Healthcare Utilization, Deprivation, and Heart-Related Disease In Kentucky

By Holly R. Barcus* and Timothy S. Hare**

*Geography Department, Macalester College, Saint Paul, MN 55105

Email: barcus@macalester.edu; Phone: 651-696-6139, Fax: 651-696-6116

**Institute for Regional Analysis and Public Policy, Morehead State University,

Morehead, KY 40351

Email: t.hare@morehead-st.edu, Phone: 606-783-9436, Fax: 606-783-5092

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Healthcare Utilization, Deprivation, and Cardio-Vascular Disease Incidence: An Analysis of Kentucky

Abstract

Heart-related diseases are widespread in Kentucky, a rural southern state with the third highest rate for heart disease and one of the highest poverty rates in the country; a situation that often leads to decreased access to and utilization of healthcare facilities. In this paper, we assess the relationship between patterns of healthcare facility utilization for heart-related disease and material deprivation using data from the 2002 Kentucky Discharge Database and explore the geographic clustering of material deprivation, heart disease prevalence, and healthcare facility utilization. We found significant clustering of healthcare facility utilization in southeastern Kentucky that corresponds with high levels of socio-economic deprivation and high rates of heart-related disease mortality. The findings suggest the need for increased need for greater services and interventions to lower the risk and prevalence of heart disease and increased research to better understand who utilizes healthcare services and their relationships to gaps in service delivery and utilization.

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Key Words: healthcare utilization, heart related diseases, Kentucky, Cluster analysis

1

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INTRODUCTION

By 2001, deaths resulting from diseases of the heart reached 246.8 per 100,000 in the United States and 294.0 per 100,000 in Kentucky (CDC 2004). As the population ages and rates of obesity and diabetes continue to climb, the prevalence of heart-related diseases is likely to grow, underscoring the need to provide adequate and accessible healthcare facilities to meet growing demand for treatment, particularly for vulnerable populations. Understanding the patterns of health service utilization and accessibility will become increasingly important for public health agencies trying to meet the growing needs of patients within limited budgets. This paper assesses the geographic distribution of patients with heart-related diseases in Kentucky that were discharged from a healthcare facility in 2002, focusing specifically on the spatial distribution of healthcare facility utilization and the corresponding patterns of socio-economically vulnerable populations.

Release of the most recent Kentucky health assessment paints a grim picture of the current health and well-being of Kentucky residents (Surveillance and Health Data Branch 2000). In 2000, Kentucky had the 10th highest death rate in the nation, the third highest rate of heart disease and cancer, and the 14th highest rate for unintentional injuries. Kentucky also has the highest percentage of smokers in the nation, the second highest prevalence of obesity, and the eighth highest rate of child poverty. These statistics, however, fail to convey variations in the spatial distribution of disease

2

occurrence, hospital utilization, and event severity across Kentucky and between disparate populations.

In this paper, we use the 2002 Kentucky Discharge Database, compiled by the Kentucky Department of Public Health (DPH), to assess spatial variation in the utilization of hospital services by patients with heart-related conditions. Our primary objectives are to explore whether utilization of hospital services for heart-related diseases in Kentucky is spatially clustered, examine the effects of social and economic deprivation on the observed pattern, and to assess the impact of these processes on health status.

While previous studies have investigated healthcare services in Kentucky (e.g., Ramsbottom-Lucie 1996), few have assessed utilization patterns (e.g., Beaulieu 2002), and none have focused on geographical patterning below the county level. Most previous studies aggregate data into larger zones or ignore spatial patterning altogether. For instance, the most recent Kentucky DPH report on Ambulatory Surgical Services aggregated data by Area Development Districts (ADDs) (which lump Kentucky's counties into fifteen areas) (Health Policy Development Branch 2003) and a geographical information system (GIS) was not used to facilitate visualization and analysis. Other investigations have used detailed studies of a sample of health services in local areas, but without explicit attention to the effect of their relative locations (Kelly 2002; Schoenberg et al. 2001). For example, the Kentucky Cancer Registry (KCR) Incidents web-GIS is the most sophisticated application of new spatial technologies to the study of health phenomena in Kentucky (2002), providing access to a spatial database of cancer incidents and mortality by type of cancer, but only at the county level and above.

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This study builds on these efforts to increase our understanding of disease incidence and service provision by exploring the spatial distribution of heart-related service utilization in Kentucky in 2002. These research questions begin to address a broader area of research that focuses on linkages between healthcare service delivery, utilization, and the severity of patient outcomes based on geographic location. Our study area is the state of Kentucky, which encompasses 120 counties, including 51 Appalachian counties, and 768 occupied zip code areas. Our study examines heart-related disease incidence, its potential overlap with areas of significant socio-economic deprivation, and the outcomes of individual events within the context of this spatial variation. The following questions form the basis of our inquiry:

1) What are the major patterns and concentrations of healthcare facility utilization for heart-related diseases at county and zip code levels?

2) Is incidence spatially clustered at either scale?

3) Can we relate those patterns to indicators of socio-economic stress? and

4) Do geographic areas with high levels of economic stress also have high incidence rates or greater severity of incidence outcomes?

We begin with a discussion of the factors that influence healthcare accessibility and utilization in the United States and socio-economic factors that increase the likelihood of disease incidence while simultaneously reducing healthcare utilization. We focus our analysis on the state of Kentucky, which has one of the highest death rates from heart-related disease in the US. This is followed by a discussion of the role of Geographic Information Systems (GIS) and spatial clustering methods. The introduction of GIS and

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4

analyze or identify underlying factors contributing to these patterns (Cromley and
McLafferty 2003). We evaluate the data at both zipcode and county levels to identify
patterns of heart-related disease incidence based on the most severe cases, those that
required at least one night of hospitalization.

