UTILIZATION AND PATTERN ANALYSIS OF AN EMERGENCY MEDICAL SERVICES SYSTEM: A GIS AND SPATIAL ANALYTICAL APPROACH

By

TIMOTHY SCOTT HAYES

Bachelor of Arts

University of California

Davis, California

1994

Submitted to the Faculty of the
Graduate College of
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May 1998

UTILIZATION AND PATTERN ANALYSIS OF AN

EMERGENCY MEDICAL SERVICES

SYSTEM: A GIS AND SPATIAL

ANALYTICAL APPROACH

Thesis Approved:

G. Allen Finchum
Thesis Advisor

Stephen W Tweedie

Wayne B Powell
Dean of the Graduate College

ACKNOWLEDGEMENTS

I wish to express my appreciation to my major advisor, Dr. Allen Finchum for his supervision and guidance. My appreciation extends to my other committee members Dr. Thomas Wikle and Dr. Stephen Tweedie whose guidance and assistance was invaluable. I would like to thank Dr. Allen Finchum and the Department of Geography for providing me with this opportunity and their generous financial support.

Moreover, I wish to express my sincere gratitude to Michael Frenn and the staff of the Solano County Emergency Medical Services Agency. Without their assistance and generous support I would not have been able to complete this study. I would also like to express my sincere gratitude to the one individual who provided me with the inspiration and desire to complete this study, the late Paul McCarthy. I would also like to express my gratitude to Dr. Jonathan Comer of the Department of Geography at OSU for the assistance he provided me relating to the statistical work.

I would also like to give my special appreciation to my wife, Hilde, for her precious suggestions to my research, her strong encouragement at times of difficulty, love and understanding throughout this whole process.

Finally, I would like to thank the Department of Geography for their support during these two years.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER I

BACKGROUND AND RESEARCH QUESTIONS

Background

The overall objective of this study was to illustrate how Geographic Information System (GIS) technology and computer-based spatial analysis can be applied to the field of Emergency Medical Services (EMS). In using these tools, an EMS organization can analyze the demographic characteristics of a service region to allow for more effective planning in the deployment of resources in the community. More specifically, these tools can be used for ambulance response time minimization, community-based education programs, determination of optimal utilization strategies for public health resources, and for EMS incident locational analysis. Using the previously mentioned analytical techniques, this study identified the segment of the population most closely associated with medical emergencies. It also identified where this segment of the population is located and why they tend to utilize EMS.

The study area includes the Cities of Fairfield, and Suisun City, both located in Solano County, California (Figure 1). Both of these cities are situated on the Northeast portion of the San Francisco Bay Area approximately 45 miles northeast of San Francisco. In 1990, these cities had a combined population of approximately 110,000, and a median household (HH) income of $47,000 per year. Table 1 gives a brief illustration of the sociodemographics of the study area.

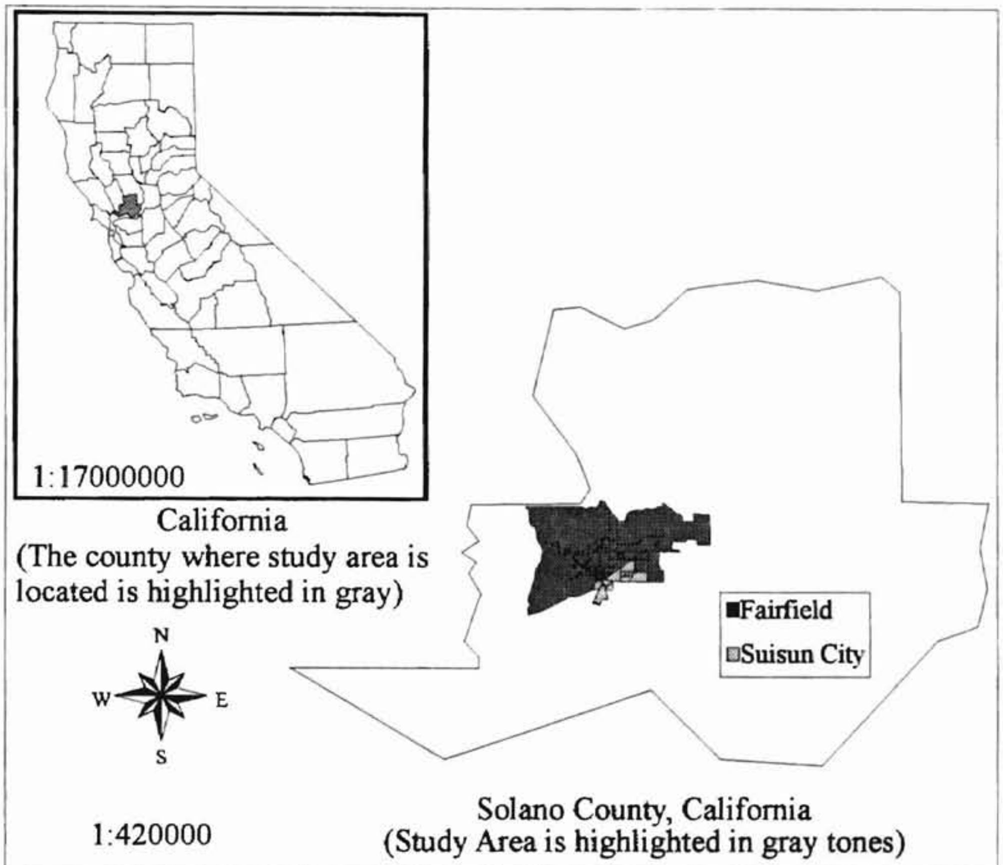


Fig. 1. Study Area.

Population of Fairfield	
1970	29,000
1980	36,000
1990	85,000
% Population by Race 1996	
White	55.0
Asian	17.0
Black	13.8
Hispanic	13.2
Native American	1.0

Population of Suisun City	
1970	3,000
1980	12,000
1990	25,000
% Population by Race 1996	
White	48.5
Asian	18.7
Hispanic	17.1
Black	14.6
Native American	1.1

Source: CA Dept. of Finance 1996

Table 1. Summary of Study Area Demographics.

Literature Review

Disease Analysis

Research material related to the spatial analysis of medical emergencies is sparse. The majority of research in medical geography has been carried to analyze disease patterns, health, and health care delivery at the hospital or physician level. Very little has dealt with emergency medical services at the pre-hospital care and provider levels. Most of the techniques and methodologies used in medical geography research that was reviewed include the use of small data sets (where $n < 500$), and the use of univariate statistical analysis techniques in pattern analysis. In addition, past studies have involved spatial analysis at very small scales and the mapping of diseases.

The spatial analysis of diseases using sociodemographic factors can be closely tied to this research. Meade et al. (1988) pointed out that where diseases occurred in a sociodemographic context they could be closely tied to the poverty syndrome. The diseases included congestive heart failure, coronary artery disease, cancer, diabetes, emphysema, and chronic obstructive pulmonary disease. These diseases seemed to occur more often among the poor than among the affluent. There seemed to be a socio-pathogenic complex made up in large part of stress, life-style, diet, housing, polluted air, old paint, and old pipes. According to Meade et al. physical, social, and mental diseases had similar patterns in urban areas. Eyles and Woods (1983) pointed out that diseases traditionally associated with low socioeconomic status included a wide range of respiratory illnesses, cardiac diseases, diabetes, cancer, and gastrointestinal disorders.

Munasinghe and Morris (1996) conducted research on disease clustering using regional spatial autocorrelation (RSAC). This was done to evaluate the localization of clusters for regions with elevated disease rates. In addition they compared this method to the choroplethic mapping and the methods used by the National Cancer Institute (NCI) for mapping cancer mortality in the United States. The distribution of pancreatic cancer among the elderly white male population in the United States was used in the comparison study. The methodology involved the use of simple univariate tests. Overall, they are in agreement that RSAC seemed to be more efficient for identifying the localization of disease clusters than the method used by the NCI. The authors do recognize the fact that the NCI method was developed to identify analytic areas with elevated rates, not to localize disease clusters. The NCI method is more appropriate for identification of individual analytic areas in densely populated regions that have disease rates different from the national rate. The RSAC method is more suitable for detecting disease clustering in a group of spatially adjacent analytic areas.

Gatrell and Bailey (1996) researched the validity and use of various statistical tools for modeling raised incidence of disease around point source pollution sites. In using various statistical techniques they looked at the clustering of childhood leukemia, Burkitt's lymphoma, larynx cancer, and childhood mortality in various parts of the world. They separated their methods into three broad classes. First, in order to obtain an accurate description of the phenomena, they used visualization methods embracing a variety of mapped displays of their data. Second, it was necessary to utilize exploratory methods of data analysis to summarize and describe map patterns and relationships. The third set of methods included the use of quantitative modeling of the disease distributions. The primary objective of their research was achieved by their illustration of the various geostatistical methods that can be used in conjunction with GIS to analyze point patterns in a geographic unit.

Accident Analysis

Levine et al. (1996) did a spatial analysis of auto accidents. Their objective was to describe spatial patterns of motor vehicle crashes in Honolulu. The method they used was to geo-code accident locations. The Nearest Neighbor Analysis method was used to develop and describe the degree of spatial concentration. The spatial patterns of accidents were analyzed for every hour of the day with weekdays and weekends examined separately. The variables used include time of day, traffic volume, weather conditions, alcohol, and vehicle speed. In describing the spatial distribution, they used various geostatistical methods to analyze crash locations in the Honolulu metropolitan area. They concluded that the urban periphery (suburbs and rural areas) produced more serious accidents due to the fact that drivers who used the roads in the urban periphery were more likely to drive at excessive speeds.

Jones et al. (1996) used the K-Function Analysis to determine the degree of clustering exhibited by auto accident residuals from a spatially referenced logistic regression. This model was constructed to ascertain the factors influencing the outcome and the likelihood of death in a road traffic accident. They applied this analysis not only to data on mortality and morbidity but also to the examination of the residuals from the spatial regression. They concluded that the majority of auto accidents were clustered around settlements as were the majority of fatalities.

Public Health

Bullen et al. (1996) conducted research concerning the application of locational analysis methods and GIS in public health planning and decision-making. They explained the use of a GIS to identify a nested hierarchy of localities for the management of primary health care in West Sussex, England. More specifically, their research involved using GIS to assess patient to general practitioner (GP) flow patterns.

Bullen generated a series of thematic layers defining various GIS coverages. They also defined perceived neighborhoods that consisted of a survey of the area residents and where these residents perceived the boundaries of their neighborhoods to be geographically located. The results of the Bullen Study were presented in three solutions. Each solution showed a different perspective in the analysis of their data. The first two solutions dealt simply with the technocratically derived visualization of health administrative boundaries in Sussex County using GIS. These solutions were not associated with any analysis of the data. The third solution revealed the actual patient to GP flows. This investigator performed a visual analysis of the mapped results of this solution. It appeared to show that the lesser the density of cities or towns in an area, the greater the distance the population will travel to a GP office. The patients to GP flows appeared to disregard administrative boundaries. Distance appeared to be the major factor-determining patient to GP flows. Finally, they emphasized the importance of choosing the spatial unit that can have the maximum visual impact and understanding while viewing a map for health planning purposes. This study did not necessarily emphasize a specific methodology in analyzing spatial data. Rather, it emphasized how a tool (GIS) can be used for effective data visualization.

A study done by Gobalet and Thomas (1996) described the use of sociodemographic data combined in a geographic information system for public health decision-making purposes. They focused on the recent changes in United States health care with an increased emphasis on how sociodemographic analyses are being incorporated into public health decision-making. They discussed the application of GIS to this process. In addition, they examined three cases in which GIS was used as an adjunct to decision-making involving sociodemographic variables.

First, Gobalet and Thomas looked at sexually transmitted disease (STD) distribution in Santa Clara County, California. The Public Health Department was asked to provide data on the distribution of adolescent child bearing and STD incidence by school district to help those planning the school-based prevention and awareness programs. Health workers needed to know the number of STD cases for each school district. In addition, information was gathered to obtain the adolescent child bearing rate for each school district. Once this was done it was determined, through the use of a GIS, that there was a high correlation between adolescent STD rates and adolescent child bearing in several school districts. Policy makers were then able to target specific school districts for intervention.

Second, Gobalet and Thomas looked at ambulatory care hospitalization of senior citizens in the same county. Their objective was to identify areas in which public health interventions might reduce unnecessary hospitalization. To accomplish this, public health officials needed to identify regions in which seniors had an above average risk of developing preventable acute conditions. The health department used the index of indicators specified in the Older American Acts of 1965 and 1992. These indicators described factors placing senior citizens at risk of reduced independence, increased reliance on health care supportive services, increased morbidity, and premature death. The indicators are high rates of linguistic isolation, living alone, poverty, limited mobility, and limited self-care. They used 1990 Census data tied to census tracts to identify areas with a meaningful population which have the characteristics associated with the index of indicators. Tracts with high values were designated Senior Risk Zones (SRZs). In addition, they used hospital discharge data that included many relevant variables, among them principal diagnosis and patient home address. The county also used a set of diagnoses known as Ambulatory Care Sensitive (ACS) conditions. These are conditions for which timely and effective primary care will reduce the risk of hospitalization by preventing the onset of illness, controlling an acute episodic illness, or managing a chronic disease. Hospitalizations for ACS conditions are considered preventable if patients receive medical attention before the condition becomes acute. An area with high ACS rates indicated preventable hospitalizations and possible problems with access to primary medical care services. As with the index of indicators, this information was also tied to census tracts.

Using the index of indicator data and the ACS data together, Gobalet and Thomas generated a map identifying the locations of two variables: 1) areas with the greatest number of preventable hospitalizations, and 2) areas previously identified as Senior Risk Zones. The results of this study were used in the preparation of the county government's new strategic plan for senior care.

Third, Gobalet and Thomas studied premature birth monitoring in Tennessee.

This case study differed from the others in the fact that the spatial unit chosen for analysis was the county. As a first step in determining the at risk population, they performed a simple correlation analysis which showed that counties with a high level of premature births tended to be those with lower housing values and large African-American populations. They also found that high premature birth rates were associated with high levels of abortion, adolescent birth, fetal death, neonatal death, and infant death.

Once the characteristics of the at-risk population were determined, a GIS was used to show the spatial distribution of the population at risk with these conditions. The results of the GIS analysis was provided using a choroplethic map which, through simple visual inspection, showed high levels of premature birth rates associated with the western portion of the state. The results of this study led state and local community health agencies to develop strategies that would promote prenatal care.

Kohli et al. (1995) conducted a study of geographical access to health care based on distance from the primary health center. A GIS was used in their study. They obtained population centroid data for the thirteen communes (or counties) located within Ostergotland Province, Sweden. In addition, a database was constructed that contained age, gender, personal identification number, what county the individual resided in, the primary health center of each individual, and their distance from the primary health center in meters. The results showed that communes with larger populations had a shorter distance to the primary health center and larger communes also had a larger percentage of population within 10km of the primary health center.

Smith (1973) published a study concerning the geography of social well being in the United States. The objective was to identify both the spatial and statistical differences of social well being in the United States at the state level. The method used was factor analysis. After he removed all factor loadings between -. 50 and .50, the results showed two factors to be dominant. Loadings that fell outside of this range indicated that the measure is highly associated with the factor. The first factor, General Socio-Economic well being, had high loadings in income, home-ownership, white-collar workers, and median years of school completed. In addition, this factor had low loadings in households with poor diets, disease, and families earning less than $3,000 annual income. The second factor, Social Pathology, had high loadings in disease, and various types of criminal activity. In addition, this factor had low loadings in registered voters, and index of home amenities.

Emergency Services

Billitier et al. (1996) conducted a study of the factors that contribute to medically unnecessary ambulance transports. They identified two objectives for this study. The first objective was to identify sociodemographic factors associated with medically unnecessary ambulance transports. The second objective was to determine the willingness of patients to utilize alternate modes of transportation to the emergency department. For their analysis they conducted a multisite prospective survey of all patients arriving by ambulance to one suburban and four urban emergency departments in New York during a one-week period. The results of the first objective showed that there is a meaningful statistical relationship between: 1) patients under forty years of age, who make less than $20,000 annually, and 2) those who receive public assistance. The results of the second objective showed that patients who used the ambulance when it was not medically necessary used it due to the lack of an alternate means of transportation to the hospital.

Dickinson et al. (1996) conducted a study pertaining to geriatric use of emergency medical services. Their objective was to quantify the use of emergency medical services by geriatric patients with that of young adult patients. They used patient age to distinguish between the two groups. The study was conducted over a 6-month period in a suburban EMS system serving a population of 76,500 residents. They concluded that geriatric patients used emergency medical services more frequently than did the younger adults. The results also showed that younger adults incurred greater charges for service, and were more likely to utilize emergency medical services for minor medical problems.

Shah-Canning et al. (1996) conducted a 30-year study of the care-seeking patterns of inner-city families using the pediatric emergency room. More specifically, this study dealt with a pediatric emergency department. Families were interviewed as they sought care in the pediatric emergency department. The goal of the questioning was to determine if the families sought care in the emergency department due to the lack of a regular pediatrician. They identified two groups. Those who sought care in the emergency department who did not have a regular source of medical care, and those who sought care in the emergency department who had a regular source of medical care. Over three decades, the results showed a steady increase in the number of families seeking medical care for their children in the emergency departments who had no regular source of care. The majority of these families tended to be on some form of public assistance.

Garrison et al. (1997) conducted a study on the role of emergency medical services in primary injury prevention (PIP). The objective was to present the consensus of a 16-member panel of leaders from the pre-hospital EMS community on essential and desirable EMS PIP activities. Essential PIP activities include: protecting individual EMS providers from injury, educating EMS providers in PIP fundamentals, supporting collection of EMS data, empowering EMS providers to conduct PIP activities, and participating in community PIP programs. The implementation of a PIP program has a possibility of reducing EMS system overload, and provides for a more efficient allocation of EMS resources in the area of injury prevention, in addition to the more traditional injury treatment role of EMS providers.

Conclusions

As can be seen from this literature, the spatial analysis of health care issues, the distribution of disease, and the provision of various health care services has been a significant focus in past geographic research. However, the specific analysis of the pattern of EMS health care provision is new and unique to the realm of geographic research. By completing this study, it is hoped that a new and vital focus in this area of health care analysis can be opened.

Research Questions and Hypotheses

For the purposes of this study, this investigator used emergency medical and sociodemographic data. Using this data, three research questions each with one or more supporting hypotheses were analyzed in this study. The following questions and associated research hypotheses were examined:

I. WHAT SOCIODEMOGRAPHIC CHARACTERISTICS ARE ASSOCIATED WITH POPULATIONS WHO UTILIZE EMERGENCY MEDICAL SERVICES AND WHAT IS THE SPATIAL PATTERN?

HYPOTHESIS:

1) Areas with poorer populations tend to utilize emergency medical services more often than areas with wealthier populations.

II. WHAT SOCIODEMOGRAPHIC FACTORS ARE MOST CLOSELY ASSOCIATED WITH SPECIFIC TYPES OF MEDICAL EMERGENCIES?

HYPOTHESES:

1) Areas with populations that rent property tend to be associated with a greater number of medical emergencies, than areas with populations that own property.

2) Areas with populations that depend on public assistance income will utilize emergency medical services more than areas with populations that do not depend on public assistance income.

