified by residence at the $\alpha = 0.05$ level for the High, Low-1, and Low-2 socio-economic categories (Table 4.13). Hospital use rates are significantly higher in rural High SES communities than compared to their urban counterparts (OR=3.31; CI=1.42–7.84). Similarly, rural Low-1 and Low-2 areas have use rates significantly higher than comparable urban ZIPs, respectively (OR=2.01; CI=1.00–4.02 and OR=2.84; CI=1.00–9.60).

Both relative scales and absolute scales of hospital use are presented graphically in the form of maps of the state. Mapping age-adjusted use rates represents an absolute scale, while replacing the absolute value by an indication of the quartile within which it lies is an example of a relative scale. Mapping of the rates for all ages by quartile shows the distinctive low urban and high rural pattern of discharge rates geographically and the contiguity of ZIP codes is a striking feature (Figure 4.9). Low rates of hospital utilization are visually discernable within the Grand Rapids region, as are higher rates around Bad Axe and West Branch, for example.

A useful statistical technique to test these spatially determined discharge rates for significance and obviate the chance occurrence of high rates due to small numbers in the numerator is to estimate the number of cases, or in the case of surgery the number of procedures, that would be performed in an area if the intensity of admission (discharge) was performed at the level of the statewide average. Using the Poisson probability model (Choynowski 1959; McGlashan 1976; Rip 1986), observed and expected numbers of discharges can be tested for significance relative to the mean rate recorded for the state as a

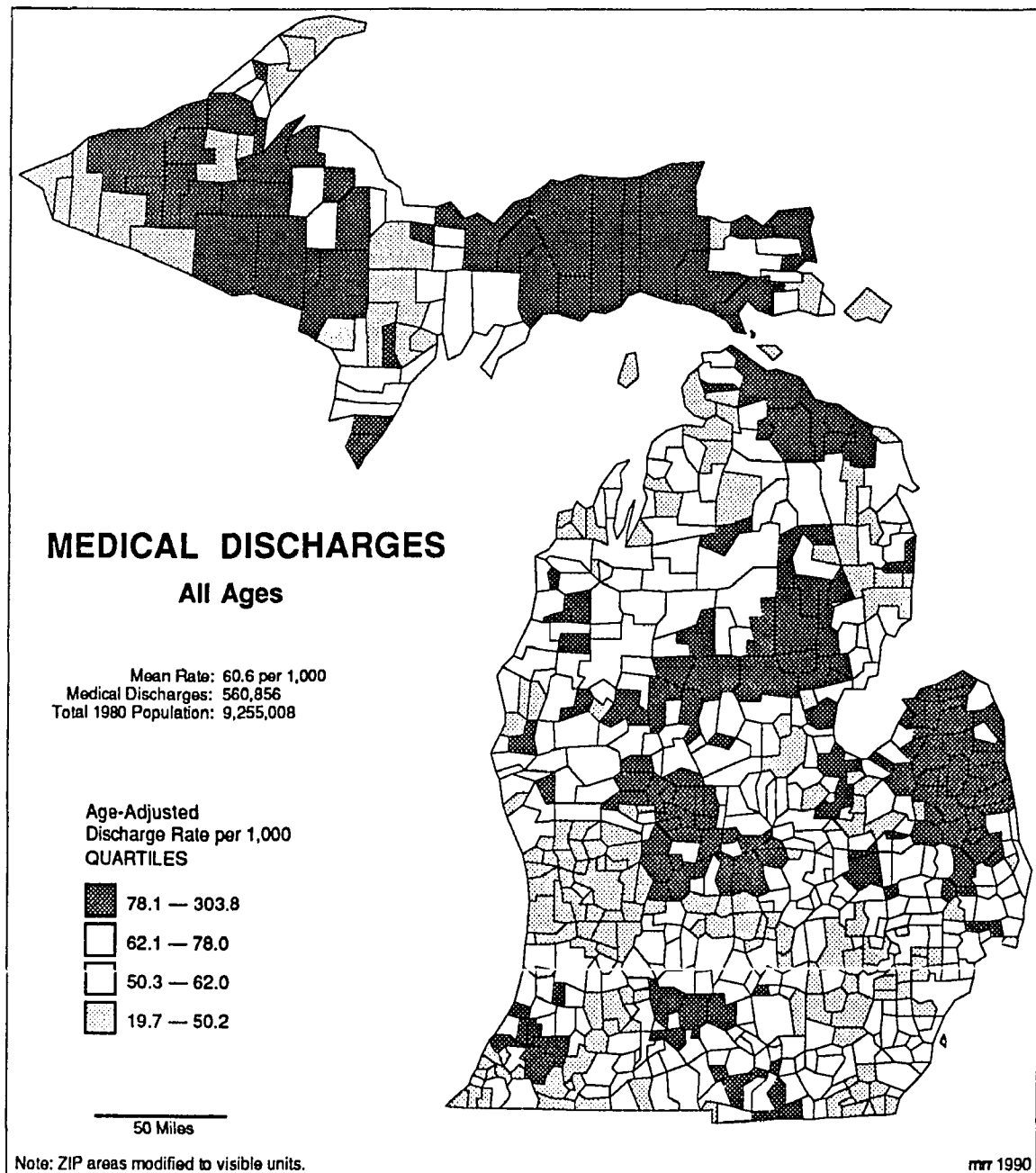


Figure 4.9: Age-Adjusted Medical Discharge Rates (All Ages) by Quartile Interval.

whole. Results of the Poisson probability method in disease/health care mapping at the national and state level can provide useful information. It is not only possible to show areas of significantly higher and lower incidence (or prevalence), but also discern geographic patterns that are otherwise not obvious. In the map shown in Figure 4.10, the idea of 'significantly high' and 'significantly low' cells is articulated by determining the chance of obtaining a level of medical hospital utilization at least as big or at least as small as that recorded if the process generating medical discharges is spatially random. Such a random generating process may be characterized by the statistical model known as the *Poisson*. Subareas, in this case ZIP codes, are assumed to act independently of each other, and each subarea is taken to have an equal and independent chance of having an event occur in it. The main role of Poisson is therefore to act as a 'no dependence' or spatially random benchmark against which data may be tested for departures from the model.

When viewing and interpreting a map showing areal variations, it is important to focus on and discuss the overall pattern rather than directing attention to specific areas where rates are statistically significantly high or low. The primary reason for seeing the map as a whole is to negate the problem of being misled by statistical fluctuations or visual artifacts of the map. For example, the data used in this study are for only one year. ZIP areas with significantly elevated use rates may not show significance in a subsequent year. Ideally, data for a number of years ought to be analyzed separately and only areas (i.e., ZIPs) that display consistently and significantly high rates for every year, or time period under study, be considered as representing a geographic area with an elevated rate. Finally, larger rural ZIPs tend to dominate the visual impression given by a map and which may well be misleading if such regions are sparsely populated. An example of this would be the Upper Peninsula of Michigan.

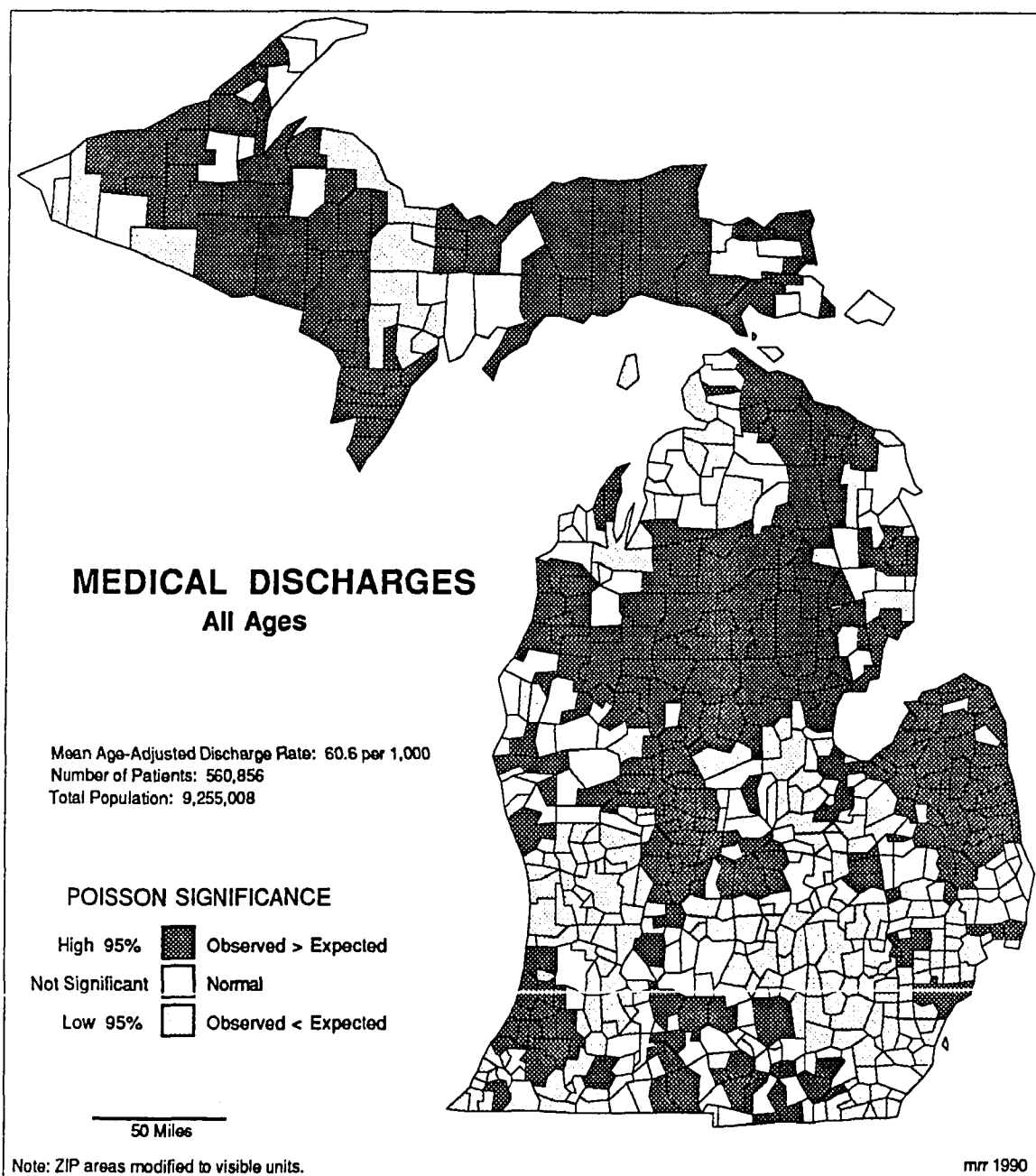


Figure 4.10: Medical Discharge Rates (All Ages) According to Poisson Probability.

Rural ZIPs display a marked pattern of elevated discharge rates when mapped according to Poisson probability at the 95% confidence level. Observed numbers of discharges far exceed the expected based upon a statewide mean rate of 60.6 per 1,000 population (Figure 4.10). The northern portion of the lower peninsula and most of the Upper Peninsula are characterized by higher than expected rates, except for urban pockets such as Traverse City, Petosky, and Marquette. In the southern section of the state, poor urban areas with significantly high medical discharge rates, like those ZIPs around Benton Harbor and Detroit City, dominate and contrast with the general pattern observed for most other large urban areas which are characterized by significantly low hospital use rates (i.e., Grand Rapids, Lansing, and Ann Arbor).

Similar, but not identical results were obtained on an age-specific basis (Tables 4.14–4.16). Table 4.17 summarizes the age-specific and age-adjusted discharge rates by residence and socio-economic status. For pediatric patients, no significant difference is apparent between urban and rural ZIPs, whereas the adult and older adult groups conform to the established situation where rural areas have significantly higher utilization rates (OR=1.90; CI=1.30–2.79 and OR=2.00; CI=1.38–2.92), respectively. These results are listed in Table 4.18.

Pediatric discharges by ZIP code mapped according to quartile intervals show higher use rates in rural areas, with much lower rates within urban areas, particularly around Grand Rapids and Ann Arbor (Figure 4.11). Once tested for significance, the pattern revealed on the Poisson map emphasizes this urban-rural distinction (Figure 4.12). Quartile and Poisson maps of the discharge rates for both adult and older adult patients (Figures 4.13 and 4.14; Figures 4.15 and 4.16) display less homogeneity and contiguity within urban-rural residence group, than the pediatric discharge map (Figure 4.12).

Table 4.14: Pediatric Medical Discharge Rates (<15 Years)
per 1,000 for all 668 ZIP Codes.

RESIDENCE	NUMBER OF ZIP CODES	SOCIO- ECONOMIC STATUS	MEDIAN ZIP Rate	LOWER QUARTILE	UPPER QUARTILE
				Rate	Rate
Urban §	132	High	33.4	4.0 - 26.6	46.3 - 96.0
	93	Middle	46.1	11.8 - 30.8	65.7 - 203.5
	59	Low-1 ¥	42.9	14.7 - 33.8	63.0 - 157.1
	19	Low-2	49.4	27.4 - 32.5	69.5 - 101.5
	303	Total	38.5	4.0 - 28.6	53.8 - 203.5
Rural §	37	High	51.3	21.6 - 34.5	71.4 - 132.9
	73	Middle	44.0	17.2 - 36.5	75.6 - 148.9
	114	Low-1 ¥	61.1	15.4 - 41.5	77.5 - 198.4
	141	Low-2	60.5	19.7 - 47.3	76.5 - 176.5
	365	Total	57.8	17.2 - 41.1	76.2 - 198.4
Michigan	169	High	35.4	4.0 - 27.8	50.5 - 132.9
	166	Middle	45.5	11.8 - 34.2	69.8 - 203.5
	173	Low-1	51.5	14.7 - 37.2	72.0 - 198.4
	160	Low-2	59.1	19.7 - 42.1	76.4 - 176.5
	668	Total	44.7	4.0 - 33.3	69.5 - 203.5

Notes:

¥ Comparisons between the number of ZIP codes above and below the median are significantly different when stratified by residence at the alpha=0.05 level for: 'Low-1' SES (OR=2.24, CI=1.11—4.55).

§ There is no significant difference by residence (OR=1.26, CI=0.88—1.26).

Table 4.15: Adult Medical Discharge Rates (30–44 Years)
per 1,000 for all 668 ZIP Codes.

RESIDENCE	NUMBER OF ZIP CODES	SOCIO- ECONOMIC STATUS	MEDIAN ZIP Rate	LOWER QUARTILE	UPPER QUARTILE
				Rate	Rate
Urban §	132	High	28.0	6.8 - 20.1	35.0 - 62.6
	93	Middle ¥	31.8	7.7 - 23.3	39.1 - 220.9
	59	Low-1	32.2	11.7 - 26.9	46.4 - 78.8
	19	Low-2	36.0	18.1 - 23.1	49.6 - 69.6
	303	Total	31.1	6.8 - 23.0	39.7 - 220.9
Rural §	37	High	39.7	16.2 - 28.0	46.8 - 67.0
	73	Middle ¥	43.9	15.8 - 29.4	58.9 - 148.0
	114	Low-1	52.1	16.5 - 36.6	66.8 - 177.5
	141	Low-2	52.7	8.9 - 36.5	75.2 - 208.1
	365	Total	48.0	8.9 - 35.0	66.8 - 208.1
Michigan	169	High	29.2	6.8 - 21.6	36.3 - 67.0
	166	Middle	35.3	7.7 - 25.3	49.0 - 220.9
	173	Low-1	41.5	11.7 - 31.7	61.8 - 177.5
	160	Low-2	50.4	8.9 - 35.6	72.0 - 208.1
	668	Total	34.4	6.8 - 26.3	52.9 - 220.9

Notes:

¥ Comparisons between the number of ZIP codes above and below the median are significantly different when stratified by residence at the alpha=0.05 level for: 'Middle' SES (OR=2.27, CI=1.16—4.46)

§ Urban and rural residence differ significantly (OR=1.90, CI=1.30—2.79)

Table 4.16: Older Adult Medical Discharge Rates (65+ Years)
per 1,000 for all 668 ZIP Codes.

RESIDENCE	NUMBER OF ZIP CODES	SOCIO- ECONOMIC STATUS	MEDIAN ZIP Rate	LOWER QUARTILE	UPPER QUARTILE
				Rate	Rate
Urban §	132	High	191.8	16.2 - 159.2	229.8 - 262.8
	93	Middle	197.2	15.1 - 150.8	233.1 - 299.0
	59	Low-1 ¢	199.2	85.2 - 173.9	234.8 - 288.3
	19	Low-2 #	200.4	118.8 - 169.2	218.5 - 265.3
	303	Total §	197.0	15.1 - 162.0	230.5 - 299.0
Rural §	37	High	220.3	99.3 - 178.0	256.4 - 304.5
	73	Middle	227.5	77.3 - 171.7	259.7 - 325.2
	114	Low-1 ¢	232.6	68.8 - 191.7	283.7 - 377.7
	141	Low-2 #	239.2	64.4 - 198.4	286.7 - 415.4
	365	Total §	229.9	64.4 - 187.1	279.1 - 415.4
Michigan	169	High	196.4	16.2 - 163.5	237.2 - 304.5
	166	Middle	199.8	15.1 - 163.6	239.0 - 325.2
	173	Low-1	220.5	68.8 - 183.2	260.1 - 377.7
	160	Low-2	230.7	64.4 - 197.6	283.7 - 415.4
	668	Total	210.1	15.1 - 176.5	253.7 - 415.4

Notes:

¢ Comparisons between the number of ZIP codes above and below the median are significantly different when stratified by residence at the alpha=0.05 level for:

¢ 'Low-1' SES (OR=2.89, CI=1.42—5.92)

'Low-2' SES (OR=5.89, CI=1.52—26.70)

§ Urban-Rural (OR=2.00, CI=1.38—2.92)

**Table 4.17: Age-Specific Median Medical Discharge Rates (per 1,000)
for all 668 ZIP Codes.**

AGE GROUP (Years)	SOCIO-ECONOMIC STATUS:				MICHIGAN
	HIGH	MIDDLE	LOW-1	LOW-2	

URBAN:

Under 15	33.4	46.1	42.9	49.4	38.5
30—44	28.0	31.8	32.2	36.0	31.1
65 and over	191.8	197.2	199.2	200.4	197.0
Total [1]	51.2	58.1	59.2	62.7	56.0

RURAL:

Under 15	51.3	44.0	61.1	60.5	57.8
30—44	39.7	43.9	52.1	52.7	48.0
65 and over	220.3	227.5	232.6	239.2	229.9
Total [1]	67.3	60.9	69.4	75.3	70.9

MICHIGAN:

Under 15	35.4	45.5	51.5	59.1	47.7
30—44	29.2	35.3	41.5	50.4	36.3
65 and over	196.4	199.8	220.5	230.7	213.5
Total [1]	54.6	58.7	68.1	73.6	62.3

Note:

1. Age-adjusted rate.

Table 4.18: Age-Specific Medical Discharge Rates (per 1,000 by Residence for all 668 ZIP Codes.

AGE GROUP (Years)	RESIDENCE			FINDINGS		
	URBAN	RURAL	MICHIGAN	OR [1]	CI [2]	p-Value
<15	38.5	57.8	44.7	1.26	0.88—1.83	0.2231
30—44	31.1	48.0	34.4	1.90	1.30—2.79	0.0007
65+	197.0	229.9	210.1	2.00	1.38—2.92	0.0002
All Ages [3]	56.0	70.9	62.1	2.04	1.40—2.95	0.0001

Notes:

1. Mantel-Haenszel weighted odds ratio (OR) calculated for rural and urban residence.
2. 95% Confidence Interval.
3. Age-adjusted rate.

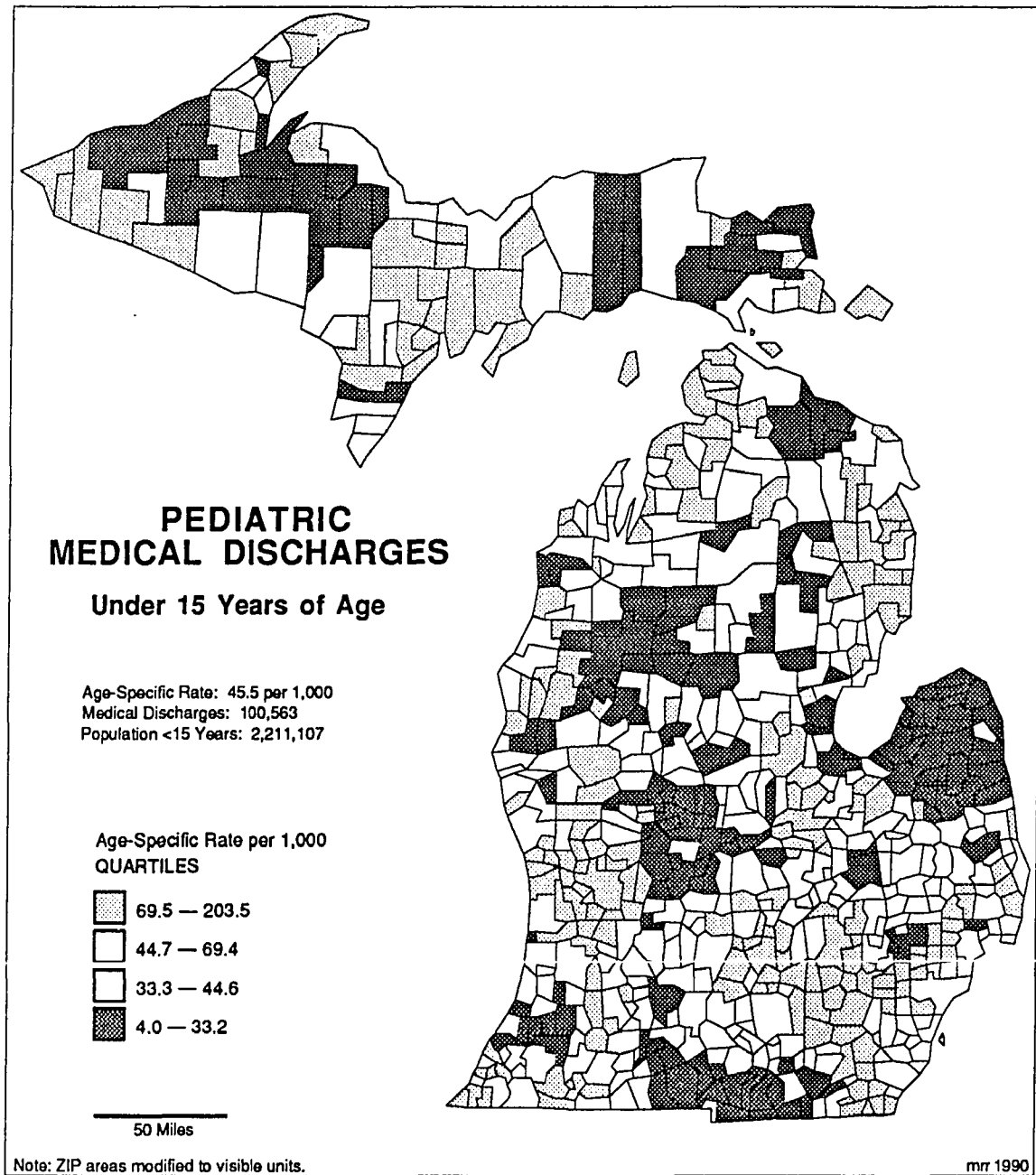


Figure 4.11: Quartile Map of Pediatric Medical Discharge Rates (<15 Years).