HEALTHCARE ACCESSIBILITY AND UTILIZATION: THE ROLE OF GEOGRAPHY AND SOCIO-ECONOMIC STATUS

Linkages between health facility utilization and accessibility are mediated by the
geographic location of the care provider and end user as well as the individual users
perceptions of the faclity and their own health. Geography plays a critical role in
determining access to heatlh care facilities (Cromley and McLafferty 2002, Gatrell 2002)
such that access is mediated by proximity to appropriate health facilities, availability of
transportation, travel time as well as an individuals' ability to pay for services (Meade
and Erickson 2000). In rural areas, proximity to facilities with appropriate specializations
becomes a primary driver of specific health facility utilization. Individuals are likely to
travel increasingly long distances to find appropriate care for rare or serious health
problems as compared to more minor problems that can be addressed at a local clinic.
Even if an individual can access services, however, one may choose not to utilize a
particular service, opting rather to travel further distances or choosing a different type of
healthcare service. The principle of distance decay describes the declining use of a
particular facility as distance from the facility increases (Cromley and McLafferty 2003,
Meade and Earickson 2000, Ricketts *et al.* 1994). Utilization is a matter of availability,

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accessibility, and subjective choices made by the individual (e.g., Nickerson and Hochstrasser 1970); therefore, access is a prerequisite to utilization, but does not guarantee utilization (Cromely and McLafferty 2002:235).

Many factors effect both healthcare accessibility and utilization including the social and economic characteristics of patients, perceived quality of care, distance from facilities, and social and cultural norms of a particular population or community (Field and Briggs 2001). Patient characteristics such as age, sex, social class, ethnicity, geographic location (urban vs. rural), and income levels all effect the likelihood that an individual will utilize particular health services (Bertakis *et al.* 2000, Newbold *et al.* 1995). Across social and demographic groups, women, minorities, and low-income individuals often have the least access to and utilization rates of health facilities in the US (Cromley and McLafferty 2002:235, Millman 1993). Gornick (2003) found that "white beneficiaries and enrollees who are economically and socially advantaged and in better health-use more of the types of services that prevent illness and improve health and functioning than do other Medicare beneficiaries who are members of minority groups, less advantaged and in poorer health" (p.753); again making the connection between socio-economic status, health condition and utilization.

Because geography and social factors interact when determining an individuals' access to health services (Gatrell 2002), assessing geographic characteristics of populations, along with ethnicity, race, and sex can help identify and locate at-risk populations. Heart-related diseases, in particular, are linked to life style factors, including poor diet and smoking, and these factors are often geographically defined in western industrialized countries (Dowler 2003, Lawlor et al. 2005). While these lifestyle

factors can affect any individual, several studies suggest that geographic areas with high rates of poverty and/or socio-economic deprivation are strongly associated with increased risk for cardio-vascular disease. In a study of 4,286 British women between the ages of 60-79, Lawlor et al. (2005) found that the socio-economic status of residential areas was more closely associated with increased heart disease than individual life course variables and Dowler (2003) suggests that low incomes are frequently associated with food poverty, including poor nutritional choices. Hahn et al. (1998) found similar geographic patterning for risk factors associated with CVD and CVD incidence at the state level. They also found that state rates of physical inactivity, diabetes, and hypertension were predictive of state rates of mortality from CVD for particular groups (Hahn et al. 1998).

GIS AND HEALTH

Geographic Information Systems have revolutionized the way researchers explore numerous social and environmental issues (Hochberg *et al.* 2000; Longley *et al.* 1999; Lyon and McCarthy 1995), including the geography of health (de Lepper *et al.* 1995; de Savigny and Wijeyaratne 1995; Gatrell and Senior 1999; Ricketts 2003; Scholten and de Lepper 1990). Two reasons for the slower development of GIS-based investigations of healthcare services is the massive quantity of data required for such investigations at even moderate levels of spatial scale and the lack of centralized sources of data for service locations and utilization. Nonetheless, the need for such analyses has been documented in the context of debates over the importance of the national information infrastructure (US Public Health Service 1995). Recent research includes attention to the geography of healthcare services (Bullen *et al.* 1996; McLafferty 2003). These studies analyze

7

healthcare need, access, and utilization and are directed at supporting the planning and evaluation of service locations (Gatrell and Senior 1999:926). In other words, researchers are developing new techniques to support spatial decision-making for healthcare delivery systems.

The interaction between the locations of demands for health services and the locations of healthcare centers necessitates the investigation of accessibility and utilization. Previous studies utilize GIS to define health service localities (Bullen et al. 1996), assess new locations for specific health services (Forbes and Todd 1995) and to calculate the potential accessibility of specialized services to populations with limited mobility (Love and Lindquist 1995). These comparisons of health center locations and consumer demand frequently entail the integration of point-referenced data, such as hospitals, with area-referenced socio-economic data (Brown *et al.* 1991; Carstairs and Morris 1991). In this context, GIS is used to identify service zones and describe associated patient profiles through comparison with social and economic data.

STUDY AREA

Kentucky is a relatively rural state with three primary metropolitan areas, all located in the northern and central regions of the state and can be divided generally east to west, into Appalachian and non-Appalachian counties, as defined by the Appalachian Regional Commission (ARC 2005) (Figure 1). The urban areas of Cincinnati, Louisville, and Lexington form an urban core in the northern portion of the state with smaller metro areas scattered around the state. Residents of counties distant from urban centers, particularly those in Appalachia, have fewer local healthcare services available and face significant

barriers to acquiring many health services (Huttlinger et al. 2004, Stensland et al. 2002), including the lack of hospital-affiliated substance abuse treatment services in distressed counties, the lack of hospital-affiliated psychiatric services, and the lack of obstetric care.

In 2000, Kentucky ranked 5th in the nation for deaths related to Cardio-Vascular Disease (CVD); 73 of 120 counties had mortality rates from CVD above the national average (Wood et al. 2000). Included in the list of risk factors associated with CVD are obesity, physical inactivity, smoking, high blood pressure, high blood cholesterol and diabetes. Release of the most recent Kentucky health assessment paints a grim picture of the current health and well-being of Kentucky residents (Surveillance and Health Data Branch 2000). In addition to ranking near the worst nationwide on many health indicators, such as heart disease, cancer, and obesity, Wood et al. (2000) found that fully 56 percent of Kentuckians had two or more risk factors associated with the disease.