3) Medical emergencies tend not to be associated with areas that have populations earning a high mean annual income.

4) Cardiac, diabetic, and respiratory medical emergencies tend to be associated with areas having older populations and not with areas having younger populations.

5) Medical emergencies resulting from acts of violence tend to be associated more with areas having younger populations than with areas having older populations.

6) Medical emergencies resulting from acts of violence tend to be associated more with areas having Black and Hispanic ethnic populations than with areas having White or Asian ethnic populations.

7) There is no relation between population density and medical emergencies.

III. IS THERE A CLUSTERED OR RANDOM PATTERN ASSOCIATED WITH SPECIFIC TYPES OF MEDICAL EMERGENCIES?

HYPOTHESES:

1) Medical emergencies will exhibit a clustering pattern rather than a random pattern in block groups.

2) Medical emergencies will most frequently occur in block groups dominated by high-density housing rather than in block groups dominated by low-density housing.

CHAPTER II

DATA SOURCES AND RESEARCH METHODOLOGY

Summary of Data Sources

The data sources used in this study are the Emergency Medical Services Patient Care Report (EMS-PCR) database from June 1991 to October 1995, and 1990 Census database. In addition, the investigator will further base the analysis of this data on work experience in the study area from 1983-1995. It was during these years that the investigator worked both as an Emergency Medical Technician (EMT) and Volunteer Fire Fighter in the study area.

The EMS-PCR database (provided by the Solano County Emergency Medical Services Agency) consists of data assembled from patient care reports filled out by private ambulance and fire department paramedics and emergency medical technicians for each medical emergency call. The individual who provided primary patient care on the incident normally completes the patient care report in the hospital emergency room immediately after each medical emergency incident. The database includes 71 fields covering a wide range of characteristics for each medical emergency. Some examples of these characteristics include ambulance response time, patient gender, and type of medical insurance. The fields used from the EMS-PCR database were clinical impression and grid (location of the incident). Clinical impression is the paramedic or EMT's impression of the clinical condition responsible for the patient's request for EMS services. It can be further summarized as the paramedic or EMT's impression or diagnosis of the clinical syndrome he/she is attempting to manage in the pre-hospital setting. It is broken down by category into 54 separate medical emergencies. Some examples of medical emergencies included in the categories are cardiac arrest, gunshot wound, assault, diabetic emergency, seizure emergency, and gastrointestinal bleed. Location is based on the location of the incident in a predetermined grid cell reference map. Each grid cell is $1/16^{th}$ square mile. There are 148 grid cells that overlay the study area. Since the data is accumulated on a continuous basis, the portion of the EMS-PCR database that will be used consists of approximately 18,000 EMS-PCR records from June 1991 to October 1995. This includes all of the EMS incidents that occurred in the study area during the time period.

The second source of data to be used for this study is the electronic format of the 1990 US Bureau of Census database. This database was used to obtain various social and economic variables that will be explained in greater detail in Chapter 2. The geographic unit for this component of the study was the block group. There are 46 block groups that cover the study area. Each block group is of varying size, normally containing 2000-4000 people, covering from 2 to 4 square miles.

Spatial Data Component

The two primary databases use different spatial units. For the purposes of analysis, it was necessary to create one spatial unit. This was done by overlaying the grid cells (Figure 2) on top of the block groups (Figure 3), as can be seen in Figure 4 (also in Figure 4 are three key urban land uses, these serve as points of reference when viewing the block groups and grid cells separately). With the assistance of both Arc/Info GIS and ArcView GIS, a polygon-on-polygon overlay was used to merge the grid cells into the block groups without changing the spatial integrity of the block groups. The merging of these two geographic units was done by determining the percentage of the area of each grid cell that is contained in each separate block group (Goodchild et al. 1993, and Moxey and Allanson 1994). Once the percentage was determined, the said percentages of

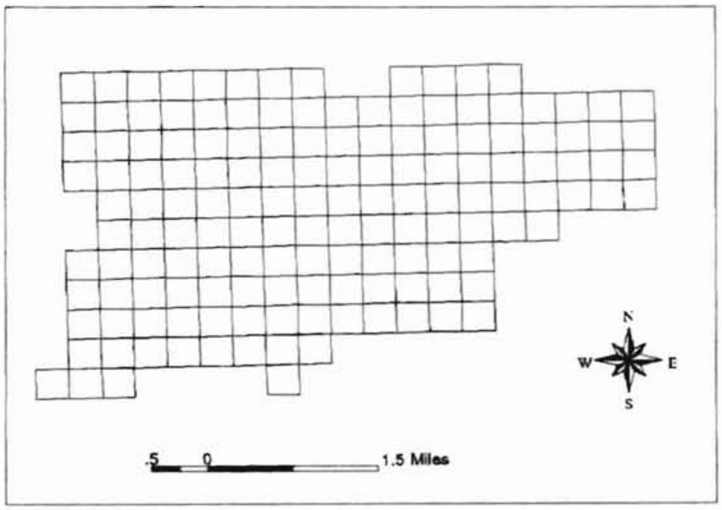


Fig. 2. Grid Cells.

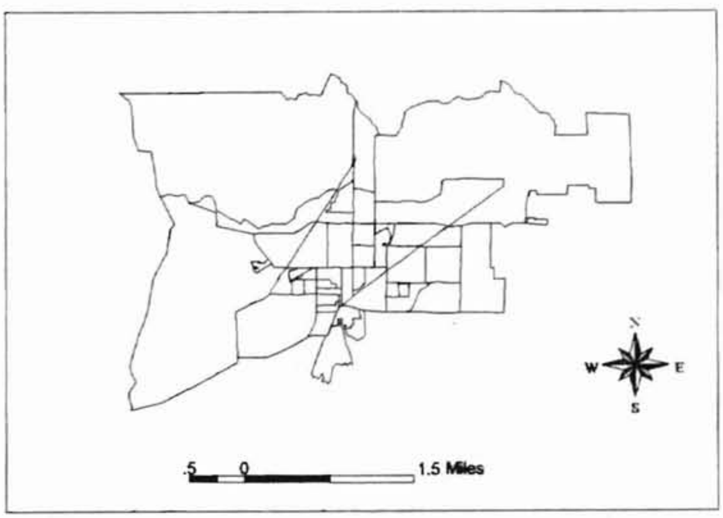


Fig. 3. Block Groups.

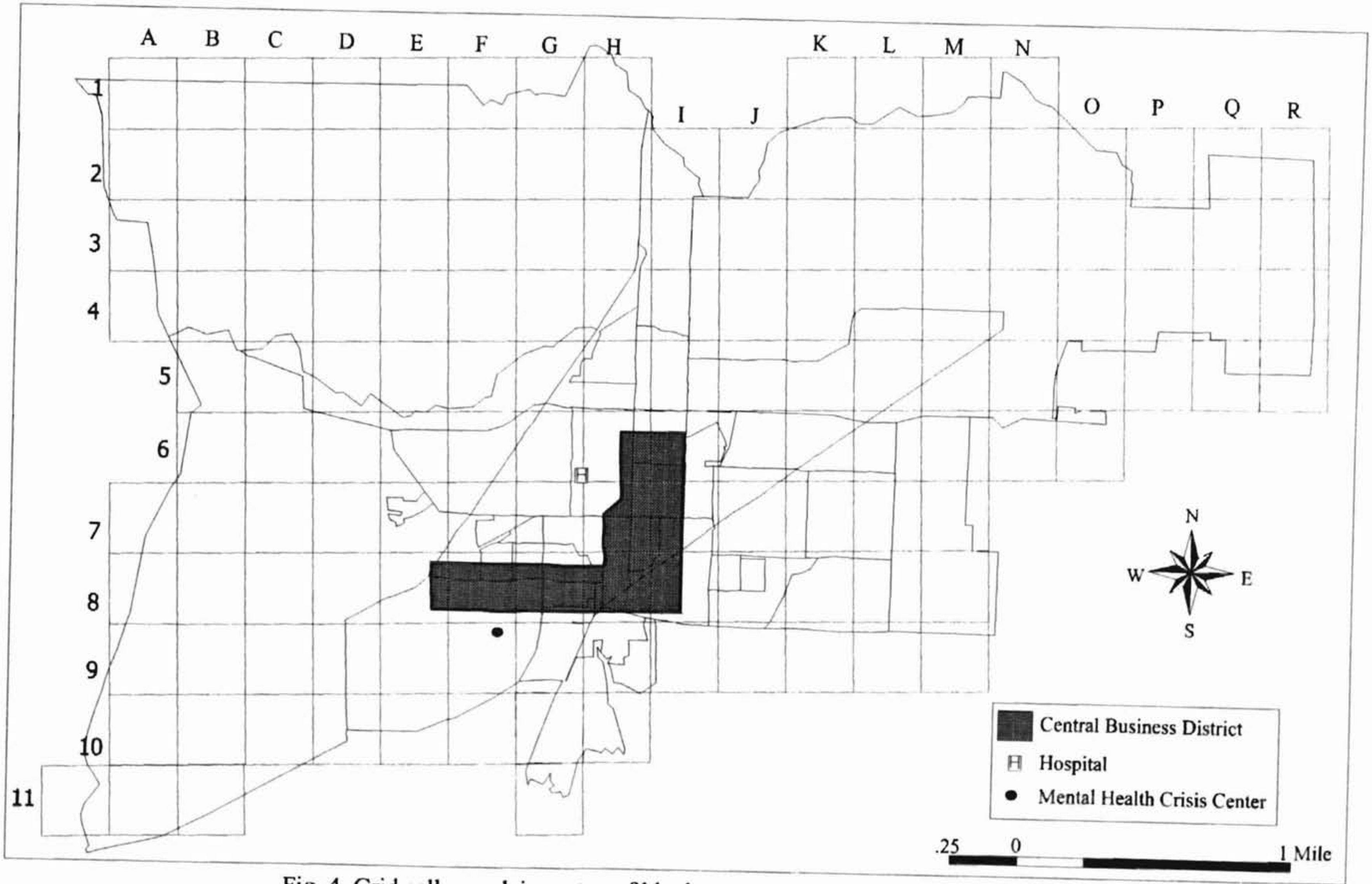


Fig. 4. Grid cells overlain on top of block groups and key urban locations..

attribute records (the raw frequency count of the total number of EMS incidents in each grid cell) were assigned to each respective block group. This process is further illustrated in Figure 5. The end result was one geographical unit (identical to the block groups in Figure 3) containing the attributes records of both the EMS-PCR database, and the 1990 census database.

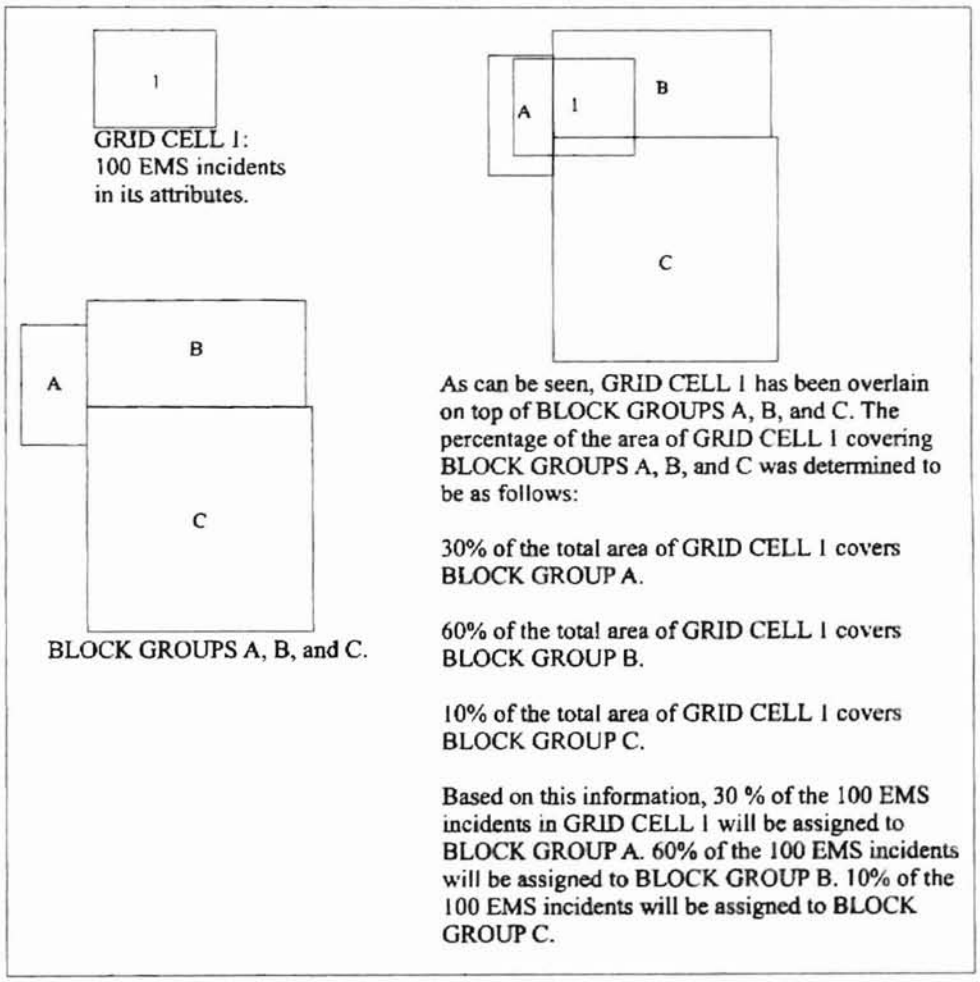


Fig. 5. Illustration of spatial unit overlay process.

Aspatial Data Component

To effectively answer each of the research questions and hypotheses, the investigator used variables from the EMS-PCR database. Due to the large quantity of data variables (54) in the EMS-PCR database available, these variables have been classified into 11 aggregate groups designated as the Classified Clinical Impression (CCI). Each of the variables in the CCI were derived using a two-step process. The first step involved minimizing the number medical emergency variables by grouping related medical emergencies into a more encompassing variable category (Appendix A). The second step involved converting the raw count data in each of the newly derived variable groupings into a format that can be used more effectively with inferential statistical methods. The format used was per capita (Appendix B).

In addition to using the CCI, the investigator used variables from the 1990 Census (Appendix C). The census variables were converted from a raw count format to percentages. This data format has proven to be more effective when using inferential statistical methods.

Methodology for Research Question I

WHAT SOCIODEMOGRAPHIC CHARACTERISTICS ARE ASSOCIATED WITH PERSONS WHO UTILIZE EMERGENCY MEDICAL SERVICES?

The objective of this research question was to develop a profile of the type of individual who utilizes the Emergency Medical Services System. The analysis portion of this question will be done using Factor Analysis on all the variables in the CCI and Census databases. The output of the Factor Analysis is known as a data matrix. The matrix of factor loadings provides a measure of the relationship between each variable and the factors. Groups of variables (typically it is the variables which have the highest and lowest factor loadings) dominate each factor and as a result they can be loosely associated in terms of interpretation. The profile was developed based on the groupings of the factor loadings. The results of the Factor Analysis discerned any meaningful relationships, which were used for addressing this question and the associated hypothesis. The factor scores were mapped to identify which block groups have the characteristics associated with the output of the factor analysis.

Methodology for Research Question II

WHAT SOCIODEMOGRAPHIC FACTORS ARE MOST CLOSELY ASSOCIATED WITH SPECIFIC TYPES OF MEDICAL EMERGENCIES?

A stepwise regression was performed to discern any meaningful relationships between each of the variables from the CCI and all the variables from the census. In a stepwise regression the independent variables are re-examined at each stage to identify any that have become superfluous following the introduction of subsequent predictors (independent variables). At each step both inclusion and exclusion are possible until neither are possible at the selected significance level (Shaw and Wheeler 1994). The output from the stepwise regression identified which specific sociodemographic variables (independent variables or predictors) are most closely associated with each of the variables in the CCI (dependent variable). The standardized residuals were mapped in order to analyze the unexplained variance associated with each regression model.

Methodology for Research Question III

IS THERE A CLUSTERED OR RANDOM PATTERN ASSOCIATED WITH MEDICAL EMERGENCIES?

The third research question consists of two objectives. The first objective was to determine if the pattern of medical emergencies is clustered or random. The second objective provided further evidence to support the first objective. For the first objective, a quadrat analysis was done based on the CCI data using the grid cells. The investigator attempted to conduct a measurement of the pattern of occurrence for each of the variables in the CCI using quadrat analysis.

The first component of the second objective was to provide support to the first objective in determining if the pattern is clustered or random. This was accomplished by calculating a chi-square contingency table. Prior to calculating chi-square, a contingency table was developed to house the categorical variables. The first set of categorical variables that was used consisted of all the variables in the CCI. For the column variables, the frequency count of each of the variables in the CCI was used in the contingency table. The second categorization, the row variables, was derived from an urban land use classification system based on several major urban land uses. The resulting contingency table will consist of 10 columns, and 5 rows. The urban land use classification system was developed based on the investigator's on-the-job experience in the study area. The system was based on the dominant urban land use that occurred within each grid cell as can be seen in Table 2.

The second component consisted of using the frequency count from each of variables in the CCI (Classified Clinical Impression) in the contingency table and their occurrences in each type of urban land use. A series of bar graphs was constructed based on the frequency of each medical emergency occurring in each type of urban land use. Based on this data, it can be determined which types of medical emergencies predominantly occur in each type of urban land use.

GRID CELL CLASSIFICATION	DEFINITION
Low-Density Urban	grid cells dominated by single family dwellings
High-Density Urban	grid cells dominated by apartment complexes and mobile home parks
Business	grid cells dominated by retail centers, convenience stores, restaurants, and other types of retail activity
Industrial	grid cells dominated by auto repair shops, wrecking yards, chemical plants, and other forms of light and heavy industry
Rural	grid cells dominated by open fields, farms, and ranches

Table 2. Definitions of Urban Land Use Classification.

Limitations and Assumptions

The polygon-on-polygon overlay process involved the grid cells and block groups. As noted earlier, this process involved merging the grid cells into the block groups. It was done this way for two reasons. The first is based on the fact that the grid cell coverage was arbitrarily placed over the study area. Thus, the grid cell boundaries do not conform to any physical, or man-made features, on the Earth. On the other hand, the block group coverage was not placed arbitrarily over the study area. Block group boundaries, being used to represent census data on a map, are placed over an area based on man-made or physical features of the landscape (Martin 1996). The second reason was based on two limitations inherent within the data. The first limitation is based on the fact that each record in the PCR-EMS database is not linked by address, or georeferenced, to a location within the $1/16^{th}$ square mile grid cells. This automatically rules out using address matching, or georeferencing, to pinpoint where each medical emergency occurs in the grid cells. Rather, each record in the PCR-EMS database is linked to a respective grid cell by a key field identified as grid. This field contains the grid cell ID number. Thus, each record is tied to a particular grid cell. In addition, the total population per grid cell is not included within the PCR-EMS database. The census data is set up in a similar way. Block group references the records contained within the Census database. However, unlike the PCR-EMS database, the total population per block group is included within this database. As a result of the limitations of the data, two assumptions must be made. These pertain to the polygon-on-polygon overlay process, converting the PCR-EMS data, and converting the census data into a format compatible for use with inferential statistical methods. The two assumptions were: medical emergencies are uniformly distributed in each grid cell, and population is uniformly distributed within each block group (Goodchild et al. 1993, and Moxey and Allanson 1994). Based on the data limitations and assumptions previously mentioned, the grid cells were merged into the block groups based on the fact that the area of each of the grid cells is considerably smaller than the area of each the block groups. The average area for a block group in this study area was over one square mile, and the area of each grid cell being $1/16^{th}$ square mile.