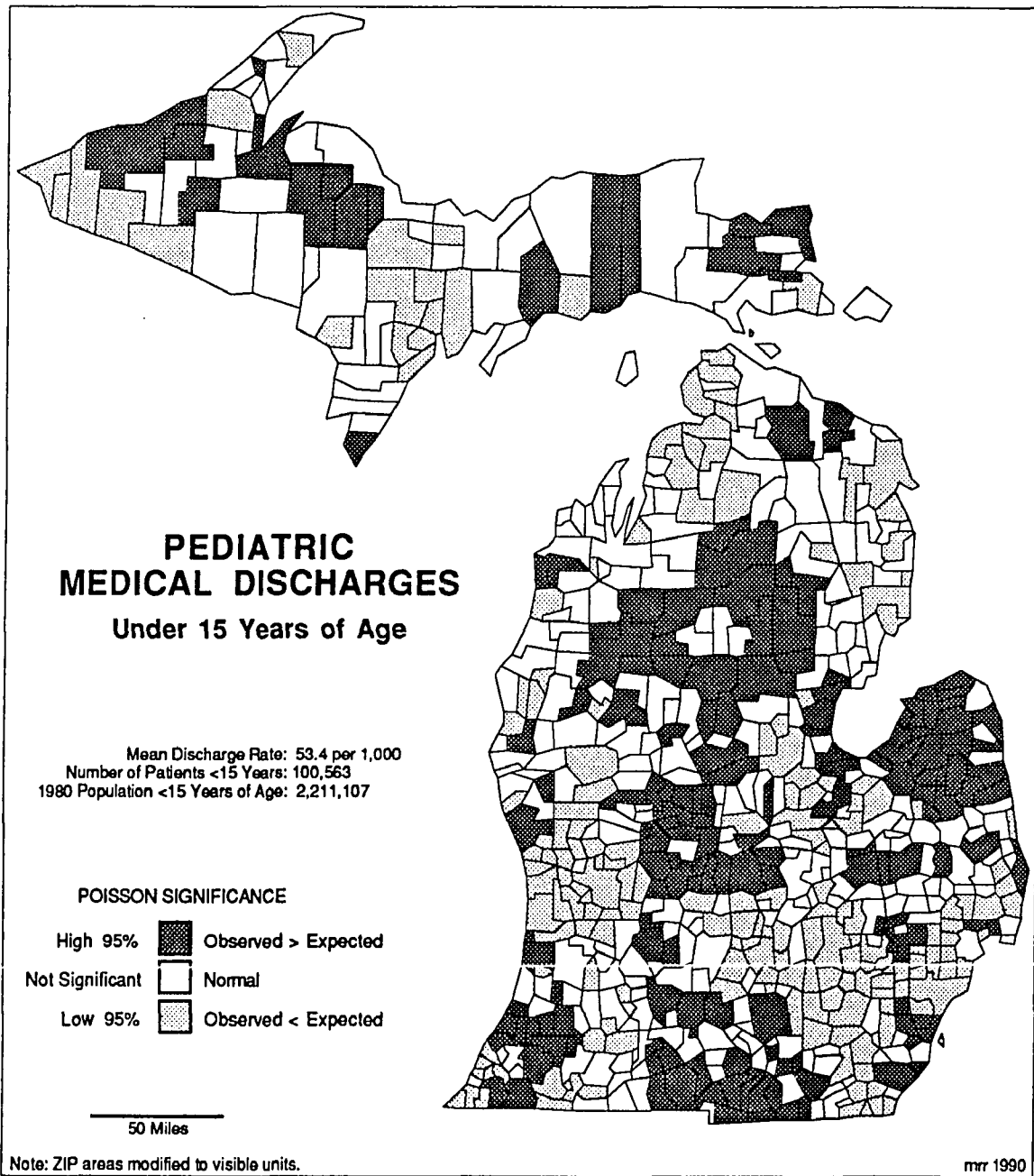


Figure 4.12: Poisson Map of Pediatric Medical Discharge Rates (<15 Years).

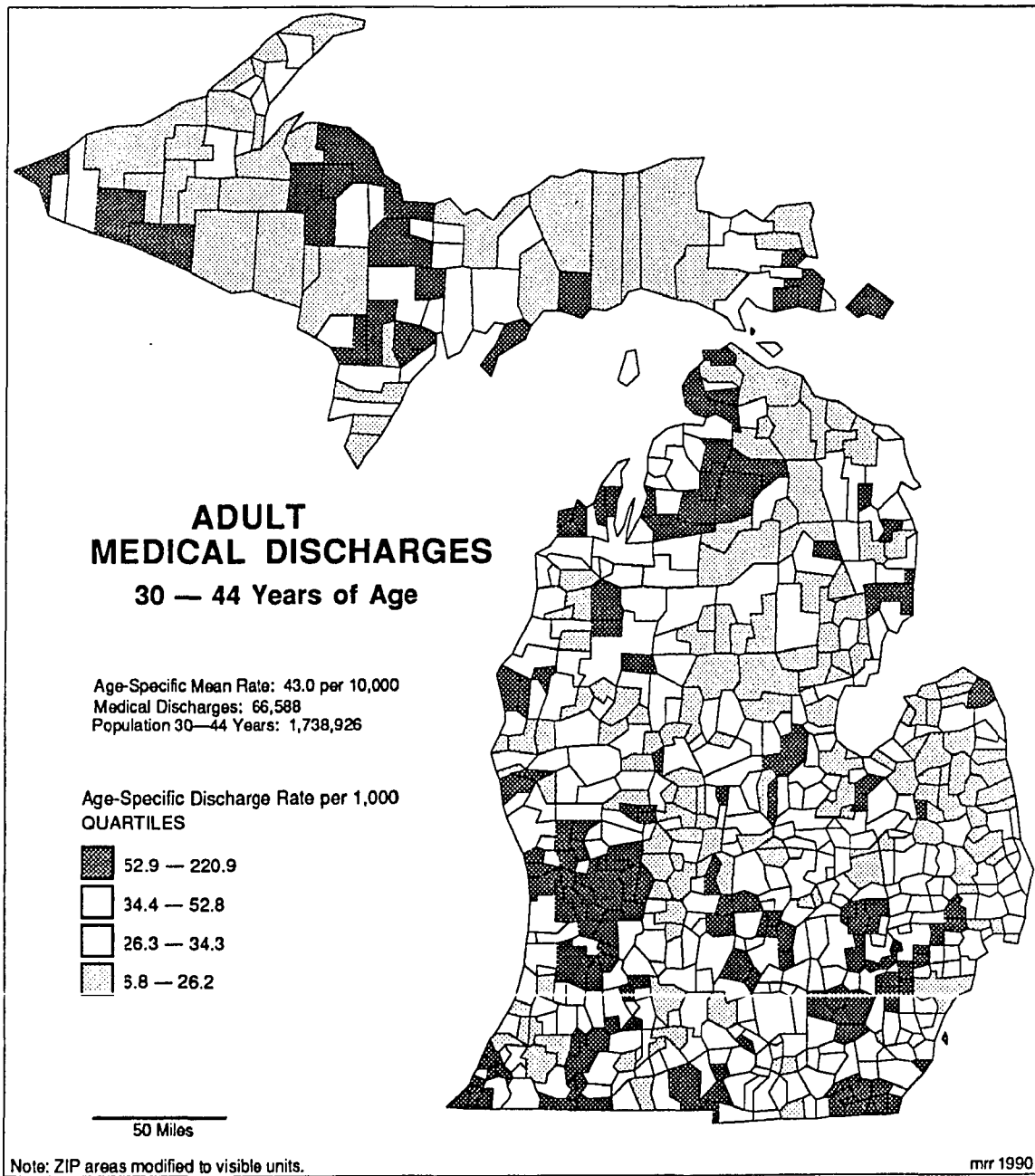


Figure 4.13: Quartile Map of Adult Medical Discharge Rates (30—44Years).

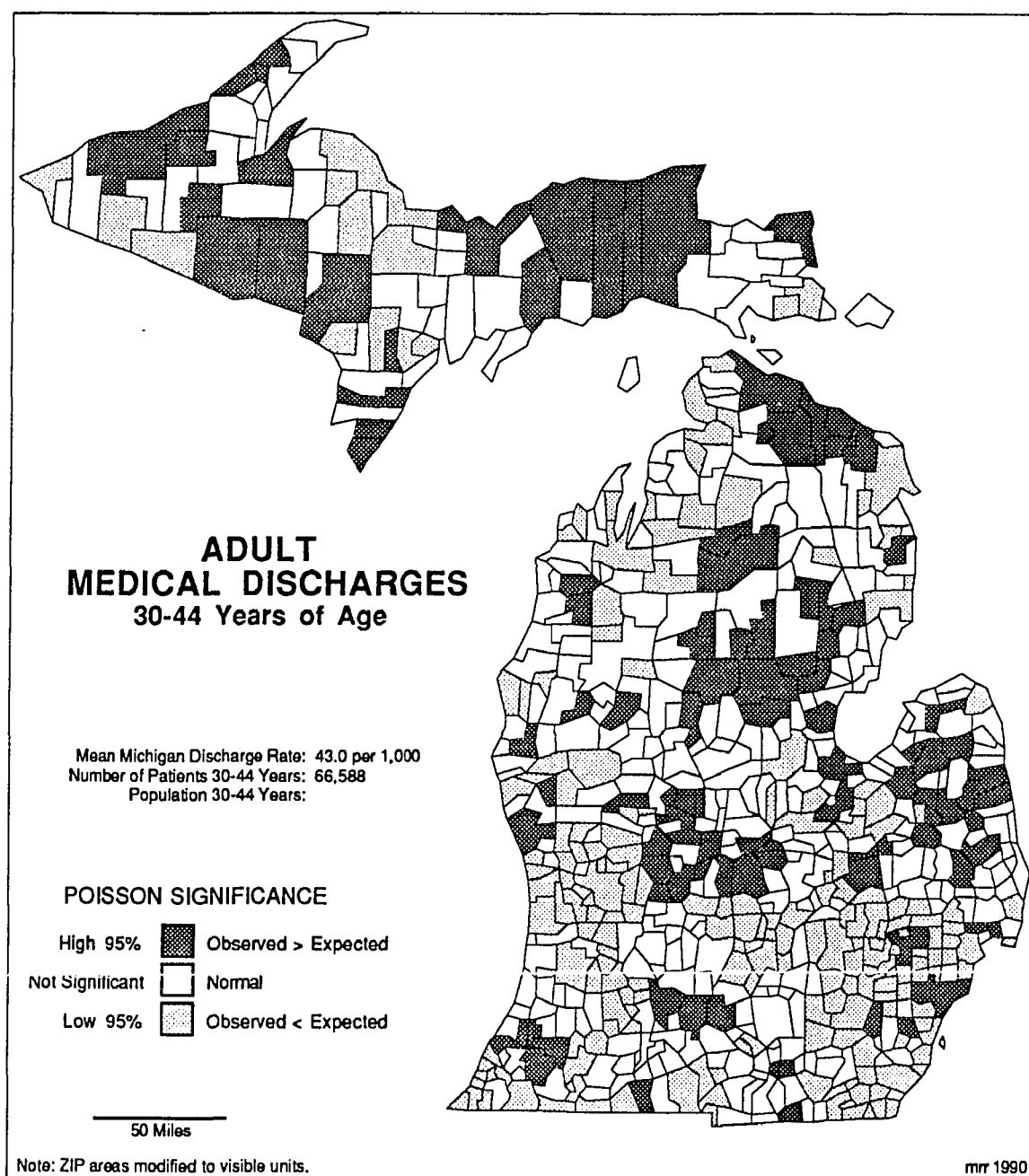


Figure 4.14: Poisson Map of Adult Medical Discharge Rates (30—44 Years).

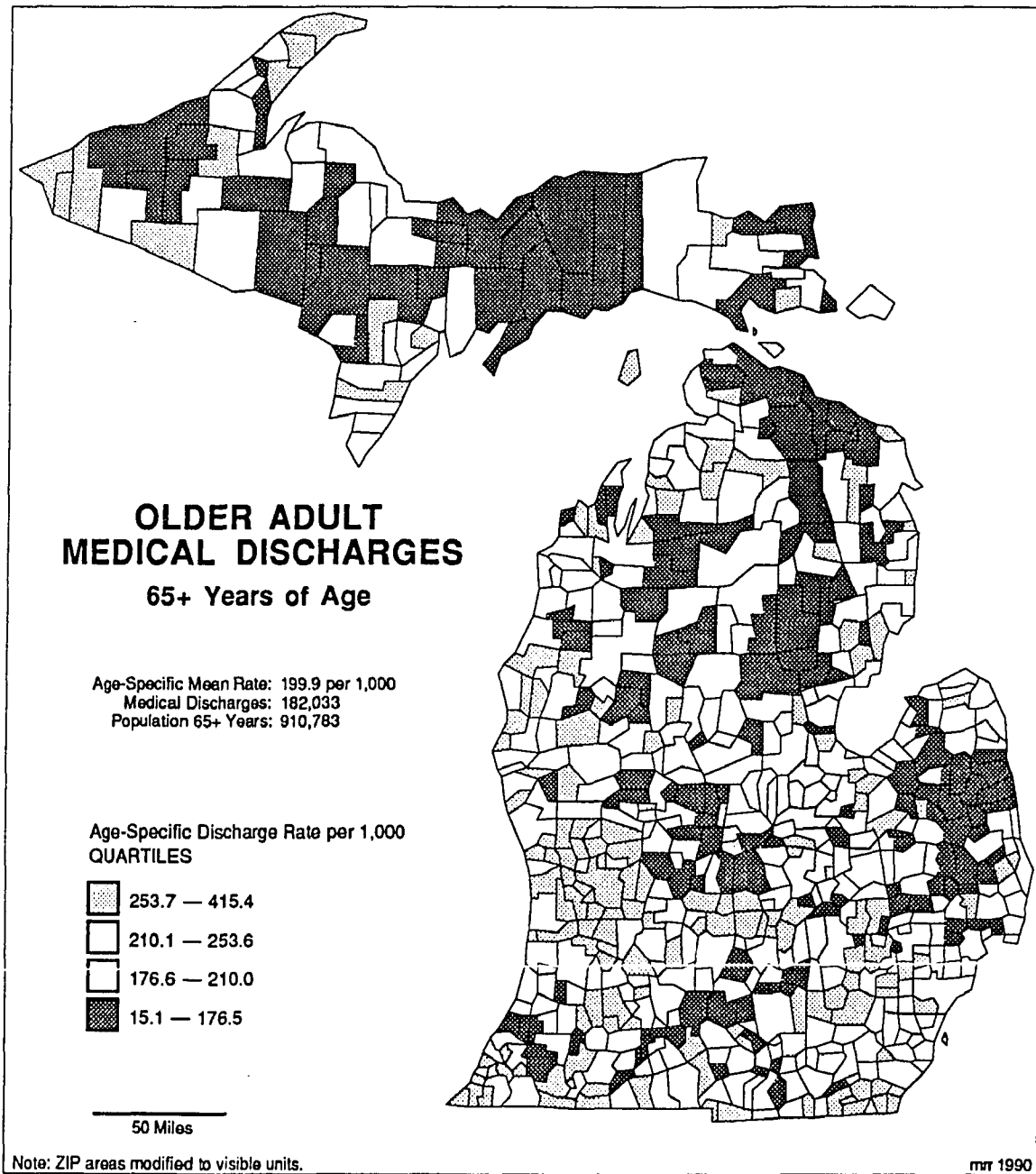


Figure 4.15: Quartile Map of Older Adult Medical Discharge Rates (65+ Years).

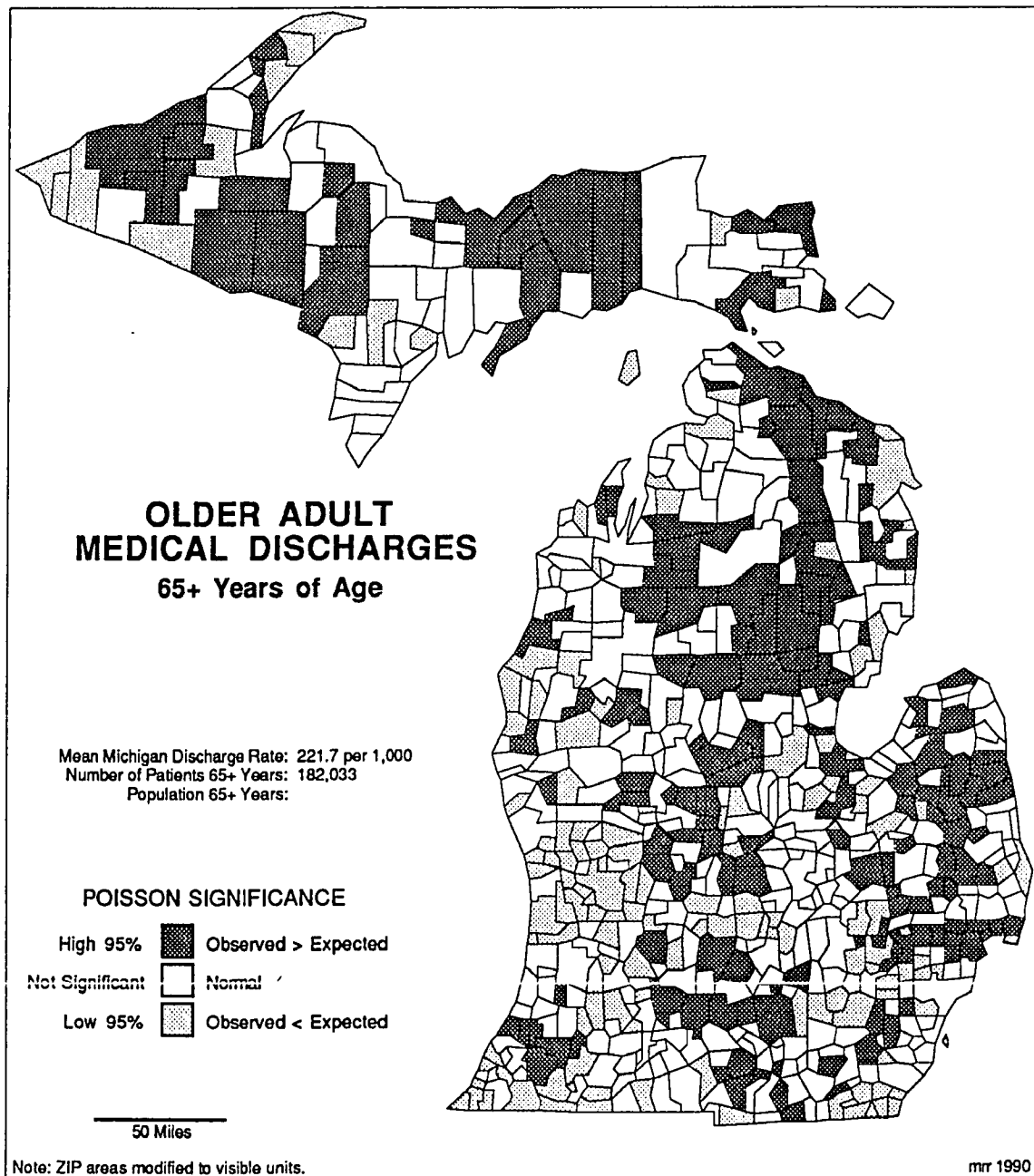


Figure 4.16: Poisson Map of Older Adult Medical Discharge Rates (65+ Years).

Nevertheless, the general pattern of higher hospital use among rural communities is evident.

SURGICAL DISCHARGES

Overall:

A total of 665,389 non-obstetrical surgical procedures were performed within Michigan community hospitals during 1980 and nine out of every 10 surgical discharges (89.6%) were to a resident of an urban community (Table 4.19).

Research Question 1: Is there a significant difference in surgical discharge rates between urban and rural communities?

Notwithstanding the large percentage difference between urban and rural residence, the age-adjusted discharge rates for urban (71.8/1,000) and rural (72.3/1,000) areas are similar (Table 4.20), and do not differ significantly ($p=0.1671$; Table 4.21). The statewide age-adjusted surgical rate is calculated to be 71.9 per 1,000 population.

Age Group:

The number of surgical discharges by age group is shown in Table 4.22. Of the age groups under study, pediatric surgical discharges comprise the smallest percentage of procedures performed (8.0%), whereas discharges to patients 65+ years of age have the highest percentage (21.5%); the adult group with 20.3% being slightly lower. While these three age groups account for 49.8%, a nearly equal number of discharges ($N=333,871$; 50.2%) are not included in any age-specific analyses. Discharges not considered are those within the two age groups, 15–29 and 45–64 years. All three age groups possess almost

Table 4.19: Total Surgical Discharges (All Ages), Michigan 1980.

RESIDENCE	[1] S.E.S.	SURGICAL DISCHARGES		
		N	% [2]	% [3]
Urban	High	228,735	38.4	34.4
	Middle	146,042	24.5	21.9
	Low-1	207,991	34.9	31.3
	Low-2	13,272	2.2	2.0
	Total	596,040	100.0	89.6
Rural	High	7,108	10.2	1.1
	Middle	15,424	22.2	2.3
	Low-1	21,911	31.6	3.3
	Low-2	24,906	35.9	3.7
	Total	69,349	100.0	10.4
Michigan	High	235,843		35.4
	Middle	161,466		24.3
	Low-1	229,902		34.6
	Low-2	38,178		5.7
	Total	665,389		100.0

Notes:

1. Socio-economic status designation.
2. Percent of group.
3. Percent of total.

Table 4.20: Total Surgical Discharges (All Ages).

RESIDENCE	SOCIO-ECONOMIC STATUS	SURGICAL		
		DISCHARGES	POPULATION	[1]
		N	N	Rate
Urban	High	228,735	3,458,728	66.1
	Middle	146,042	2,009,026	72.9
	Low-1	207,991	2,642,152	78.9
	Low-2	13,272	212,840	65.4
	Total	596,040	8,322,746	71.8
Rural	High	7,108	98,021	73.1
	Middle	15,424	215,708	70.1
	Low-1	21,911	293,430	72.6
	Low-2	24,906	325,103	74.9
	Total	69,349	932,262	72.3
Michigan [2]	High	235,843	3,556,749	66.3
	Middle	161,466	2,224,734	72.6
	Low-1	229,902	2,935,582	78.3
	Low-2	38,178	537,943	71.0
	Total	665,389	9,255,008	71.9

Notes:

1. Age-adjusted rate per 1,000.
2. An analysis of Michigan as a whole, shows that the SES categories differ significantly ($F=5.17$; $df=3, 667$; $p=0.0015$). Using Bonferroni Post-Hoc procedures at $\alpha=0.05$ suggests that each SES stratum differs from the 'High' category, and that no other category is significantly different.

Table 4.21: Analysis of Variance Results for Surgical Discharges (All Ages).

SOURCE	df	MEAN SQUARE	F	p-Value
Residence ¥	1	1,056.6	1.91	0.1671
Socio-Economic Status ¢	3	792.6	1.44	0.2314
Residence x SES	3	193.3	0.35	0.7892
Error	667	552.3		

Notes:

- ¥ Rural residence is not significantly greater than urban (72.3 vs. 71.8)
- ¢ Using Bonferroni Post-Hoc procedures shows that the 'High' SES stratum differs significantly from the 'Low-1' and 'Low-2' strata, and that no other pairwise comparison is significant at the $p=0.05$ level or greater.

Table 4.22: Numbers of Surgical Discharges by Residence and Age Group.

AGE GROUP (Years)	RESIDENCE		MICHIGAN
	URBAN	RURAL	
Pediatric (<15)	46,982	6,144	53,126
Adult (30-44)	122,777	12,544	135,321
Older Adult (65+)	124,641	18,430	143,071
All Ages	596,040	69,349	665,389

equal proportions of discharges originating from urban communities; pediatric discharges were 88.4%, adult 90.7% and older adult 87.1% (Table 4.23). Hence, few surgical discharges originate from rural ZIPs; the largest (12.9%) being for the older adult group. The pediatric discharge rate is approximately six times lower than the older adult rate in both residence settings.

Research Question 2: Are rural age-specific surgical use rates higher than compared to those in urban areas?

Age-specific surgical discharge rates according to residence are presented in Table 4.23. In addition, these rates are detailed for each age group in Tables 4.24; 4.26; and 4.28. The largest difference in discharge rate between urban and rural residence is observed for the adult group (3.0/1,000). However, surgical use rates do not appear to differ significantly when stratified by residence for each of the three age groups (Figure 4.17), and this finding is statistically confirmed (Tables 4.25; 4.27; and 4.29).

Research Question 3: Do surgical procedure rates change with age, when controlled for residence?

Not only does the number of surgical discharges increase with age, but so do the age-specific discharge rates. Figure 4.18 reveals the large percentage contribution of discharges from urban High SES areas for all age groups. A noticeable feature is the rural excess of total percent of discharges from Low-2 SES postal codes, as well as the constant increase of the percent discharges with falling socio-economic status. These figures are summarized in Table 4.23. Overall, pediatric is the lowest with a rate of 24.0 per 1,000, increasing to 77.8 for the adult group and reaching a maximum in the older adult population (157.1/1,000). This pattern is repeated when surgical discharges are stratified by residence; surgical rates rise markedly with age, irrespective of urban or rural residence of

Table 4.23: Surgical Discharges by Residence and Age Group.

RESIDENCE	AGE GROUP (Years):		
	<15	30-44	65+
Urban:			
Number	46,982	122,777	124,641
Population:	1,977,649	1,571,897	793,622
Rate [1]	23.8 ¥	78.1 #	157.1 §
Rural:			
Number	6,144	12,544	18,430
Population:	233,458	167,029	117,161
Rate [1]	26.3 ¥	75.1 #	157.3 §
Michigan:			
Number	53,126	135,321	143,071
Population:	2,211,107	1,738,926	910,783
Rate [2]	24.0	77.8	157.1

Note:

1. Age-specific rate per 1,000 population.

2. Age-adjusted rate per 1,000 population.

¥ Not significantly different (NS), $p=0.0635$.# NS, $p=0.1867$.§ NS, $p=0.4884$.

Table 4.24: Pediatric Surgical Discharges (<15 Years).

RESIDENCE	SOCIO-ECONOMIC STATUS	SURGICAL		
		DISCHARGES	POPULATION	[1]
		N	N	Rate
Urban	High	18,132	801,042	22.6
	Middle	13,141	497,624	26.4
	Low-1	14,731	632,661	23.3
	Low-2	978	46,322	21.1
	Total	46,982	1,977,649	23.8
Rural	High	716	26,278	27.2
	Middle	1,512	55,172	27.4
	Low-1	1,850	71,890	25.7
	Low-2	2,066	80,118	25.8
	Total	6,144	233,458	26.3
Michigan [2]	High	18,848	827,320	22.8
	Middle	14,653	552,796	26.5
	Low-1	16,581	704,551	23.5
	Low-2	3,044	126,440	24.1
	Total	53,126	2,211,107	24.0

Notes:

1. Age-specific rate per 1,000 population.
2. An analysis of Michigan as a whole, shows that the SES categories differ significantly ($F=4.22$; $df=3, 667$; $p=0.0057$). Using Bonferroni Post-Hoc procedures at $\alpha=0.05$ suggests that only the 'Middle' stratum differs from the 'High' category, and that no other category is significantly different.