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DATA AND METHODOLOGY

We use hospital discharge records provided by the Kentucky Department of Public Health, which includes information about all patients discharged from any Kentucky hospital during 2002 (Kentucky Dept. of Public Health 2004). Discharge records contain demographic and health data for individuals by zip code of residence and allow the examination of discharge rates, as a proxy for utilization, and the creation of related maps (Figure 2). Included in the database are the primary treatment options, major disease categories (MDC), Diagnosis Related Groups (DRG) and ICD9 codes for diagnoses and procedures. By definition, individuals captured in the database spent at least one night in the hospital, thus the records reflect relatively acute or severe cases. Discharge records

are also specific to each event, so an individual who has multiple episodes requiring overnight care will appear in the database for each episode. We chose to evaluate diseases of the heart because of the high incidence rates in Kentucky and geographically widespread incidence at both the county and zip code levels. Diseases of the heart can also be associated with lifestyle factors and socio-economic deprivation. Diseases of the heart include all disease incidence categories with ICD-9 codes (Ninth Revision of the International Classification of Diseases) (US Department of Health and Human Services 1980) 390-398, 402, 404-429 (CDC 2005). The database contains 73,220 cases of heart-related disease hospital discharges, 50.7 percent of which are male, and 59.5 percent are patients who are 65 years and older.

All data in this project are aggregated by zip code or county. We calculated age-adjusted rates to reduce the effect of age-based variability rates and enhance the comparison of populations with different age structures (Goldman and Brender 2000; Kulldorf, 1999; Rushton, 2003). These rates are adjusted by the direct method using the year 2000 US standard population distribution (Anderson and Rosenberg, 1998). Age-adjusted rates are calculated by multiplying the age-specific rates by the corresponding weight from the specified standard population, summing the results for all age groups, and multiplying the result by 100,000.

The use of rates aggregated by area raises several methodological issues. For example, spatial patterns in the distributions of some variables might exist only at finer spatial scales (Messner and Anselin, 2002). Aggregating data by area can obscure these patterns. Using smaller areal units can alleviate this problem, but also creates another. Areal aggregated data often show heterogeneity of rates for varying populations at risk

due to the different population sizes in each areal unit. Ratios for areal units with small counts are particularly sensitive to rate heterogeneity. This can generate spurious outliers, and weaken the reliability of some tests of spatial autocorrelation. Despite these problems, zip code zones and counties appear to be useful compromises depending on the frequencies of the particular variables investigated. Most county populations are large enough to alleviate the problem of rate heterogeneity, even in cases of relatively rare events, while still providing a fine enough scale to identify meaningful patterns. Zip code zones provide finer detail in the evaluation of spatial patterns, but only for relatively high frequency events.

We constructed indices of deprivation and severity in order to evaluate linkages between spatial patterns of socio-economic deprivation, heart-related hospital utilization and the severity of outcomes.

Index of deprivation

We derived a single factor for assessing variability in the degree of material deprivation to simplify the comparison of material deprivation and hospital usage. There is a complex relationship between many socio-economic, cultural, and behavioral factors and measures of accessibility, utilization, morbidity and mortality (Hillemeier et al. 2003, Mitchell *et al.* 2004; Townsend *et al.* 1988). Nonetheless, there is considerable evidence for systematic links between indicators of poor health and limited access to employment opportunities, public services and community resources, as well as poverty, relative and absolute levels of inequality, poor quality housing, and poor physical environmental conditions (Gatrell 2002:121-132). The investigation and development of models

11

explaining the specific contributions of such forces to poor health are fruitfull in-and-of-themselves (Crombie *et al.* 1989, Starrin *et al.* 1990); our attention is on providing a baseline for comparison with hospital utilization data.

Numerous systems for quantifying material deprivation in relation to health status have been developed using a wide variety of variables and methodologies (Carstairs and Morris 1989, Gatrell 2002:121-132, SAHRU 1997, Townsend *et al.* 1988). These deprivation indices commonly use measures such as unemployment, crowding, home ownership, available amenities, income, and social class. These measures are then combined into a single variable that identifies areas and populations subject to particular levels of material deprivation.

Specifically, we followed Falkingham and Namazie's methodology using factor analysis to create a single factor reflecting the level of material deprivation for each area (2002). The socio-economic variables used for constructing the index of deprivation are from the 2000 US Census (US Census Bureau, 2003). The factor loadings for the primary factor identified in the factor analysis are listed in Table 1. The variables reflect common measures of social and economic distress.

Variables	Factor Loadings
Percentage of housing units without source of fuel	0.116
Percentage of housing units without plumbing	0.707
Percentage of housing units with telephone	-0.824
Percentage of housing units owner occupied	-0.653
Average household size	-0.154
Percentage of families in poverty	0.953
Percentage of employment in white collar jobs	-0.417
Median household income	-0.905
Percentage of persons 25 or older with high school diploma	-0.277
Percentage of females without work	0.945
Percentage of males without work	0.944

12

Table 1: Factor loadings for Factor 1 utilized for the deprivation index.

Outcome Severity

We used the discharge status variable from the discharge database and heart-related mortality rates to measure event severity. The discharge database includes information about the outcome for each patient upon hospital discharge. There are 23 categories of outcomes which we grouped into five general categories: Routine discharge; Terminal outcome, including death and hospice cases; Home healthcare; Continued care; and Other. We chose the most severe outcome, Terminal, to indicate the worst-case scenario for hospitalizations related to diseases of the heart.

Initially we proposed to develop an index of severity that would capture aspects of each hospital stay such as cost, length of stay, and outcome of stay. We were hopeful that this would help capture some aspect of health status upon arrival at the hospital. For example, more serious cases might be related to delayed treatment (for economic or personal reasons) or to increased morbidity due to multiple health conditions. Due to the complexity of clearly identifying unambiguous mechanisms for explaining outcomes, however, we used mortality, the most severe outcome, to measure severity. After mapping several variations of the index we were convinced that variations in length of stay and cost were more closely related to differences in the type and comprehensiveness of health insurance coverage and other potential factors rather than the severity of the condition alone.

In addition to the index of severity, we compared heart–related utilization rates to mortality rates due to heart-related conditions. All mortality data in this study are from

13

the Compressed Mortality File (US Dept. of Health and Human Services. 2004) and are age-adjusted using the year 2000 US standard population distribution (Anderson and Rosenberg, 1998).

<u>Software and Methods</u> We use ESRI's ArcGis 9.0 and ArcView 3.3 for processing, visualization, and accessibility analysis of the data, and GeoDa 0.9.5-i to apply a variety of exploratory spatial data analysis techniques. GeoDa is a free collection of software tools for a variety of spatial analysis techniques (Anselin, 2003 & 2004) and supports dynamic and interactive analysis of linked tables, charts, and maps. Preliminary data analysis revealed complex patterns and significant spatial autocorrelation. Spatially autocorrelated data contradict the statistical assumption of the independence of observations and underlying spatial effects can distort the results of statistical analyses (Messner and Anselin, 2002). To alleviate these problems, we selected several spatial statistical techniques that provide inferential tests of spatial patterns. These techniques reduce the subjectivity in the interpretation of complex patterns and minimize the impact of spatial effects, such as spatial dependence and heterogeneity.