CHAPTER III

DATA ANALYSIS AND RESEARCH FINDINGS

Findings for Research Question 1

Using Factor Analysis with a varimax rotation, the underlying dimensions of variation can be extracted from a data matrix consisting of all the variables from the block groups. These dimensions of variation can be used to identify relationships among each of the variables in the data matrix. Variables extracted from the data matrix, which had loadings that fell between - 0. 50 and 0.50 were discarded. In using Factor Analysis it is common practice to exclude factor loadings that fall outside of this range. Only those variables with the largest positive and negative loadings were retained (Shaw and Wheeler, 1994). For the purposes of this question, the objective was to identify the characteristics of the population that were most closely associated with medical emergencies in the pre-hospital environment. Within the context of this objective the associated hypothesis was explained. The hypothesis was that areas with poorer persons would be most closely associated with medical emergencies in the CCI than would areas with wealthier persons. In the unrotated factor and rotated factor matrix, ten factors had eigenvalues greater than one. Rotating just the top five factors produced a similar result. Table 3 shows the factor loadings for variables from the rotated factor (factor one) that accounted for the highest percentage of total variance. Factor one has been identified as the *Social-Economic-Health-Pathology Factor*. This factor accounted for 27.7% of the

Variables Explained Variance: 27.7%	**Factor: Social-Economic-Health Pathology**
PCAP Pediatric Medical Emergencies (< 13 yrs)	0.901
PCAP Medical Emergencies Involving Females (< 17 yrs)	0.900
PCAP Medical Emergencies Resulting from Acts of Violence	0.887
PCAP Medical Emergencies Involving Drugs/Alcohol	0.887
PCAP Diabetic/Seizure Medical Emergencies	0.879
% of Housing Units Rented by Whites	0.877
PCAP Geriatric Medical Emergencies (> 64 yrs)	0.871
PCAP Environmental Medical Emergencies	0.869
PCAP Respiratory Medical Emergencies	0.863
PCAP Cardiac Medical Emergencies	0.851
% of Households Renting Property	0.791
% of Households Paying $400-$599 Monthly Rent	0.785
% of Population Receiving Public Assistance	0.750
% of Population < 30 yrs of Age	0.646
% of Housing Units with 2-19 Units	0.540
1989 Per Capita Income	-0.511
% of Home Ownership-White	-0.717

Table 3. Rotated Factor Loadings

total variance. Nine of the ten variables measuring medical emergency rates loaded on this rotated factor. Mental health emergency calls was the only category that did not load on factor one, but its loading on any of the other factors was less than 0.50. It clearly identifies the characteristics of the population associated with medical emergencies in the pre-hospital environment. This can be further explained by the preponderance of high loading medical emergency variables, and the fact that the other non-medical emergency variable loadings seem to be associated with poorer segments of the population. It clearly shows that populations who are relatively young in age, rent property, receive public assistance income, live in multi-unit housing, and have a low per capita income, are associated most closely with medical emergencies in the pre-hospital environment (Billitier et al. 1996). This evidence clearly supports the hypothesis that block groups with poorer persons tend to utilize emergency medical services more often than block groups with wealthier persons. Subsequent factors were not considered as they not considered as they independently accounted for little of the total variation or had variable loadings that fell within the rejection range. As can be seen in the map of the factor scores (Fig. 6.) the highest scores occur in block groups in and around the central business district. This area is characterized by urban blight, and high-density rental housing occupied by persons dependent upon public assistance.

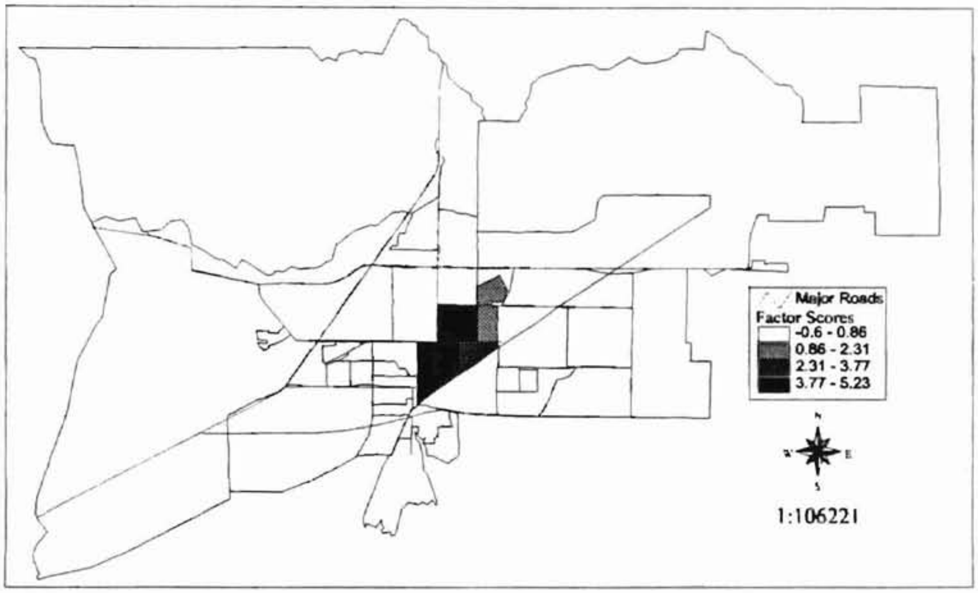


Fig.6.Map of Factor Scores.

Findings for Research Question II

A series of ten stepwise linear regressions were done using each variable in the CCI (Appendix B) as the dependent variable. The independent variables consisted of all the variables in the 1990 US Census database (Appendix C). All the regressions used the same set of independent variables. SPSS statistical software package was used. The variables entered into each model were based on the significance level of .05. The output from the regressions showed only those independent variables that had a significance level less than or equal to .05. The independent variables were ranked in the order that they were entered into the regression model. There were 46 observations corresponding to each block group. In addition, in order to look for multicollinearity among the independent variables, a Pearsons Correlation Matrix was calculated among all the independent variables. This matrix can be viewed in Appendix D.

In order to identify if statistically meaningful correlations exist between each dependent variable and the independent variables, a Pearsons Correlation was done. This can be viewed in Appendix E. Upon examination of the correlations, they showed that all the dependent variables, except one (see the PCAP Mental Health Medical Emergencies Regression Model, page 42), had statistically meaningful positive correlations with the percentage of the population renting property and the percentage of population receiving public assistance. These two variables indicate that the poorer segments of the population (those receiving public assistance) are most commonly associated with medical emergencies.

The standardized residuals were mapped to identify any other underlying relationships not presented in the regression results. These maps can be seen in Appendix F. The spatial patterns on each map showed a tendency for the highest residuals to occur in and around the Central Business District (CBD)(refer to Chapter II, page 17, Fig. 4. for the location of this and other key urban areas). Significant areas of urban blight characterize the CBD and its immediate surroundings. Multi-unit apartments and mobile home parks housing large numbers of people dependent upon public assistance are also located in this area. The only exception was the map of the standardized residuals for PCAP Mental Health Emergencies. The highest residuals for this map clustered in a block group where a large private mental health treatment center or halfway house is located. The maps of the standardized residuals provide some explanation of the variation not explained in the regression models. These maps support the fact that the unexplained variation is related to poverty and urban blight.

When the stepwise regression models were analyzed several predictors (independent variables) were shown repeatedly to have statistically meaningful relationships to all or several of the dependent variables. These predictors were all associated with those segments of the population that rent, i.e. the percentage of housing units rented by Whites, the percentage of households paying $400 to $599 monthly rent, and the percentage of housing units with 20-49 units. The reason for these predictors being shown as statistically meaningful could be because those segments of the population who rent are typically associated with high density housing, have less education, and are more prone to have medical problems due to poor diet, personal hygiene, and sub-standard living conditions. In several stepwise regression models other predictors had a statistically meaningful relationship which could not be explained such as the percentage of housing units owned by Asians. Further research is necessary to determine exactly what relationship this predictor has with the dependent variables.

The first stepwise linear regression model was done using PCAP Pediatric Medical Emergencies (< 13 yrs) as the dependent variable. The model summary can be seen in Table 4. The R-square associated with the results clearly showed a meaningful statistical relationship between PCAP Pediatric Medical Emergencies (< 13 yrs) and the predictors. The predictors can be defined as the independent variables with the strongest statistical relationship to the dependent variable in their order of appearance. Based on

Dependent Variable(DV):

PCAP Pediatric Medical Emergencies (< 13 yrs)

Steps	**Variable(s) Entered**	**Cumulative R –square**
1	% of HUS rented by Whites	0.449
2	% of HUS rented by Whites % of HUS with 1 housing unit at address	0.576
3	% of HUS rented by Whites % of HUS with 1 unit at address % of population with < 12 yrs of education	0.627
4	% of HUS rented by Whites % of HUS with 1 housing unit at address % of population with < 12 yrs of education % of HUS owned by Asians	0.667

Letter*	**Predictors**	**Partial R-square**	**p-value**
a =	% of HUS rented by Whites	0.449	0.000
b =	% of HUS with 1 housing unit at address	0.127	0.000
c =	% of population with < 12 yrs of education	0.050	0.005
d =	% of HUS owned by Asians	0.041	0.030

* letter designations for variables included in regression equation

Regression Equation
DV= -.182 + .337a + .376b + .351c + .258d

Table 4. Model 1: PCAP Pediatric Medical Emergencies (< 13 yrs)

the evidence in Table 4, the percentage of housing units rented by Whites is the leading predictor. The next highest predictor was the percentage of housing units with 1 unit at each address. The regression equation shows that all the variables have a positive relationship to PCAP Pediatric Medical Emergencies (< 13 yrs). The predictors taken together produce an R-square of .667. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations with the percentage of population receiving public assistance (.596), the percentage of population paying $400 to $599 monthly rent (.538), the percentage of population renting property (.514), and the percentage of population less than 30 years of age (.442). It has statistically meaningful negative correlations with the percentage of housing units owned by Whites (-.475), the percentage of housing units owned by Blacks (-.326), and the percentage of male population (-.320). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model.

The second stepwise linear regression used the PCAP Cardiac Medical Emergencies as the dependent variable. Refer to Table 5, for the model summary. As in the previous regression's results, the most statistically meaningful predictor is the percentage of housing units rented by Whites. The next highest predictor is the percentage of households paying greater than $599 monthly rent. In Table 5, in steps 2-6 of the regression, the percentage of housing units with 1 unit at each address is the second highest predictor. However, this variable is removed in the final step, step 7. The regression equation shows a positive relationship exists between the dependent variable and the percentage of housing units rented by Whites, and the percentage of housing units owned by Asians. A negative relationship exists between the percentage of households paying greater than $599 monthly rent, the percentage of housing units rented by Hispanics, and the percentage of housing units with twenty to forty-nine units at each address. The predictors taken together produce an R-square of .685. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations exist with the percentage of population receiving public assistance (.517), the percentage of population paying $400 to $599 monthly rent (.480),

Dependent Variable (DV):

PCAP Cardiac Medical Emergencies

Steps	Variable(s) Entered	Cumulative R-square
1	% of HUS rented by Whites	0.360
2	% of HUS rented by Whites % of HUS with 1 housing unit at address	0.510
3	% of HUS rented by Whites % of HUS with 1 housing unit at address % of HH paying > $599 monthly rent	0.577
4	% of HUS rented by Whites % of HUS with 1 housing unit at address % of HH paying > $599 monthly rent % of HUS rented by Hispanics	0.620
5	% of HUS rented by Whites % of HUS with 1 housing unit at address % of HH paying > $599 monthly rent % of HUS rented by Hispanics % of HUS with 20-49 housing units at address	0.665
6	% of HUS rented by Whites % of HUS with 1 housing unit at address % of HH paying > $599 monthly rent % of HUS rented by Hispanics % of HUS with 20-49 housing units at address % of HUS ownership -Asian	0.700
7	% of HUS rented by Whites % of HH paying > $599 monthly rent % of HUS rented by Hispanics % of HUS with 20-49 housing units at address % of HUS ownership -Asian	0.685

Letter*	Predictors	Partial R-square	p-value
a =	% of HUS rented by Whites	0.360	0.000
b =	% of HH paying > $599 monthly rent	0.067	0.003
c =	% of HUS rented by Hispanics	0.043	0.014
d =	% of HUS with 20-49 housing units at address	0.045	0.002
e=	% of HUS ownership -Asian	0.035	0.009

* letter designations for variables included in regression equation

Regression Equation
DV= -.019 + .281a - .384b - .205c - .490d + .167e

Table 5. Model 2: PCAP Cardiac Medical Emergencies.

the percentage of population renting property (.431), and the percentage of population less than 30 years of age (.385). It was found that negative correlations exist with the percentage of housing units owned by Whites (-.402), and the percentage housing units owned by Blacks (-. 303). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model.

The third stepwise linear regression used the PCAP Diabetic/Seizure Medical Emergencies as the dependent variable. Refer to Table 6 for model summary. The regression results for this model show that Diabetic/Seizure Medical Emergencies were again statistically related to the percentage of housing units rented by Whites. The next highest predictor was the percentage of housing units with one unit at each address. The regression equation shows a positive relationship exists with the percentage of housing units rented by Whites, the percentage of housing units with one unit at each address, the percentage of Hispanic population, and the percentage of unemployed. It shows a negative relationship exists with the percentage of households paying greater than $599 monthly rent, the percentage of housing units with twenty to forty-nine units at each address, the percentage of housing units owned by Blacks, and the percentage of housing units owned by Whites. The predictors taken together produce an R-square of .776. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations exist with the percentage of population receiving public assistance (.562), the percentage of population paying $400 to $599 monthly rent (.493), the percentage of population renting property (.458), and the percentage of population

Dependent Variable (DV):
PCAP Diabetic/Seizure Medical Emergencies

Steps	Variable(s) Entered	Cumulative R-square
1	% of HUS rented by Whites	0.407
2	% of HUS rented by Whites % of HUS with 1 unit at address	0.523
3	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent	0.586
4	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent % of HUS with 20-49 units at address	0.639
5	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent % of HUS with 20-49 units at address % Hispanic population	0.682
6	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent % of HUS with 20-49 units at address % Hispanic population % unemployed	0.712
7	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent % of HUS with 20-49 units at address % Hispanic population % unemployed % of HUS ownership - Black	0.747
8	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent % of HUS with 20-49 units at address % Hispanic population % unemployed % of HUS ownership - Black % of HUS ownership - White	0.776

Letter*	Predictors	Partial R-square	p-value
a=	% of HUS rented by Whites	0.406	0.000
b=	% of HUS with 1 unit at address	0.125	0.002
c=	% of HH paying > $599 monthly rent	0.054	0.009
d=	% of HUS with 20-49 units at address	0.053	0.007
e=	% Hispanic population	0.043	0.001
f=	% unemployed	0.030	0.007
g=	% of HUS ownership - Black	0.034	0.009
h=	% of HUS ownership - White	0.029	0.034

* letter designations for variables included in regression equation

Regression Equation
DV= -.005 + .123a + .120b - .190c - .262d + .121e + .387f - .146g - .041h

Table 6. Model 3: PCAP Diabetic/Seizure Medical Emergencies.

less than 30 years of age (.410). It was found that a negative correlation exists with the percentage of male population (-.312). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model. The predictors in this model seem to confirm the pattern explained earlier. Several of the predictors are associated with those segments of the population that rent. Others appear to be associated with those segments of the population that own property, e.g. the percentage of housing units with one unit, the percentage of housing units owned by Blacks, and the percentage of housing units owned by Whites. This may indicate that Diabetic/Seizure medical emergencies are not only associated with poorer segments of the population, but also with the wealthier segments of the population.

The fourth stepwise linear regression used PCAP Medical Emergencies Involving Drugs/Alcohol as the dependent variable. Refer to Table 7 for model summary. The results of this regression model show Medical Emergencies Associated with Drugs/Alcohol to be statistically related to the percentage of housing units rented by Whites. The next highest predictor is the percentage of housing units with twenty to forty-nine units at each address. The regression equation shows a positive relationship exists with housing units rented by Whites, population density, and the percentage of population receiving public assistance. It shows a negative relationship exists with the percentage of housing units with twenty to forty-nine units at each address, the percentage of households paying greater than $599 monthly rent, the percentage of housing units rented by Asians, and the percentage of households paying less than $399 monthly rent. The predictors taken together produce an R-square of .782. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations exist with the percentage of population paying $400 to $599 monthly rent (.524), the percentage of population renting property (.482), and the

Dependent Variable (DV):

PCAP Medical Emergencies Involving Drugs/Alcohol

Steps	Variable(s) Entered	Cumulative R -square
1	% of HUS rented by Whites	0.433
2	% of HUS rented by Whites % of HUS with 20-49 units at address	0.553
3	% of HUS rented by Whites % of HUS with 20-49 units at address Population Density (per sq. mile)	0.627
4	% of HUS rented by Whites % of HUS with 20-49 units at address Population Density (per sq. mile) % of HH paying > $599 monthly rent	0.676
5	% of HUS rented by Whites % of HUS with 20-49 units at address Population Density (per sq. mile) % of HH paying > $599 monthly rent % of HUS rented by Asians	0.726
6	% of HUS rented by Whites % of HUS with 20-49 units at address Population Density (per sq. mile) % of HH paying > $599 monthly rent % of HUS rented by Asians % of population receiving public assistance	0.757
7	% of HUS rented by Whites % of HUS with 20-49 units at address Population Density (per sq. mile) % of HH paying > $599 monthly rent % of HUS rented by Asians % of population receiving public assistance % of HH paying > $399 monthly rent	0.782

Letter*	Predictors	Partial R-square	p-value
a=	% of HUS rented by Whites	0.433	0.000
b=	% of HUS with 20-49 units at address	0.120	0.000
c=	Population Density (per sq. mile)	0.074	0.048
d=	% of HH paying > $599 monthly rent	0.048	0.004
e=	% of HUS rented by Asians	0.050	0.001
f=	% of population receiving public assistance	0.031	0.014
g=	% of HH paying > $399 monthly rent	0.025	0.045

* letter designations for variables included in regression equation

Regression Equation
DV=.002 + .241a - .513b + .00012c - .317d - .243e + .414f - .341g

Table 7. Model 4: PCAP Medical Emergencies Involving Drugs/Alcohol.

percentage of population less than 30 years of age (.431). It was found that a negative correlation exists with the percentage of housing units owned by Whites (-.450). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model.