Table 4.25: Analysis of Variance Results for Pediatric Surgical Discharges (<15 Years).

SOURCE	df	MEAN SQUARE	F	p-value
Residence ¥	1	528.9	3.45	0.0635
Socio-Economic Status ¢	3	608.9	3.98	0.0080
Residence x SES	3	100.0	0.65	0.5810
Error	667	153.1		

Notes:

- ¥ Rural residence is not significantly greater than urban (26.3 vs. 23.8)
- ¢ Using the Bonferroni Post-Hoc procedure shows that the 'High' SES stratum differs significantly from the 'Middle' strata, and that no other pairwise comparison is significant at the $p=0.05$ level or greater.

Table 4.26: Adult Surgical Discharges (30—44 Years).

RESIDENCE	SOCIO-ECONOMIC STATUS	SURGICAL		
		DISCHARGES	POPULATION	[1]
		N	N	Rate
Urban	High	48,547	698,604	69.5
	Middle	29,893	386,554	77.3
	Low-1	42,044	454,894	92.4
	Low-2	2,293	31,845	72.0
	Total	122,777	1,571,897	78.1
Rural	High	1,463	19,348	75.6
	Middle	3,092	41,257	74.9
	Low-1	3,763	50,655	74.3
	Low-2	4,226	55,769	75.8
	Total	12,544	167,029	75.1
Michigan [2]	High	50,010	717,952	69.7
	Middle	32,985	427,811	77.1
	Low-1	45,807	505,549	90.6
	Low-2	6,519	87,614	74.4
	Total	135,321	1,738,926	77.8

Notes:

1. Age-specific rate per 1,000 population.
2. An analysis of Michigan as a whole, shows that the SES categories do not differ significantly ($F=1.72$; $df=3, 667$; $p=0.1609$). Using Bonferroni Post-Hoc procedures at $\alpha=0.05$, suggests that there is no significant difference between the SES strata.

Table 4.27: Analysis of Variance Results for Adult Surgical Discharges (30—44 Years).

SOURCE	df	MEAN SQUARE	F	p-value
Residence ¥	1	1,732.2	1.75	0.1867
Socio-Economic Status ¢	3	1,228.2	1.24	0.2947
Residence x SES	3	217.1	0.22	0.8833
Error	667	991.6		

Notes:

- ¥ Rural residence is not significantly greater than urban (75.1 vs. 78.1)
- ¢ Using the Bonferroni Post-Hoc procedure shows that no pairwise comparison is significant at the $p=0.05$ level or greater.

Table 4.28: Older Adult Medical Discharges (65+ Years).

RESIDENCE	SOCIO-ECONOMIC STATUS	SURGICAL		
		DISCHARGES	POPULATION	[1]
		N	N	Rate
Urban	High	45,093	285,773	157.8
	Middle	30,527	189,653	161.0
	Low-1	45,629	295,233	154.6
	Low-2	3,392	22,963	147.7
	Total	124,641	793,622	157.1
Rural	High	1,558	9,237	168.7
	Middle	3,628	24,569	147.7
	Low-1	6,022	39,152	153.8
	Low-2	7,222	44,203	163.4
	Total	18,430	117,161	157.3
Michigan [2]	High	46,651	295,010	158.1
	Middle	34,155	214,222	159.4
	Low-1	51,651	334,385	154.5
	Low-2	10,614	67,166	158.0
	Total	143,071	910,783	157.1

Notes:

1. Age-specific rate per 1,000 population.
2. An analysis of Michigan as a whole, shows that the SES categories do not differ significantly ($F=0.25$; $df=3, 667$; $p=0.8605$). Using Bonferroni Post-Hoc procedures at $\alpha=0.05$, suggests that each SES stratum do not differ from each other.

Table 4.29: Analysis of Variance Results for Older Adult Surgical Discharges (65+ Years).

SOURCE	df	MEAN SQUARE	F	p-value
Residence ¥	1	1,427.5	0.48	0.4884
Socio-Economic Status ¢	3	1,189.1	0.40	0.7528
Residence x SES	3	1,316.7	0.44	0.7221
Error	667	2,970.4		

Notes:

- ¥ Rural residence is not significantly greater than urban (157.3 vs. 157.1)
- ¢ Using the Bonferroni Post-Hoc procedure shows that no pairwise comparison is significant at the $p=0.05$ level or greater.

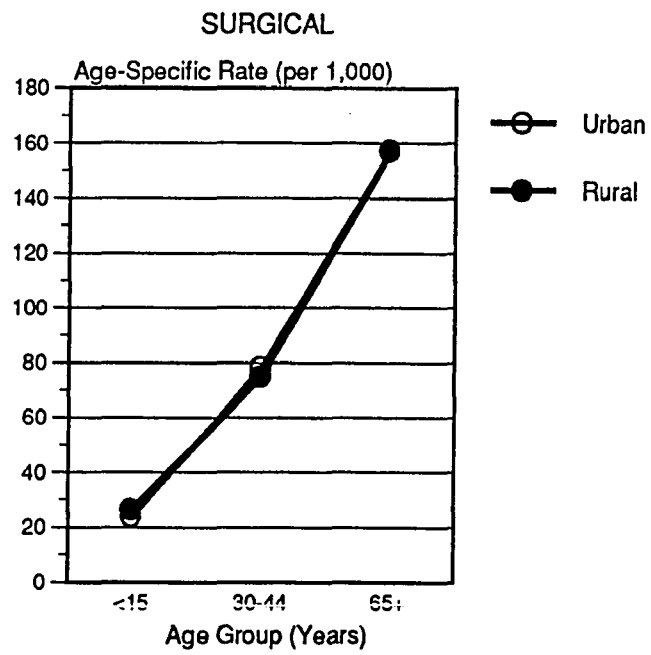


Figure 4.17: Surgical Discharge Rates by Residence and Age Group.

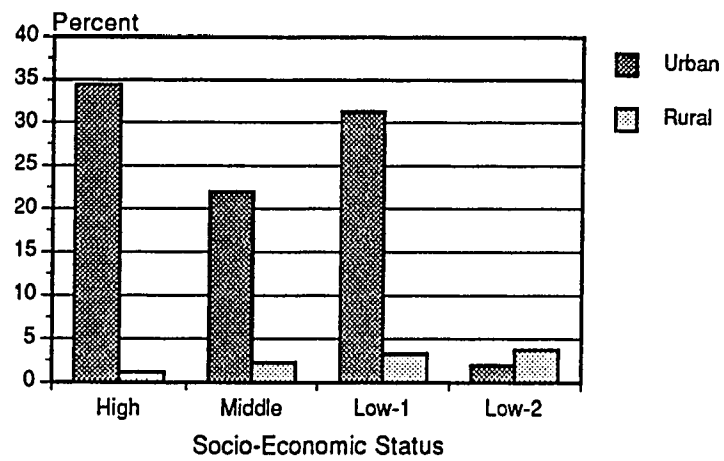


Figure 4.18: Percent of All Surgical Discharges by Residence and Socio-Economic Status.

the population. All tests for residence by SES interactions are not statistically significant (Tables 4.21, 4.25, 4.27, and 4.29).

Pearson pairwise correlation coefficients between surgical discharge rates for each age group and residence are shown in Table 4.30. Age-adjusted (for all ages) and age-specific rates are significantly associated ($p < 0.001$) with every other age group as well as by residence category.

Socio-Economic Status:

Communities characterized by Low-1 socio-economic status have the highest age-adjusted discharge rate (78.3/1,000), while the High group has the lowest (66.3/1,000) which is 15.3% less (Table 4.20 and Figure 4.19). It is interesting to note that 268,080 discharges are from 'Low' SES areas; fully 32,237 larger than High SES areas.

Research Question 4: Do socio-economic classes differ with respect to the rate of surgical procedures performed?

Whereas the percentage of surgical discharges for the state as a whole is highest for communities characterized by High SES (35.4%; Table 4.19), the age-adjusted rates show that there is an apparent inverse relationship with social class (Tables 4.20 and 4.21; and Figure 4.19). An analysis of all surgical discharges shows that the socio-economic status categories differ significantly ($p = 0.0015$). Using Bonferroni Post-Hoc procedures at $\alpha = 0.05$ suggests that each SES stratum differs from the 'High' category, and that no other SES category is significantly different. The socio-economic classes do differ significantly for Pediatric discharges ($F = 4.22$; $p < 0.001$; Table 4.24). Both of the other age groups show no statistically significant relationship between SES categories (Tables 4.26 and 4.28). These relationships are shown in Figure 4.20 ($p = 0.0015$).

Table 4.30: Pearson Correlations for Surgical Discharge Rates by Age Group.

RESIDENCE	DISCHARGE CATEGORY BY AGE (Years):			
	[1]	SURGICAL [1]		
	SURGICAL	<15	30—44	65+
Urban	<15	—		
	30—44	0.73	—	
	65+	0.53	0.74	—
	All [2]	0.78	0.95	0.83
Rural	<15	—		
	30—44	0.44	—	
	65+	0.40	0.52	—
	All	0.65	0.81	0.77
Michigan	<15	—		
	30—44	0.55	—	
	65+	0.44	0.59	—
	All	0.70	0.86	0.79

Notes:

1. All pairwise correlation coefficients are significant at the $p < 0.001$ level.
2. Age—adjusted rates (per 1,000). All other rates are age—specific.

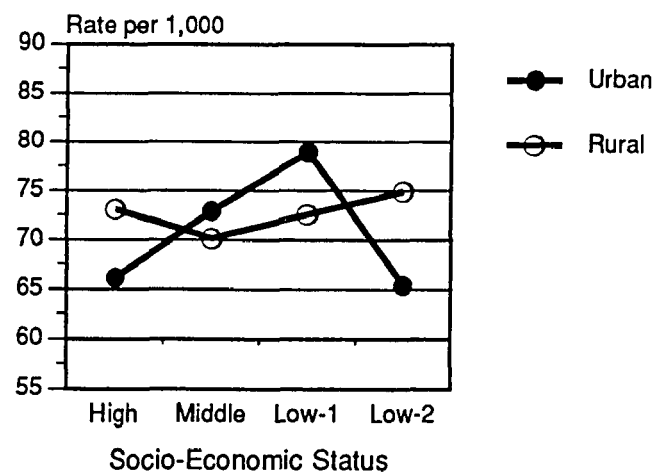


Figure 4.19: Age-Adjusted Surgical Discharge Rates by Residence and Socio-Economic Status.

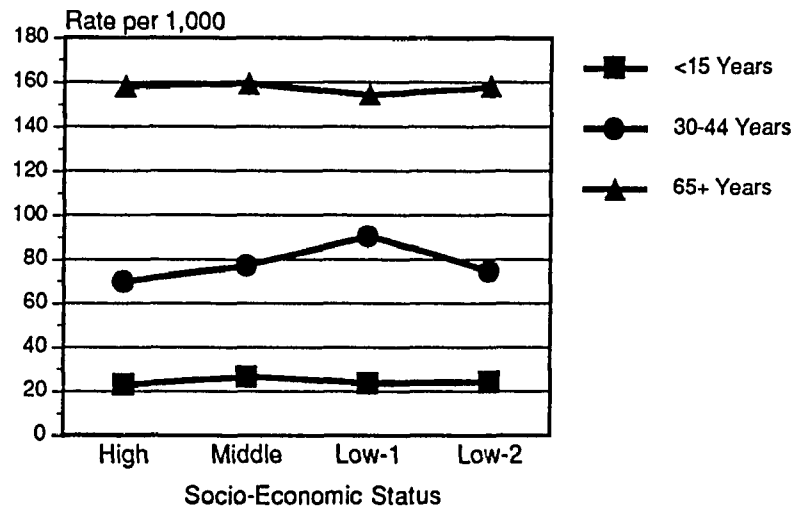


Figure 4.20: Age-Adjusted Surgical Discharge Rates by Age Group and Socio-Economic Status.

Research Question 5: Does residence interact with socio-economic status on surgical discharge rates?

The percent of surgical discharges by residence and socio-economic status is presented in Figure 4.20. The percentage contribution of discharges from urban High and Low-1 areas dominate. However, the percentage of rural Low-2 ZIPs is higher than their urban counterparts (Table 4.19 and Figure 4.21). A most noticable feature is the stability of rural rates by socio-economic category (Figure 4.19 and Table 4.20). The urban trend is quite different where the discharge rates rise with declining social class, but then the rate drops sharply for the lowest SES (Low-2) group. In fact, the expected rate is approximately 85/1,000, however, a value of only 65.4/1,000 is observed. While 33.3% of discharges originate from urban Low ZIPs, only 7.0% are from comparable rural areas (Table 4.19). More specifically, a larger percentage of discharges occur from rural Low-2 ZIPs (3.7%) than from the similar urban category (2.0%). Urban and rural ZIP code areas do not differ significantly for all ages combined with respect to SES levels ($F=0.35$, $p=0.7892$; Table 4.21), as well as for pediatric ($p=0.5810$; Table 4.25), adult ($p=0.8833$; Table 4.27), and older adult groups ($p=0.7221$; Table 4.29).

Research Question 6 : Is there a difference in surgical use rates between urban and

Research Question 6 : Is there a difference in surgical use rates between urban and rural residence after matching on socio-economic status?

Only the High SES category with a rate of 66.3/1,000 is significantly different compared with the other three classes which all have slightly higher discharge rates ($F=5.17$; $p=0.0015$). Discharge rates for each age group by residence and socio-economic status is shown in Figure 4.22.

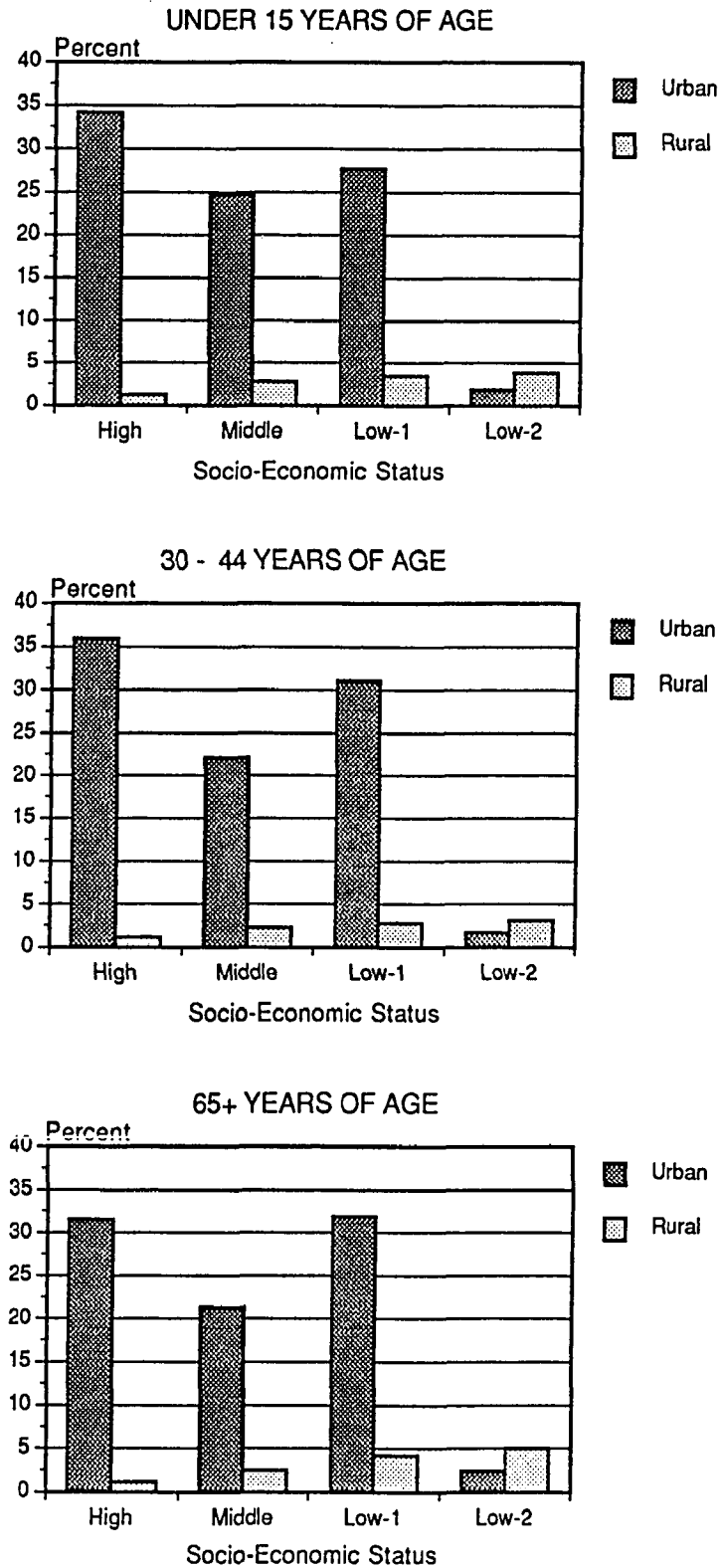
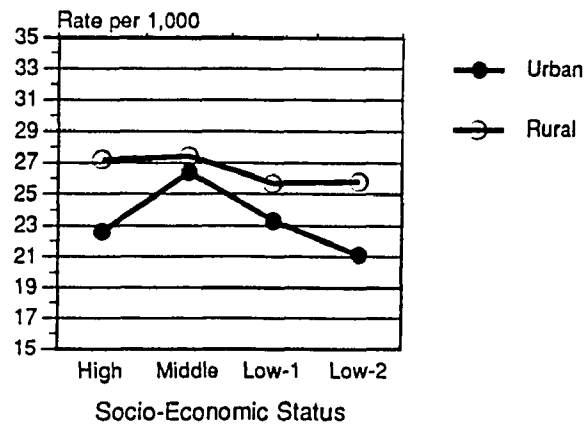
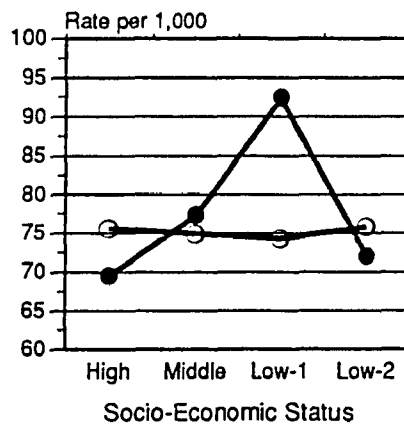


Figure 4.21: Percent of Surgical Discharges by Residence and Socio-Economic Status for Each Age Group.

Pediatric Surgical Discharges (<15 Years)



Adult Surgical Discharges (30-44 Years)



Older Adult Surgical Discharges (65+ Years)

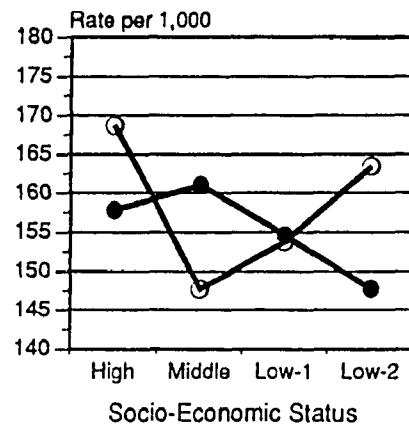


Figure 4.22: Surgical Discharge Rates by Residence and Socio-Economic Status for Each Age Group.

Geographical Patterns:

Statewide surgical discharges, as well as for each age group are analyzed for geographical variation in the same manner as for medical discharges. Age-adjusted surgical discharge rates (for all ages) plotted by ZIP code show a relatively normal distribution (mean=71.9/1,000; median=71.0/1,000; Figure 4.23). Rural communities show slightly higher median use rates (median=72.9/1,000) than do urban areas (median=69.9/1,000; Figure 4.24). On an ZIP-specific basis, the computed odds ratio indicates that this difference is significant (Table 4.31). Furthermore, urban areas are half as likely to experience a hospital discharge with a surgical diagnosis (OR=1.54, CI=1.07–2.23).

Comparisons between the number of communities above and below the median rate are not significantly different when stratified by residence at the $\alpha=0.05$ level for each socio-economic stratum (Table 4.31).

Median age-adjusted discharge rates mapped by quartile indicates the general pattern of higher use found in rural communities (Figure 4.25). The majority of urban areas have surgical use rates in the lower quartile; Detroit is the prominent exception in the southern portion of the lower peninsula.

The spatial clustering of ZIPs which are significantly higher than expected based upon the statewide surgical discharge rate of 71.9 per 1,000 population, is apparent in Figure 4.26. Urban communities surrounding Detroit, as well as Benton Harbor, Battle Creek, and Jackson display elevated use rates on this Poisson map, as do many rural ZIPs within the Grayling-Cadillac-Gladwin-West Branch quadrangle.

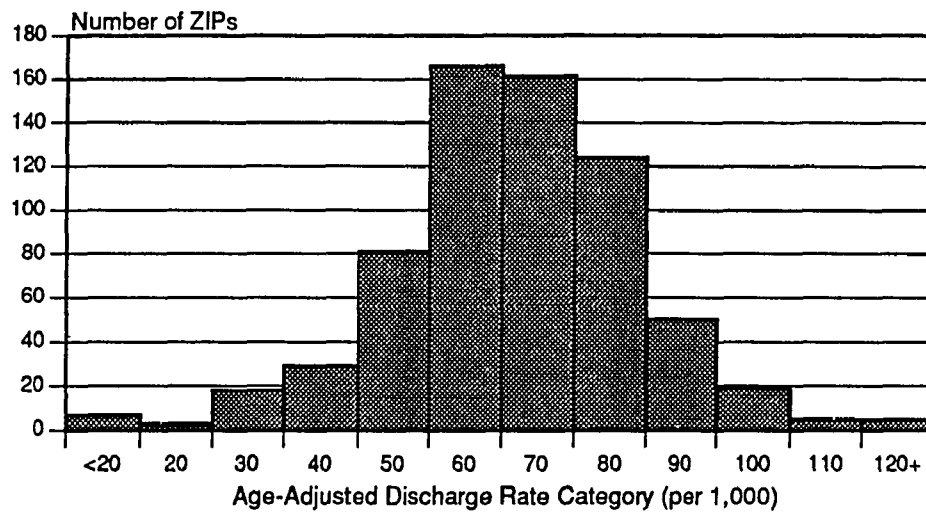


Figure 4.23: Age-Adjusted Surgical Discharge Rates (All Ages) by Postal Code.

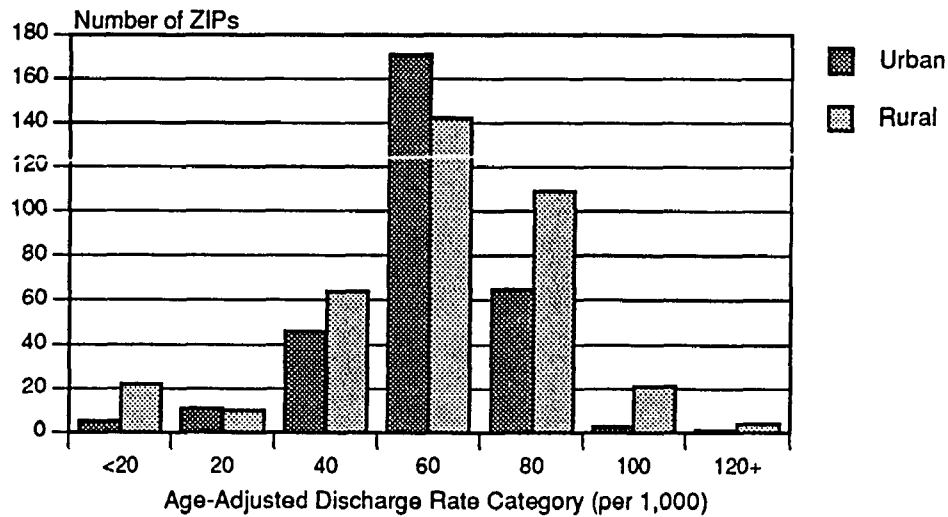


Figure 4.24: Surgical Discharge Rates (All Ages) by ZIP Code According to Residence.