The spatial distributions of hospital usage were assessed using thematic maps, charts, and spatial statistics, including univariate Moran's I, Moran Scatterplots, and univariate Local Moran LISA cluster maps (Anselin, 2003 & 2004). GeoDa calculates significance values for Moran's I and Local Moran using a permutation approach that compares the data with spatially random distributions of the same data values. The spatial weights matrix used was based on rook's case contiguity.

Local Indicators of Spatial Association (LISA) compare values in specific locations with those of their neighbors and test the null hypothesis of spatial randomness in their associated distributions. LISA techniques applied to a single variable highlight statistically significant clusters of positive or negative spatial autocorrelation. LISA techniques applied to two variables indicate areas in which both variables cluster.

Finally, after completing the analysis at the zip code and county levels it was clear that the patterns are reinforced at both scales and the clustering results remain stable. For the purpose of clarity, we chose to present only the county-level maps although the tables contain statistical results for both zip code and county-level analysis.

RESULTS

Patterns and clusters of healthcare facility utilization for heart-related diseases at county and zip code levels.

The choropleth map of hospital utilization rates for heart-related diseases (Figure 3) shows a strong east-west patterning. Higher rates of utilization are characteristic of the counties in the Appalachian region, the most mountainous and inaccessible counties in the state, and in northern Kentucky along the Ohio border. Lower rates of utilization appear to dominate the central and western portions of the state. The Moran's I test result (Table 2) suggests that the data deviates from a random pattern and is positively spatially autocorrelated. The univariate LISA cluster map of heart-related utilization rates clearly depicts a high degree of spatial clustering in southeastern Kentucky (Figure 4). A

moderate-sized cluster of low utilization rates is located in the southwestern portion of the state and a smaller cluster is around the Lexington-Fayette county area in central

15

Kentucky. These figures illustrate a strong spatial patterning of health facility utilization for heart-related diseases. Appalachian Kentucky, especially the area in the southeastern corner of the state along the Virginia border, has higher utilization rates than other areas, even after adjusting for differences in population age structure. This area, however, has a slightly lower percentage of terminal outcomes (3.1 percent) than the state (3.5 percent). There are several possible explanations for high utilization and lower severity in this area. First, the data may indirectly indicate conditions of compromised health status in which individuals have multiple repeat episodes or false alarms due to other health conditions. With the increased rates of obesity and other endemic health problems in Appalachia, this may explain part of the high utilization, low severity outcome for many cases. Another possibility is that individuals are being discharged to another care facility or released because they lack the requisite insurance to remain in the hospital. In either scenario, the result is an increased rate of utilization but lower percentage of terminal cases. We know however, that while hospital cases with terminal outcomes are low, mortality due to heart-related diseases is high in this area (Figure 8).

The 15 counties in the southeastern cluster (Figure 4) are among the most economically depressed in Appalachia, with all except one, Laural county, considered economically distressed by the Appalachian Regional Commission in 2002 (ARC 2005). A county categorized as 'distressed' has a poverty rate of 150 percent or more of the average US poverty rate, 150% or more of the three-year average unemployment of the US and 67 percent or less or the US average per capita income (ARC 2005). Laural county was a 'transitional' county in 2002 which means that it meets the criteria for 'distressed' on at least two categories but not the third category. This is also a relatively

16

isolated region, with most places distant from a major interstate or highway, limiting access to resources and, specifically, health facilities outside of this core. The combination of high utilization rates and levels of distress suggests that there is indeed a link between these two factors. In the next section, we explore this further.

	Univariate Moran's I	Bivariate Moran's I (Versus Utilization Rates)
ZIPCODE LEVEL		
Age-Adjusted Cardio Utilization	0.1337*	.
Age-Adjusted Heart Mortality	NA***	NA***
Deprivation Index	0.6700*	0.2018*
% Terminal Cases	-.0020	-0.0209
COUNTY LEVEL		
Age-Adjusted Cardio Utilization	0.5064*	.
Age-Adjusted Heart Mortality	0.2762*	0.3309*
Deprivation Index	0.7111*	0.5386**
% Terminal Cases	0.1979*	-.1085**

Table 2: Moran's I and LISA results.

*: p-value < 0.001

**: p-value < 0.01

***: Mortality data are not available at the zip-code level.

Material deprivation and healthcare facility utilization rates for heart-related diseases

Not surprisingly, our index of deprivation shows that Appalachian counties in Kentucky have the highest levels of distress and the urban corridor between Lexington, Louisville and Cincinnati has the least (Figure 5). In addition, rural areas in the southwestern half of the state also reflect moderate levels of distress. Moran's I for the deprivation index at the zip-code level is 0.6700 and at the county level is 0.7111. Both results indicate a high degree of positive spatial autocorrelation.

The bivariate Moran's I for the deprivation index scores and healthcare facility utilization rates at both the zip code and county levels indicates a strong and significant degree of positive spatial association (Table 2). The bivariate LISA cluster map of utilization rates and the deprivation index (Figure 6) shows clear associations of high utilization and high deprivation and low utilization and low deprivation. Counties depicted in black are part of spatial clusters with high utilization rates and high levels of deprivation and are all located in southeastern Appalachian Kentucky. In contrast, the semi-urbanized areas around and between Lexington and Louisville emerge as a large contiguous spatial cluster of counties with low utilization rates and low levels of deprivation. The same high utilization areas that were clustered in Figure 4 remain clustered and show a high degree of statistically significant positive spatial autocorrelation in relation to material deprivation.

These maps together clearly depict the socio-economic divide in Kentucky and the parallel divide in hospital utilization rates for heart-related diseases. The material deprivation of Appalachian Kentucky has long been documented by geographers and other social scientists (see for example Isserman 1996, McLaughlin et al. 1999)

18

as has the limited healthcare resources for the residents of this area (Huttlinger et al. 2004, Stensland et al. 2002). This linkage also supports the research by Lawlor et al. (2005) which suggests that geographic location, particularly one in which socio-economic deprivation is present, can be clearly associated with increased incidence of heart-related disease.