The fifth stepwise linear regression uses PCAP Geriatric Medical Emergencies (> 64 yrs) as the dependent variable. Refer to Table 8 for the model summary. The results

Dependent Variable (DV):
PCAP Geriatric Medical Emergencies (> 64 yrs)

Steps	Variable(s) Entered	Cumulative R -square
1	% of HUS rented by Whites	0.385
2	% of HUS rented by Whites % of HUS with 1 unit at address	0.489
3	% of HUS rented by Whites % of HUS with 1 unit at address % of population receiving public assistance	0.558
4	% of HUS rented by Whites % of HUS with 1 unit at address % of population receiving public assistance % male population	0.611**

Letter*	Predictors	Partial R-square	p-value
a=	% of HUS rented by Whites	0.384	0.000
b=	% of HUS with 1 unit at address	0.105	0.000
c=	% of population receiving public assistance	0.068	0.004
d=	% male population	0.053	0.023

* letter designations for variables included in regression equation

Regression Equation
DV = -.296 + .275a + .409b + .940c + .307d

Table 8. Model 5: PCAP Geriatric Medical Emergencies (> 64 yrs).

of this regression model show Geriatric Medical Emergencies (> 64 yrs) to be statistically related to the percentage of housing units housing units rented by Whites. The next highest predictor is the percentage of housing units with one unit at each address. The regression equation shows all the predictors in this model have a positive relationship with the dependent variable. The predictors taken together produce an R-square of .611. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations exist with the percentage of population paying $400 to $599 monthly rent, the percentage of population renting property (.480), and the percentage of population less than 30 years of age (.375). It was found that negative correlations exist with the percentage of housing units owned by Whites (-.436), the percentage of housing units owned by Blacks (-.321). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model. It remains unclear as to why the percentage of population greater than 59 years of age did not enter into this model. In addition, upon further examination of the Pearsons Correlation, the percentage of population greater than 59 years of age had a .195 correlation with PCAP Geriatric Medical Emergencies. Further research needs to be done on with regards to this relationship. Based on the predictors the percentage of housing units with one unit could be attributed to the fact that most older persons own their home, rather than rent, and live in single family dwellings. The percentage of male population may have proven statistically meaningful due to the fact that older males have more health problems than older females.

The sixth stepwise linear regression uses PCAP Environmental Medical Emergencies as the dependent variable. Refer to Table 9 for the model summary.

Dependent Variable (DV):

PCAP Environmental Medical Emergencies

Steps	Variable(s) Entered	Cumulative R -square
1	% of HUS rented by Whites	0.415
2	% of HUS rented by Whites % of HUS with 1 unit at address	0.538
3	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent	0.597
4	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent % of HUS with 20-49 units at address	0.653
5	% of HUS rented by Whites % of HUS with 1 unit at address % of HH paying > $599 monthly rent % of HUS with 20-49 units at address % of HUS rented by Hispanics	0.710

Letter*	Predictors	Partial R-square	p-value
a=	% of HUS rented by Whites	0.415	0.000
b=	% of HUS with 1 unit at address	0.123	0.091
c=	% of HH paying > $599 monthly rent	0.058	0.001
d=	% of HUS with 20-49 units at address	0.056	0.005
e=	% of HUS rented by Hispanics	0.057	0.008

* letter designations for variables included in regression equation

Regression Equation
DV= - .009 + .098a + .028b - .132c - .140d - .070e

Table 9. Model 6. PCAP Environmental Medical Emergencies.

The results of this regression model show Environmental Medical Emergencies to be statistically related to the percentage of housing units rented by Whites. The next highest predictor is the percentage of housing units with one unit at each address. The regression equation shows a positive relationship exists with the percentage of housing units housing units rented by Whites, and the percentage of housing units with one unit at each address. A negative relationship exists with the percentage of households paying greater than $599 monthly rent, the percentage of housing units with twenty to forty-nine units at each address, and the percentage of housing units rented by Hispanics. The predictors taken together produce an R- square of .710. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations exist with the percentage of population receiving public assistance (.562), the percentage of population paying $400 to $599 monthly rent (.485), the percentage of population renting property (.447), and the percentage of population less than 30 years of age (.435). It was found that negative correlations exist with the percentage of housing units owned by Whites (-.440), and the percentage of male population (-.303). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model. In Providing a further explanation of the results of this model, it appears that the percentage of housing units with one unit may have proven to be statistically meaningful due to the fact occupants of single-family dwelling tend to be outdoors more often taking care of their yards, thus they may have a higher rate of injury.

The seventh stepwise linear regression uses PCAP Medical Emergencies Involving Females (17-64 yrs) as the dependent variable. Refer to Table 10 for the model summary. The results of this regression model show Medical Emergencies Involving Females (17-64 yrs) to be statistically related to the percentage of housing units rented Whites. The next highest predictor is the percentage of housing units with one unit at each address. The regression equation shows a positive relationship exists among all the predictors and the dependent variable. The predictors taken together produce an R- square of .658. The Pearsons Correlations, Appendix E, were

Dependent Variable (DV):

PCAP Medical Emergencies Involving Females (> 17 yrs)

Steps	Variable(s) Entered	Cumulative R -square
1	% of HUS rented by Whites	0.441
2	% of HUS rented by Whites % of HUS with 1 unit at address	0.556
3	% of HUS rented by Whites % of HUS with 1 unit at address % male population	0.603
4	% of HUS rented by Whites % of HUS with 1 unit at address % male population % of population receiving public assistance	0.658

Letter*	Predictors	Partial R-square	p-value
a=	% of HUS rented by Whites	0.447	0.000
b=	% of HUS with 1 unit at address	0.116	0.000
c=	% male population	0.046	0.009
d=	% of population receiving public assistance	0.056	0.013

* letter designations for variables included in regression equation

Regression Equation
DV = -.676 + .679a + .902b + .700c + 1.573d

Table 10. Model 7: PCAP Medical Emergencies Involving Females (17-64 yrs).

examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations exist with the percentage of population paying $400 to $599 monthly rent (.520), and the percentage of population less than 30 years of age (.432). It was that negative correlations exist with the percentage of housing units owned by Whites (-.471) the percentage of housing units owned by Blacks (-.301). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model. In providing a further explanation of this models results it is unclear to this investigator why the percentage of housing units with one unit and the percentage of males proved to be statistically meaningful.

The eighth stepwise linear regression uses PCAP Mental Health Medical Emergencies as the dependent variable. Refer to Table 11 for the model summary.

Dependent Variable (DV):
PCAP Mental Health Medical Emergencies

Steps	Variable(s) Entered	Cumulative R -square
1	% of HUS rented by Whites	0.12

Letter*	Predictors	Partial R-square	p-value
a=	% of HUS rented by Whites	0.120	0.019

* letter designations for variables included in regression equation

Regression Equation
DV = .0001 + .023a

Table 11. Model 8: PCAP Mental Health Medical Emergencies.

The results of this regression model show no clear relationship between the dependent variable and the independent variables entered into the model. This was clearly illustrated by the low R-square of .120. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically relationship to the dependent variable. It was found that no other independent variables had a statistically meaningful relationship. The correlation of the percentage of housing units rented by Whites was .346. As in the regression model, this was the only independent variable that had a statistically meaningful relationship with the dependent variable. Upon examination of the Pearsons Correlation Matrix, Appendix D, the percentage of housing units rented by Whites exhibits multicollinearity with more than 50% of the independent variables. This may explain why this variable was the only one analyzed in the regression model. The reason for only one predictor entering this model is most likely due to where the majority of this type of medical emergency occurs. In the study area the majority of incidents relating to this type of medical emergency occur in one block group. Within that one block group is the Solano Mental Health Crisis Center. It is here that all mental health medical emergencies are brought. Persons involved in this type of medical emergency are brought to the Crisis Center by local law enforcement. Thus, the original location of where the medical emergency occurred is not known. When the Crisis Center Staff calls the ambulance, it is this location that is subsequently entered into the PCR-EMS database by ambulance personnel as the location of the medical emergency

The ninth stepwise linear regression used PCAP Respiratory Medical Emergencies as the dependent variable. Refer Table 12 for the model summary. The results of this regression model show the dependent variable to be statistically related to the percentage of housing units rented by Whites. The next highest predictor was the percentage of housing units owned by Asians. The regression equation shows a positive relationship exists with the percentage of housing units rented by Whites, the percentage of housing units owned by Asians, and the percentage of households paying $400 to $599 monthly rent. It shows a negative relationship with the percentage of housing units with twenty to forty-nine units at each address. The predictors taken together produce an R-square of .589. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations exist with the percentage of population receiving public assistance (.509), the percentage of population renting property (.467), and the percentage of population less than 30 years of age (.375). It was found that negative correlations exist with the percentage of housing units owned by

Dependent Variable (DV):
PCAP Respiratory Medical Emergencies

Steps	Variable(s) Entered	Cumulative R -square
1	% of HUS rented by Whites	0.363
2	% of HUS rented by Whites % of HUS ownership – Asian	0.477
3	% of HUS rented by Whites % of HUS ownership – Asian % of HUS with 20-49 units at address	0.538
4	% of HUS rented by Whites % of HUS ownership -- Asian % of HUS with 20-49 units at address % of HH paying $400-$599 monthly rent	0.589

Letter*	Predictors	Partial R-square	p-value
a=	% of HUS rented by Whites	0.362	0.023
b=	% of HUS ownership – Asian	0.115	0.001
c=	% of HUS with 20-49 units at address	0.061	0.003
d=	% of HH paying $400-$599 monthly rent	0.051	0.029

* letter designations for variables included in regression equation

Regression Equation
DV = -.009 + .061a + .131b - .319c + .133d

Table 12. Model 9: Respiratory Medical Emergencies.

Whites (-.415), and the percentage of housing units owned by Blacks (-.324). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model.

The tenth stepwise linear regression uses PCAP Medical Emergencies Resulting from Acts of Violence as the dependent variable. Refer to Table 13 for the model summary. The results of this regression model show the dependent variable to be statistically related to the percentage of housing units rented by Whites. The next highest predictor was percentage of housing units with one unit at each address. The regression equation shows a positive relationship exists with the percentage of housing units rented

Dependent Variable (DV):
PCAP Medical Emergencies Resulting from Acts of Violence

Steps	Variable(s) Entered	Cumulative R-square
1	% of HUS rented by Whites	0.435
2	% of HUS rented by Whites % of HUS with 1 unit at address	0.55
3	% of HUS rented by Whites % of HUS with 1 unit at address % of HUS paying >$599 monthly rent	0.604
4	% of HUS rented by Whites % of HUS with 1 unit at address % of HUS paying >$599 monthly rent % of HUS with 20-49 units at address	0.653
5	% of HUS rented by Whites % of HUS with 1 unit at address % of HUS paying >$599 monthly rent % of HUS with 20-49 units at address % Hispanic population	0.699
6	% of HUS rented by Whites % of HUS with 1 unit at address % of HUS paying >$599 monthly rent % of HUS with 20-49 units at address % Hispanic population % of unemployed	0.741
7	% of HUS rented by Whites % of HUS with 1 unit at address % of HUS paying >$599 monthly rent % of HUS with 20-49 units at address % Hispanic population % of unemployed % of HUS ownership – Black	0.769
8	% of HUS rented by Whites % of HUS with 1 unit at address % of HUS paying >$599 monthly rent % of HUS with 20-49 units at address % Hispanic population % of unemployed % of HUS ownership – Black % of HUS ownership – White	.0.802

Letter*	Predictors	Partial R-square	p-value
a=	% of HUS rented by Whites	0.435	0.000
b=	% of HUS with 1 unit at address	0.115	0.002
c=	% of HUS paying >$599 monthly rent	0.054	0.005
d=	% of HUS with 20-49 units at address	0.049	0.007
e=	% Hispanic population	0.046	0.000
f=	% of unemployed	0.042	0.002
g=	% of HUS ownership – Black	0.028	0.011
h=	% of HUS ownership – White	0.033	0.018

* letter designations for variables included in regression equation

Regression Equation
DV = .004 + .084a + .077b - .128c - .167d - .081e + .289f - .090g - .029h

Table 13. Model 10: PCAP Medical Emergencies Resulting from Acts of Violence.

by Whites, the percentage of housing units with one unit at each address, and the percent of unemployed. A negative relationship exists with the percentage of households paying greater than $599 monthly rent, the percentage of housing units with twenty to forty-nine units at address, the percentage of Hispanic population, the percentage of housing units owned by Blacks, and the percentage of housing units owned by Whites. The predictors taken together produce an R-square of .802. The Pearsons Correlations, Appendix E, were examined to determine if any other independent variables had a statistically meaningful relationship to the dependent variable. It was found that positive correlations exist with the percentage of population receiving public assistance (.552), the percentage of population paying $400 to $599 monthly rent (.516), the percentage of population renting property (.485), and the percentage of population less than 30 years of age (.445). It was determined that negative correlations exist with the percentage of housing units owned by Hispanics (-.304), and the percentage of male population (-.300). When the Pearsons Correlation Matrix, Appendix D, was analyzed it was determined that these variables did not enter the regression due to each of them having a high degree of multicollinearity with one or more of the predictors entered into this model. In providing a further explanation of this model, it is unclear why the percentage of housing units with one unit, housing units owned by Blacks, housing units owned by Whites, and the percentage of Hispanic population proved to be statistically meaningful.

The first hypothesis associated with this research question: Areas with populations that rent property tend to be associated with a greater number of medical emergencies, than areas with populations that own property. The regression results in conjunction with the correlation analysis confirmed this hypothesis. As was seen in all of the regression models the leading predictor appears to be the percentage of housing units rented by Whites. In all the regression equations, a positive relationship exists with this predictor. The regression model most closely in agreement with this hypothesis with regards to predictors was PCAP Medical Emergencies Involving Drugs/Alcohol. All of the predictors in this model are associated with areas having populations that rent property. In looking at the Pearsons Correlations, Appendix E, statistically meaningful positive correlations exist between each of the dependent variables and the percentage of population renting property. The only exception was mental health medical emergencies. The only independent variable that has a statistically meaningful positive correlation to this dependent variable is the percentage of housing units rented by Whites. Overall, the statistical evidence supports this research hypothesis.

The second hypothesis: Areas with populations that depend on public assistance income will utilize emergency medical services more than areas with populations that do not depend on public assistance income. The regression results that had public assistance in their predictors were PCAP Medical Emergencies Involving Females (> 17 yrs) and PCAP Geriatric Medical Emergencies (> 64 yrs). In both of these regression models the percentage of population receiving public assistance predictor was positively related to the dependent variable. In looking at the Pearsons Correlations, Appendix E, the percentage of population receiving public assistance has statistically meaningful positive correlations with all but one of the independent variables. The exception is PCAP mental health medical emergencies. The reason for this variable not having a statistically meaningful correlation is the same reason explained in the summary of the results in the PCAP Mental Medical Emergencies regression model earlier. Overall, the statistical evidence supports this research hypothesis.

The third hypothesis: Medical emergencies tend not to be associated with areas that have populations earning a high mean annual income. Based on the evidence provided in the regression models, income alone does not appear to play a role in which populations utilize emergency medical services. However, upon examination of the Pearsons Correlations, Appendix E, it is revealed as previously stated that the percentage of population receiving public assistance does indeed have a statistically meaningful positive correlation with all the dependent variables except one, PCAP Mental Health Medical Emergencies. Issues relating to that one dependent variable have already been discussed in the previous paragraph. Overall, the statistical evidence supports this research hypothesis.

The fourth hypothesis: Cardiac, diabetic, and respiratory medical emergencies tend to be associated with areas having older populations and not with areas having younger populations. The results provided in the relevant regression models (refer to Table 5, page 27; Table 6, page 29; Table 12, page 36) showed that age does not appear to play a role in these types of medical emergencies. However, upon examination of the Pearsons Correlations, Appendix E, it appears the percentage of population under 30 years of age has a statistically meaningful positive correlation with all the dependent variables. However, the statistical results show no statistically meaningful relationship with the percentage of population greater than 59. Economic factors appear to play more statistically meaningful role. Based on evidence from the regression models, and the Pearsons Correlations it appears that these types of medical emergencies are associated with poorer segments of the population. Age alone does not appear to play a role these types of medical emergencies. The statistical evidence does not support this research hypothesis.

The fifth hypothesis: Medical emergencies resulting from acts of violence tend to be associated more with areas having younger populations than with areas having older populations. The results provided in the PCAP Medical Emergencies Resulting from Acts of Violence regression model showed that age does not play a role in this type of medical emergency. However, upon examination of the Pearsons Correlations, Appendix E, it appears that PCAP medical emergencies resulting from acts of violence has a statistically meaningful positive correlation to the percentage of population less than 30 years of age. In addition, there appears to be no statistically meaningful correlation between PCAP Medical Emergencies Resulting from Acts of Violence and the percentage of population greater than 59 years of age. Age may not have been statistically meaningful in the regression models due to issues relating to multicollinearity discussed in each model summary. The statistical evidence supports this research hypothesis.

The sixth hypothesis: Medical emergencies resulting from acts of violence tend to be associated more with areas having Black and Hispanic ethnic populations than with areas having White or Asian ethnic populations. The results of the PCAP Medical Emergencies Resulting from Acts of Violence regression model showed that there was a positive association between percentage of housing units rented by Whites and the dependent variable. In addition, this predictor was the dominant predictor in the model. The other ethnic predictors in this model: the percentage of Hispanic population, the percentage of housing units owned by Blacks, and the percentage of housing units owned by Whites were negatively associated with the dependent variable. As a result, based solely on the evidence in the regression model, it appears that the ethnic group associated most with medical emergencies resulting from acts of violence is White. Examination of the Pearsons Correlation, Appendix E, confirmed these results. However, economic circumstances also play a role. One of the dominant economic predictors in this model that supports this statement is the fact that the percentage of unemployed, the sixth predictor, was positively associated with the dependent variable. Overall, the statistical evidence does not support this research hypothesis.

The seventh hypothesis: There is no relation between population density and medical emergencies. The only regression model in which population density showed up in the predictors was the PCAP Medical Emergencies Involving Drugs/Alcohol. To better determine if population density does indeed play a role in medical emergencies one must look at other predictors in the regression models. The predictors in six out of ten regression models show evidence confirming that certain medical emergencies have a statistically meaningful relationship to population density. These predictors are the percentage of housing units with two to nineteen units, twenty to forty-nine units, and fifty or more units. At least one of these predictors had a statistically meaningful relationship in six out of ten of the regression models. Being that these predictors indicate high-density housing, thus high population density, it is safe to conclude that the statistical evidence supports this research hypothesis.

Findings for Research Question III

Two methods were used to determine the spatial pattern for the medical emergency data. For both methods, the Urban Land Use Classification System (refer to Chapter 2, page 26, table 2_) was used to assist in determining where specific medical emergencies occur in the study area. The first method, quadrat analysis, was done using the 148 1/16th square mile grid cells overlain onto the study. The pattern was determined by extracting the variance-mean ratio of the observed distribution. Based on this ratio, regularly located points will yield a variance-mean ratio < 1.0. Randomly located points will yield a variance-mean ratio of 1.0. A clustered point pattern will yield a variance-mean ratio > 1.0. The greater the degree of departure from 1.0 the greater the regularity or clustering of the point pattern (Shaw and Wheeler 1994). The variance-mean ratio is illustrated in Table 14.

Type of Medical Emergency	VMR*
Pediatric Medical Emergencies (< 12 yrs)	78.03
Cardiac Medical Emergencies	35.93
Diabetic/Seizure Medical Emergencies	16.49
Medical Emergencies Involving Drugs/Alcohol	22.25
Geriatric Medical Emergencies (> 64 yrs)	94.49
Environmental Medical Emergencies	6.62
Medical Emergencies Involving Females (17 - 64 yrs)	114.5
Mental Health Medical Emergencies	194.4
Respiratory Medical Emergencies	23.25
Medical Emergencies Resulting from Acts of Violence	13.61

*VMR = variance-mean ratio

Table 14. Quadrat Analysis: Variance-Mean Ratio.