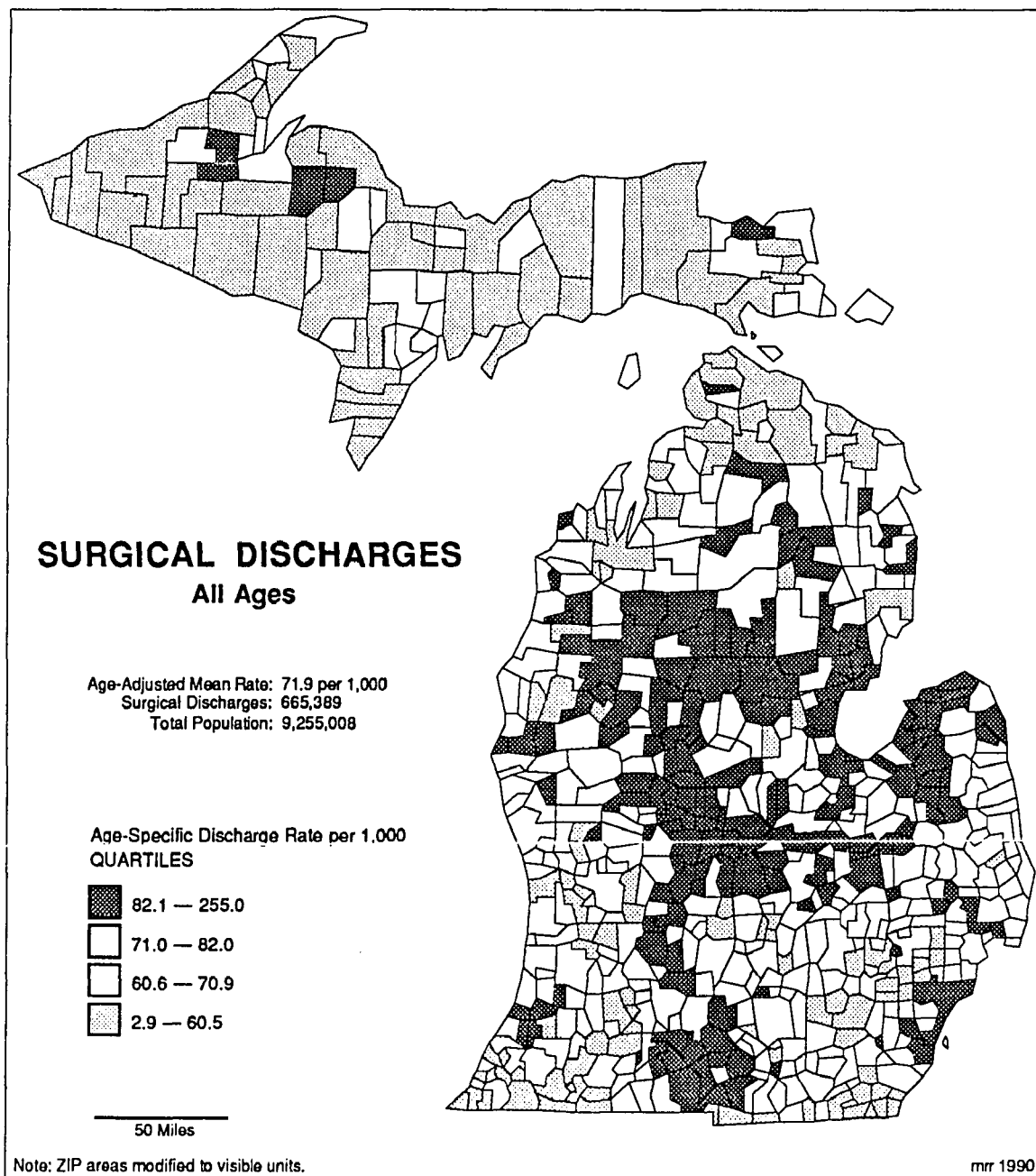


Figure 4.25: Age-Adjusted Surgical Discharge Rates (All Ages)
by Quartile Interval.

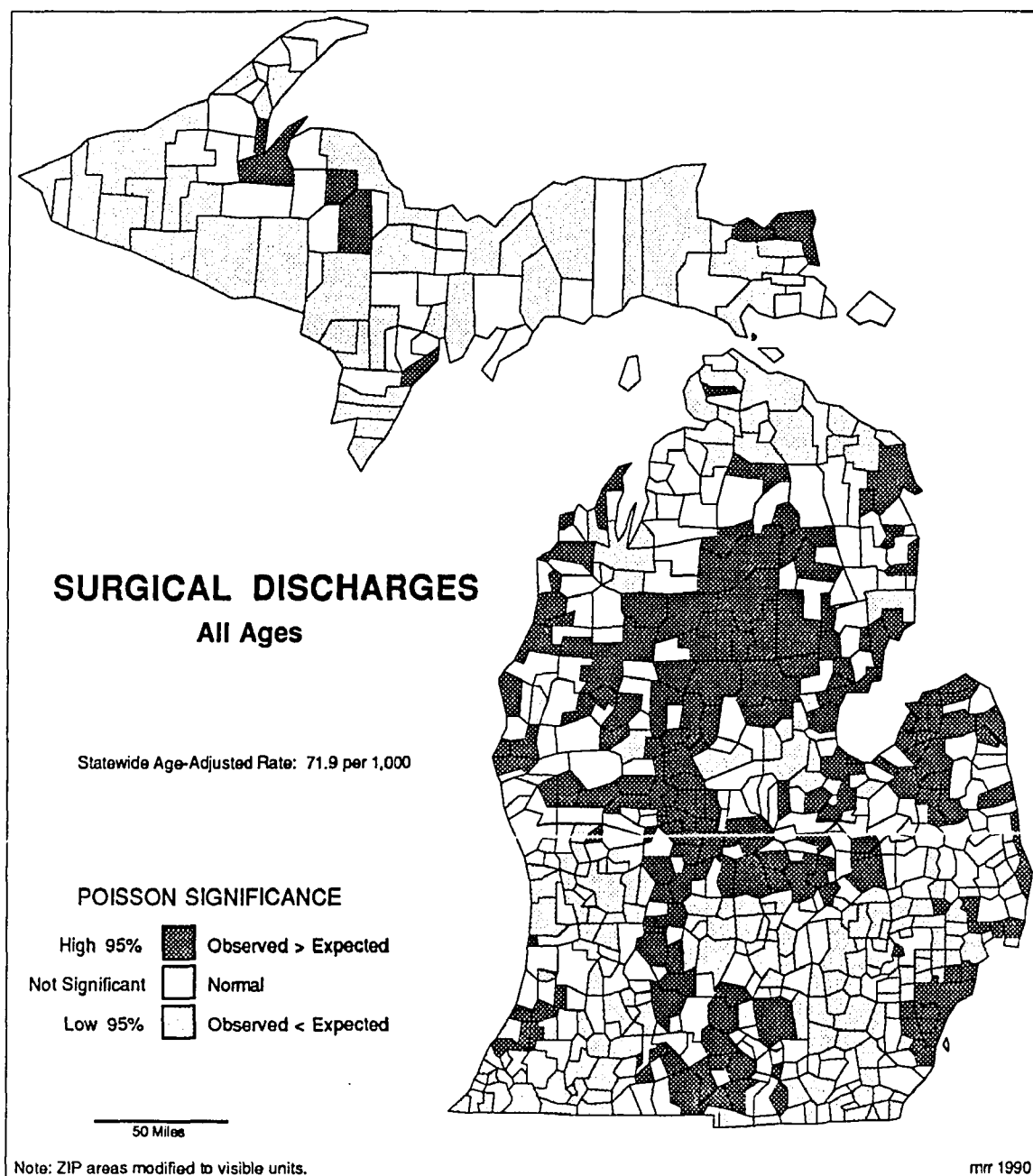


Figure 4.26: Surgical Discharge Rates (All Ages) According to Poisson Probability.

Table 4.31: Median Surgical Discharge Rates (All Ages)
per 1,000 for all 668 ZIP Codes.

RESIDENCE	NUMBER OF ZIP CODES	SOCIO- ECONOMIC STATUS ¢	MEDIAN ZIP Rate	LOWER QUARTILE	UPPER QUARTILE
				Rate	Rate
Urban	132	High	68.6	2.9 - 60.6	77.4 - 99.8
	93	Middle	71.2	10.7 - 62.7	80.6 - 255.0
	59	Low-1	70.0	31.5 - 61.2	77.7 - 107.5
	19	Low-2	65.3	36.4 - 57.7	75.6 - 86.3
	303	Total ¥	69.9	2.9 - 61.3	79.1 - 355.0
Rural	37	High	74.7	46.1 - 64.6	85.5 - 97.3
	73	Middle	72.8	19.1 - 62.9	87.5 - 121.7
	114	Low-1	72.7	31.2 - 64.9	83.5 - 114.7
	141	Low-2	72.8	4.9 - 59.9	85.6 - 201.3
	365	Total ¥	72.9	4.9 - 58.4	85.2 - 201.3
Michigan *	169	High	70.5	2.9 - 61.7	79.5 - 99.8
	166	Middle	71.6	10.7 - 62.9	81.2 - 255.0
	173	Low-1	71.8	31.2 - 64.0	81.6 - 114.7
	160	Low-2	72.4	4.9 - 59.6	84.9 - 201.3
	668	Total	71.0	2.9 - 60.5	82.1 - 255.0

Notes:

¢ Comparisons between the number of ZIP codes above and below the median rate within each socio-economic stratum are not statistically significant ($\alpha=0.05$) when stratified by residence, except for residence as a whole:

¥ Urban-Rural (OR=1.54, CI=1.07—2.23, $p=0.021$).

* The socio-economic groups differ significantly from each other according to surgical discharge rates ($H=1,857$; $df=3$; $p<0.0001$).

Age-specific discharges by residence and socio-economic status for all 668 ZIPs are presented in Tables 4.32; 4.33; and 4.34. No significant difference is detected between residence and discharge rate for each of the age groups, as well as by residence and SES.

Table 4.35 summarizes the age-specific and age-adjusted discharge rates by residence and SES. No statistically significant urban-rural bias is present in hospital use for each age group (OR=1.38, CI=0.96–1.99; OR=1.24, CI=0.86–1.79; OR=1.29, 0.90–1.86), however, there is a significant difference by residence for the all ages group (OR=1.54, CI=1.07–2.23; Table 4.36).

Pediatric discharge rates mapped on a ZIP-specific basis by quartile show the persistent pattern of rural elevation with urban communities being generally in the lower quartile (Figure 4.27). Of note is the fact that all of the large population centers in the southern portion of the state possess rates within one quartile of the statewide median rate. A similar pattern is observable for adults and older adult groups (Figures 4.29 and 4.31). Once tested for significance using the Poisson probability model, predominantly rural ZIPs with higher discharges (at the 95% level) for all three age groups (Figures 4.28; 4.30; and 4.32) display a more fragmented pattern than is the case with the all ages group (Figure 4.28).

MEDICAL AND SURGICAL DISCHARGES COMPARED

Overall:

Surgical discharges outnumber medical by 19% (N=665,389 vs. 560,856). Slightly more medical patients reside in rural areas (13.1%) than surgical (10.4%); the difference being only 4,068 discharges (Tables 4.1 and 4.19). The age-adjusted surgical

Table 4.32: Pediatric Surgical Discharge Rates (<15 Years)
per 1,000 for all 668 ZIP Codes.

RESIDENCE	NUMBER OF ZIP CODES	SOCIO- ECONOMIC STATUS §	MEDIAN ZIP Rate	LOWER QUARTILE	UPPER QUARTILE
				Rate	Rate
Urban §	132	High	21.8	1.5 - 17.1	27.2 - 50.3
	93	Middle	26.5	2.8 - 22.8	30.9 - 143.5
	59	Low-1	22.8	2.8 - 17.7	28.9 - 44.6
	19	Low-2	23.0	9.1 - 36.4	24.3 - 36.4
	303	Total	23.3	1.5 - 143.5	28.6 - 143.5
Rural §	37	High	27.3	3.1 - 19.5	31.8 - 53.7
	73	Middle	25.5	6.5 - 20.5	33.0 - 86.7
	114	Low-1	23.2	3.0 - 16.8	33.3 - 99.1
	141	Low-2	24.7	3.9 - 16.8	31.9 - 106.4
	365	Total	24.6	3.0 - 18.0	32.6 - 106.4
Michigan	169	High	22.8	1.5 - 17.7	28.5 - 53.7
	166	Middle	26.5	2.8 - 22.2	32.3 - 143.5
	173	Low-1	23.0	2.8 - 17.2	30.2 - 99.1
	160	Low-2	24.1	3.9 - 16.3	30.9 - 106.4
	668	Total	24.2	1.5 - 18.1	30.2 - 143.5

Notes:

§ Comparisons between the number of ZIP codes above and below the median rate within each socio-economic stratum are not statistically significant ($\alpha=0.05$) when stratified by residence.

§ There is no significant urban-rural difference ($OR=1.38$, $CI=0.96-1.99$).

Table 4.33: Adult Surgical Discharge Rates (30–44 Years)
per 1,000 for all 668 ZIP Codes.

RESIDENCE	NUMBER OF ZIP CODES	SOCIO- ECONOMIC STATUS ¢	MEDIAN ZIP Rate	LOWER QUARTILE	UPPER QUARTILE
				Rate	Rate
Urban §	132	High	69.2	3.5 - 57.4	81.3 - 121.5
	93	Middle	70.4	12.6 - 60.6	86.8 - 217.5
	59	Low-1	71.6	34.2 - 60.9	80.3 - 146.6
	19	Low-2	72.4	35.4 - 54.2	83.5 - 101.5
	303	Total	70.9	3.5 - 57.6	81.9 - 217.5
Rural §	37	High	79.8	24.4 - 55.1	94.0 - 125.9
	73	Middle	73.4	19.2 - 63.1	92.6 - 181.4
	114	Low-1	76.6	5.0 - 55.3	94.4 - 150.7
	141	Low-2	73.6	0.0 - 57.1	94.1 - 185.5
	365	Total	74.4	0.0 - 57.5	94.0 - 185.5
Michigan	169	High	71.4	3.5 - 57.4	82.0 - 125.9
	166	Middle	71.0	12.6 - 61.8	87.5 - 217.5
	173	Low-1	73.6	5.0 - 54.7	89.2 - 150.7
	160	Low-2	72.4	0.0 - 56.1	93.1 - 185.5
	668	Total	71.9	0.0 - 57.8	88.0 - 217.5

Notes:

¢ Comparisons between the number of ZIP codes above and below the median rate within each socio-economic stratum are not statistically significant ($\alpha=0.05$) when stratified by residence.

§ There is no significant difference between urban-rural residence ($OR=1.24$, $CI=0.86-1.79$).

Table 4.34: Older Adult Surgical Discharge Rates (65+ Years)
per 1,000 for all 668 ZIP Codes.

RESIDENCE	NUMBER OF ZIP CODES	SOCIO- ECONOMIC STATUS ¢	MEDIAN ZIP Rate	LOWER QUARTILE	UPPER QUARTILE
				Rate	Rate
Urban §	132	High	160.8	8.4 - 139.0	186.6 - 276.1
	93	Middle ¢	157.9	17.3 - 141.1	175.2 - 365.9
	59	Low-1	157.1	61.8 - 292.6	173.3 - 292.6
	19	Low-2	156.3	94.3 - 135.5	176.5 - 192.6
	303	Total	160.0	8.4 - 139.4	179.1 - 365.9
Rural §	37	High	169.7	22.2 - 148.3	206.6 - 258.9
	73	Middle ¢	161.5	43.5 - 131.3	186.5 - 259.5
	114	Low-1	160.4	26.3 - 127.2	190.0 - 313.0
	141	Low-2	158.5	20.8 - 129.0	196.7 - 365.4
	365	Total	162.1	20.8 - 127.3	192.3 - 365.4
Michigan	169	High	163.1	8.4 - 139.4	189.6 - 276.1
	166	Middle	160.0	17.3 - 139.9	180.1 - 365.9
	173	Low-1	158.5	26.3 - 133.3	182.9 - 313.0
	160	Low-2	157.9	20.8 - 127.2	191.5 - 365.4
	668	Total	160.6	8.4 - 134.8	186.9 - 365.9

Notes:

¢ Comparisons between the number of ZIP codes above and below the median rate within each socio-economic stratum are statistically significant ($\alpha=0.05$) when stratified by residence for the 'Middle' SES category only (OR=1.32, CI=1.32—2.55).

§ There is no significant difference between urban-rural residence (OR=1.29, CI=0.90—1.86)

**Table 4.35: Age-Specific Median Surgical Discharge Rates (per 1,000)
for all 668 ZIP Codes.**

AGE GROUP (Years)	SOCIO-ECONOMIC STATUS:				MICHIGAN
	HIGH	MIDDLE	LOW-1	LOW-2	
URBAN:					
Under 15	21.8	26.5	22.8	23.0	23.3
30—44	69.2	70.4	71.6	72.4	70.9
65 and over	160.8	157.9	157.1	156.3	160.0
All Ages [1]	68.6	71.2	70.0	65.3	69.9
RURAL:					
Under 15	27.3	25.5	23.2	24.7	24.6
30—44	79.8	73.4	76.6	73.6	74.4
65 and over	169.7	161.5	160.4	158.5	162.1
All Ages [1]	74.7	72.8	72.7	72.8	72.9
MICHIGAN:					
Under 15	22.8	26.5	23.0	24.1	24.2
30—44	71.4	71.0	73.6	72.4	72.1
65 and over	163.1	160.0	158.5	157.9	160.8
All Ages [1]	70.5	71.6	71.8	72.8	71.8

Note:

1. Age-adjusted rate.

**Table 4.36: Age-Specific Surgical Discharge Rates (per 1,000)
by Residence for all 668 ZIP Codes.**

AGE GROUP (Years)	RESIDENCE			FINDINGS		
	URBAN	RURAL	MICHIGAN	OR [1]	CI [2]	p-Value
<15	23.3	24.6	24.2	1.38	0.96—1.99	0.864
30—44	70.9	74.4	71.9	1.24	0.86—1.79	0.269
65+	160.0	162.1	160.6	1.29	0.90—1.86	0.182
All Ages [3]	69.9	72.9	71.0	1.54	1.07—2.23	0.021

Notes:

1. Mantel-Haenszel weighted odds ratio (OR) calculated for rural and urban residence.
2. 95% Confidence Interval.
3. Age-adjusted rate.

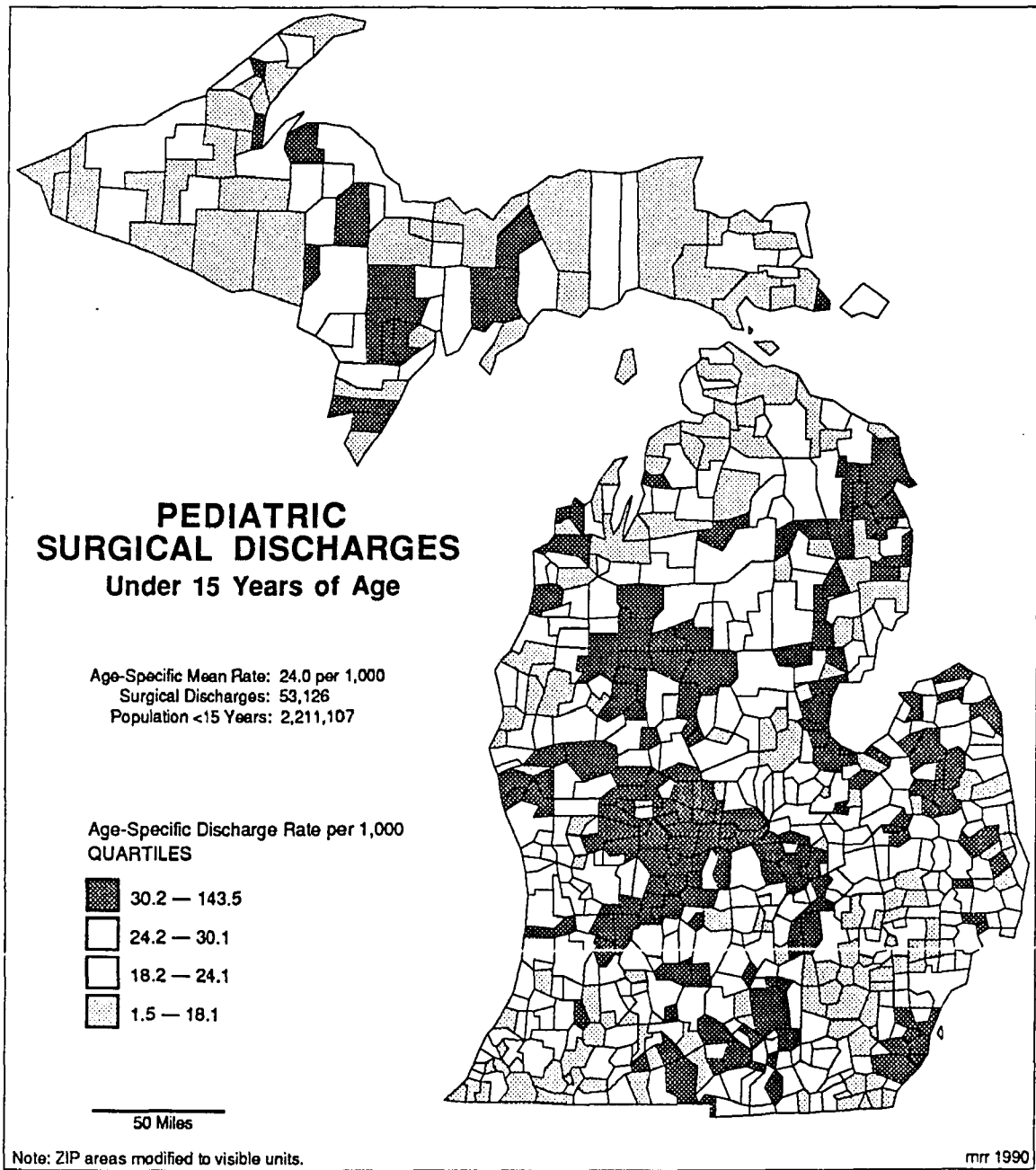


Figure 4.27: Quartile Map of Pediatric Surgical Discharge Rates (<15 Years).

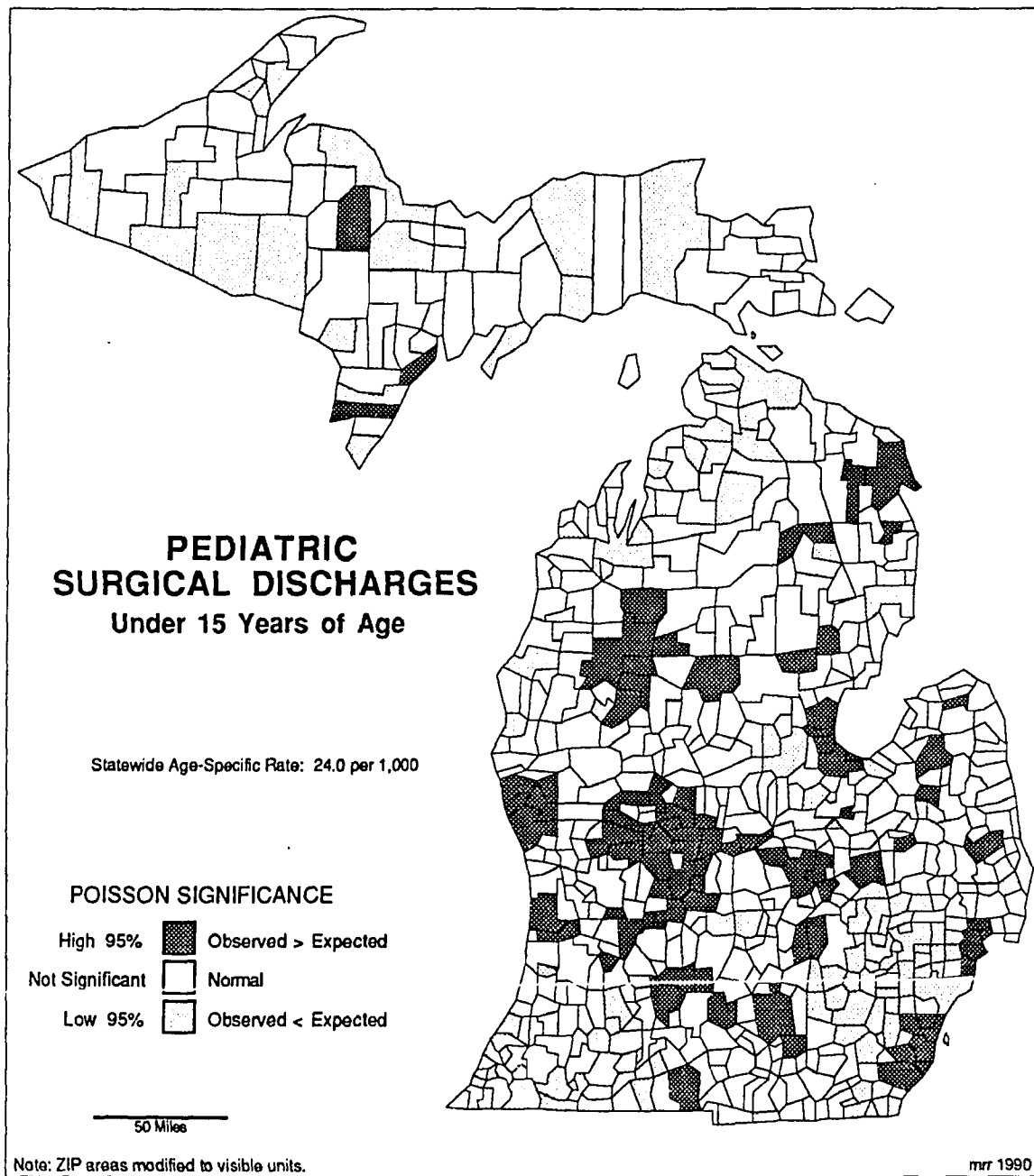


Figure 4.28: Poisson Map of Pediatric Surgical Discharge Rates (<15 Years).