Are geographic areas with high utilization rates associated with greater severity of incidence outcomes?

Finally, we assessed the severity of each incident based on the proportion of cases with a terminal outcome and mortality rates from heart-related conditions. Again we used Moran's I to determine the degree of spatial autocorrelation and LISA to identify significant clusters of high and low outcome severity and mortality (Table 2). While the county-level terminal outcome data are weakly positively spatially autocorrelated, the zip-code level data are not. Figure 7 shows a more mixed pattern than for utilization and deprivation. Similarly, the bivariate Moran's I comparing percent terminal outcome and utilization at the county level only weakly positive and significant.

Heart-related age-adjusted mortality rates show a similar pattern with utilization and deprivation, with a high degree of positive spatial autocorrelation in Appalachian Kentucky (Figure 8). The southeastern cluster of high mortality rates is similar to the same clusters of high utilization and deprivation. A cluster of low mortality emerges surrounding the Lexington-Fayette county area and contiguous counties to the southwest. The cluster of high mortality rates is not as extensive as that of utilization and deprivation but it clearly reinforces the importance of addressing health and utilization issues in this

19

southeastern region of the state. This area has high rates of deprivation, utilization and mortality.

CONCLUSIONS

Most previous research focuses on the geography of disease and health problems through the field of spatial epidemiology (Cromley 2003) using disease mapping, geographical correlation studies, risk assessment, and disease clustering (Elliot et al. 2000). We extend this analysis in Kentucky to look at clusters of discharge cases related to diseases of the heart and find that there are indeed several noteworthy clusters of high hospital utilization for heart-related conditions and these clusters correspond with areas of socio-economic deprivation , outcome severity, and high mortality rates.

We posed four questions related to the spatial clustering of heart-related disease in Kentucky and its relationship with socio-economic deprivation. We found that utilization rates for heart-related disease are spatially clustered in the southeastern corner of Kentucky and that this cluster corresponds with high rates of material deprivation. This finding corroborates the findings of several other studies linking low socio-economic status with higher rates of heart-related disease and generally poor health (Dowler 2003, Lawlor et al. 2005). We also found clear evidence of high mortality rates in southeastern Kentucky; however, this cluster was not nearly as spatially extensive as that of utilization or deprivation clusters.

For Kentucky, these findings stress the need for continued and increased focus on healthcare in the Appalachian counties, and specifically in southeastern Kentucky. The connection between deprivation and poor health illustrates the need for strategies such as

20

increased public awareness campaigns about identifying the early warning signs of heart-

related diseases, and community-level outreach programs aimed at changing diet and

exercise habits, particularly among young residents. Linkages between geographic

location and increased rates of incidence, utilization, and mortality further underscore the

need for programs that address not only individual circumstances but broader

community-level quality of life issues as well.

These patterns and associations leave many questions unanswered, for example,

why are utilization rates so high in this area and which health facilities are utilized the

most (or least)? Do residents utilize local facilities and hospitals or do they travel to

larger facilities in more urbanized areas? Why are the rates of mortality so high? What

factors contribute to the strong and similar spatial patterns of these factors? Further

research is needed to tease out the underlying issues associated with higher rates of heart-

related diseases and mortality.

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32

List of Figures

Figure 1. Kentucky Population Distribution.

Population Per Sq. Mile

- 21.10 - 36.70
- 36.71 - 48.00
- 48.01 - 71.00
- 71.01 - 99.40
- 99.41 - 500.00
- 500.01 - 1799.80
- Appalachia