The second method involved using the chi-square statistic with an associated contingency table in an attempt to confirm the results of the first method and to further assess where various types of medical emergencies occur in the study area. The column categories consisted of the various types of medical emergencies. The row categories consisted of the five urban land use classifications as outline in Chapter II, page 22, Table 2. In order to obtain accurate results with this method it was necessary to separate the medical emergency variables into two categories, mutually exclusive and non-mutually exclusive. The mutually exclusive variables were cardiac medical emergencies, diabetic/seizure medical emergencies, medical emergencies involving drugs and alcohol, environmental medical emergencies, respiratory medical emergencies, and medical emergencies resulting from acts of violence. The non-mutually exclusive variables were based only on medical emergencies associated with different age groups. These variables were pediatric medical emergencies (< 13 yrs), medical emergencies involving females (17 – 64 yrs), and geriatric medical emergencies (> 64 yrs). The medical emergencies included within this category were all the medical emergencies in the mutually exclusive category, and several others such as DOAS(Dead On Arrival at Scene), suicide attempts, and syncopal episodes. Mental health medical emergencies were excluded from both tables due to it being a statistically anomaly for previously mentioned reasons. The results of this method can be seen in Table 15 and Table 16. In Table 15 can be seen the chi-square tables for the mutually exclusive category. In Table 16 can be seen the chi-square table for the non-mutually exclusive category. In addition a series of bar graphs were constructed illustrating the frequency distribution of these categories in Appendix G.

In analyzing the partial chi-square values along with the values for the observed minus the expected portions of Table 15 it was shown that cardiac, diabetic/seizure, drug/alcohol, respiratory, and violence-related medical emergencies all exhibit statistically meaningful clustering in business, industrial, or high-density residential urban land uses. This clustering is most likely attributed to the fact that in the majority of areas where these types of land uses exist, there also exists some degree of high-density residential housing. The occupants of this housing classification in these areas are typically receiving public assistance and thus can be classified as economically disadvantaged. Respiratory medical emergencies also exhibited statistically meaningful clustering in low-density residential land use. Further research is necessary in order to explain why this type of medical emergency exhibited clustering in this type of land use.

Environmental medical emergencies exhibit clustering in low-density residential. This

OBSERVED (O):

Class	Cardiac	Diabetic/Seizure	Drug/Alcohol	Environmental	Respiratory	Violent	ROW SUMS
LDR	369	228	212	119	334	176	1438
HDR	402	305	352	109	388	228	1784
B	413	270	319	86	256	181	1525
I	38	20	61	16	36	19	190
R	18	22	22	11	23	10	106
COLUMN SUMS	1240	845	966	341	1037	614	5043

EXPECTED (E):

Class	Cardiac	Diabetic/Seizure	Drug/Alcohol	Environmental	Respiratory	Violent	ROW SUMS
LDR	353.583	240.950	275.453	97.235	295.698	175.081	1438
HDR	438.660	298.925	341.730	120.631	366.847	217.207	1784
B	374.975	255.527	292.118	103.118	313.588	185.673	1525
I	46.718	31.836	36.395	12.848	39.070	23.133	190
R	26.064	17.761	20.305	7.168	21.797	12.906	106
COLUMN SUMS	1240	845	966	341	1037	614	5043

OBSERVED - EXPECTED(O - E):

Class	Cardiac	Diabetic/Seizure	Drug/Alcohol	Environmental	Respiratory	Violent
LDR	15.417	-12.950	-63.453	21.765	38.302	0.919
HDR	-36.660	6.075	10.270	-11.631	21.153	10.793
B	38.025	14.473	26.882	-17.118	-57.588	-4.673
I	-8.718	-11.836	24.605	3.152	-3.070	-4.133
R	-8.064	4.239	1.695	3.832	1.203	-2.906

$(O - E)^2/E$ = partial chi-square:

Class	Cardiac	Diabetic/Seizure	Drug/Alcohol	Environmental	Respiratory	Violent
LDR	0.672	0.696	14.617	4.872	4.961	0.005
HDR	3.064	0.123	0.309	1.122	1.220	0.536
B	3.856	0.820	2.474	2.842	10.576	0.118
I	1.627	4.401	16.634	0.774	0.241	0.738
R	2.495	1.012	0.142	2.049	0.066	0.654

df = 20

significance level = .05

Critical Value = 31.41

Chi-Square = 83.713

Table 15. Mutually Exclusive Category.

may be attributed to the fact that these types of medical emergencies occur most frequently in this area because they are dominated by single-family homes. Occupants of single-family homes typically will spend more time outdoors than the occupants of other type of housing. Overall, a clustering pattern is exhibited due to the fact that the chi-square value, 83.713, is greater than the critical value of 31.41. These results confirm the results in the quadrat analysis.

In analyzing the partial chi-square values along with the values for the observed minus the expected portions of Table 16, pediatric medical emergencies exhibit

OBSERVED (O)				
Class	Pediatric	Females	Geriatric	**ROW SUMS**
LDR	905	1872	1100	3877
HDR	1103	2211	1284	4598
B	913	1576	795	3284
I	360	430	106	896
R	78	127	62	267
COLUMN SUMS	3359	6216	3347	12922

EXPECTED (E)				
Class	Pediatric	Females	Geriatric	**ROW SUMS**
LDR	1007.804	1864.992	1004.204	3877
HDR	1195.224	2211.822	1190.954	4598
B	853.657	1579.736	850.607	3284
I	232.910	431.012	232.078	896
R	69.405	128.438	69.157	267
COLUMN SUMS	3359	6216	3347	12922

OBSERVED - EXPECTED (O - E)			
Class	Pediatric	Females	Geriatric
LDR	-102.804	7.008	95.796
HDR	-92.224	-0.822	93.046
B	59.343	-3.736	-55.607
I	127.090	-1.012	-126.078
R	8.595	-1.438	-7.157

(O- E)2/E = partial chi-square:			
Class	Pediatric	Females	Geriatric
LDR	10.487	0.026	9.139
HDR	7.116	0.000	7.269
B	4.125	0.009	3.635
I	69.348	0.002	68.493
R	1.064	0.016	0.741

df =8
significance level =.05 Chi-Square = 181.471
critical value = 15.51

Table 16. Non-Mutually Exclusive Categories.

statistically meaningful clustering in industrial and business land uses. Further research is necessary in order to explain why this type of medical emergency exhibited clustering in these types of land use. Analyzing the results of the category for medical emergencies involving females showed that only a slight degree of clustering was exhibited and all of the partial chi-square values contributed very little to the overall chi-square test statistic. Further statistical testing is necessary in examining this category to provide a clear explanation as to its relationship to this urban land use classification scheme. Geriatric medical emergencies exhibited statistically meaningful clustering in low-density and high-density residential land uses. This is attributed to the fact that the population in this age group will most likely live in areas with types of urban land uses. For the spatial interpretation of the distribution of each medical emergency using the grid cell coverage, it is necessary to use the Urban Land Use Classification map (Fig. 7) developed by this investigator. This map should also be used as a reference for the maps

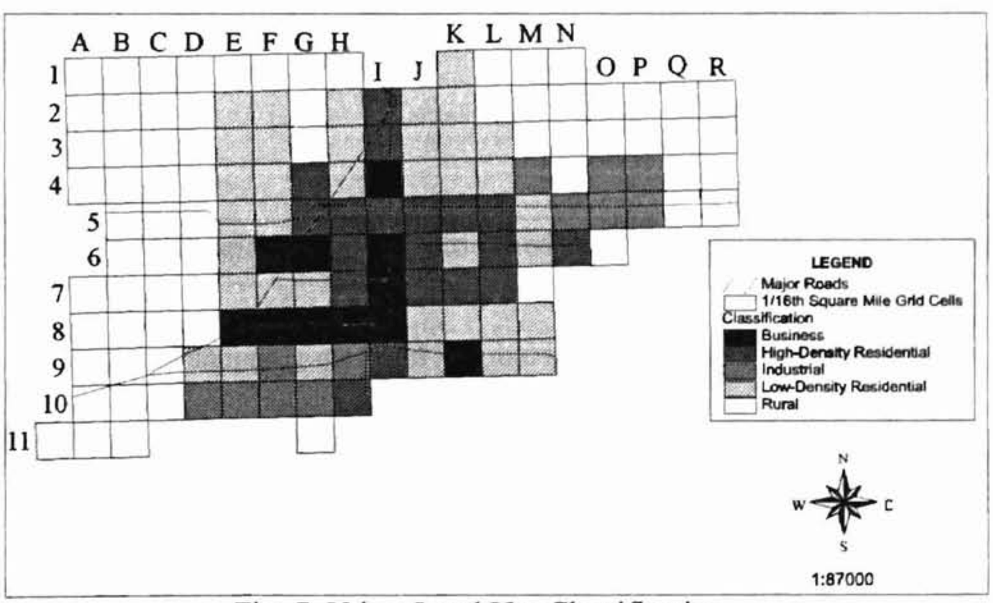


Fig. 7. Urban Land Use Classification.

illustrating the frequency count distribution of each medical emergency. In addition, the terms primary and secondary clustering will be used. Primary clustering is defined as the grid cell(s) where the frequency counts were in the highest-class interval on the map. Secondary clustering is defined as the grid cell(s) where the frequency counts were in the second highest-class interval on the map. Class intervals were based on Arcview's natural breaks option.

Upon viewing the frequency count distribution of Pediatric Medical Emergencies (<13yrs) (Figure 8), the majority pediatric emergencies seem to be clustered in three different types of urban land use. Business, high-density residential, and industrial.

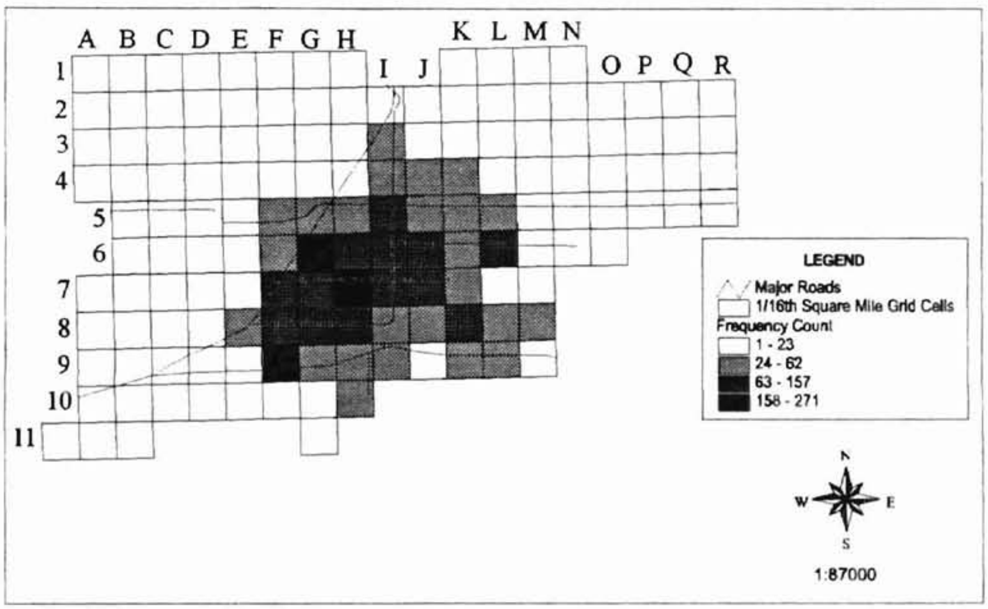


Fig. 8. Distribution of Pediatric Medical Emergencies (< 13 yrs of age).

The only regional shopping mall and hospital in the study area are located in the business urban land use. Older housing and low-income apartments characterize the high-density residential urban land use. Light industry, county government offices, and the county mental health crisis center characterize the industrial urban land use. This medical emergency also exhibits secondary clustering in and around the Central Business District.

Cardiac Medical Emergencies (Figure 9) exhibit primary clustering in the grid

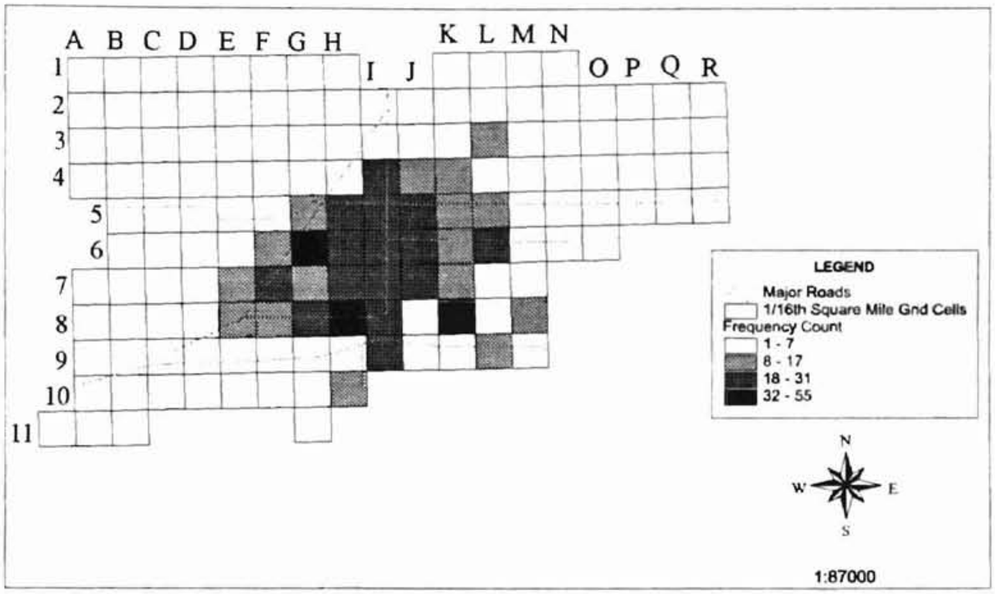


Fig. 9. Distribution of Cardiac Medical Emergencies.

cell where the regional shopping center and hospital are located. It also exhibits secondary clustering in grid cells characterized by low-income housing and convalescent care homes.

Diabetic/Seizure Medical Emergencies (Figure 10) exhibit primary clustering in the grid cell where the regional shopping mall and hospital are located. Primary

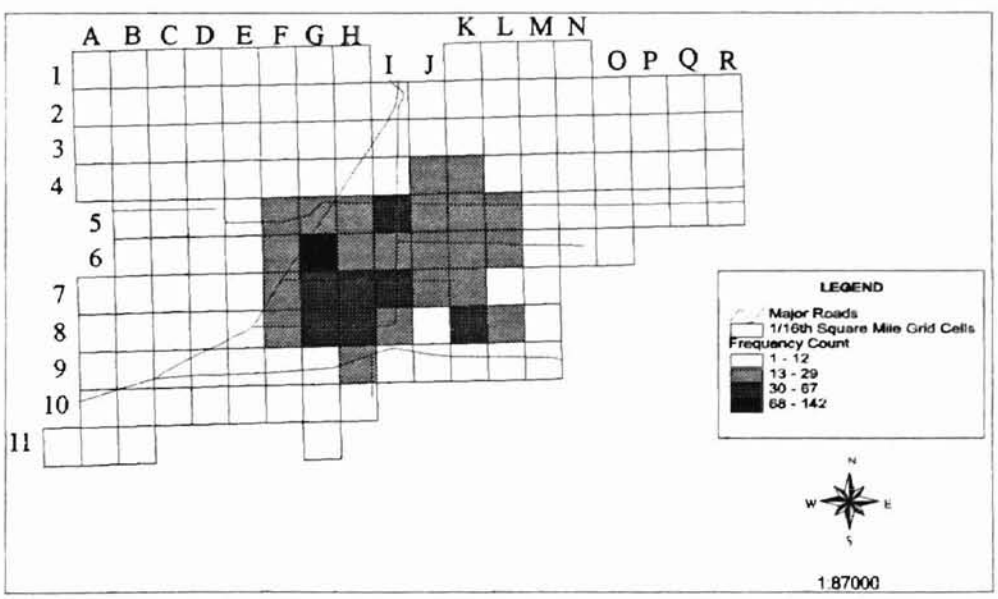


Fig. 10. Distribution of Diabetic/Seizure Medical Emergencies.

clustering also exists in the grid cell where the oldest section of the business district exists. Secondary clustering exists in the grid cells in and adjacent to the Central Business District and cells characterized by high-density housing.

Medical Emergencies Involving Drugs/Alcohol (Figure 11) exhibit primary clustering in the grid cells comprising the oldest and newest portions of the Central Business District. Secondary clustering is exhibited in high-density housing areas adjacent to the business district.

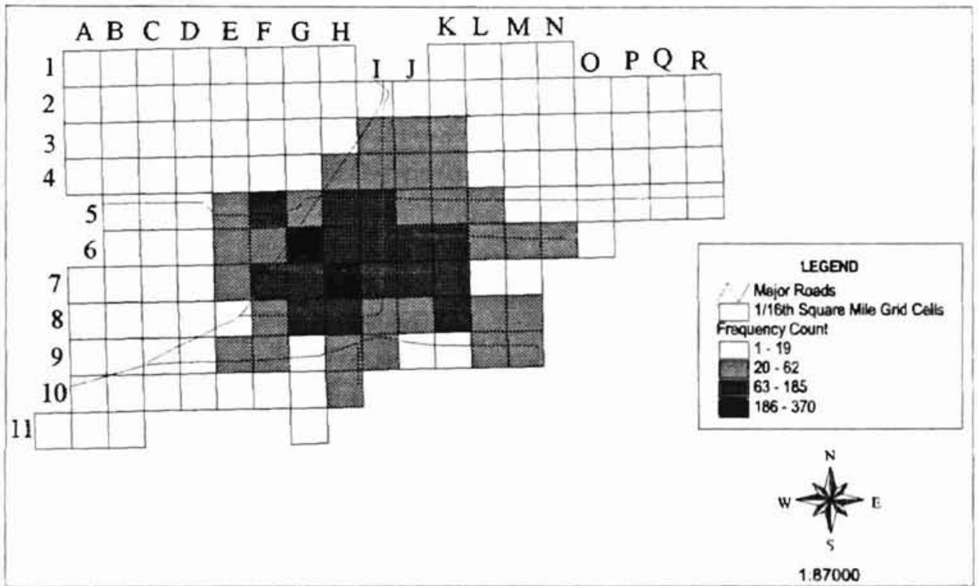


Fig. 11. Distribution of Medical Emergencies Involving Drugs/Alcohol.

Geriatric Medical Emergencies (>64yrs) (Figure 12) exhibit primary clustering in the two grid cells where the hospital and elderly care homes exist. Secondary clustering exists in grid cells dominated by businesses, and high-density housing.

Environmental Related Medical Emergencies (Figure 13) exhibit primary clustering in the Central Business District. In addition, it exhibits secondary clustering in the high-density housing grid cells adjacent to the Central Business District.