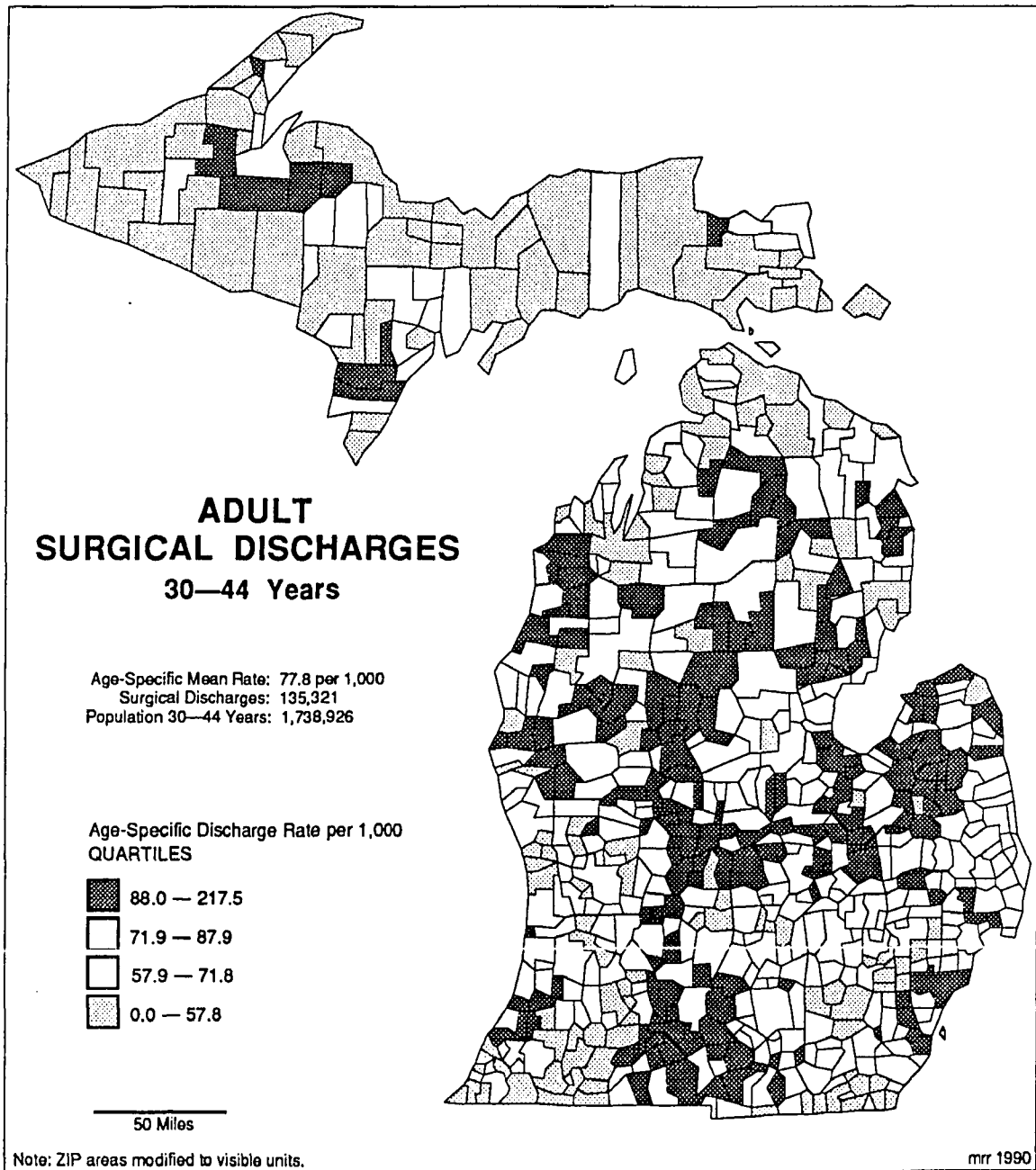


Figure 4.29: Quartile Map of Adult Surgical Discharge Rates (30—44Years).

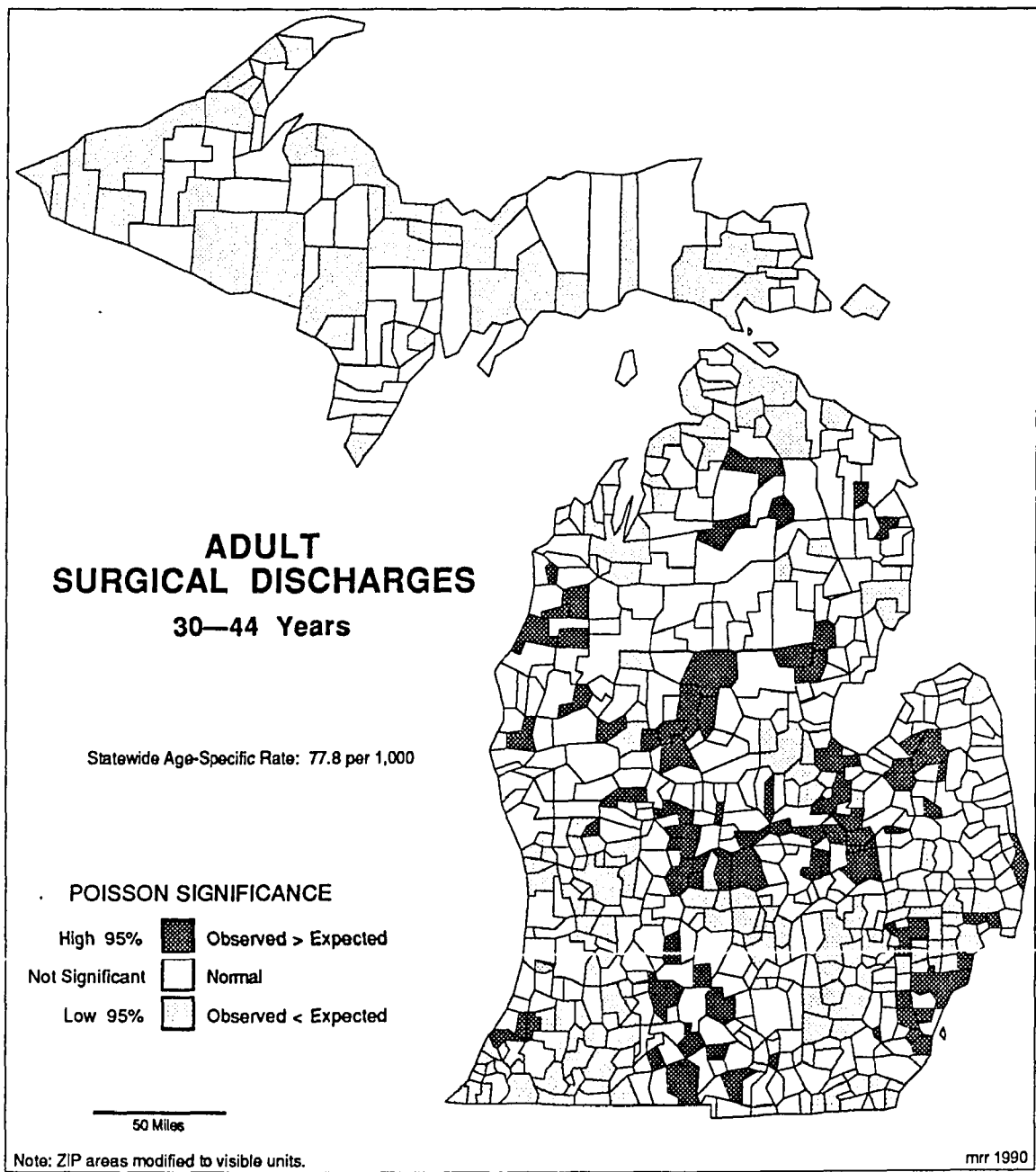


Figure 4.30: Poisson Map of Adult Surgical Discharge Rates (30—44 Years).

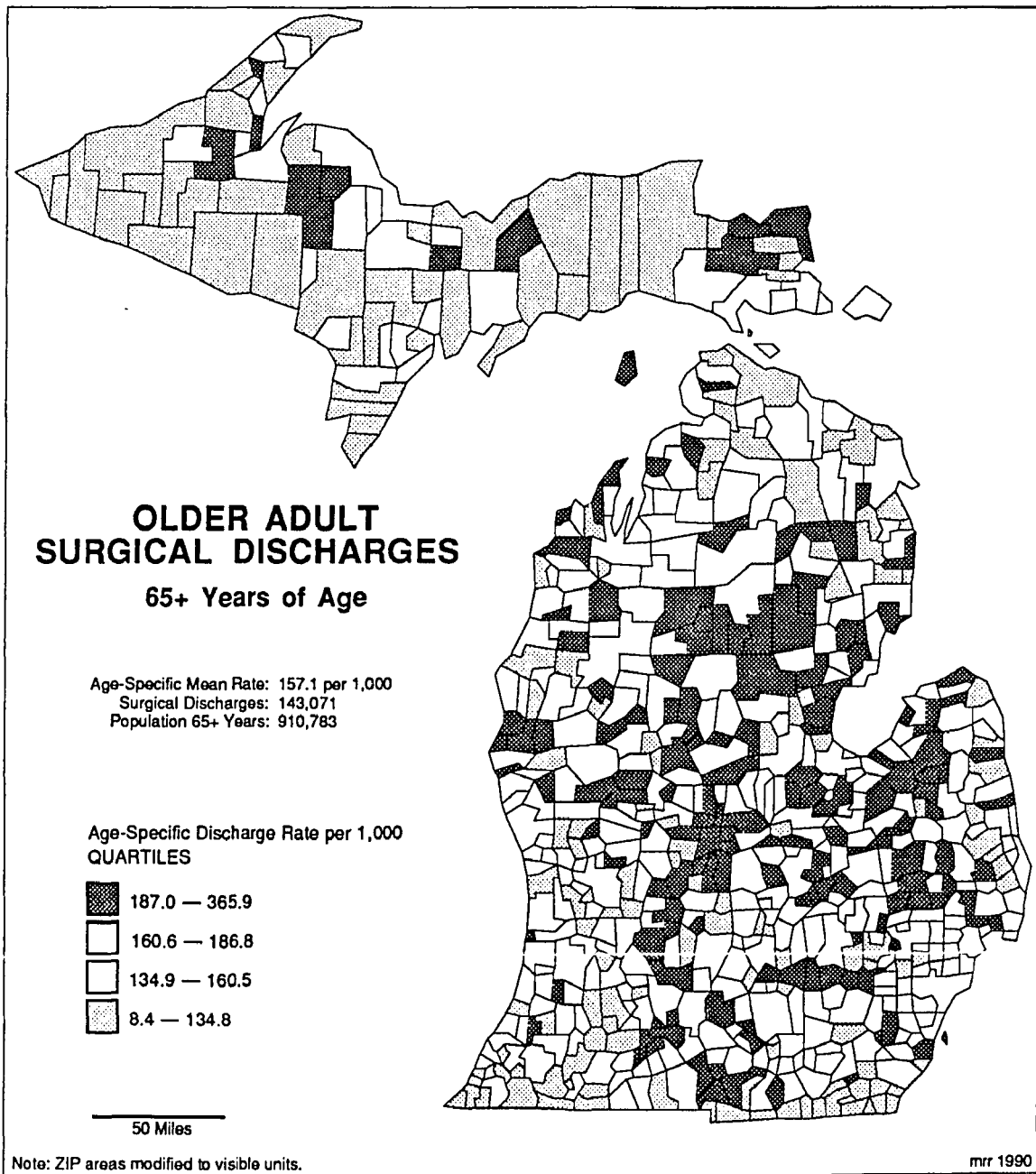


Figure 4.31: Quartile Map of Older Adult Surgical Discharge Rates (65+ Years).

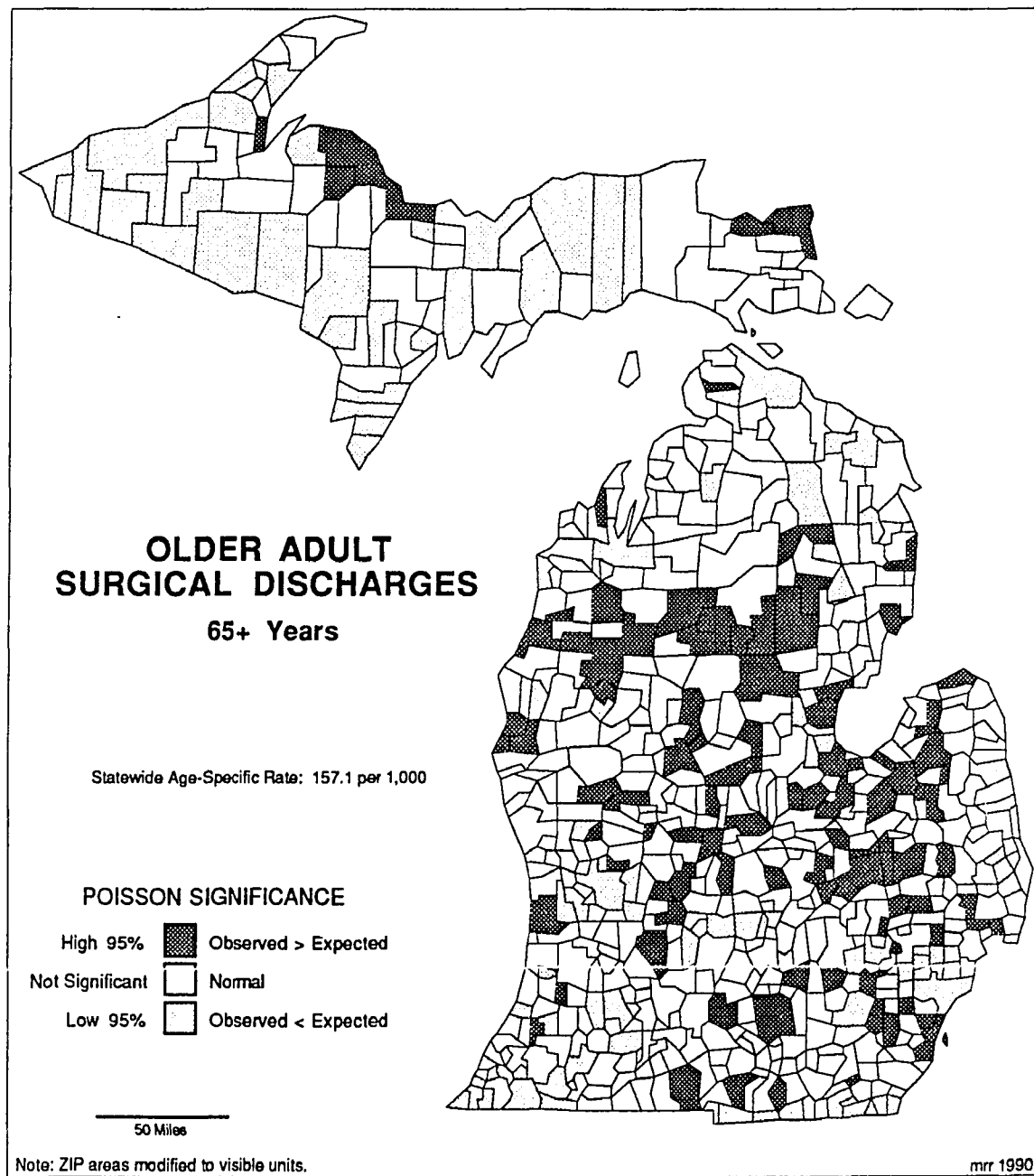


Figure 4.32: Poisson Map of Older Adult Surgical Discharge Rates (65+ Years).

discharge rate (71.9/1,000) is higher than that computed for medical discharges (60.6/1,000; Tables 4.2 and 4.20).

Research Question 1: Is there a significant difference in medical and surgical discharge rates between urban and rural communities?

Place of residence shows quite different use patterns for both medical and surgical discharges. In both cases, rural communities have higher hospital use rates (Tables 4.2 and 4.20). The age-adjusted medical rate is 69.7/1,000, fully 10.0 per 1,000 higher than for urban areas, whereas the comparable surgical rate for rural ZIPs is 72.3/1,000 which is only 0.5/1,000 larger than for urban communities. The difference is statistically significant for medical causes but not for the surgical category (Tables 4.3 and 4.23).

Age Group:

Overall, medical discharges for the three age groups studied is 62.4% of the total, but is less than half of all surgical discharges (49.8%; calculated from Tables 4.4 and 4.22). Pediatric surgical use comprises the smallest percentage of the three age groups (8.0%), while the value is the second largest for the medical category (18.0%).

The rural residence component of percent medical and surgical discharges is similar for each of the three age groups. For each age group, the percentage of medical discharges from rural ZIPs declined with respect to surgical cases. For example, older adult discharges for medical diagnoses dropped from 15.2% to 12.9% for surgical in rural areas.

Research Question 2: Are rural age-specific discharge rates, for medical and surgical conditions, higher than compared to those in urban areas?

Age-specific discharge rates, for both medical and surgical conditions, are higher in rural communities, except for adult (30–44 years) surgical patients. There is a striking difference between medical and surgical use rates when tested for significance. Medical age-specific discharge rates are all statistically significant ($p < 0.001$), whereas no difference between residence and surgical rates is present (Tables 4.2 and 4.20).

Research Question 3: Do medical and surgical discharge rates change with age, and when controlled for residence?

In general, age-specific use rates rise with age. The only exception is for the adult medical group which drops slightly from the pediatric rate before peaking with older adult patients (Tables 4.6; 4.8; and 4.10). For both pediatric and older adult patients, the age-specific use rate is considerably higher for medical rather than surgical discharges. In fact, the medical pediatric rate is almost double the surgical rate (45.5 vs. 24.0/1,000; Tables 4.6 and 4.24). Adult use rates, however, differ from that demonstrated by pediatric and older adult groups — the surgical discharge rate for 30–44 year old patients being double (2.03) that for medical causes (77.8 vs. 38.3/1,000; Tables 4.26 and 4.8; and Figure 4.33).

When place of residence is considered, age-specific medical discharge rates remain statistically significantly higher in rural communities as opposed to urban ones ($p < 0.001$; Tables 4.7, 4.9, and 4.11). Surgical use rates by residence for each age group show no such differentiation (Tables 4.25, 2.27, and 4.29). In addition, the trend for medically higher discharge rates is present in both urban and rural settings — as it is for the state as a whole — with the exception of the adult age group. For patients between 30 and 44 years

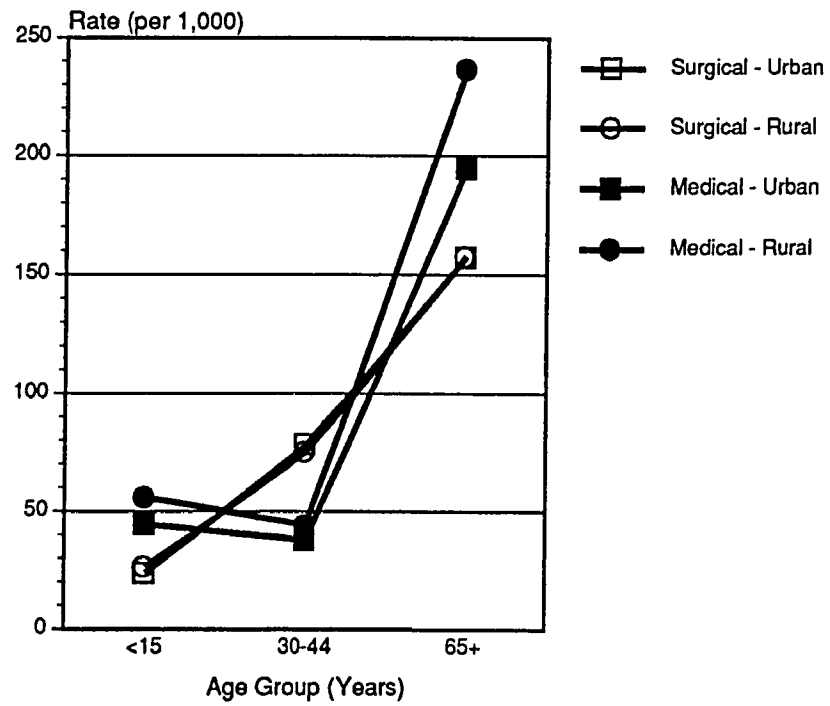


Figure 4.33: Urban and Rural Age-Adjusted Medical and Surgical Discharge Rates by Age Group.

of age, surgical rates are higher than medical for both urban and rural communities (Figure 4.33). All tests for residence by socio-economic status interaction are not statistically significant for both medical and surgical discharges.

Pearson pairwise correlation coefficients between medical and surgical discharge rates by the three age groups are presented in Table 4.37. Discharge rates for every age group are significantly associated ($p < 0.001$). These associations are graphically presented in scatter plots for each age group (Figures 4.34–4.37).

Socio-Economic Status:

Communities characterized by Low-1 SES have the largest percentage of medical discharges (37.1%; Table 4.1). However, for surgical procedures the SES category that has the largest number of discharges is the High SES group (35.4%; Table 4.19). For both diagnostic groups, Low-2 areas contribute the least amount of patients (medical=7.3%; surgical=5.7%).

Research Question 4: Do medical and surgical discharge rates differ with respect to socio-economic classes?

For the state as a whole, age-adjusted medical discharge rates rise markedly in an inverse fashion with SES. Surgical rates are essentially similar, with surgical rates greater than medical rates; however, the Low-2 SES category rate drops slightly below the Low-1 rate (refer to Figure 4.38). SES categories differ significantly for both medical and surgical discharges ($p < 0.01$; Tables 4.2 and 4.20). However, more SES categories display significant differences within medical discharges than is the case with surgical. Bonferroni Post-Hoc procedures show that each SES stratum differs from the High category for both medical and surgical use, but that only for the medical discharge category is there additional

Table 4.37: Pearson Pairwise Correlation Coefficients between Medical and Surgical Discharge Rates (per 1,000).

RESIDENCE	DISCHARGE CATEGORY BY AGE (Years):				
	[1] MEDICAL	SURGICAL [1]			
		<15	30-44	65+	All [2]
Urban	<15	0.49	0.63	0.45	0.62
	30-44	0.55	0.74	0.53	0.73
	65+	0.54	0.71	0.69	0.77
	All [2]	0.60	0.78	0.63	0.80
Rural	<15	0.34	0.39	0.32	0.50
	30-44	0.19	0.43	0.25	0.38
	65+	0.30	0.35	0.47	0.47
	All	0.35	0.43	0.38	0.53
Michigan	<15	0.40	0.47	0.35	0.54
	30-44	0.30	0.52	0.32	0.48
	65+	0.39	0.48	0.53	0.57
	All	0.43	0.55	0.45	0.62

Note:

1. All pairwise correlation coefficients are significant at the $p < 0.001$ level.
2. Age-adjusted rates (per 1,000). All other rates are age-specific.

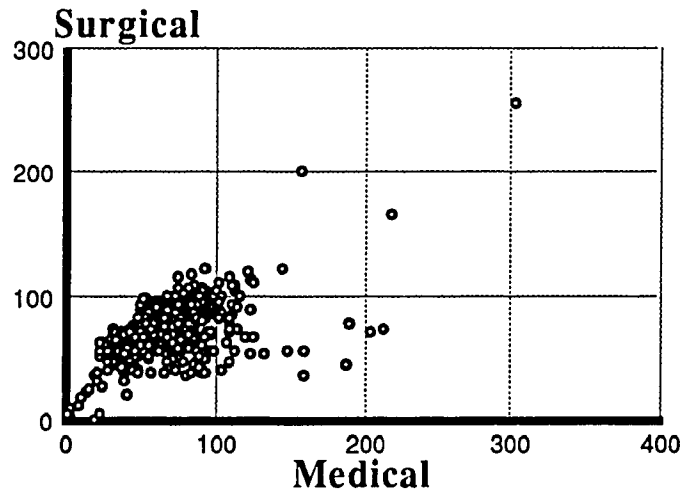


Figure 4.34: Scatterplot of Medical and Surgical Discharge Rates (All Ages).

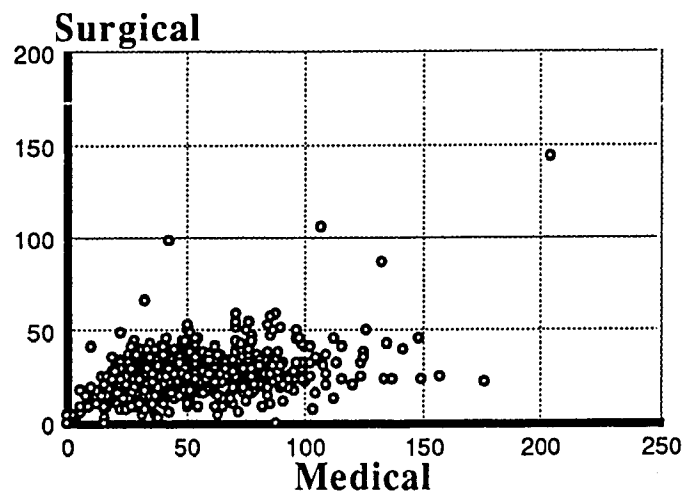


Figure 4.35: Scatterplot of Pediatric Medical and Surgical Discharge Rates (<15 Years).

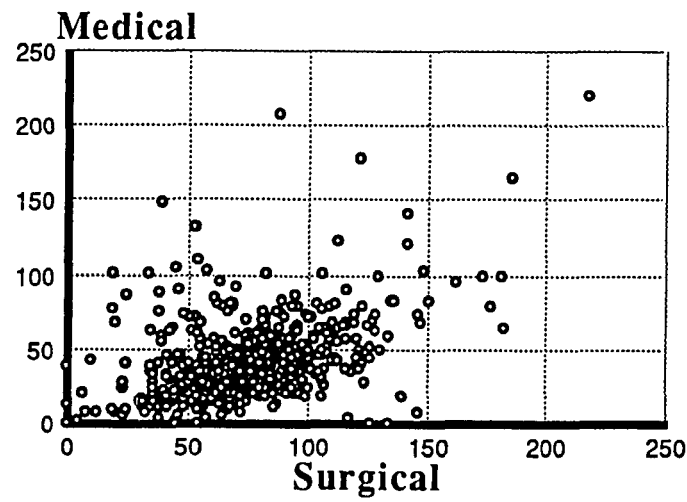


Figure 4.36: Scatterplot of Adult Medical and Surgical Discharge Rates (30—44 Years).