City Populations

- ○ 250,000 to 499,999
- ○ 100,000 to 249,999
- ▫ 50,000 to 99,999

Cincinnati

Louisville

Lexington-Fayette

Evansville

Miles
0   25   50   75   100
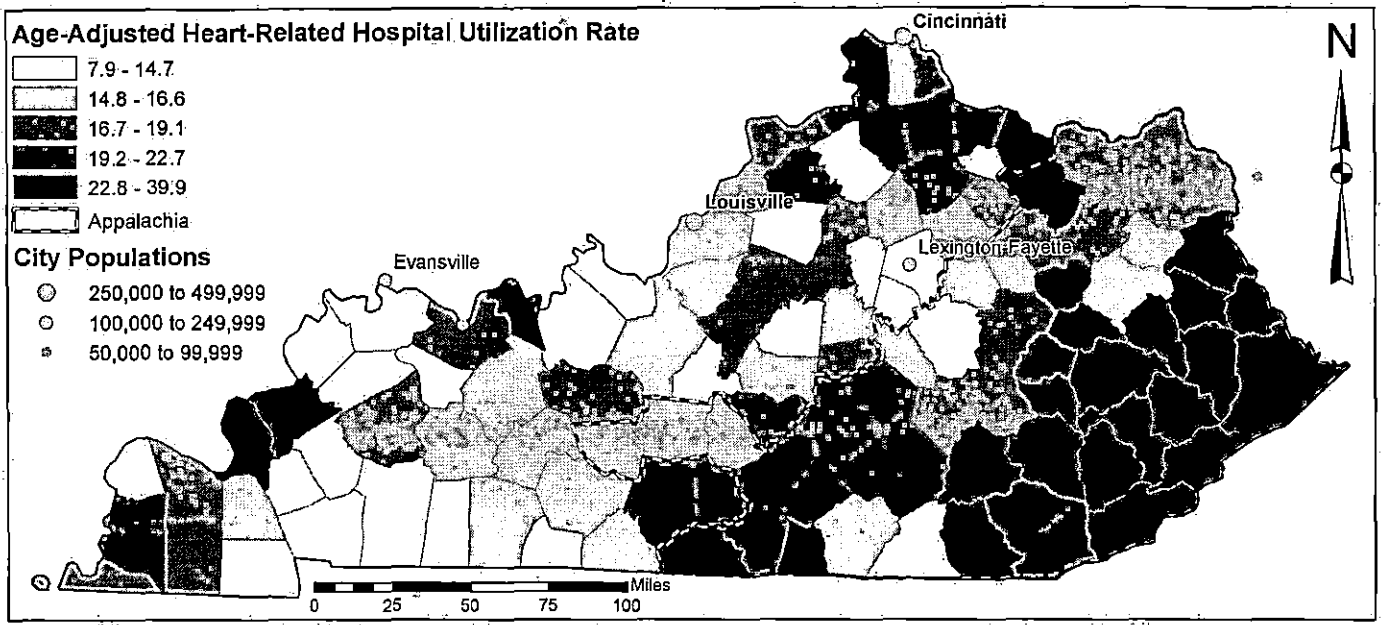
34

Figure 2.   Total Inpatient Hospital Usage By Zip Code Zones.
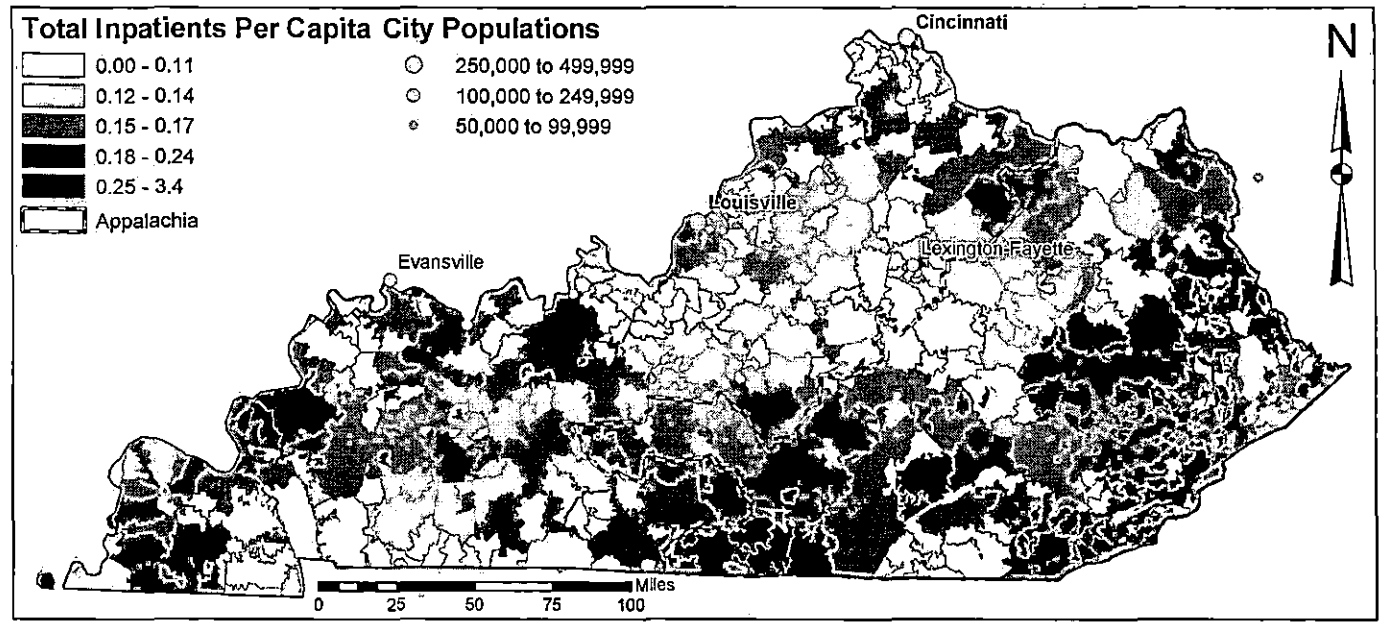
Figure 3.   Total Age-Adjusted Heart-Related Hospital Utilization Rates by County.

36

Lisa Cluster Map of Heart-Related Utilization

- ■ High Utilization - High Utilization
- Low Utilization - Low Utilization
- ▨ Low Utilization - High Utilization
- High Utilization - Low Utilization
- □ No Clustering

City Populations

- ◎ 250,000 to 499,999
- ○ 100,000 to 249,999
- ○ 50,000 to 99,999

Cincinnati

Louisville

Evansville

Lexington-Fayette

N

Miles
0   25   50   75   100
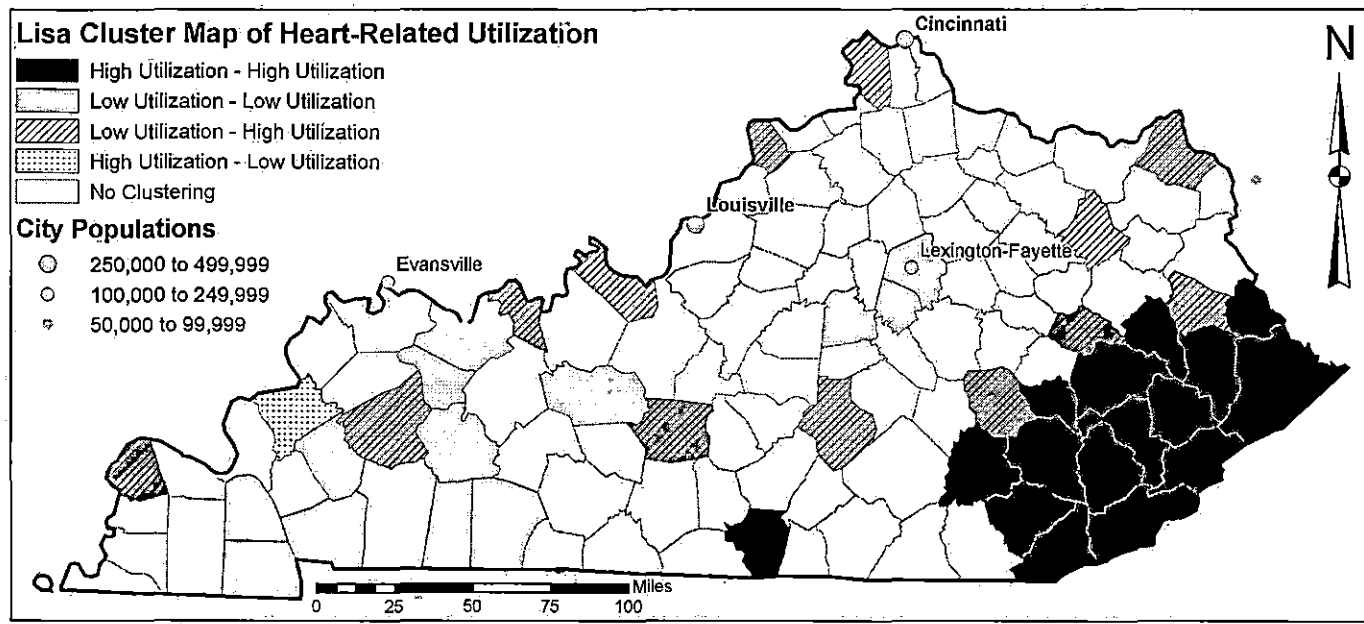
Figure 5. Deprivation Index by County.