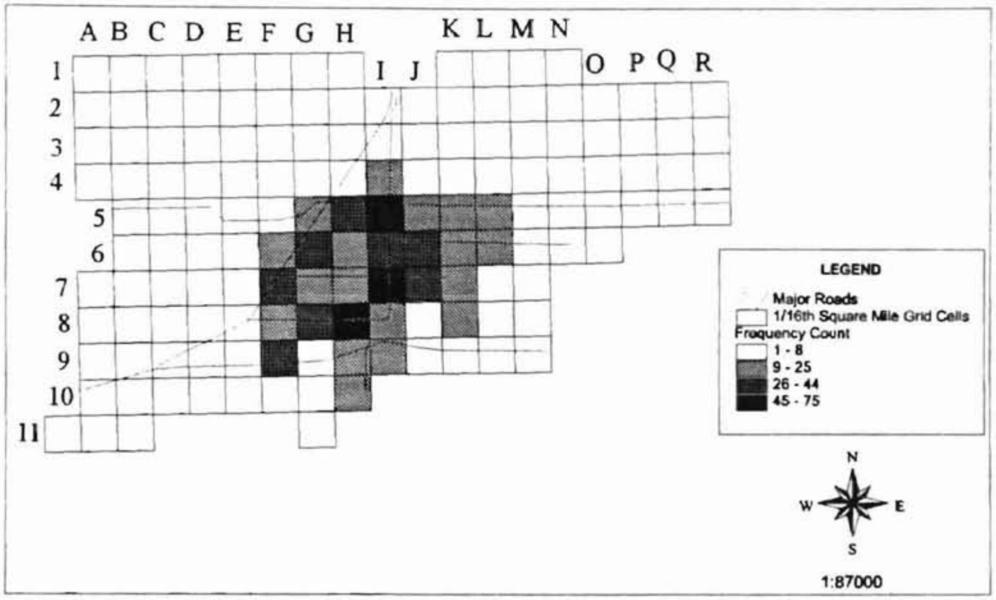


Fig. 12. Distribution of Geriatric Medical Emergencies (>64 yrs of age).

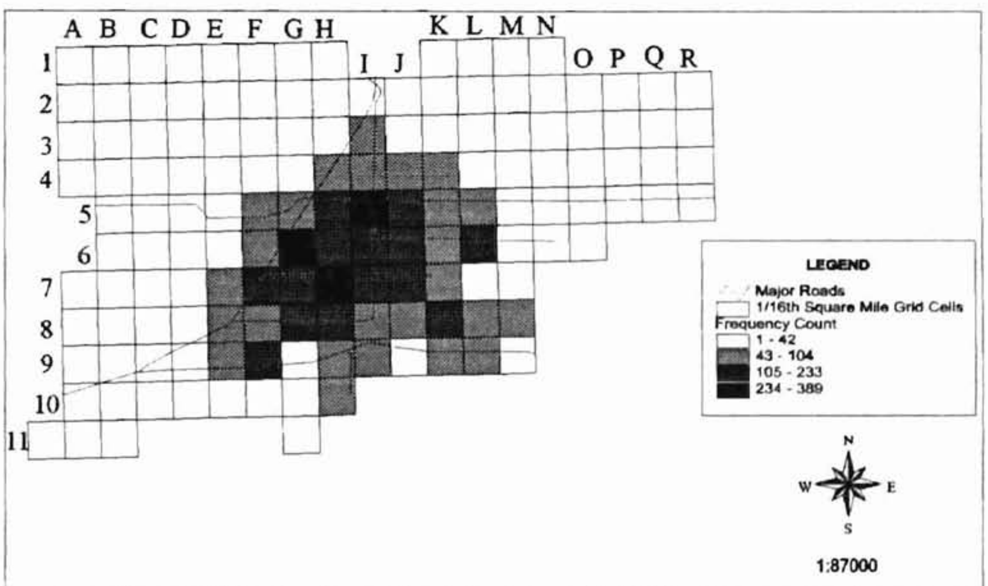


Fig. 13. Distribution of Environmental Medical Emergencies.

Medical Emergencies Involving Females (17 - 64 yrs) (Figure 14) exhibit much the same clustering as the other types of medical emergencies. Primary clustering exists in the grid cells associate with business activity, hospitals, and elderly care homes.

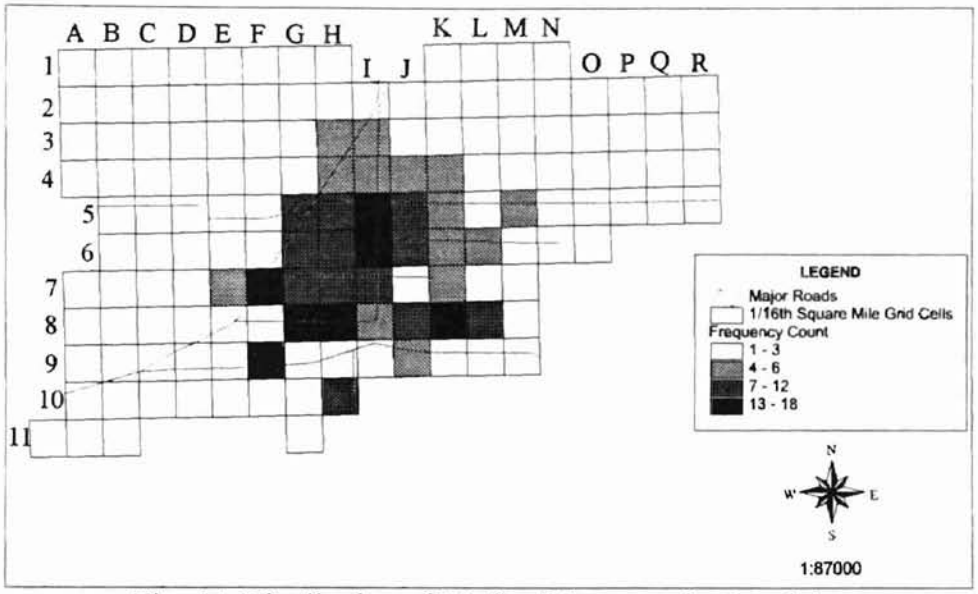


Fig. 14. Distribution of Medical Emergencies Involving Females (17-64 yrs of age).

Secondary clustering exists in other areas of the Central Business District and the high-density housing grid cells.

Mental Health Medical Emergencies (Figure 15) exhibit clustering in one cell. The primary feature in this cell that would attract these types of medical emergencies is the Solano County Mental Health Crisis Center. This center handles mental health emergencies 24-hours per day.

Respiratory Medical Emergencies (Figure 16) exhibit primary clustering in the same grid cells as several previous medical emergencies. These cells are where the local hospital and elderly care homes exist. Secondary clustering exists in adjacent high-density residential cells.

Medical Emergencies Resulting from Acts of Violence (Figure 17) exhibit a unique primary clustering pattern. It appears to cluster in all the high-density residential cells where the poorest populations exist in the study area. In addition, it also clusters in

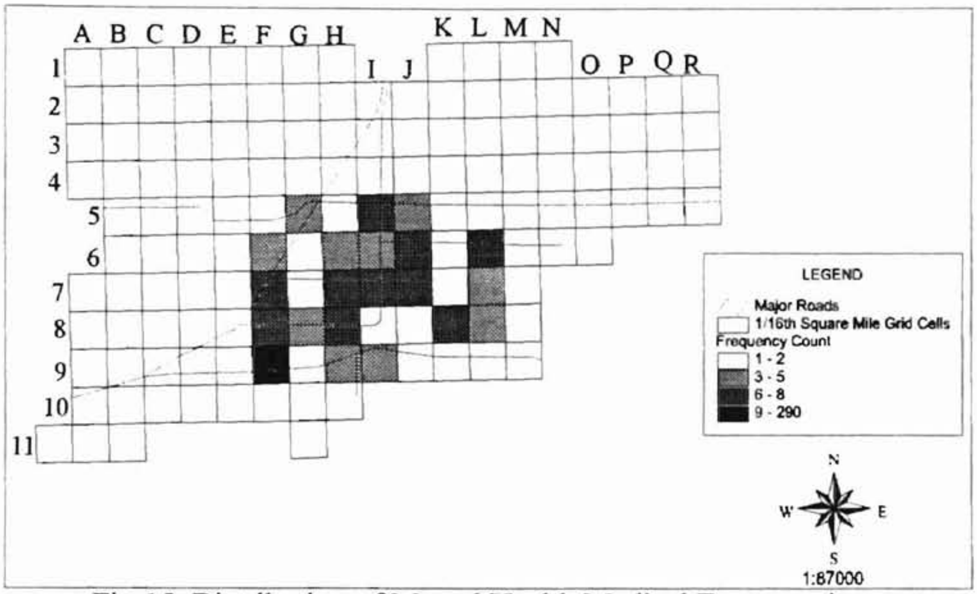


Fig.15. Distribution of Mental Health Medical Emergencies.

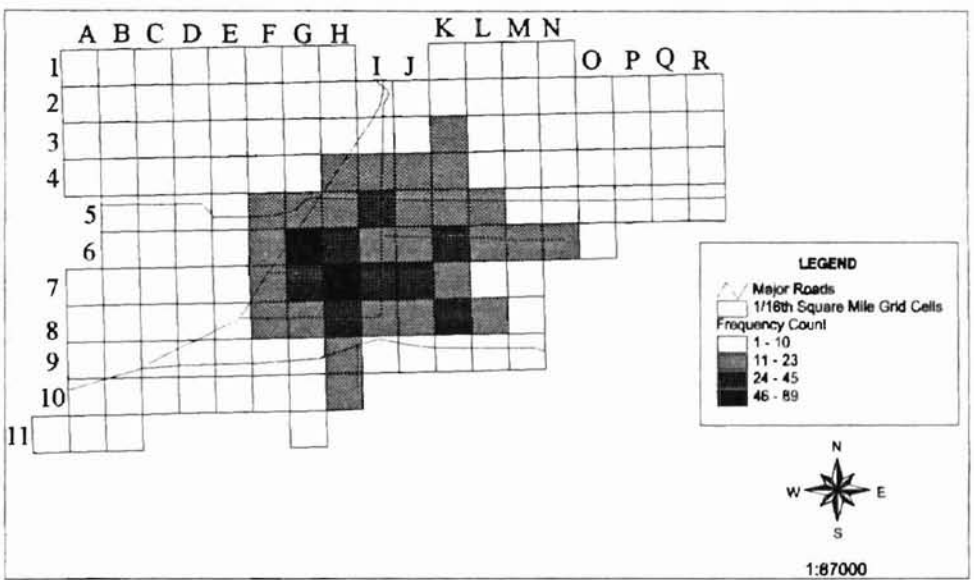


Fig. 16. Distribution of Respiratory Medical Emergencies.

the business cells of the Central Business District, and the adjacent high-density residential cells.

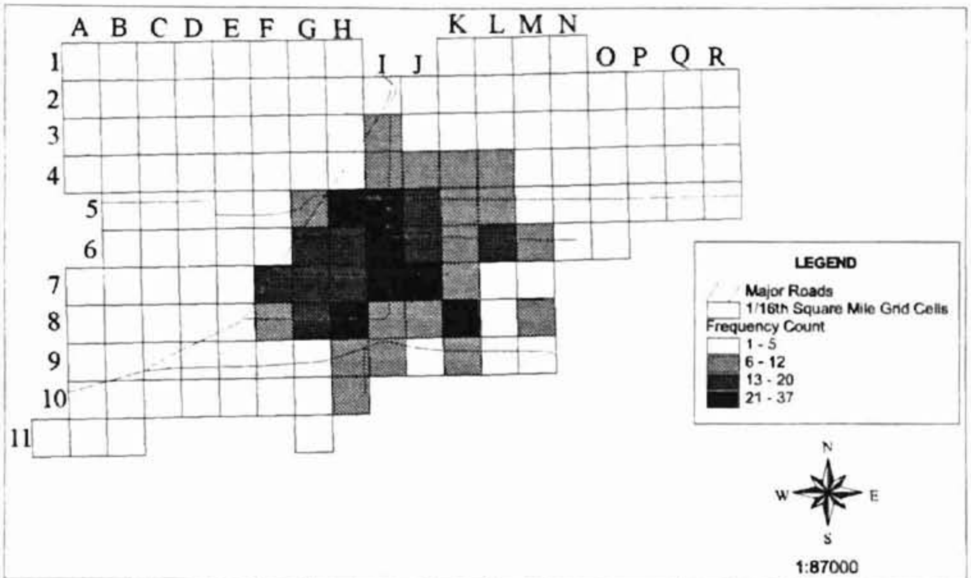


Fig. 17. Distribution of Medical Emergencies Resulting form Acts of Violence.

The first hypothesis associated with this research question stated that medical emergencies would exhibit a clustering pattern rather than a random pattern. According to the evidence provided in Tables 14, 15, and 16. all ten types of medical emergencies will exhibit a clustering pattern in the study area. This hypothesis was supported.

For the second hypothesis associated with this research question: Medical emergencies will most frequently occur in high density housing areas rather than in low density housing areas. This research hypothesis is supported based on the statistical evidence provided in the quadrat analysis, and chi-square analysis, and the visual evidence provided in the bar graphs in Appendix G, and Figures 8 - 17.

CHAPTER IV

CONCLUSIONS

Summary of Results

The results of whether each of the research hypotheses were supported or unsupported by the statistical and non-statistical evidence provided can be seen in Table 17.

RESEARCH HYPOTHESES	Supported
Research Question I:	
Areas with poorer populations tend to utilize emergency medical services more often than areas with wealthier populations.	YES
Research Question II:	
Areas with populations that rent property tend to be associated with a greater number of medical emergencies, than areas with populations that own property.	YES
Areas with populations that depend on public assistance income will utilize emergency medical services more than areas with populations that do not depend on public assistance income.	YES
Medical emergencies tend not to be associated with areas that have populations earning a high mean annual income.	YES
Cardiac, diabetic, and respiratory medical emergencies tend to be associated with areas having older populations and not with areas having younger populations.	NO
Medical emergencies resulting from acts of violence tend to be associated more with areas having younger populations than with areas having older populations.	YES
Medical emergencies resulting from acts of violence tend to be associated more with areas having Black and Hispanic ethnic populations than with areas having White or Asian ethnic populations.	NO
There is no relation between population density and medical emergencies.	NO
Research Question III:	
Medical emergencies will exhibit a clustering pattern rather than a random pattern in block groups.	YES
Medical emergencies will most frequently occur in block groups dominated by high-density housing rather than in block groups dominated by low-density housing.	YES

Table 17. Supported and Unsupported Research Hypotheses.

The first research question stated what sociodemographic characteristics are associated with populations who utilize Emergency Medical Services (EMS). The first hypothesis stated that areas with poorer populations tend to utilize emergency medical services more often than areas with wealthier populations. The demographic profile developed to determine the characteristics of the population that utilizes EMS showed that poorer segments (defined as those segments of the population receiving public assistance) of the population tended to utilize EMS more than wealthier segments of the population. This may be the result of the fact that poorer segments of the population appear not to have access to regular health care. As a result, sometimes the only time they are in contact with a health care provider is through the EMS. Issues related to health care access for the poor include, but are not limited to, lack of transportation to the hospital, and lack of financial resources to pay for non-emergency health care services. In addition, the roles of education and awareness are important. Poorer segments of the population may not have the knowledge or education needed to understand issues relating to preventative medicine. Steps taken to minimize the chances of personal injury, improve personal and environmental hygiene, and improve diet and other personal habits, can only be accomplished through community education and awareness programs.

The second research question stated what sociodemographic factors are most closely associated with specific types of medical emergencies. The first hypothesis, areas with populations that rent property tend to be associated with a greater number of medical emergencies than areas with populations that own property was confirmed by the results. The results showed that renters are associated with a disproportionate number of medical emergencies. Of the ten different types of medical emergencies tested, all were meaningfully associated with renters. In addition, there were statistically meaningful positive correlations between the percentage of renters and nine out of the ten types of medical emergencies. The one that was not included was mental health medical emergencies. This emergency was not statistically meaningful due to the fact that the original location of where the medical emergency occurred was entered into the database. This is due to the fact that, in accordance with local policy, law enforcement officials will transport the individual associated with the mental health emergency to the local county mental health crisis center. The original location of the medical emergency was not entered into the PCR-EMS database. What is known is the location the ambulance responded to for the medical emergency. That location was the Solano County Mental Health Crisis Center. It was this location that was entered into the PCR-EMS database used in this study. Put simply, every mental health medical emergency occurred at many different locations but only one location (where the mental health crisis center is located) was entered into the PCR-EMS database thus rendering the result inaccurate. The second hypothesis, areas with populations that depend on public assistance income will utilize emergency medical services more than areas with populations that do not depend on public assistance income was also confirmed by the results. The percentage of population receiving public assistance was shown to be statistically relevant in only one of the regression models. However, when the Pearsons Correlations were examined this independent variable had a statistically meaningful positive correlation to all the dependent variables. The third hypothesis, medical emergencies tend not to be associated with areas that have populations earning a high mean annual income. In the various regression models, the results showed income not playing a role in any of the models. This variable may not have been deemed statistically meaningful in any of the model due to multicollinearity. When the Pearsons Correlations were examined, the percentage of population receiving public assistance had statistically meaningful positive correlations with nine out of ten types of medical emergencies. Mental health medical emergencies were not statistically meaningful for reasons explained earlier. The fourth hypothesis, Cardiac, diabetic, and respiratory medical emergencies tend to be associated with areas having older populations and not with areas having younger populations. According to the results of the regression models, age seems not to play a meaningful role in who utilizes EMS. Rather, according to the results provided in the regression models, economic factors play a more meaningful role. When the Pearsons Correlations were examined, the percentage of population less than 30 years of age had statistically meaningful positive correlations to nine out of ten types of medical emergencies. The percentage of population greater than 59 were not statistically meaningful for reasons possibly relating to multicollinearity. The fifth hypothesis, medical emergencies resulting from acts of violence tend to be associated more with areas having younger populations than with areas having older populations. When the Pearsons Correlations were examined, the percentage of population less than 30 years of age had a statistically meaningful positive correlation to nine out of ten types of medical emergencies. The sixth hypothesis, medical emergencies resulting from acts of violence tend to be associated more with areas having Black and Hispanic ethnic populations than with areas having White or Asian ethnic populations. Based on the results of the regression models the ethnic associated most with this type of medical emergency is White. However, economic factors such as unemployment and whether the population rents property were also statistically meaningful. The seventh hypothesis, there is no relation between population density and medical emergencies. According to the results provided in the regression models, population density was statistically meaningful in only one out ten medical emergencies. Further examination of the output from the regression models showed that variables related to multi-unit housing were statistically meaningful. This investigator believes that based on this evidence, there is a meaningful statistical relationship between population density and the number of medical emergencies.

In looking at the results of the third research question, is there a clustered or random pattern associated with specific types of medical emergencies. The results of the first hypothesis, medical emergencies will exhibit a clustering pattern rather than a random pattern, showed a definite clustered pattern. Clustering was exhibited in high-density housing areas where the poorer segments of the population reside. The results of the first hypothesis also confirm the results of the second hypothesis, medical emergencies will most frequently occur in high density housing areas than in low density housing areas.