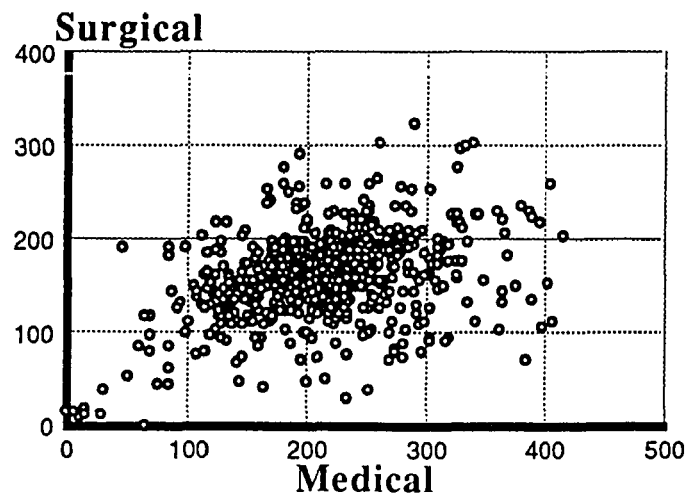


Figure 4.37: Scatterplot of Older Adult Medical and Surgical Discharge Rates (65+ Years).

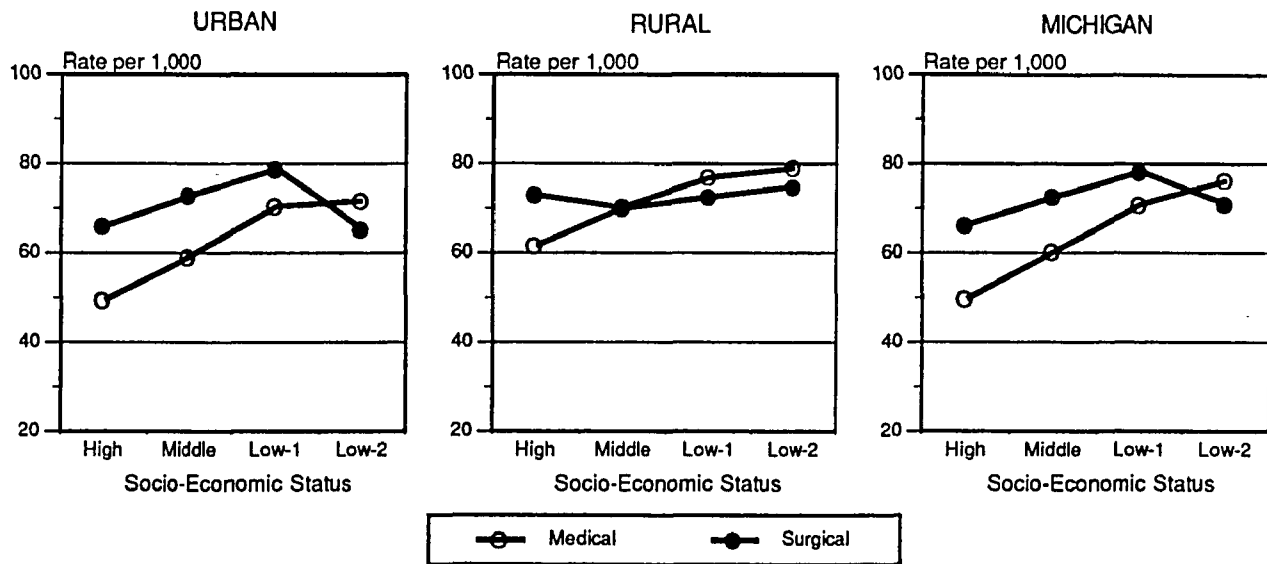


Figure 4.38: All Medical and Surgical Discharges by Residence and Socio-Economic Status

differentiation where the Low-2 group is significantly different from the Middle SES group.

Surgical discharges and socio-economic class do not differ significantly for the adult and older adult groups (Tables 4.26 and 4.28). All age groups within the medical category and pediatric surgical discharges do show significant differences with SES ($p < 0.001$; Tables 4.6; 4.8; 4.9; and 4.24).

Research Question 5: Does residence interact with socio-economic status on medical and surgical discharge rates?

Place of residence has a marked influence on hospital use (Tables 4.2 and 4.20). For medical discharges, the age-adjusted rates rise significantly as socio-economic status declines and this trend is consistent for both urban and rural settings ($p < 0.001$; Table 4.3). A similar situation holds for urban surgical rates, but the upward trend is interrupted by a lowered rate for the Low-2 SES group (Figure 4.38). Unlike medical diagnoses, surgical discharges show a non-significant association with residence and SES ($p = 0.2314$; Table 4.21).

Unlike pediatric and older adult discharges, the Adult group possess higher surgical use rates both by residence and SES than medical (Figures 4.39–4.41). In addition, the general inverse relationship between urban medical discharge rates and socio-economic status is well represented. In rural communities, medical and surgical use rates tend to be stable across the SES gradient. However, older adult medical discharges in rural areas rise markedly with decreasing social class (Figure 4.41).

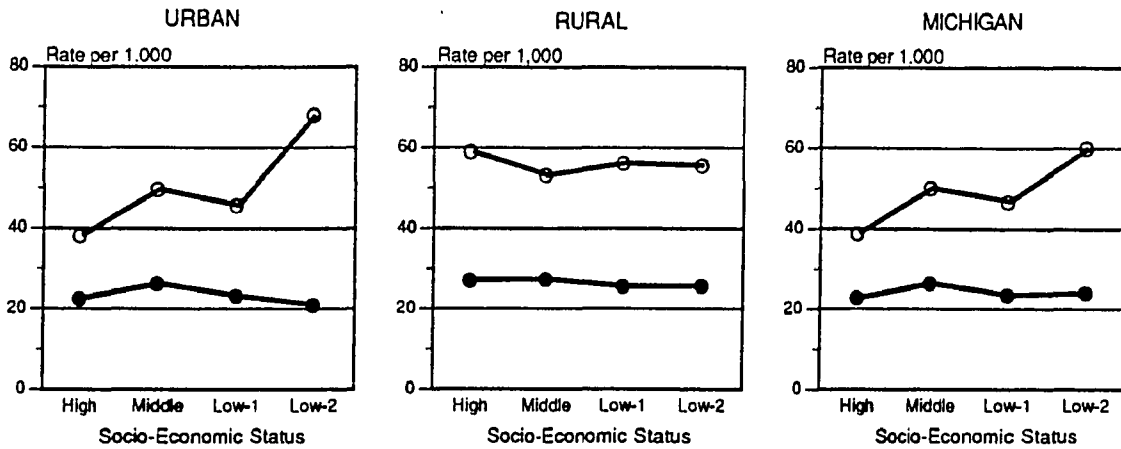


Figure 4.39: Pediatric (<15 Years) Medical and Surgical Discharges by Residence and Socio-Economic Status

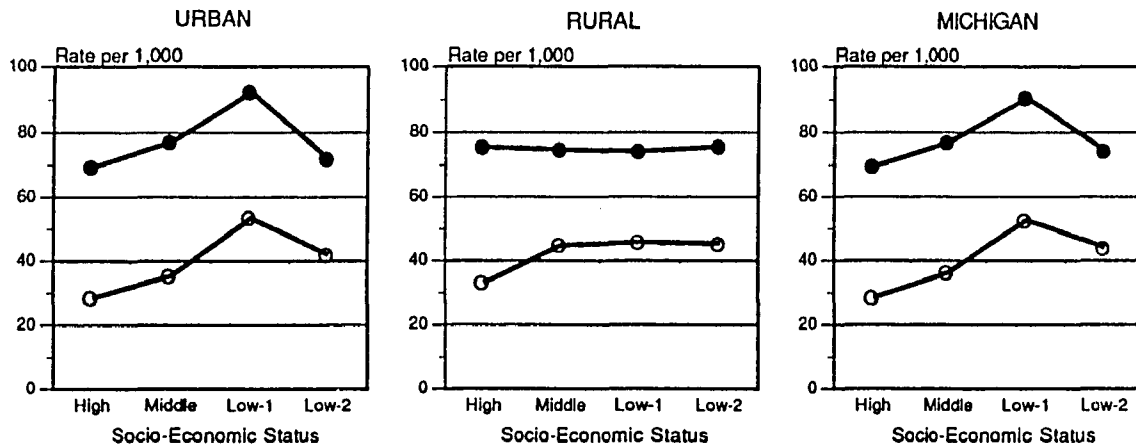


Figure 4.40: Adult (30—44 Years) Medical and Surgical Discharges by Residence and Socio-Economic Status

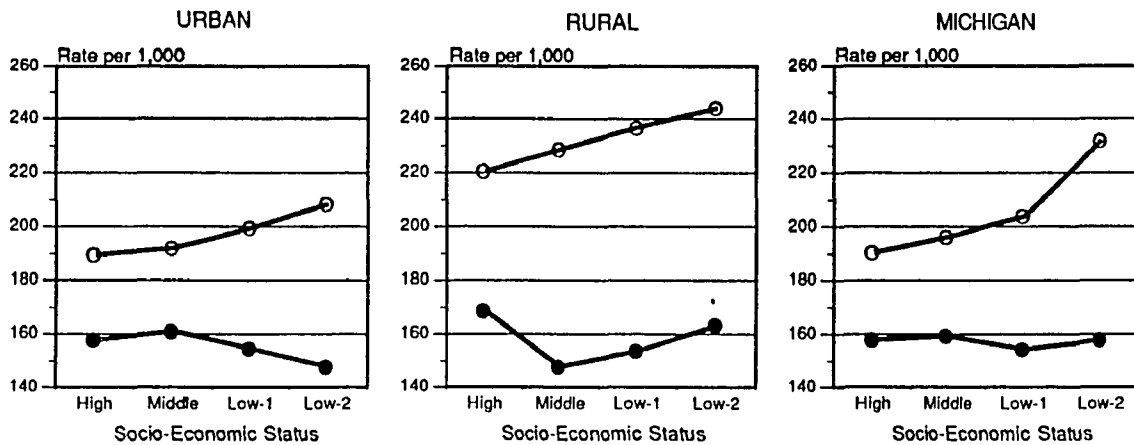
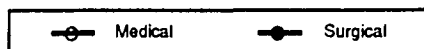


Figure 4.41: Older Adult (65+ Years) Medical and Surgical Discharges by Residence and Socio-Economic Status.



Research Question 6: Is there a difference in hospital use rates between urban and rural residence after matching on socio-economic status?

More SES categories display significant differences within medical discharges than is the case with surgical. Bonferroni Post-Hoc procedures show that each SES stratum differs from the High category for both medical and surgical use, but that only for the medical discharge category is there additional differentiation where the Low-2 group is significantly different from the Middle SES group (Tables 4.2 and 4.20).

Geographical Patterns:

A ZIP-specific analysis of age-adjusted medical and surgical discharge rates reveals the spatially clustered and rural character of communities characterized by high hospital use. When areas within the upper quartile (top 25%) of the discharge rate distribution, concordant for both medical and surgical use rates are mapped, the pattern that emerges is essentially one of elevated use rates in the central region of the lower Peninsula, with low (lowest 25%) areas in the south, around urban areas, and in the western Upper Peninsula adjacent to the Wisconsin border (Figure 4.42). Similar geographical distributions are evident for the pediatric, adult, and older adult age groups (Figures 4.43–4.45).

The frequency distribution of ZIP-specific age-adjusted discharge rates for medical and surgical causes shows that each has a discrete distribution with surgical rates being higher than medical (Figure 4.46).

For the All Ages group there is a statistically significant difference between urban and rural residence relative to medical and surgical discharges ($OR > 1$; Table 4.38). However, age-specific rates between residence sites show a slightly different pattern. Pediatric discharge rates show no significant differences when looked at by place of

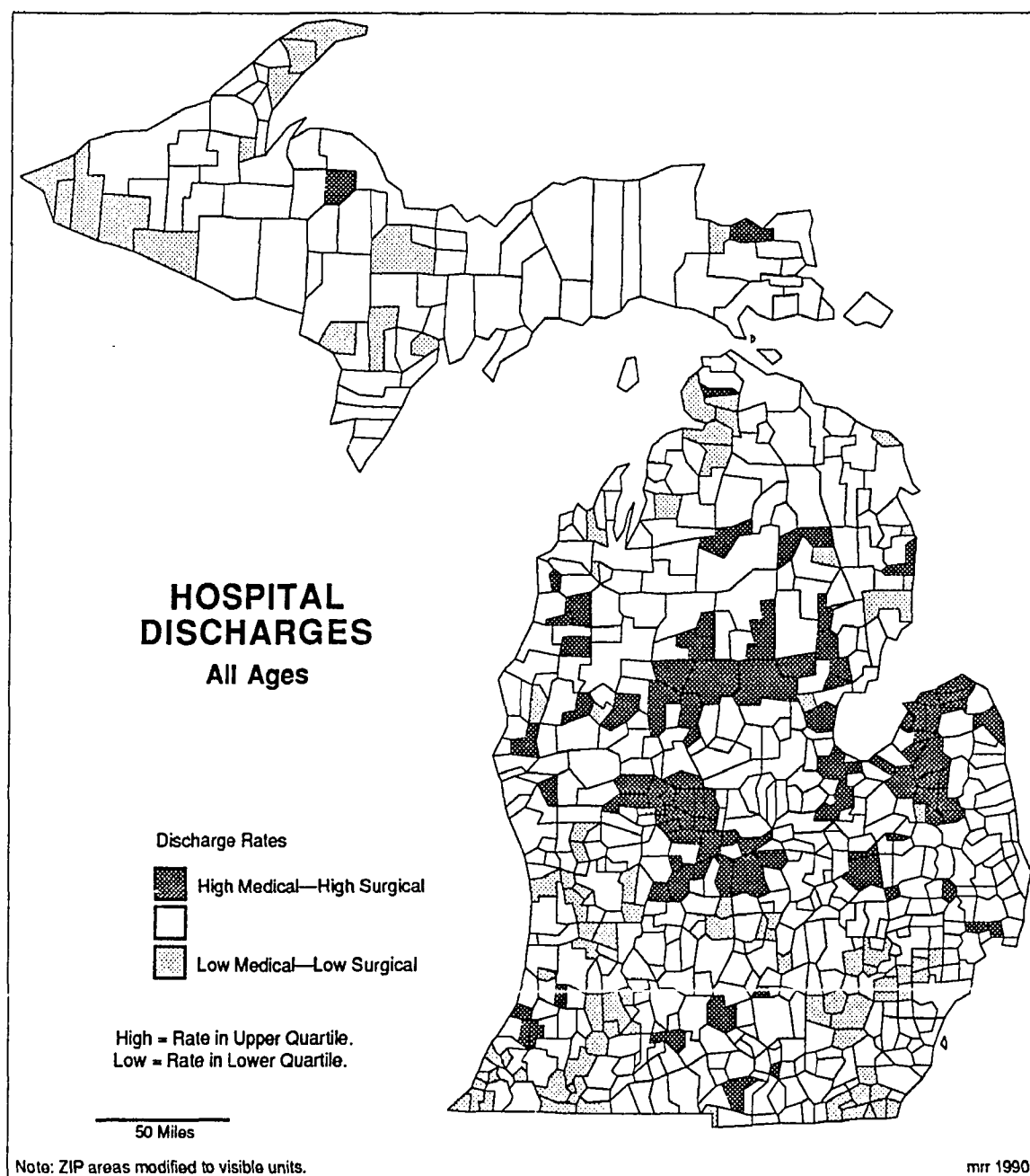


Figure 4.42: Map of High (Upper Quartile) and Low (Lower Quartile) Age-Adjusted Medical and Surgical Discharge Rates by ZIP Code (All Ages).

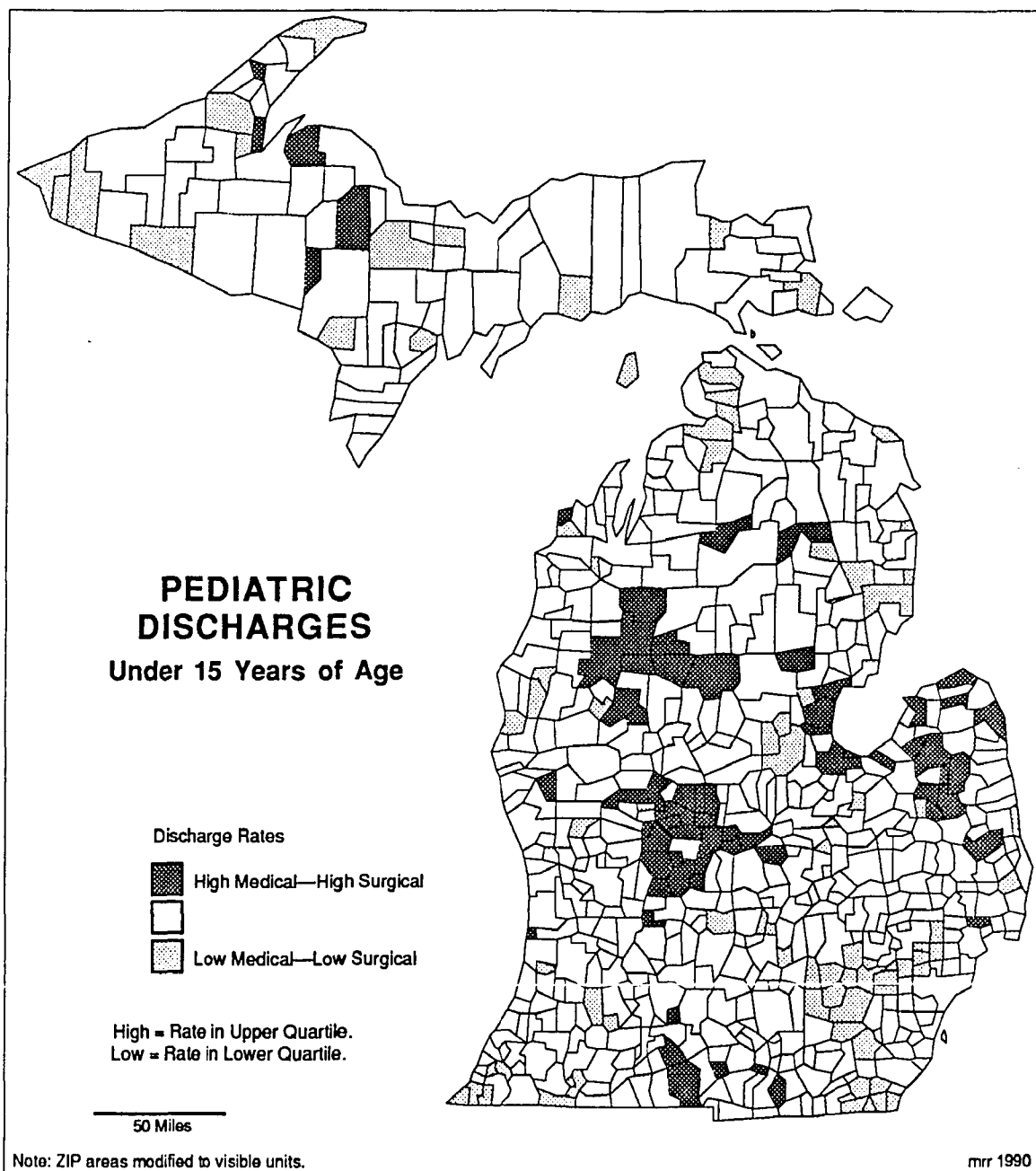


Figure 4.43: Map of High (Upper Quartile) and Low (Lower Quartile) Age-Specific Medical and Surgical Discharge Rates by ZIP Code (<15 Years of Age).

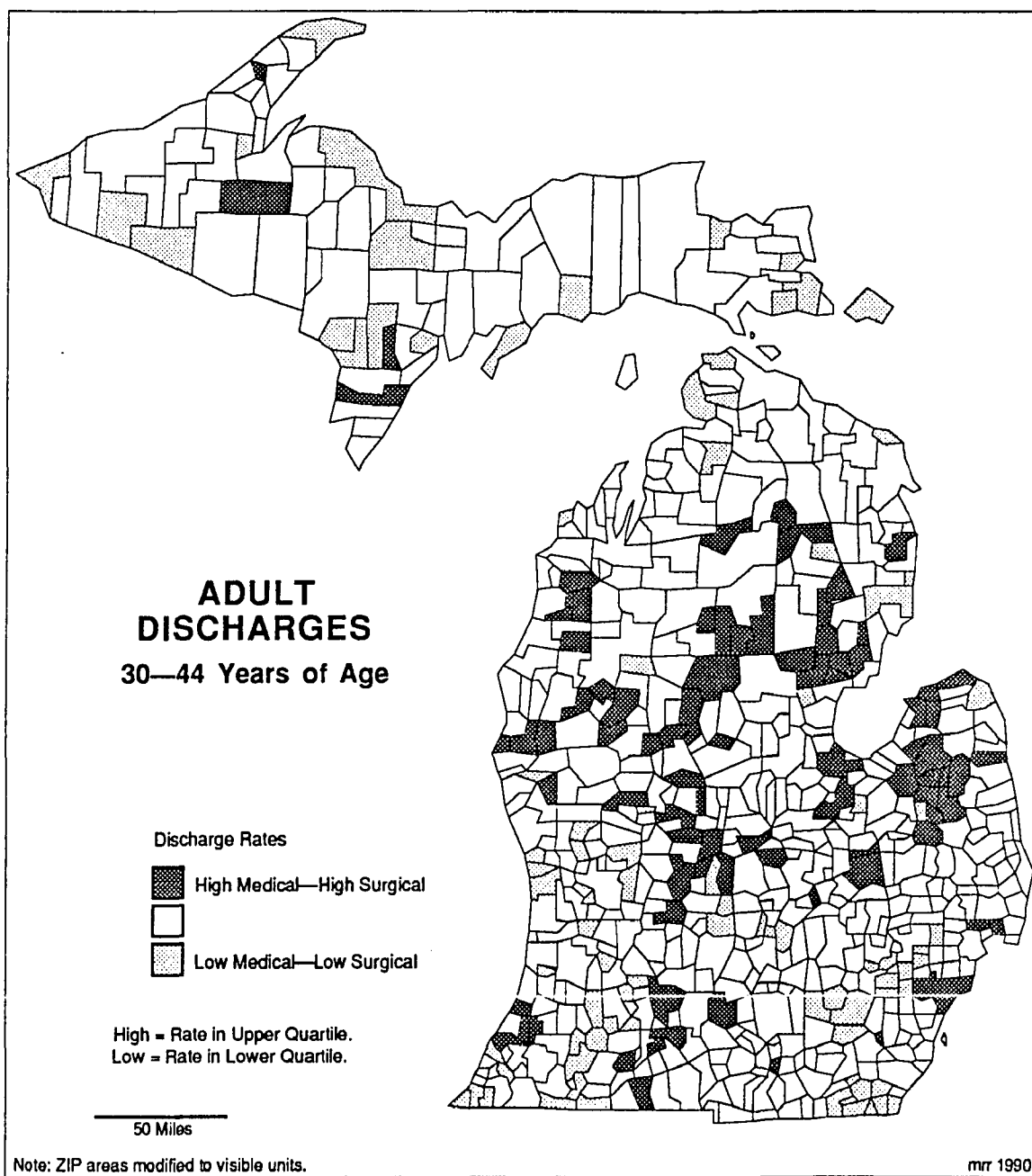


Figure 4.44: Map of High (Upper Quartile) and Low (Lower Quartile) Age-Specific Medical and Surgical Discharge Rates by ZIP Code (30—44 Years of Age).