Deprivation Index
- -1.97 - -0.79
- -0.78 - -0.44
- -0.43 - 0.12
- 0.13 - 0.98
- 0.99 - 2.52
- Appalachia

City Populations
- ○ 250,000 to 499,999
- ○ 100,000 to 249,999
- ○ 50,000 to 99,999

Cincinnati
Louisville
Lexington-Fayette
Evansville

Miles
0   25   50   .75   100

N

38
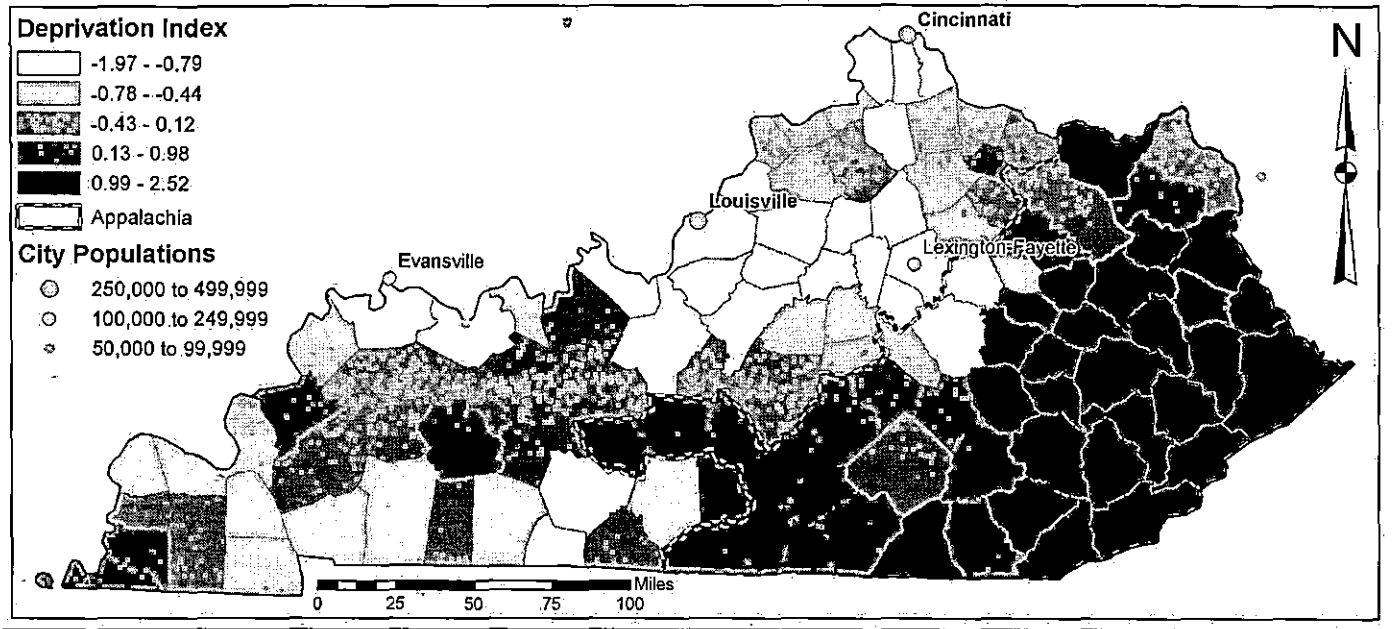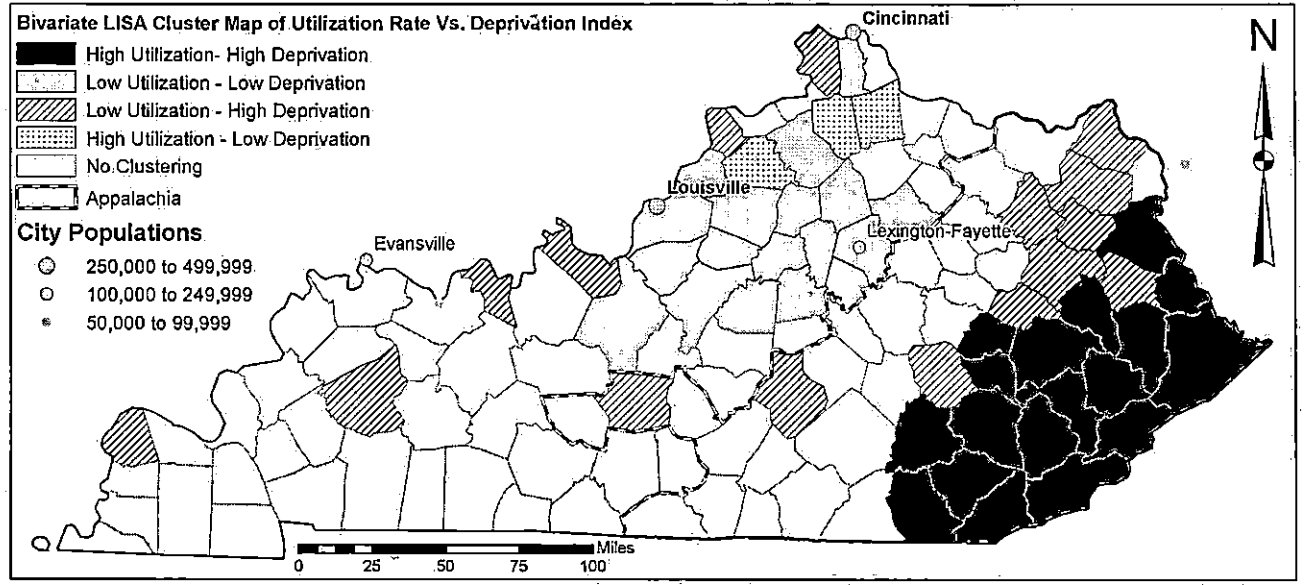
Figure 6. Bivariate LISA Cluster Map of Age-Adjusted Heart-Related Utilization Rate and Deprivation Index.