The overall results of this study show a definite pattern that is partially supported by Billittier et al. (1996), Dickinson et al. (1996), Shah-Canning et al. (1996), Meade et al. (1988), and Smith (1973). The results generally show that poorer populations are more prone to disease and injury. Thus, they will utilize emergency medical services more frequently than wealthier populations. However, this may be true to a certain extent, but the major reason why this population utilizes emergency medical services is usually not for services requiring immediate medical attention (Billittier et al. 1996). It seems that the majority of the time this population utilizes emergency medical services for non-life threatening injuries or health problems. These injuries and health problems can usually be treated at home by the individual, or by routine medical appointment. The problem of persons accessing emergency medical services when it is unnecessary has grown to crisis levels in EMS service areas, particularly urban EMS service areas, in the United States. This situation can be positively altered by the introduction of injury prevention programs (Garrison et al. 1997). Public awareness and education that targets the geographic areas where these populations reside is one solution to solving this problem that has plagued EMS service areas for several decades.

Implications and Future Research

The methodologies in this research paper can be applied to both types of ambulance deployment strategies. The first type is known as System Status Management (SSM). This EMS resource deployment strategy has been adopted by many private EMS organizations nationwide. SSM is a management strategy developed to place ambulances in geographic areas that have the highest call volume during specific hours of the day. Ambulances are deployed on a roaming basis to strategic positions throughout a geographic area in such a way as to minimize response times and maximize the availability of EMS resources. Using a GIS in combination with various spatial analytical tools, an EMS Manager can visualize from the desktop where ambulances are located and the status of each ambulance. The locations of where the majority of medical emergencies occur can be found on a digital map and ambulance deployed accordingly. In addition, applying the techniques in this research paper, an EMS Manager can identify where specific types of medical emergencies occur in relatively high frequency. Specific EMS resources specially geared toward treating, or preventing, those types of medical emergencies can then be diverted to those areas. The other ambulance deployment plan is based on fixed locations. This type of EMS resource deployment strategy is commonly used by public EMS organizations. Ambulances are situated at fixed locations, typically a fire station, and cover a specific geographic area. Using the techniques outlined in this research paper, areas with the highest frequency of medical emergencies can be precisely located. From this information it can be determined whether a specific fixed location is optimal or not optimal. Action can be taken to find a fixed location that allows for the most acceptable response time to a specific area. In addition, these techniques can assist in decisions relating to whether or not more fixed locations need to be constructed in a specific area based on the frequency and type of medical emergency.

It is hoped that the techniques and methodologies used here will spur future geographic research in the realm of pre-hospital emergency medical services (PH-EMS). All too often research dealing with the non-motor vehicle accident side of PH-EMS has been neglected by geographers. One reason for this maybe the lack of availability of PH-EMS data in a format compatible with geographic research. With the computerization of PH-EMS data by state and local emergency medical services agencies, along with the growing recognition of the value of GIS and spatial data management in the EMS community, geographers will be able to take advantage of these data sources for future research.

BIBLIOGRAPHY

Aldrich, Timothy; Savitz, Lucy; Wittie, Peggy; Geographic Methods for Health Services Research; University Press of America, Lanham-New York-London; 1994

Billittier IV, Anthony J, MD; Moscati, Ronald, MD; Janicke, David, MD, PHD; Lerner, Brooke E, BA, EMT-P; Seymour, Jeffrey, MD; Olsson, Daniel, DO; A Multisite Survey of Factors Contributing to Medically Unnecessary Ambulance Transports; Academic Emergency Medicine Vol. 3 No. 11, 1046-1052; Nov 1996.

Bullen, Nina; Jones, Kelvyn; Moon, Graham; Defining Localities for Health Planning: A GIS Approach; Social Science and Medicine, Vol. 42 No. 6, 801-816; 1996.

Dickinson, Edward T, MD; Verdile, Vincent P, MD; Kostyun, Christopher T, BS, EMT-P; Salluzo, Richard F, MD; Geriatric Use of Emergency Medical Services; Annals of Emergency Medicine Vol. 27 No. 2, 199-203; Feb 1996.

Garrison, Herbert G, MD, MPH; Foltin, George L, MD; Becker, Les R, MA, NREMTP; Chew John L; Johnson, Mark; Madsen, Gail M; Miller, David R; Ozmar, Barbara H, BSN, MPH; The Role of Emergency Medical Services in Primary Injury Prevention; Annals of Emergency Medicine Vol. 30 No. 1, 84-91; July 1997.

Gatrell, A.C.; Bailey, T.C.; Interactive Spatial Data Analysis in Medical Geography; Social Science and Medicine, Vol 42 No. 6, 843-855; 1996.

Gillum, Richard, MD; Is Variation in Fatal Cardiac Arrest Related to Emergency Medical Services?; Annals of Emergency Medicine, Vol. 27 No. 4, 532; April 1996.

Gobalet, Jeanne; Thomas, Richard; Demographic Data and Geographic Information Systems for Decision-Making: The Case of Public Health; Population Research and Policy Review 15, 537-548; December 1996.

Goodchild, M.F.; Anselin, L.; Deichmann, U.; A Framework for the Areal Interpolation of Socioeconomic Data; Environment and Planning Vol. A, No. 25, 383-397; 1993.

Hartshorne, Truman A.; Interpreting the City: An Urban Geography 2nd Edition; John Wiley and Sons, New York; 1992.

Hu, Sheng-Chuan M.D.; Kao, Wei-Fong M.D.; Outcomes in Severely Ill Patients Transported Without Pre-Hospital ALS; American Journal of Emergency Medicine 14, 86-88; 1996.

Jones, Andrew; Langford, Ian; Bentham, Graham; The Application of K-Function Analysis to the Geographical Distribution of Road Traffic Accident Outcomes in Norfolk, England; Social Science and Medicine, Vol. 42 No. 6, 879-885; 1996.

Kohli, S; Sahl—n K; Sivertun, A; L¬fman, O; Trell, E; Wigertz, O; Distance from Primary Health Center: A GIS Method to Study Geographical Access to Health Care; Journal of Medical Systems, Vol. 19 No. 6, 425-436; 1995.

Levine, Ned; Kim, Karl; Nitz, Lawrence; Spatial Analysis of Honolulu Motor Vehicle Crashes: I. Spatial Patterns; Accident Anlaysis and Prevention, Vol. 27 No. 5, 663-674; 1996.

Martin, David; Geographic Information Systems: Socioeconomic Applications; Routledge, New York-London; 1996.

Meade, Melinda; Florin, John; Gesler, Wilbert; Medical Geography; The Guilford Press, New York-London; 1988; p. 196.

Moxey A.; Allanson, P.; Areal Interpolation of Spatially Extensive Variables: A Comparison of Alternative Techniques; International Journal of GIS Vol. 8 No. 5, 479-487; 1994.

Munasinghe, Rajika; Morris, Robert; Localization of Disease Clusters Using Regional Measures of Spatial Autocorrelation; Statistics in Medicine, Vol 15, 893-905; 1996.

Pyle, Gerald; Applied Medical Geography; V.H. Winston and Sons, Washington D.C.; 1979.

Ricketts, Thomas; Geographic Methods for Health Services Research; University Press of America, Lanham-New York-London; 1994.

Shah-Canning, Deval, MD; Alpert, Joel J, MD; Bauchner, Howard, MD; Care-Seeking Patterns of Inner-City Families Using an Emergency Room: A Three Decade Comparison; Medical Care Vol. 34 No. 12, 1171-1179; 1996

Shaw, Garreth; Wheeler, Dennis; Statistical Techniques in Geographical Analysis; John Wiley and Sons, New York; 1994.

Van Buer, Michael; Venta, Enrique; Lurigio, Arthur; Hurter, Arthur; The Effect of Vehicular Flow Patterns on Crime and Emergency Services: The Location of Cul-De-Sacs and One-way Streets; Journal of the Operational Research Society 47, 1110-1119; 1996.

APPENDIX A

Derivation of Classified Clinical Impression for EMS-PCR Data
Pediatric Medical Emergencies (<13 yrs) Any Medical Emergency involving a child < 13 years of age
Medical Emergencies Involving Females (17 – 64 yrs) Any Medical Emergency involving a female 17 – 64 years of age
Medical Emergencies Resulting from Acts of Violence Gunshot Wound,Stabbing,Other Assault, Traumatic Cardiac Arrest
Medical Emergencies Involving Drugs/Alcohol Any Medical Emergency involving Drugs or Alcohol
Diabetic/Seizure Medical Emergencies Diabetic Complications, Seizure Disorder
Geriatric Medical Emergencies (>64 yrs) Any Medical Emergency involving a person > 64 years of age
Environmental Medical Emergencies Burn,Bite/Sting,Allergic Reaction, Heat Injury,Cold Injury, Accidental Overdose
Respiratory Medical Emergencies Respiratory Distress, Respiratory Arrest, Hyperventilation
Cardiac Medical Emergencies Medical Cardiac Arrest, Chest Pain/Discomfort
Mental Health Medical Emergencies Behavioral Related Emergencies, Intentional Overdose

APPENDIX B

CCI Data obtained from EMS-PCR database
PCAP* Pediatric Medical Emergencies (<13 yrs)
PCAP Medical Emergencies Involving Females (17 – 64 yrs)
PCAP Medical Emergencies Resulting from Acts of Violence
PCAP Medical Emergencies Involving Drugs/Alcohol
PCAP Diabetic/Seizure Medical Emergencies
PCAP Geriatric Medical Emergencies (>64 yrs)
PCAP Environmental Medical Emergencies
PCAP Respiratory Medical Emergencies
PCAP Mental Health Medical Emergencies
PCAP Cardiac Medical Emergencies

*PCAP = Per Capita

APPENDIX C

Socio-Economic Data obtained from 1990 US Census database
% of HUS* Rented by Whites
% of HUS Rented by Hispanics
% of HUS Rented by Blacks
% of HUS Rented by Asians
% of HUS Ownership-White
% of HUS Ownership-Hispanic
% of HUS Ownership-Black
% of HUS Ownership-Asian
% of Population < 30 yrs
% of Population > 59 yrs
% of HH** Paying <$399 Monthly Rent
% of HH Paying $400-$599 Monthly Rent
% of HH Paying >$599 Monthly Rent
% of HUS with 1 Housing Unit at Address
% of HUS with 2-19 Housing Units at Address
% of HUS with 20-49 Housing Units at Address
% of HUS with > 50 Housing Units at Address
% of HUS with Mobile Home/Trailer at Address
% of Rental Households
% of Population Receiving Public Assistance
% Unemployment
% Male Population
% of Population with < 12 yrs of Education
1989 PCAP Income
Population Density
% White Population
% Hispanic Population
% Black Population
% Asian Population

*HUS = Housing Units

*HH = Households

APPENDIX D

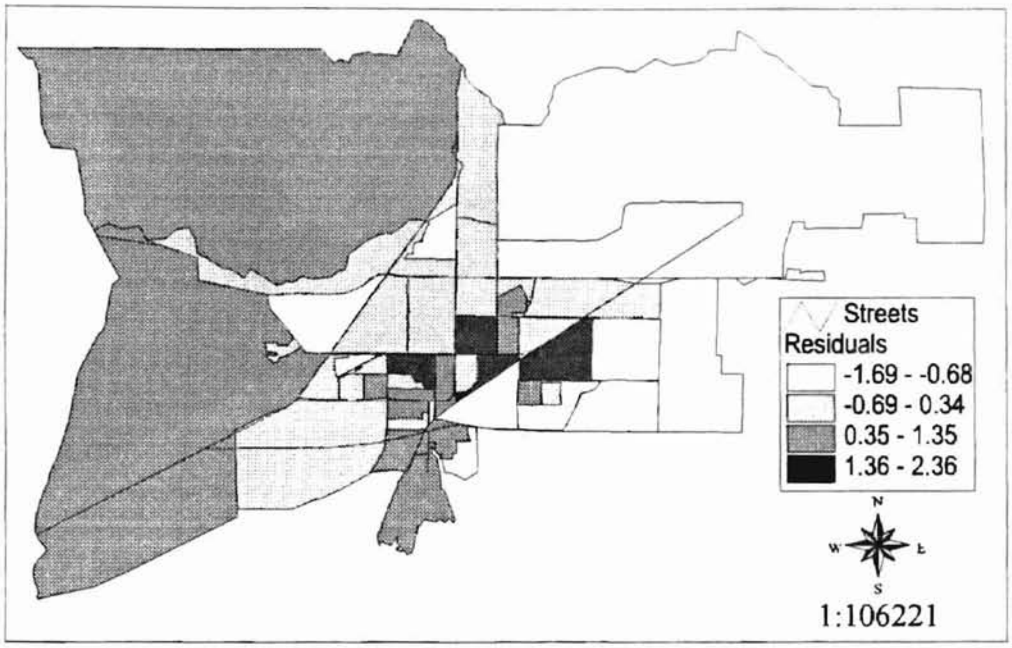
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
1.000	-0.545	-0.442	-0.324	-0.270	0.419	0.275	0.448	0.577	-0.409	-0.385	-0.477	-0.312	0.122	-0.461	-0.185	0.409	-0.331	-0.452	-0.092	-0.439	0.186	-0.248	0.561	-0.536	-0.340	-0.644	-0.371	0.123	1
	1.000	0.372	0.108	-0.017	-0.375	-0.373	-0.389	-0.518	0.432	0.503	0.612	0.650	-0.107	0.158	0.057	-0.167	0.661	0.805	0.301	0.854	-0.322	0.379	-0.298	0.277	-0.174	0.180	0.522	0.218	2
		1.000	0.337	0.021	-0.075	-0.191	-0.144	-0.308	0.013	0.557	0.251	0.346	-0.100	0.155	-0.001	-0.086	0.367	0.508	0.135	0.506	-0.117	0.228	-0.199	0.068	-0.153	0.132	0.198	0.042	3
			1.000	0.035	-0.109	0.044	-0.272	-0.187	0.050	0.210	0.284	0.245	-0.069	0.063	0.068	-0.051	0.302	0.249	0.079	0.282	-0.056	0.123	-0.128	0.014	-0.089	0.314	0.095	0.053	4
				1.000	-0.035	-0.087	-0.071	0.085	0.077	-0.012	0.058	-0.032	0.034	-0.115	-0.065	0.084	-0.063	-0.021	0.041	-0.016	0.046	0.062	-0.032	0.053	0.010	0.011	-0.177	0.187	5
					1.000	0.125	0.092	0.034	-0.313	-0.271	-0.274	-0.058	0.727	-0.288	-0.235	-0.147	-0.266	-0.146	-0.087	-0.195	0.049	-0.018	0.231	-0.407	-0.165	-0.401	0.087	-0.221	6
						1.000	-0.045	0.237	-0.215	-0.124	-0.315	-0.370	0.101	0.314	-0.310	-0.252	-0.284	-0.456	-0.051	-0.418	0.236	-0.308	0.198	-0.426	-0.058	-0.075	-0.227	-0.083	7
							1.000	0.482	-0.277	-0.284	-0.216	-0.398	-0.122	-0.420	0.516	0.338	-0.256	-0.430	-0.120	-0.424	0.209	-0.368	0.269	-0.209	-0.009	-0.224	-0.218	-0.205	8
								1.000	-0.344	-0.346	-0.472	-0.732	-0.135	-0.401	-0.043	0.663	-0.355	-0.628	-0.377	-0.684	0.177	-0.558	0.750	-0.551	-0.085	-0.452	-0.690	-0.016	9
									1.000	0.117	0.599	0.256	0.371	-0.165	0.321	-0.351	0.193	0.324	0.084	0.311	-0.173	0.390	-0.367	0.498	-0.007	0.265	0.347	0.150	10
										1.000	0.070	0.382	-0.186	0.455	-0.165	-0.270	0.347	0.430	0.418	0.552	-0.186	0.358	-0.341	-0.017	-0.400	0.274	0.348	0.041	11
											1.000	0.479	0.060	-0.130	0.561	-0.264	0.550	0.577	0.028	0.559	-0.136	0.403	-0.453	0.539	0.014	0.231	0.430	0.150	12
												1.000	0.054	-0.035	-0.018	-0.125	0.448	0.808	0.540	0.900	-0.163	0.667	-0.507	0.269	-0.449	0.147	0.676	0.188	13
													1.000	-0.352	-0.097	-0.405	-0.205	-0.001	-0.015	-0.050	-0.013	0.217	0.036	-0.120	-0.157	-0.196	0.254	-0.174	14
														1.000	-0.300	-0.548	0.095	0.026	0.077	0.068	-0.104	-0.061	-0.362	0.165	0.353	0.454	0.092	-0.151	15
															1.000	-0.042	0.176	0.023	-0.136	0.004	0.087	0.034	-0.257	0.410	0.143	0.247	0.180	-0.148	16
																1.000	-0.075	-0.122	-0.111	-0.149	0.002	-0.271	0.531	-0.340	-0.237	-0.376	-0.441	0.225	17
																	1.000	0.636	-0.035	0.683	-0.161	0.444	-0.284	0.300	-0.136	0.088	0.224	0.429	18
																		1.000	0.110	0.920	-0.228	0.600	-0.406	0.298	-0.263	0.091	0.624	0.257	19
																			1.000	0.449	-0.145	0.190	-0.224	-0.056	-0.427	0.185	0.306	0.058	20
																				1.000	-0.260	0.613	-0.441	0.262	-0.387	0.152	0.624	0.308	21
																					1.000	0.039	0.058	0.085	-0.096	-0.011	-0.061	-0.248	22
																						1.000	-0.565	0.419	-0.368	0.077	0.478	0.245	23
																							1.000	-0.639	-0.009	-0.600	-0.599	-0.018	24
																								1.000	0.399	0.524	0.221	0.150	25
																									1.000	0.274	-0.258	-0.202	26
																										1.000	0.222	-0.082	27
																											1.000	-0.323	28
																												1.000	29

1	Percentage of Housing Units with 1 unit
2	Percentage of Housing Units with 2 - 19 units
3	Percentage of Housing Units with 20 - 49 units
4	Percentage of Housing Units with 50 + units
5	Percentage of Mobile Homes
6	Percentage of Housing Units Owned by Asians
7	Percentage of Housing Units Owned by Blacks
8	Percentage of Housing Units Owned by Hispanics
9	Percentage of Housing Units Owned by Whites
10	Percentage of Housing Units Rented by Asians
11	Percentage of Housing Units Rented by Blacks
12	Percentage of Housing Units Rented by Hispanics
13	Percentage of Housing Units Rented by Whites
14	Percentage of Asian Population
15	Percentage of Black Population
16	Percentage of Hispanic Population
17	Percentage of White Population
18	Percentage of Population Paying < $399 Monthly Rent
19	Percentage of Population Paying $400 - $599 Monthly Rent
20	Percentage of Population Paying > $599 Monthly Rent
21	Percentage of Population Renting Property
22	Percentage of Population Unemployed
23	Percentage of Population Receiving Public Assistance
24	Per Capita Income
25	Percentage of the Population with Less than 12 years of Education
26	Percentage of Male Population
27	Population Density
28	Percentage of Population Less than 30 years of Age
29	Percentage of Population Greater than 59 years of Age