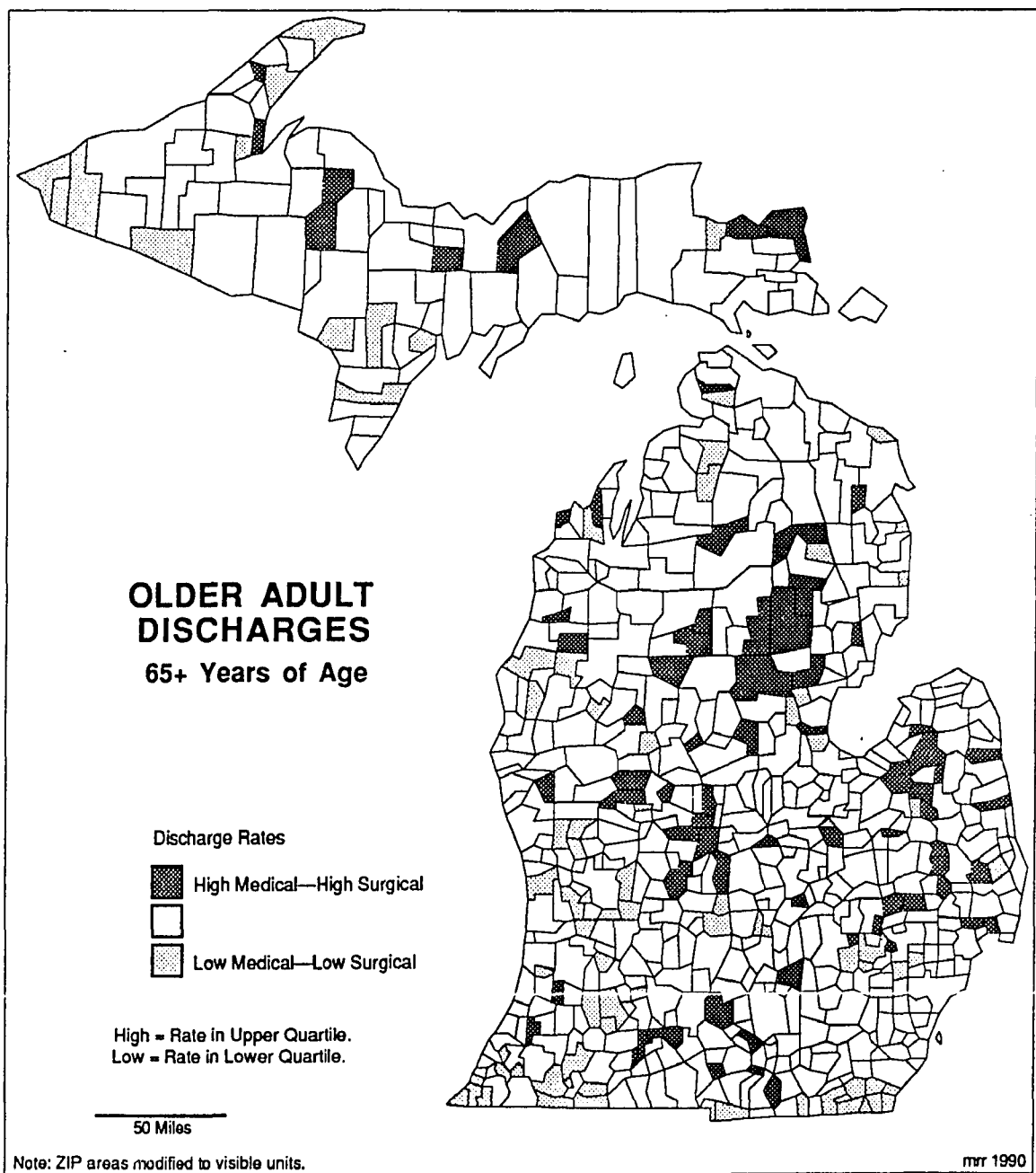


Figure 4.45: Map of High (Upper Quartile) and Low (Lower Quartile) Age-Specific Medical and Surgical Discharge Rates by ZIP Code (65+ Years of Age).

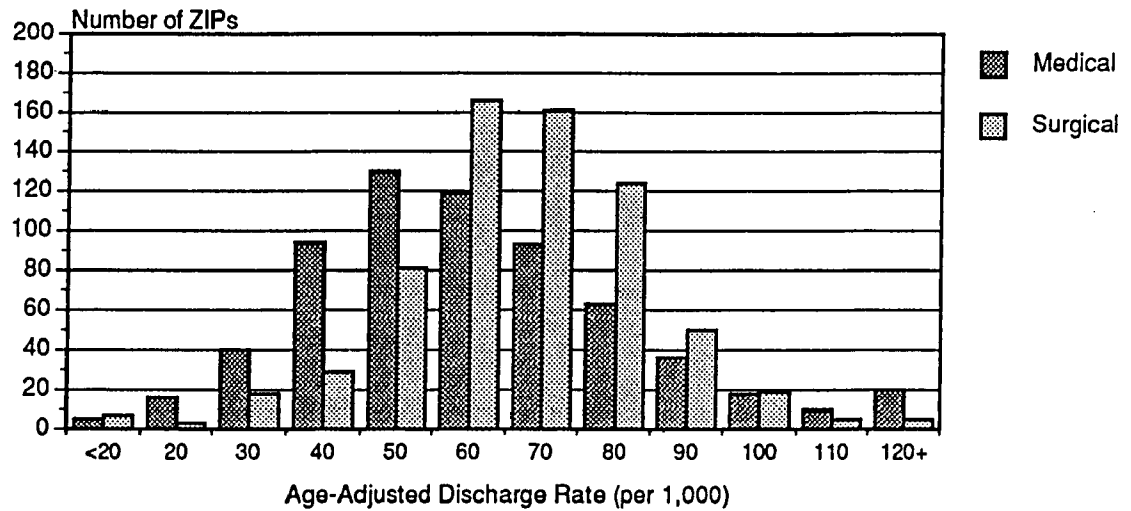


Figure 4.46: Frequency Distribution of ZIP Code-Specific Medical and Surgical Discharge Rates.

**Table 4.38: Age-Specific Median Discharge Rates
(per 1,000) for All 668 ZIP Codes.**

AGE GROUP (Years)	RESIDENCE			FINDINGS		
	URBAN	RURAL	MICHIGAN	OR [1]	CI [2]	p-Value
<i>Medical Discharges:</i>						
<15	38.5	57.8	44.7	1.26	0.88—1.83	0.2231
30—44	31.1	48.0	34.4	1.90	1.30—2.79	0.0007
65+	197.0	229.9	210.1	2.00	1.38—2.92	0.0002
All Ages [3]	56.0	70.9	62.1	2.04	1.40—2.95	0.0001
<i>Surgical Discharges:</i>						
<15	23.3	24.6	24.2	1.38	0.96—1.99	0.864
30—44	70.9	74.4	71.9	1.24	0.86—1.79	0.269
65+	160.0	162.1	160.6	1.29	0.90—1.86	0.182
All Ages [3]	69.9	72.9	71.0	1.54	1.07—2.23	0.021

Notes:

1. OR: Mantel-Haenszel weighted odds ratio calculated for rural and urban residence.
2. CI: 95% Confidence Interval.
3. Age-adjusted rate.

residence. Adults (30–44 years and 65+ age groups) differ for medical discharges only. The age-specific rates for surgery do not differ across residency stratum. This might be explained by the fact that the age groups 15–29 and 45–64 are not represented in this study. These age groups are traditionally high surgical users.

SUMMARY

More surgical discharges occur than medical; the ratio is approximately 1.0:0.8. Rural residence is shown to be an important variable in describing the overall pattern of hospital use in the state of Michigan during 1980. Even though a little more than 10% of medical (13.1%) and surgical (10.4%) discharges originate from rural communities, only medical use rates are statistically significantly higher than discharge rates found in urban areas. Detailed mapping at the ZIP-specific level is shown to be a useful product in documenting this pattern of hospital utilization. The rural bias for medical conditions is not only confirmed via the mapping process, but spatial clustering is clearly visible.

Age of patient is directly related to hospital use. As expected, surgical discharge rates rise almost linearly with advancing age and for medical discharges the age-specific rates are lowest for adult patients and reach a maximum in the older adult group. In general, medical discharges exceed surgical, however, this does not hold in the adult group where the opposite is true.

It seems that geography — the spatial location of communities within Michigan — is a more important ‘predictor’ of medical use rates during this period of time than socioeconomic status. Whereas communities differ significantly according to medical discharge and SES, medical use rate differences are more striking when stratified by residence.

Overall, it is medical discharge rates which display an inverse relationship with regard to socio-economic status, while little SES differentiation is seen with surgical rates.

The implications of aging in the population on the use of hospital services is to increase useage. The data are consistent with this statement. It can be postulated that without any alterations the health care delivery system during the 1980s, hospital use rates would continue to increase. Furthermore, it does not seem reasonable to look at the number of practicing physicians as an explanation for this statement, because the use rate has outgained the number of new physicians. Medical and surgical discharges are different in as much as surgical tends to be self-constrained relative to medical. That is to say, multiple surgeries on one individual is much less common than one hospital visit per medical patient.

CHAPTER V

IMPLICATIONS AND SUMMARY

Results derived from this study are discussed and interpreted in this chapter. Due to the ecologic nature of the methodology employed and the lack of definitive causal factors responsible for the observed variations in hospital use rates, the discussion takes place within the framework of previous research findings and speculation is avoided. The chapter concludes with a brief summary of the major findings, conclusions and future research.

The findings of this descriptive ecologic study identified substantial community-wide population characteristics, namely, age, urban-rural location of a community, and socio-economic status that are significantly associated with differences in hospital discharge rates for Michigan during 1980. This study avoids the small-area analysis approach to patient-origin studies and thus its inherent methodological pitfalls and limitations. While not considering patient mobility (i.e., relating patients to their hospital of use), this study nevertheless provides useful baseline epidemiological and geographical information of hospital utilization across the state at a fine spatial resolution.

Utilization of health care facilities is regarded as a complex interaction between perceptions of illness, the health status of the population, the inclination to seek medical care, socio-demographic characteristics and the availability and proximity of services. Attempts to explain regional variations in hospital use usually involve analyses of population characteristics, or features of health care delivery systems within regions

(Rothberg 1982). The former approach considers ethnic composition, socio-economic status, degree of urbanization, age-related characteristics and patient demand as sources of variation in hospital use. The latter approach concentrates on such factors as diagnostic mix, hospital bed supply, physician supply and nursing home bed supply. Empirical support for the importance of population characteristics is mixed. For example, relationships between such factors as ethnic and age composition of areas and utilization have been found. However, they have not been consistently replicated across studies using different methods. A similar situation pertains with health care delivery characteristics on hospital use rates — significant spatial variations persist even when supply variables are held constant. As a result, a number of researchers have concluded that differences in physician practice styles is the important missing dimension that directs the relationship between population characteristics, health care service supply, and hospital use (Wennberg 1984; Wennberg *et al.* 1984).

While socio-demographic factors have been shown to alter utilization patterns, none of them has been found to explain more than a small percent of measured geographic variations. For example, age is a strong predictor of hospital use of all forms of medical services (Hulka and Wheat 1985). Gender affects utilization: women undergo surgery more frequently than men. Income has a strong positive effect, especially for children and the aged (Bombardier *et al* 1977). In addition, variations in aggregate health status in a region do not seem to be a significant predictor of geographic variations. Nor are illness levels regularly higher in high-use areas (Wennberg and Gittelsohn 1975a; Roos and Roos 1982). Geographic variations have not been shown to be related to the ability of the patient to find or get to a physician (Roos and Roos 1982).

Although the relationship of factors identified as explaining geographic variations in hospital use to some degree is interesting (e.g., bed-supply, number of physicians, socio-

economic difference, patient characteristics, the health care system, and the practice style of physicians), it does not provide a direct answer to the question of whether geographic variations indicate unnecessary use.

While a number of studies have demonstrated that the greater the supply of surgeons, the greater the number of operations which will be observed (Detmer and Tyson 1978), the data for Michigan does not support this general finding. Many more surgeons practice in large urban hospitals and their per-capita presence supports this. However, no statistically significant difference in age-adjusted surgical discharge rate is found between urban and rural communities, even when matched for socio-economic status and age group.

The results of an analysis of surgery rates in Kansas showed that they supported a medical variation in Parkinson's Law: patient admissions for surgery expand to fill beds, operating suites, and surgeons' time (Lewis 1969). However, the finding of an association between resources and surgeons has not been substantiated in Canada (Mindell *et al.* 1982). Large small-area differences in surgical rates have been explained both by supply and demand factors. Variables such as medical need, ability to pay, and supply of physicians were all important determinants of utilization across the US (Mitchell and Cromwell 1982).

Griffith *et al* (1981) used the same 1980 database from which the data for this research is drawn and found a strong positive correlation with community size and length of stay. The size of a community was defined by the numerical size of the population contained within that area. A total of 54 hospital service areas, covering 90% of Michigan's lower peninsula, were defined according to the Relevance Index methodology. However, almost all surgery and medical discharges showed no apparent association with

community size. In addition, the effect of age-adjustment was shown to be of importance as 24% of the communities experienced a shift of more than 10% from the unadjusted rate. This illustrates the necessity for age-adjusting area use rates to permit reliable comparisons between communities (however defined).

The 1985 study of hospital use in Michigan during 1980 showed that length of stay rates were significantly higher in the metropolitan counties where the cities of Detroit, Saginaw, Flint, and Battle Creek are located (Office of Health and Medical Affairs 1985). Low-use urban counties were situated in the Ann Arbor, Grand Rapids, and Lansing areas.

Counties with high bed-to-population ratios have been found to have high utilization rates regardless of whether the physician-to-population ratio was high or low (Joffe 1979). Moreover, a generous supply of hospital beds in the Northeast and Northwest states — particularly in rural areas — was responsible for increased admission rates during the 1970s, as compared to the West of the country (Knickman and Foltz 1985). Discharge planning has been shown to be an important factor in length of hospital stays and decreased readmissions — important cost factors (Proctor *et al.* 1990). Good discharge planning may be less prevalent in the case of rural Michigan patients. In rural Michigan it has been found that non-surgical admission rates are higher in communities with more empty beds per capita (Zeddies *et al.*, reported in Clark and Hamilton 1986) and with a greater number of physician specialists (Wilson and Tedeschi 1984). However, the association between hospital bed supply and physicians (particularly specialists) is not consistent across studies.

One of the earliest suspected predictors of hospital use was urban versus rural residence. Generally, admissions have been shown to be lower for city dwellers (Andersen and Anderson 1973). However, there is conflicting evidence primarily

originating from investigations of urban-rural mix that have been conducted largely on a small geographic scale — that is to say, at a state or county scale (Wennberg and Gittelsohn 1973; Anderson 1973; Ferguson *et al.* 1976). A recent analysis of hospital use in Michigan in 1983 did not consider the rural character of small hospitals, but concluded that the rural nature of many high use hospital service areas indicated that location is an important variable and ought to be included in future research (Clark 1988). This study attempts to fill that gap.

In rural Michigan, physicians are in greater supply in communities that have fewer specialists and this substitution may explain the significantly higher medical use rates observed in these settings, particularly for the north-central part of the lower peninsula. An analysis of relative hospital use in Michigan (1980) showed that length of stay in rural counties exhibited a wide variation (Office of Health and Medical Affairs 1985). Even though no clear geographic pattern was evident, a group of high-use rural counties were clustered in the north-central part of the lower peninsula.

A recent example of using large areas for variation analyses is that undertaken by Mitchell and Davidson (1989) who analyzed Medicare physician claims for surgical operations from ten states: Alabama, Arizona, Connecticut, Georgia, Kansas, New Jersey, Oklahoma, Oregon, Washington, and Wisconsin. Six procedures were chosen for comparison and assigned to a MSA or a rural area (non-MSA) based on the location of the surgeon's practice. That study represents one of the first to attempt to assess fee variations that place a physician's practice "in an area as *small* as an MSA and that permits comparisons among urban (MSA) areas and between urban and rural areas" (sic) (emphasis mine) (Mitchell and Davidson 1989, p.114). Previous small-area analysis applied to Medicare data has used the reasonable charge locality, which, in many cases, is an *entire*

state. Urban/rural differences in surgical fees were found to be much smaller than those across states.

An analysis of utilization rates by county in North Carolina during 1983 showed that the single most significant variable in explaining a group's use rate was *where* they were located in the state (Greene 1984). Rural low-cost hospitals admitted patients more frequently than did counties in which expensive teaching hospitals are located. The distribution and intensity of age-adjusted hospital discharge rates for medical diagnoses within Michigan confirms this finding; the rural rate being 14% higher than for corresponding urban communities (Table 4.3).

A disproportionate share of poor Americans live in rural areas. Rural poverty rates are higher than those for urban areas and mirrors the broader pattern of poverty found in all regions of the country (Rowland and Lyons 1989). Studies based on the 1977 National Medical Care Expenditure Survey showed that a higher proportion of the rural population relative to the urban population was without insurance, and that the most extensive lack of insurance was in areas that were more than 60% rural (Walden *et al.* 1985). Rural residents had higher rates of lack of insurance. In addition, when insurance status was examined specifically for the poor and near-poor, there were more people without insurance coverage and fewer people with Medicaid coverage in rural areas than in urban areas (Wilensky and Berk 1982). In 1987, thirty-eight percent of poor rural residents were uninsured. These rates were found to be troubling because lack of insurance results in reduced access to care (Davis and Rowland 1983). Medicaid coverage was found to be lowest in rural areas; on average just over a third (36%) of the rural poor have Medicaid coverage compared to 44% of urban poor residents (Rowland and Lyons 1989). A number of explanations have been advanced as to why Medicaid coverage is so low in rural areas (*ibid.*, p. 986). Medicaid eligibility has traditionally been more generous in heavily urbanized areas and the eligibility policy favors single-parent families, a family group that

is more prevalent in urban areas. Residents in rural areas may also be less aware of Medicaid as a source of finance or less willing to enroll in a means-tested program linked to welfare assistance. (It appears that the gap between the urban and rural uninsured is narrowing because the proportion of individuals without insurance is growing faster in urban areas: 34% of urban poor in 1980 rose to 37% in 1988, while comparable figures for the rural group was 37% and 39%, respectively).

Rural residents — including children and the elderly — are less likely to report acute conditions than urban residents and are more likely to suffer from chronic conditions (National Center for Health Statistics 1986). When self-reported health status — a widely used measure of health — is examined for the non-elderly population, reported health status does not vary substantially between urban and rural areas (National Health Interview Survey conducted in 1984). Within rural areas where shortages of health care providers were found, the residents reported fair or poor health more frequently than rural residents from areas with adequate health resources (Berk *et al.* 1983).

The definition of hospital service area in predominantly rural regions has been considered previously by Clark (1990). It was postulated that part of the explanation of higher use rates in rural areas may be that hospital use increases in areas where there is a substantial distance between the hospital and the boundary edge of the service area (*ibid.*, p. 77). Patient visits to physicians' offices in Newfoundland is cited as supporting this notion (Girt 1973). Physicians do play a mediating role in the influence of population characteristics on hospital use and three nonclinical factors influence their decision to hospitalize a patient, namely, (i) the distance between patient's residence and hospital, (ii) the absence of social support for the patient, and (iii) the degree of financial hardship imposed on the patient (Kuder *et al.* 1985). Preliminary analysis for this dissertation indicates that patient travel times (in minutes) between the centroids of member ZIP codes

within rural hospital service areas in Michigan (defined via the plurality method as used by Clark) may be substantial and the frequent use of linear distances produces misleading results. Overall, physical access — as defined by travel times — appears not to be a significant issue for rural residents in Michigan; witness their high hospital utilization rates. This seems to confirm the suspicion that it is the complexity of physician practice style/pattern, and not geographical constraints or considerations, that may explain the significantly elevated rural use rates. Moreover, explanations of geographical variations in use rates ought to consider variations between individual clinicians.

Hospital care is generally as available to rural residents as it is to urban residents (on bed to population size ratio), however, it is often less accessible because of distance, transportation, and weather-related problems. (Moreover, more rural hospitals are closing, thus further decreasing residents' access to care in many rural areas.) More health care access problems are expected in rural areas because of the lack of adequate providers, the scarcity of organized outpatient departments, and the long travel time-distances between care settings. Furthermore, hospital facilities are generally smaller, further away and less adequately equipped than urban facilities.

An urban-rural bias in the distribution of physicians, the 'gate-keepers' to the hospitals, is well known (Shannon and Dever 1982, pp. 70—88). Rural populations are doubly disadvantaged by having fewer available physicians than urban dwellers and have greater difficulty obtaining health care services due to problems of accessibility (financial and physical). However, several studies have failed to confirm the widely reported findings that hospital use declines with increasing distance from the source of care (for example: Ciocco and Altman, cited in Shannon and Dever 1982, p. 97).

The 1977 National Medical Care Expenditure Survey results showed that the proportion of the rural population that experienced a hospitalization was higher than for those living in urban areas (Taylor 1983). Significant differences in hospital utilization between the insured and uninsured have been documented. Insured residents of rural areas appeared to use twice as many hospital days per 100 persons as their uninsured counterparts (Davis and Rowland 1983). The higher hospitalization rate among rural residents may be attributable to a variety of factors. First, lack of available ambulatory services may mean that patients in rural areas who could have been treated in an outpatient setting require hospitalization. Second, rural residents may also be sicker by the time they seek care and therefore require hospitalization. Finally, because rural residents may need to travel further to reach a treatment facility or obtain care, hospitalization may be used in place of multiple outpatient visits (Rowland and Lyons 1989). It has been found that lower socio-economic status is associated with higher reports of morbidity (Syme and Berkman 1976).

In order to answer the question, “why are hospitalization rates higher in rural areas?”, the influence of the combined effects of poverty, lack of insurance, and rural residence on access to, and use of, health care services warrants careful study within rural areas.

The role of socio-economic factors as a determinant of small-area variation in hospital discharge rates can be used to illustrate some problems of small-area analysis methodology in general. Although many studies have been performed, there is still a lack of consensus about the role of socio-economic factors. It seems that this disagreement stems, in part, from the difficulty in comparing results across studies that use different geographic units and methods of analysis (McLaughlin *et al.* 1989).

Socio-economic status influences access to medical services. Overall, poor children are less likely to be seen by medical professionals for either short- or long-term care, and they are more likely to present with an advanced illness or more severe symptoms (Starfield and Budetti 1985). Different rates of hospitalization suggests differential need. Although the determinants of clinical need are inherently complex, socio-economic status has been shown to be crucial (Wise and Meyers 1988). However, gross similarities in aggregate socio-economic data do not imply identical clinical needs (Wise and Eisenberg 1989).

A number of studies have shown that socio-economic status is related to patterns of hospital use. Andersen and Anderson (1973) have demonstrated that admission rates vary inversely with family income. This finding has been substantiated by Rosenthal (1964) and Richardson (1969). Feldstein and German (1975) have also shown that median family income is predictive of statewide hospital utilization rates. However, race has been shown to alter hospital use; black people enter hospitals less frequently than white people do (Battistella 1961). In Michigan, there is a paucity of rural black poor people. Hence, this may confound crude measures of utilization rates since they are unadjusted for race. This could serve as a partial explanation for the observed high rural use rates.

Numerous studies have found that health and medical care utilization are confounded by influences outside the medical care system. For example, earlier research published by Martini *et al* (1977) shows that traditional outcome measures — like discharge rates — are more sensitive to variations in the socio-economic-demographic circumstances of the population than to the amount and type of medical care provided and/or available. An inverse relationship between socio-economic status and hospital discharges is confirmed by many studies across the nation (i.e., in Vermont by Brewer and Freedman 1982). Brewer and Freedman (1982) found a negative correlation between personal income and hospital discharges ($r=-0.40$; NS) and a positive correlation with poverty

($r=0.33$; NS). However, when all socio-demographic factors are taken together, the multiple correlation coefficient ($r^2=0.83$) is significant at the $p<0.05$ level. Overall, utilization was not related to the availability of hospital beds. The six socio-economic factors explained 70% of the variation in hospital discharges.

Vladeck (1985) has shown that the 10 highest hospital discharge rates in the city of New York are from low socio-economic status communities (ZIP code areas), whereas the lowest use rate areas are middle-class areas. The results from this study support the finding that urban low SES areas have high use rates.

There appears to be a strong association between high hospital use and low socio-economic status, in both rural and urban communities of Michigan. It is important to note that this association is essentially with the proffered definition of poverty and not based solely on income. Not only are 50% (334) of the ZIP communities characterized by 'low' socio-economic status and contribute 44.4% of all medical discharges and 40.3% of surgical discharges, but most have significantly high use rates. Of note is the fact that some large urban communities, Detroit for example, possess significantly high medical and surgical discharge rates (refer to Figures 4.10 and 4.26).

Several studies have concluded that low-income families are less willing to travel long distances for medical care (Williams 1960; Kane 1969). The results from this study, however, suggest that in rural areas, patients who travel greater distances for medical care are the largest consumers of hospital resources. The high rural use rates, particularly for medical conditions, seems not to support the role of distance (either linear or time) in hospital utilization. According to traditional distance-decay theory — the concept that facilities will be proportionately more frequently used by populations nearer to a health center, for example than by those at increasing distances from it — rural use should be

lowest as more patients live not only further away from a hospital, but there are also fewer facilities available to them. Somehow the friction of distance is being overcome. Interestingly, it is the lowest socio-economic status communities in rural areas which are heavy users of health care and it is not unreasonable to postulate that this group of patients are most severely disadvantaged by accessibility. However, in 1980, unlike the situation prevailing today, most low socio-economic status people possessed some form of health insurance and therefore did not experience limited access due to financial constraints. However, none of these studies have used a severity of illness index to categorize people seeking health care. It might be hypothesized that because of the distance factor, rural poor people would have to be sicker than their urban counterparts to seek initial contact with a hospital. Thus, their decreased frequency of contact would be offset by the "amount" of health care services rendered, including increased length of stay. Further study on this utilization issue controlling for illness as a confounding variable — by using a severity of illness index — is suggested.

Little is known about the utilization of health care among rural populations in Michigan, particularly the fastest growing segment — the elderly (65+ years of age). It is possible to hypothesize that the rural elderly should be heavy users of health care resources because of the relationship between aging and hospital utilization, particularly medical care. However, the dispersed location of residence in rural regions inhibits access and should discourage the utilization of health care resources. On the contrary, older adult residents in Michigan's rural areas have significantly higher medical use rates than their urban counterparts. Overall, this indicates that physical access is not a problem, although locally in certain areas of the Upper Peninsula time-distance (patient travel time) to a hospital facility may be a factor.