Bivariate LISA Cluster Map of Utilization Rate Vs. Deprivation Index

- High Utilization- High Deprivation
- Low Utilization - Low Deprivation
- Low Utilization - High Deprivation
- High Utilization - Low Deprivation
- No Clustering
- Appalachia

City Populations

- 250,000 to 499,999
- 100,000 to 249,999
- 50,000 to 99,999

Cincinnati
Louisville
Lexington-Fayette
Evansville

Miles
0   25   50   75   100

N

Figure 7. Percentage Terminal Cases by County.

% Terminal
- 40.61 - 54.66
- 54.67 - 57.99
- 58.00 - 61.58
- 61.59 - 66.03
- 66.04 - 77.91
- Appalachia

City Populations
- ○ 250,000 to 499,999
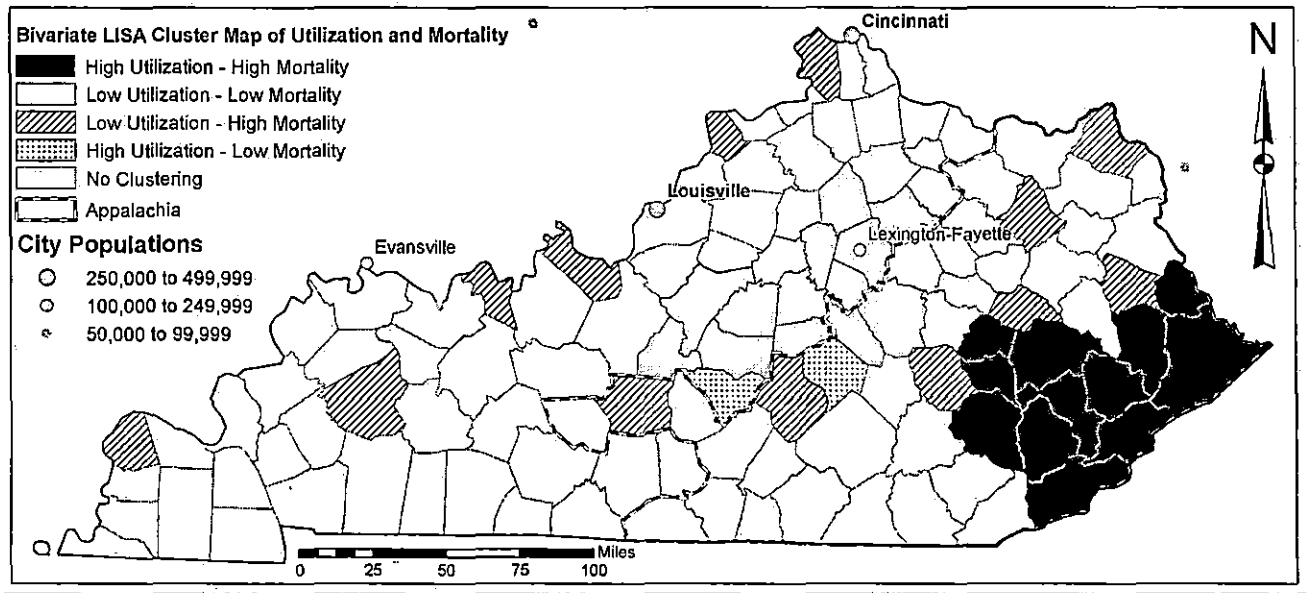- ○ 100,000 to 249,999
- ○ 50,000 to 99,999

40
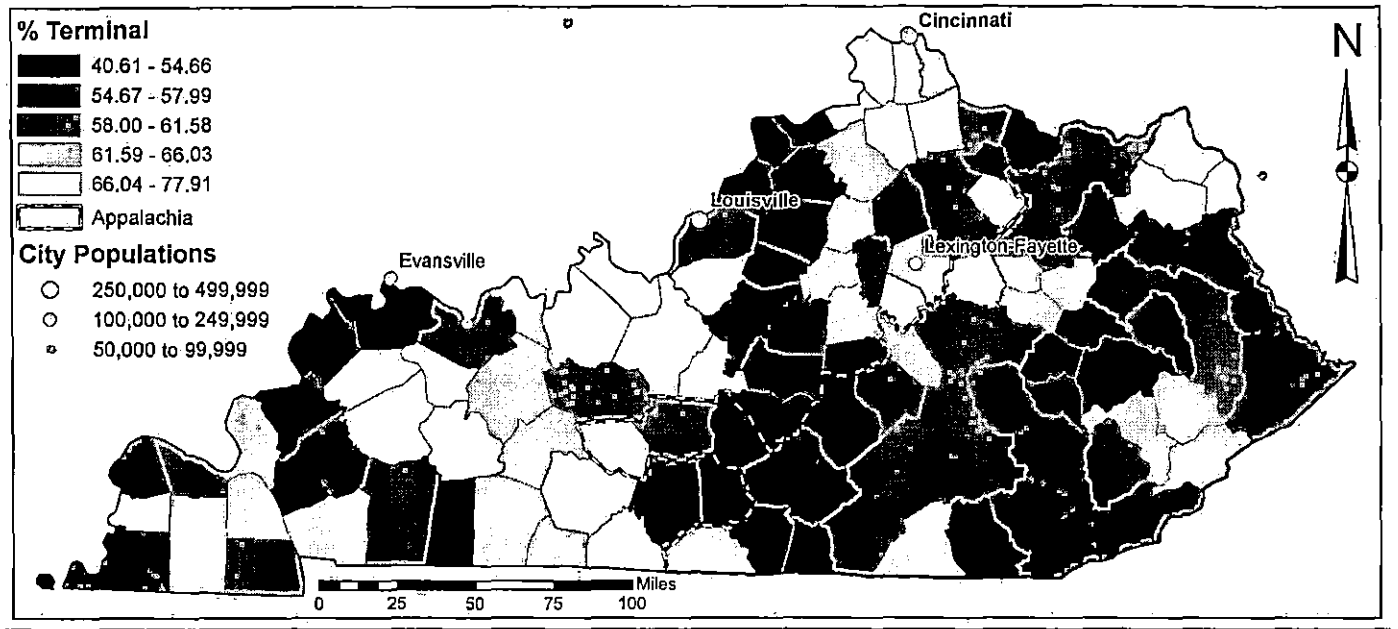
Figure 8. Bivariate LISA Cluster Map of Heart-Related Age-Adjusted Mortality Rate and Heart-Related Age-Adjusted Utilization Rate.

41