A recent study suggests that rural and urban hospital markets may be larger than previously believed (Morrisey *et al.* 1989). The economics and health services literature holds that many rural area hospitals are virtual monopolies in isolated markets, and that urban hospital catchments coincide with the boundaries of the Standard Metropolitan Statistical Areas in which they are located. Using Medicare patient-origin data for patients aged 65 years and older resident in rural Nebraska during 1984, the analysis shows that the average “single” hospital market area, that is sole community provider, encompasses six counties and contains 16 hospitals (*Ibid.*). Similar results have been obtained by the author for a single rural hospital in Michigan; 11 counties and 13 hospitals. The finding that hospital markets are relatively large reflects a willingness on the part of individuals to travel some distance to a “rival” hospital and suggests that patients obtain similar services in other health care settings. Further, many urban hospital markets in the United States extend beyond the boundaries of their Standard Metropolitan Statistical Areas. The study concludes that access to rural hospital care may not be as critical an issue as widely believed. In addition, the county may be too small a market area on which to base planning decisions.

Is it possible that lower socio-economic status populations are experiencing higher discharge rates as a consequence of excess morbidity, or can their higher use of health care services be attributed to physician/provider practice or behavior patterns? An alternative possibility is that termed the ‘inverse care law’ whereby the availability of good medical care varies inversely with the need for it, thus necessitating additional visits (Hart 1971).

Current discussions of health policies for the poor typically assume that poverty is a cause of medical deprivation. Two ‘facts’ are accepted as true: (i) poverty leads to less medical care; and (ii) poverty results in diminished health (Lefcowitz 1973). The finding

that for medical causes rural low socio-economic status communities have significantly high use rates tends to call these established 'facts' into question.

Lower social class populations have long been shown to experience substantially higher rates of general morbidity, infant death, and severe illness (Lerner 1969). Health status in turn is strongly related to utilization of health services. When health status is considered, the relation with socio-demographic variables is strongest for persons who experience milder illnesses (Richardson 1970). It seems that lower socio-economic groups are sensitive to the method of financing health care and hospital use increases markedly when insurance coverage is extended to lower income populations (Andersen and Benham 1970). However, even when financial barriers are removed, differences in utilization are still evident (Nolan *et al.* 1969). On the basis of the social systems approach to understanding utilization behavior, hospital use and health status are seen to be related to the supply of hospital beds, aggregate levels of education, employment, income, and socio-demographic characteristics of the population, as well as general practitioners and medical specialists (Anderson 1973).

Roos and co-workers draw attention to the fact that marked variations in hospitalization cannot be explained by the health status or socio-economic-demographic characteristics of patients. Rural physicians practicing in areas with high bed-to-population ratios and low occupancy rates are particularly high users of hospitals (Roos *et al.* 1986). Their study was conducted in Manitoba, Canada, which is within the context of another health care system and a lesser supply of physicians per capita. The economic implication of different practice styles appear to be quite significant; physicians who were high users of hospitals serve 27% of the patients but their patients consume 42% of the hospital days (*Ibid.*, p. 49). Their research, as well as the present study, complements the findings of others that small groups of patients consume a disproportionate share of health care

resources (McCall and Wai 1983; Schroeder *et al.* 1979). In addition, an earlier study in the same region (rural Manitoba) indicates that the arrival of a surgically active physician seems to lead to increased utilization (Roos 1983). This finding has not been explored in Michigan.

An important question for health care planners and policy makers is how does socio-economic status influence the use of health care services? Lower income groups are well known to have significantly higher levels of morbidity and shorter life expectancies than higher socio-economic groups. Inequalities in health are often said to be due, in part, to more restricted accessibility and thus lower utilization of health care services among lower income groups. However, medical use rates for 1980 are shown to be significantly inversely related to socio-economic status; the lower the socio-economic status of a community the higher its hospital use.

While socio-economic factors are shown to be significantly associated with hospital use rates in this study, it appears that previous small-area analyses may have incorrectly concluded that socio-economic characteristics do not explain differences in utilization rates (McLaughlin *et al.* 1989). These authors, using 1980 patient-origin data for Michigan, conclude that socio-economic factors are statistically significant determinants of the variation in both medical and surgical discharge rates, whether the method of analysis is simple correlations or multiple regressions, and whether the geographic unit of analysis is the county or a well-defined hospital service area. The present study supports these findings and questions the long-held notion among leading analysts of small-area variation that population characteristics are not important determinants of the observed variation in community use rates (i.e., Roos and Roos 1982; Wennberg 1985b). As stressed earlier in this dissertation, a definition of socio-economic status which uses income as a surrogate measure of 'poverty' is inadequate. The character and nature of rural poverty is quite

different to urban poverty and this is not captured when income is used as a single descriptor. There is no evidence to suggest that these conclusions could not be replicated with the comprehensive definition of poverty proffered in this study. However, this remains a subject for further study.

Overall, the substantial correlation between medical and surgical community-specific discharge rates suggests that the patterns of medical and surgical discharge rates are similar across communities in Michigan. High-use ZIPs as measured by medical use rates also tend to be high-use areas with respect to surgical rates. This general pattern has also been shown by Wolfe *et al.* (1989), that high correlations seem to indicate a large component of the cause of small-area variation may be due to community-specific characteristics in addition to, or instead of, physician-specific explanations. The ZIP-specific results from this study appear to confirm this notion.

Case-mix specialization — the concentration of hospitals on certain types of inpatient care such as obstetrics and orthopedics — has increased significantly between 1980 and 1985 (Farley and Hogan 1990). Most of the increase has occurred since the introduction in 1983 of Medicare's flat-rate prospective payment system for reimbursing hospitals for inpatient care. Case-mix specialization appears to lower costs and make the delivery of health care more efficient. While the financial advantages are not to be ignored, the geographic consequences of this trend have yet to be adequately appreciated. Hospital specialization, superficially similar to the concept of regionalization, may systematically alter the distribution, and hence accessibility, of certain health care services in a detrimental manner.

The inverse relationship between income and utilization among rural communities is confirmed in a recent study by Hart *et al.* (1989) who performed a detailed analysis of

survey questionnaires that were administered to 6,000 households across the nation. It appears that rural hospitals provide disproportionately large amounts of care for government beneficiaries — Medicaid and Medicare patients — and also render care to increasingly large numbers of uninsured (and underinsured) patients; a finding that seems to be applicable in Michigan.

Since 1984, total hospital admissions declined in the United States. Some of this decline, no doubt, results from efforts to control utilization also being undertaken by many purchasers and carriers of group health insurance, such as mandatory second opinions before surgery or pre-admission review of certain kinds of cases. Additional hypotheses explaining the decline are the growing supply of physicians and the growth of the Health Maintenance Organizations (HMOs) and other prepaid arrangements which have economic incentives to reduce hospitalization. Medicare's new prospective payment system, which pays hospitals a flat amount on a per-case basis, is perhaps the cause of changes in hospital use, notwithstanding the fact that per-case payment gives hospitals incentives to increase rather than reduce admissions, nor the more important fact that utilization appears to be falling more rapidly among younger persons than among Medicare beneficiaries (Vladeck 1985, p. 1).

By looking at the hospital utilization of those aged 65 years and older, it is possible to isolate the discharge rates of that segment of the population that is currently directly affected by the Medicare Prospective Payment System. It can be assumed that changes in the payment system and in other market conditions during the decade of the 1980s will have affected their level of hospital utilization.

The negative averaging effect of the population-based plurality assignment of ZIP codes to hospital service areas can be seen by considering its application to the so-called

“Lansing cluster”. Using the modified ZIP areas (visual units) as outlined in this study, the four hospitals within the city of Lansing (Ingham Medical Center, Lansing General, Sparrow, and St. Lawrence), as well as four others in relatively close proximity surrounding Lansing (Mason General, Eaton Rapids, Clinton Memorial, and Hayes-Green-Beach), and accompanying populations are assigned to one hospital service area that is made up of 26 individual postal codes. These ZIP codes not only cover the entire socio-economic spectrum, but also range from urban, peri-urban and rural in setting. Consequently, whereas the present ZIP-specific study maintains the integrity of each ZIP code, the plurality scheme does not and deletes any ‘micro-scale’ analysis by aggregating individual communities into one large hospital service area. This approach has the net effect of moving any variation towards the mean.

It is recommended when small-area analysis is being performed using sparse data, that log-linear regression-adjusted synthetic estimates be produced. The application of this technique to functional dependency in the noninstitutionalized American population age 65 years and over is a recent example (Elston *et al.* 1991). Such an approach will help reduce the number of small-area units discarded from the final analysis due to small numbers.

The results and findings derived from the analysis of Michigan data for 1980 have significant health and social policy implications. In recent years health care expenditures in Michigan and the nation have escalated at an alarming rate. In 1950, Americans spent \$12.7 billion on health care. This figure represented almost \$82 per capita and 4% of the Gross National Product (GNP). By 1970, the per capita expenditure had risen to \$950 (in constant dollars) However, by 1979, a total of \$212 billion or slightly less than \$1,000 for every person and 9% of the GNP was consumed by health care. Prior to the introduction of Medicare’s Prospective Payment System, these trends were estimated to continue so that by the year 1990 the US would pay \$800 billion for health care services (Freeland and

Schendler 1981). In reality, the trend has been slightly lower. Health care absorbed nearly 12% (\$604 billion) of the GNP in 1989; almost double that spent in 1982. Nevertheless, the per capita expenditure — \$2,350 in 1989 — continues to rise. A regression analysis of GNP per person costs for 1989 and health spending per person for the 14 member countries of the Organization for Economic Cooperation and Development,¹ reveals that the United States does not adhere to the pattern of the other member countries. The United States registers the highest GNP per person and per-capita health expenditures and does not conform to the regression pattern formed by the other 13 member states. The observed per capita health expenditure of \$2,350 is 23% higher than the \$1,800 figure predicted by the regression equation. Inpatient hospital care accounted for 40% of all health expenditures in 1979–80, and increased at a greater rate than any other component of the medical system. The negative relationship between preventive care and hospital utilization revealed in the study by Brewer and Freedman (1982) argues for more preventive medicine and earlier intervention as a means of controlling inpatient utilization and hence, costs.

If one accepts the general implication of all studies of variation in use of medical care — that significant amounts of both hospitalization and surgery may be of little or no medical benefit — one then must ask why this situation exists and what can be done about it. Two primary factors stand out as being of major importance. First is the failure of the medical profession to discover what impact new medical and surgical technologies have on patient outcome before advocating their adoption into routine practice. New diagnostic (i.e., fetal heart monitoring) and treatment (i.e., magnetic resonance imaging; lithotripsy) technologies are one of the principal drivers behind rising health care costs and in many cases their efficacy and efficiency is not well understood. Second are third-party payments. Such a system opens up many opportunities for industry growth were more is

¹ Australia, Belgium, Britain, Canada, France, Japan, Holland, Italy, New Zealand, Spain, Sweden, Switzerland, United States, and Western Germany.

thought to be better. As of 1979, as much as 92% of hospital costs are covered by payments from government or private health insurance (Wennberg 1979). Considering that physicians are reimbursed on a percentage of their usual billing rates, it is not surprising that such a strong bias toward delivering services on an inpatient basis is seen. Such a reality led to the adoption of a new reimbursement policy adopted by Medicaid under its PPS system in the third quarter of 1983. The effect has been to drastically diminish inpatient hospitalizations and a concomitant increase in ambulatory outpatient care. Finally, should a significant amount of medical discharges in rural areas in 1980 be due to overutilization, the important question rural hospital closures during the decade of the 1980s arises, i.e. the impact of closure on surrounding communities, and resultant effects on the availability of health care.

The incidence of hospitalization for most Diagnosis Related Groups is highly variable (Wennberg *et al.* 1984). Overall, it is admission policies which are more important than length of stay decisions in determining the use of hospital beds. The DRG system appears not to be a successful cost-containment tool because the system does not take into account the importance of physicians' practice styles in determining hospital case-mix and the volume of hospital admissions. Their analysis suggests that many opportunities to increase admissions exist, leading to the hypothesis that hospitals and their physician staffs will respond to some and perhaps most threats of DRG-induced losses by modifying their admission policies to adopt more lucrative (though clinically acceptable) practice styles and by adjusting the way in which cases are labelled (nosology).

Prior to late 1983, Medicare paid hospitals on a cost-based retrospective basis. To achieve the objective of cost containment, Medicare began paying a single flat rate per case type, the diagnosis related group (DRG), and utilizing a Prospective Payment System (PPS); both were phased in commencing as hospitals began the fiscal year after October 1,

1983. The new system markedly altered the incentives given to hospitals. Faced with a fixed rather than variable prices, hospitals could react by: 1) reducing waste and inefficiency; 2) reducing length of stay, ancillary services, and/or intensive care use; 3) finding legal ways to maximize Medicare payment by more careful coding of the patient's condition; and/or 4) attempting to improve financial position by refusing to treat unprofitable cases (Sloan *et al.* 1988).

Recent studies have documented an increase in the number and rate of rural hospital closures across the United States and Michigan in the 1980s (Mullner and McNeil 1986; Stratton 1989). In nearly 80% of these closures a community lost its only non-Federal short-stay general hospital. Although hospitals, especially small hospitals (under 100 beds), are closing in both urban and rural areas, the factors affecting closures in these respective settings are thought to be quite different. Rural closings tend to be associated with a more chronic set of factors. Changes in the reimbursement structure — the Prospective Payment System — is identified as being one of the primary contributors to hospital closure, as well as changes in demographic structure, a declining rural economy, Mullner and Rydman 1990). The high age-adjusted per capita hospital use rates (Mullner and Rydman 1990). The high age-adjusted per capita hospital use rates documented for rural Michigan during the pre-PPS era in this study, suggests that hospitals in these areas were at risk for closure following introduction of Medicare's reimbursement system. For example, the demographic profile of many Michigan rural areas shows a large percentage of elderly residents (Groop and Manson 1987). Hence, most rural hospitals suffer from a dependency on Medicare and Medicaid. Consequently, the pre-Medicare reimbursement structure was imperative to the economic viability of rural hospitals. Moreover, it now appears that admission rates and readmission rates are the strongest determinants of the total hospitalizations per capita (Wennberg 1984; Knickman and Foltz 1985; Roos *et al.* 1986).

Variation in admission/discharge rates noted in Michigan and elsewhere have a number of etiologies. Non-clinical factors influencing a physician's decision as to whether a patient ought to be admitted to hospital or not, offer potential explanations. Socio-economic status is one such variable that has been proposed and considered. However, the geographic location of communities — that is patients within a ZIP code — and the socio-economic characteristics of such communities have not yet been studied in Michigan. This research shows that rural residence is particularly important when analyzing hospital use rates for medical diagnoses, as well as the interrelationship between residence and socio-economic status. Our ability to document regional and small-area variations in rates of hospitalization has been greater than our ability to explain and mobilize a response to them.

The delivery of health care in Michigan has undergone fundamental changes during the 1980s. Hospitals are continually facing the challenges of downsizing; witness the decrease in patient admissions from 1.5 million in 1980, to 1.1 million in 1990, to an estimated 800,000 by the year 2000 (Michigan Hospital Association 1989). The availability of patient beds will continue to decline, from near 35,000 in 1989 to an anticipated bed need of only 21,000 in the year 2000. Accompanied by this projected downsizing is the continued closing of hospitals. This will necessitate reviewing alternative provider models and different approaches to deliver health care. Another trend which is making a marked impact on access and utilization is the rise of the outpatient component of health care. It is projected that Michigan's health care delivery system will comprise fully 45% of ambulatory care, about 30% acute care, and 25% home-based and extended care. Clearly, the challenge facing medical geographers interested in health care delivery is to respond to these projections of a new hospital environment and to develop methodologies and undertake research which will provide the necessary data upon which appropriate planning and decision-making can proceed.

SUMMARY

The epidemiological and geographical analysis of community hospital discharges in Michigan has revealed a number of significant issues. While it is recognized that the number of aggregate discharges analyzed is large, the data only effectively applied to one year (1980). Subsequent spatial analyses require the use of data spanning a number of consecutive years, so that extreme fluctuations in use rates can be stabilized. In addition, Poisson significance tests need to be applied to annual data over a period of a few years in order to establish with certainty those ZIP code communities that have consistently significantly high or low hospital utilization rates.

Nevertheless, this descriptive ecological study has been able to statistically characterize the magnitude and geographical pattern of community hospital use. Overall, this study has:

- (i) offered an alternative for analyzing small-area variations in hospital utilization. It is based on well accepted health care terms, statistical verifiability, and geographic principles.
- (ii) constructed a multivariable index of poverty which is empirically derived and goes beyond the traditional single descriptive factor of household income so often used in small-area analysis research.
- (iii) used the spatial distribution of communities to explicate possible differences in health care utilization in the state of Michigan.
- (iv) used epidemiologic methods to express the relative difference in hospital use rates between urban and rural residence.
- (v) critically reviewed foundational studies in small-area analyses on the topic of health care utilization.

CONCLUSIONS

The following are the most significant conclusions to emerge from this study:

- 1). The 'plurality' methodology used by population-based small-area analyses for defining and aggregating ZIP codes into hospital service areas, developed by Wennberg and Gittelsohn during the early 1970s, possesses severe limitations and is geographically flawed. In light of this, a ZIP-specific geographical analysis should be undertaken complementary to both hospital-specific market penetration studies and those based on a plurality approach. The results from each approach can provide information that is lacking in the others, thereby leading to a better understanding of hospital use across a state.
- 2). The character and geographical patterning of hospital discharge rates is distinctly influenced by residential location; rural communities have statistically significantly higher age-adjusted medical discharge rates (OR=2.04; CI=1.40–2.93), and age-specific rates as well. Although surgical rates are higher for rural areas, they are not statistically significantly different.
- 3). A marked inverse relationship is evident between age-adjusted medical and surgical discharge rates and socio-economic status. Generally, this applies to age-specific rates too. However, only medical conditions are statistically significantly different ($p<0.001$). In addition, more socio-economic status categories display significant differences within medical discharges than is the case with surgical discharges.
- 4). Community location and socio-economic status show a marked inverse relationship for medical discharges; an inverse relationship being present in both urban and rural settings. Unlike medical diagnoses, surgical discharges show a non-significant association with residence and socio-economic status.

- 5). The spatial structure of hospital use rates is generally one of clustering, where adjacent rural areas possess elevated discharge rates — for both medical and surgical causes — as well as for some larger urban areas, such as the city of Detroit.

SUGGESTIONS FOR FUTURE RESEARCH

- Because of the limited data available for this study, an ecological approach had to be adopted. Nevertheless, it is recommended that additional analyses, following the outline of the research presented in this dissertation, should be pursued incorporating the following aspects: (i) diagnosis related groups; and (ii) severity of illness measure(s). In addition, hospital closures during the 1980s, and the shift to outpatient settings need to be assessed.
- A temporal analysis, using the 1980 baseline data and findings presented in this study and 1990 hospital discharge abstracts, together with 1990 census data, will allow the effects of the DRG system (introduced in 1983) and hospital closures on hospital use rates across the state to be quantified. Moreover, changes in the magnitude and geographical distribution of the socio-economic profile of each small-area (ZIP) can be readily determined, and will assist in the understanding of contemporary utilization of hospital services.
- In the state of Michigan it would appear that the character of socio-economic status is different in rural areas as compared with urban situations; the former setting generally involves poor white communities while the latter is comprised of predominantly black inner city neighborhoods. Consequently, it is suggested that hospital use according to improved indices of 'poverty' be investigated more thoroughly. Univariate descriptors of 'poverty', such as income, are inadequate to describe the complex spectrum of social class. A composite index, taking into account social, economic, and behavioral factors needs to be included to arrive at a useful stratifying status index.

- A comprehensive study by medical geographers into the definition(s) of hospital service area ought to be initiated, including the probable effects various definitions — aggregations of spatial units — have on observed hospital use rates and their geographic variability. Issues such as spatial autocorrelation and the modifiable areal unit problem (MAUP) require further investigation.

While this study has produced an understanding and assessment of the characteristics and patterning, both epidemiologically and spatially, of hospital use in Michigan, the approach and techniques used and the conclusions drawn have implications in other settings across the United States. It has also provided justification for a more geographically-sensitive analysis and provision of health care services, including cost control programs, which will assure availability, quality, and access.

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APPENDICES

APPENDIX A

APPENDIX A

Population by Residence, Socio-Economic Status and Age Group. Michigan 1980.

RESIDENCE	S.E.S. [1]	AGE GROUP (Years):									TOTAL
		< 1	< 5	< 15	15 - 29	30 - 44	45 - 64	65 +	75+		
Urban	High	48,349	233,601	801,042	978,606	698,604	1,677,210	694,703	285,773	109,636	3,458,728
	Middle	34,493	159,384	497,624	563,521	386,554	950,075	371,674	189,653	74,703	2,009,026
	Low-1	43,554	202,475	632,661	749,450	454,894	1,204,344	509,914	295,233	117,739	2,642,152
	Low-2	3,331	15,265	46,322	77,247	31,845	109,092	34,463	22,963	8,425	212,840
	Total	129,727	610,725	1,977,649	2,368,824	1,571,897	3,940,721	1,610,754	793,622	310,503	8,322,746
Rural	High	1,683	7,947	26,278	24,740	19,348	44,088	18,418	9,237	3,467	98,021
	Middle	3,498	16,854	55,172	54,418	41,257	95,675	40,292	24,569	9,728	215,708
	Low-1	4,834	22,714	71,890	71,221	50,655	121,876	60,512	39,152	14,062	293,430
	Low-2	5,536	25,546	80,118	79,679	55,769	135,448	65,334	44,203	15,055	325,103
	Total	15,551	73,061	233,458	230,058	167,029	397,087	184,556	117,161	42,312	932,262
Michigan	High	50,032	241,548	827,320	1,003,346	717,952	1,721,298	713,121	295,010	113,103	3,556,749
	Middle	37,991	176,238	552,796	617,939	427,811	1,045,750	411,966	214,222	84,431	2,224,734
	Low-1	48,388	225,189	704,551	820,671	505,549	1,326,220	570,426	334,385	131,801	2,935,582
	Low-2	8,867	40,811	126,440	156,926	87,614	244,540	99,797	67,166	23,480	537,943
	Total	145,278	683,786	2,211,107	2,598,882	1,738,926	4,337,808	1,795,310	910,783	352,815	9,255,008

Note:

1. Socio-economic status designation.

APPENDIX B

APPENDIX B

Total Medical Discharges by Residence, Socio-Economic Status and Age Group. Michigan 1980.

RESIDENCE	[1] S.E.S.	AGE CATEGORY (Years)						All Ages
		0-14	15-29	30-44	45-54	45-64	65+	
Urban	High	30609	16535	19906	36441	49736	54163	170,988
	Middle	24780	12041	13685	25726	31202	36428	118,164
	Low-1	29001	20501	24324	44825	51463	58936	184,274
	Low-2	3159	1616	1330	2946	3117	4788	14,013
	Total	87,549	50,693	59,245	109,938	135,518	154,315	487,439
Rural	High	1553	555	641	1196	1530	2039	6,321
	Middle	2951	1640	1851	3491	3927	5618	15,989
	Low-1	4051	2322	2322	4644	6075	9272	24,043
	Low-2	4459	2215	2529	4744	7060	10789	27,064
	Total	13,014	6,732	7,343	14,075	18,592	27,718	73,417
Michigan	High	32,162	17,090	20,547	37,637	51,266	56,202	177,309
	Middle	27,731	13,681	15,536	29,217	35,129	42,046	134,153
	Low-1	33,052	22,823	26,646	49,469	57,538	68,208	208,317
	Low-2	7,618	3,831	3,859	7,690	10,177	15,577	41,077
	Total	100,563	57,425	66,588	124,013	154,110	182,033	560,856

A total of 137 patients were of unknown age.

Note: 1. Socio-economic status designation.

APPENDIX C

APPENDIX C

Total Surgical Discharges by Residence, Socio-Economic Status and Age Group.
Michigan 1980.

RESIDENCE	[1]	AGE CATEGORY (Years)						All Ages
	S.E.S.	0-14	15-29	30-44	15-44	45-64	65+	
Urban	High	18,132	50,586	48,547	99,133	66,363	45,093	228,735
	Middle	13,141	33,568	29,893	63,461	38,902	30,527	146,042
	High	14,731	52,639	42,044	94,683	52,924	45,629	207,991
	Low-2	978	3,282	2,293	5,575	3,326	3,392	13,272
	Total	46,982	140,075	122,777	262,852	161,515	124,641	596,040
Rural	High	716	1,495	1,463	2,958	1,876	1,558	7,108
	Middle	1,512	3,228	3,092	6,320	3,962	3,628	15,424
	Low-1	1,850	4,343	3,763	8,106	5,931	6,022	21,911
	Low-2	2,066	4,564	4,226	8,790	6,825	7,222	24,906
	Total	6,144	13,630	12,544	26,174	18,594	18,430	69,349
Michigan	High	18,848	52,081	50,010	102,091	68,239	46,651	235,843
	Middle	14,653	36,796	32,985	69,781	42,864	34,155	161,466
	Low-1	16,581	56,982	45,807	102,789	58,855	51,651	229,902
	Low-2	3,044	7,846	6,519	14,365	10,151	10,614	38,178
	Total	53,126	153,705	135,321	289,026	180,109	143,071	665,389

A total of 57 surgical patients were of unknown age.

Note: 1. Socio-economic status designation.