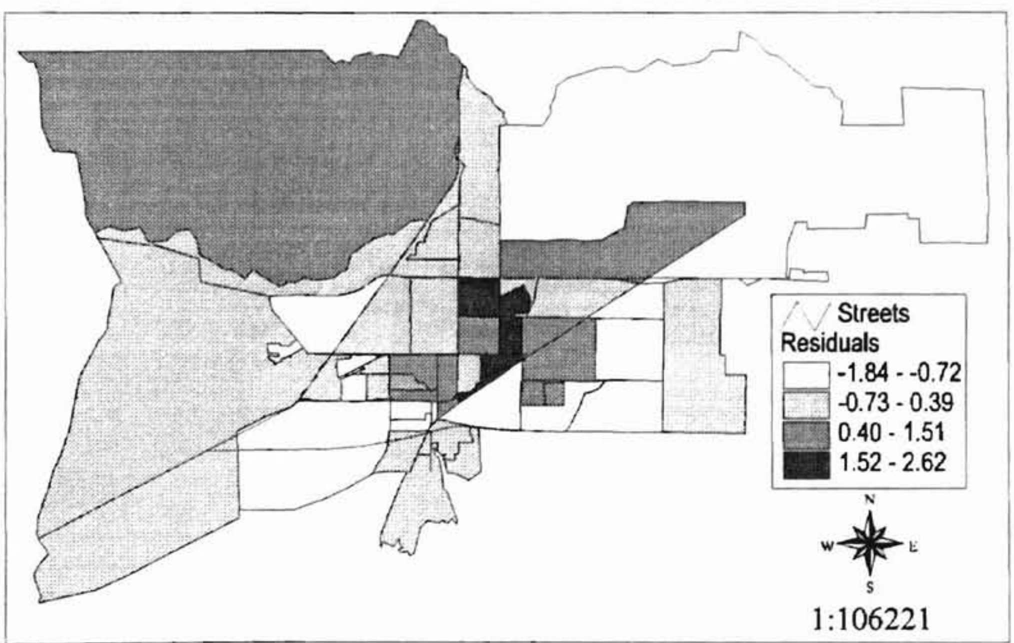
APPENDIX E

Pearsons Correlations Columns: Dependent Variables from CCI Rows: Independent Variables from Census	PCAP Pediatric Medical Emergencies (< 12 yrs)	PCAP Cardiac Medical Emergencies	PCAP Diabetic and Seizure Medical Emergencies	PCAP Medical Emergencies Involving Drugs/Alcohol	PCAP Geriatric Medical Emergencies (> 64 yrs)	PCAP Environmental Medical Emergencies	PCAP Medical Emergencies Involving Females (> 17 yrs)	PCAP Mental Health Medical Emergencies	PCAP Respiratory Medical Emergencies	PCAP Medical Emergencies Resulting from Acts of Violence
Percentage of Housing Units with 1 unit	0.130	0.182	0.137	0.117	0.114	0.132	0.116	0.075	0.085	0.116
Percentage of Housing Units with 2 - 19 units	0.224	0.178	0.193	0.222	0.207	0.165	0.212	0.068	0.241	0.206
Percentage of Housing Units with 20 - 49 units	-0.038	-0.095	-0.097	-0.097	0.007	-0.099	-0.046	0.065	-0.041	-0.077
Percentage of Housing Units with 50 + units	-0.084	-0.101	-0.065	-0.062	-0.060	-0.068	-0.053	-0.093	-0.078	-0.025
Percentage of Mobile Homes	-0.104	-0.101	-0.096	-0.080	-0.093	-0.078	-0.101	-0.027	-0.077	-0.099
Percentage of Housing Units Owned by Asians	0.237	0.333	0.254	0.233	0.242	0.292	0.253	0.178	0.303	0.248
Percentage of Housing Units Owned by Blacks	-0.326	-0.303	-0.278	-0.292	-0.321	-0.281	-0.301	-0.128	-0.324	-0.266
Percentage of Housing Units Owned by Hispanics	-0.243	-0.226	-0.292	-0.294	-0.239	-0.287	-0.281	-0.157	-0.298	-0.304
Percentage of Housing Units Owned by Whites	-0.475	-0.402	-0.434	-0.450	-0.436	-0.440	-0.471	-0.269	-0.415	-0.463
Percentage of Housing Units Rented by Asians	-0.034	-0.102	-0.059	-0.054	-0.017	-0.075	-0.040	-0.056	-0.047	-0.042
Percentage of Housing Units Rented by Blacks	0.013	-0.064	-0.029	-0.038	0.021	-0.049	0.005	0.015	-0.035	-0.024
Percentage of Housing Units Rented by Hispanics	0.135	0.055	0.097	0.128	0.112	0.075	0.110	0.110	0.100	0.110
Percentage of Housing Units Rented by Whites	0.670	0.600	0.638	0.658	0.620	0.645	0.664	0.346	0.602	0.660
Percentage of Asian Population	0.134	0.187	0.152	0.130	0.155	0.181	0.157	0.092	0.206	0.159
Percentage of Black Population	-0.128	-0.142	-0.094	-0.092	-0.140	-0.112	-0.105	-0.045	-0.119	-0.092
Percentage of Hispanic Population	-0.155	-0.241	-0.235	-0.214	-0.186	-0.242	-0.214	-0.048	-0.264	-0.238
Percentage of White Population	-0.040	-0.003	-0.026	-0.020	-0.032	-0.021	-0.044	-0.077	-0.015	-0.033
Percentage of Population Paying < $399 Monthly Rent	0.184	0.112	0.125	0.163	0.163	0.111	0.161	0.166	0.145	0.157
Percentage of Population Paying $400 - $599 Monthly Rent	0.538	0.480	0.493	0.524	0.494	0.485	0.520	0.244	0.514	0.516
Percentage of Population Paying > $599 Monthly Rent	0.206	0.139	0.178	0.160	0.216	0.173	0.212	0.062	0.152	0.188
Percentage of Population Renting Property	0.514	0.431	0.458	0.482	0.480	0.447	0.498	0.241	0.467	0.485
Percentage of Population Unemployed	0.096	0.105	0.115	0.118	0.117	0.127	0.101	0.050	0.026	0.139
Percentage of Population Receiving Public Assistance	0.596	0.517	0.562	0.561	0.594	0.562	0.575	0.278	0.509	0.552
Per Capita Income	-0.286	-0.184	-0.261	-0.273	-0.257	-0.256	-0.282	-0.143	-0.222	-0.283
Percentage of the Population with Less than 12 years of Education	0.198	0.110	0.163	0.175	0.223	0.129	0.183	0.039	0.159	0.172
Percentage of Male Population	-0.320	-0.282	-0.312	-0.297	-0.306	-0.303	-0.312	-0.114	-0.258	-0.300
Population Density	-0.212	-0.257	-0.206	-0.202	-0.196	-0.212	-0.197	-0.217	-0.214	-0.182
Percentage of Population Less than 30 years of Age	0.442	0.385	0.410	0.431	0.375	0.435	0.432	0.244	0.375	0.445
Percentage of Population Greater than 59 years of Age	0.221	0.152	0.163	0.158	0.254	0.100	0.195	0.002	0.214	0.167

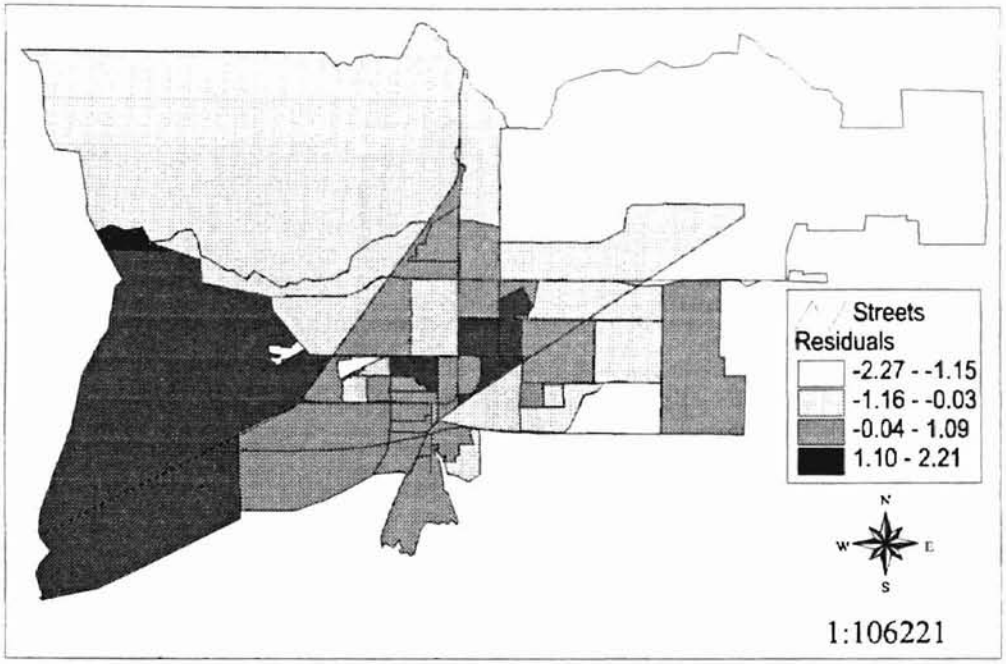
APPENDIX F



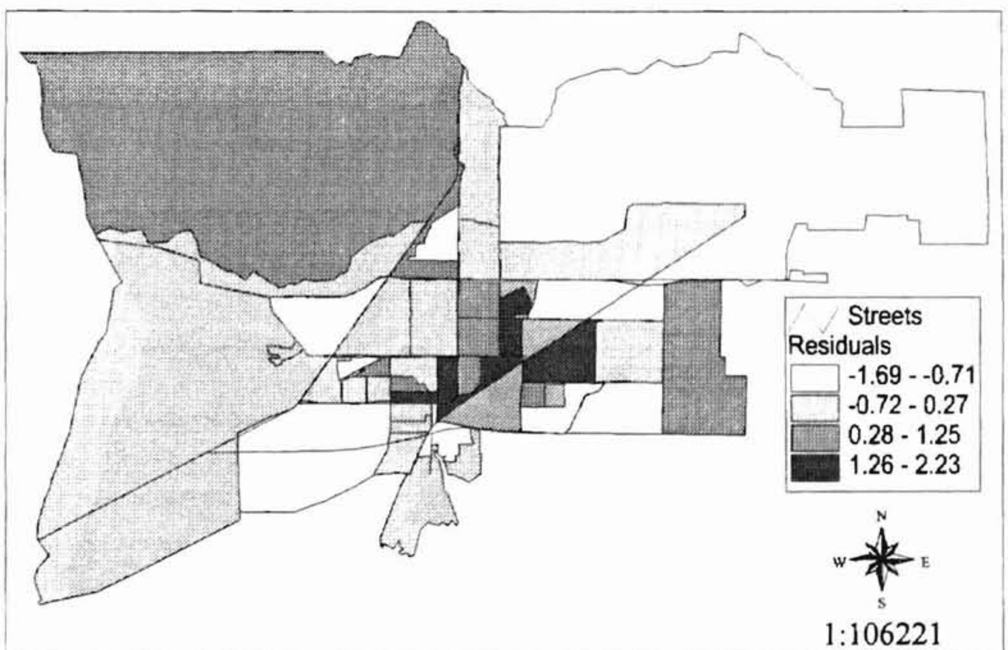
Standardized Residuals: Pediatric Medical Emergencies (<13 yrs).



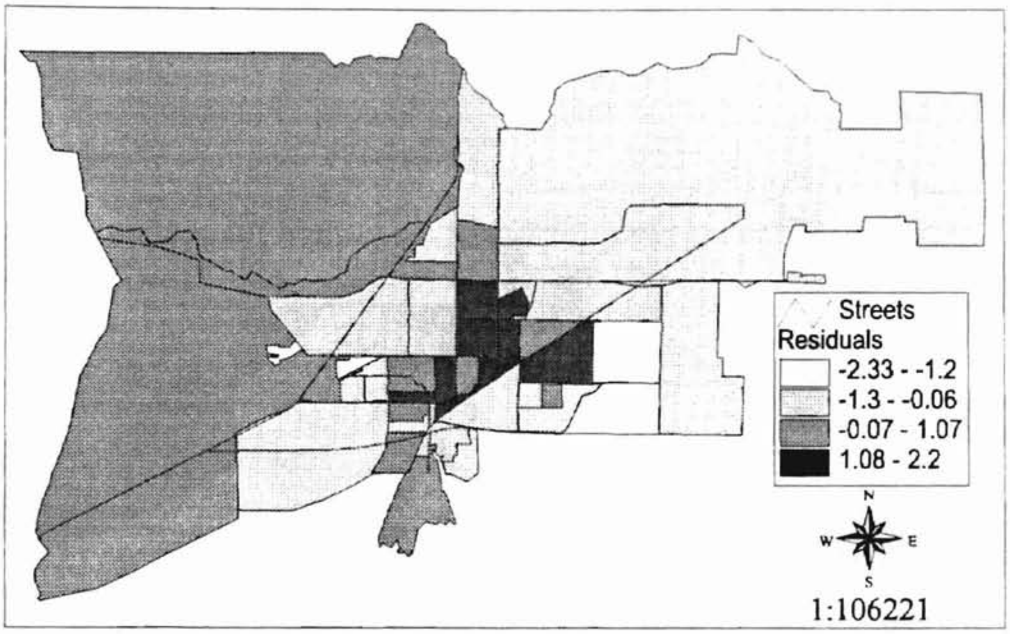
Standardized Residuals: Cardiac Medical Emergencies.



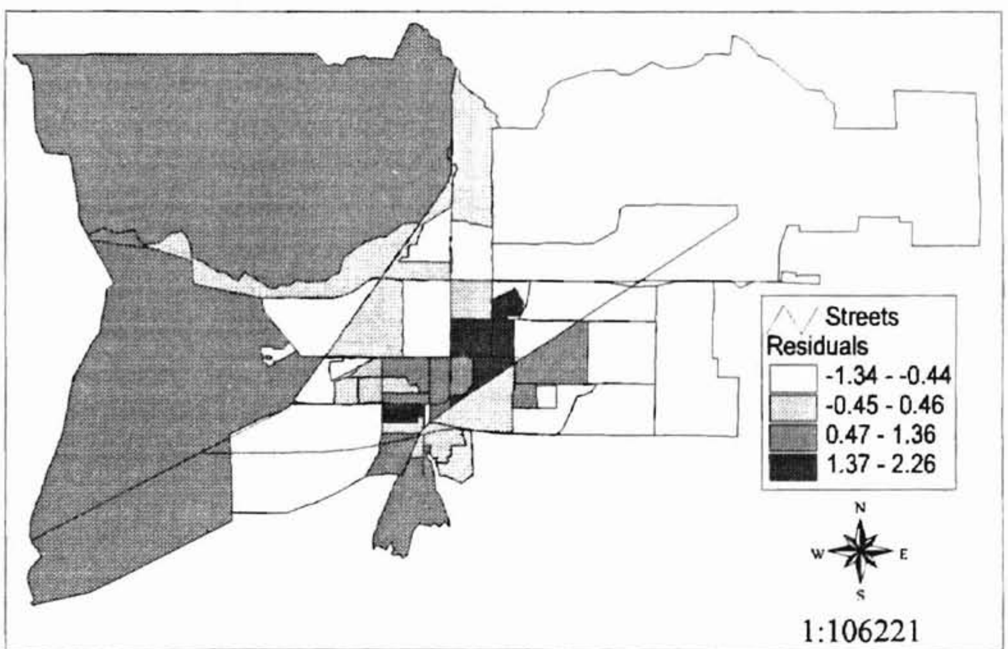
Standardized Residuals: Diabetic/Seizure Medical Emergencies.



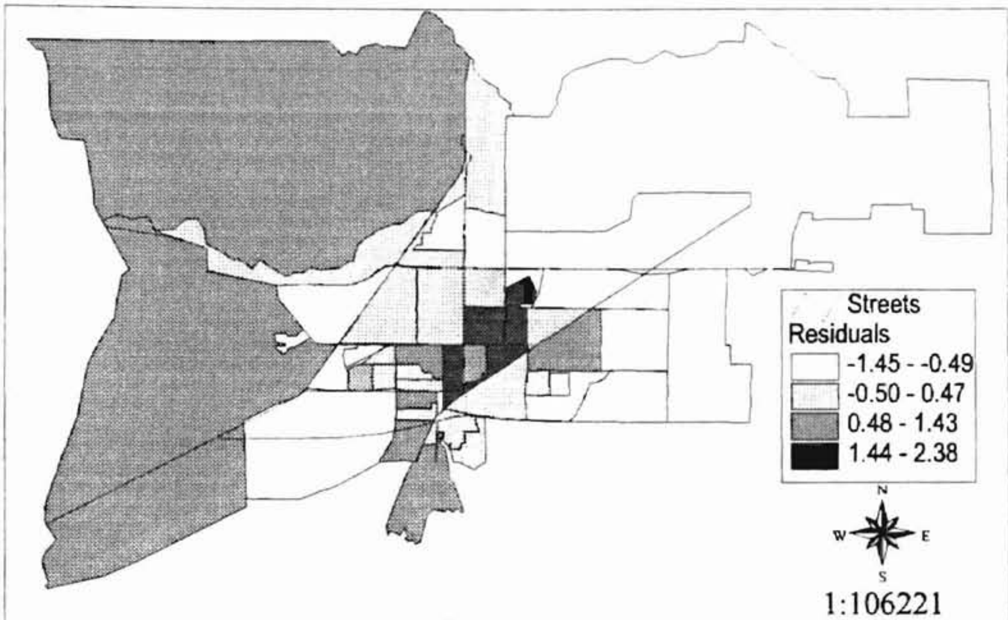
Standardized Residuals: Medical Emergencies Involving Drugs/Alcohol.



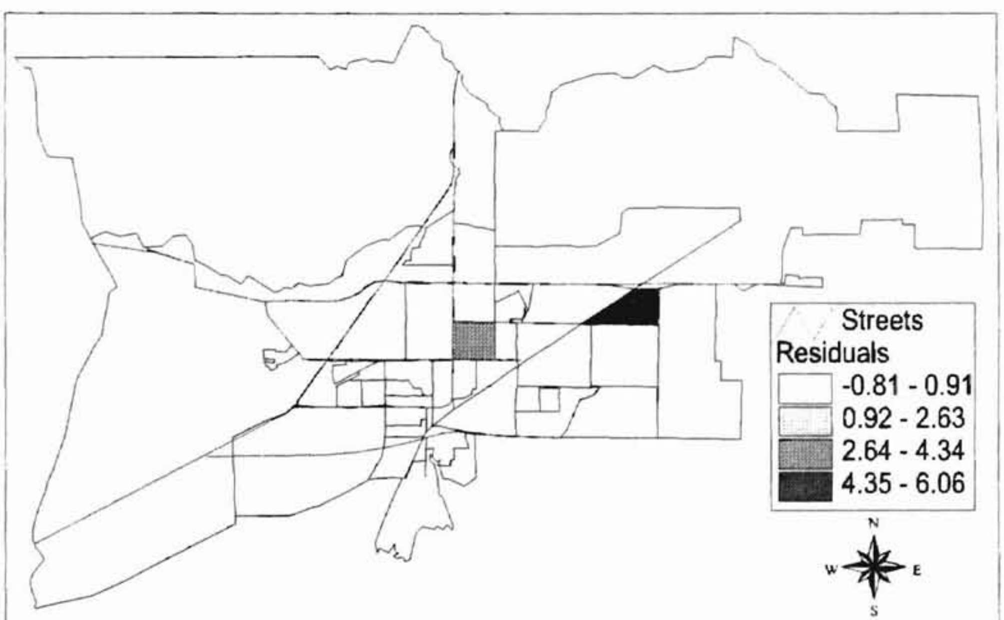
Standardized Residuals: Environmental Medical Emergencies.



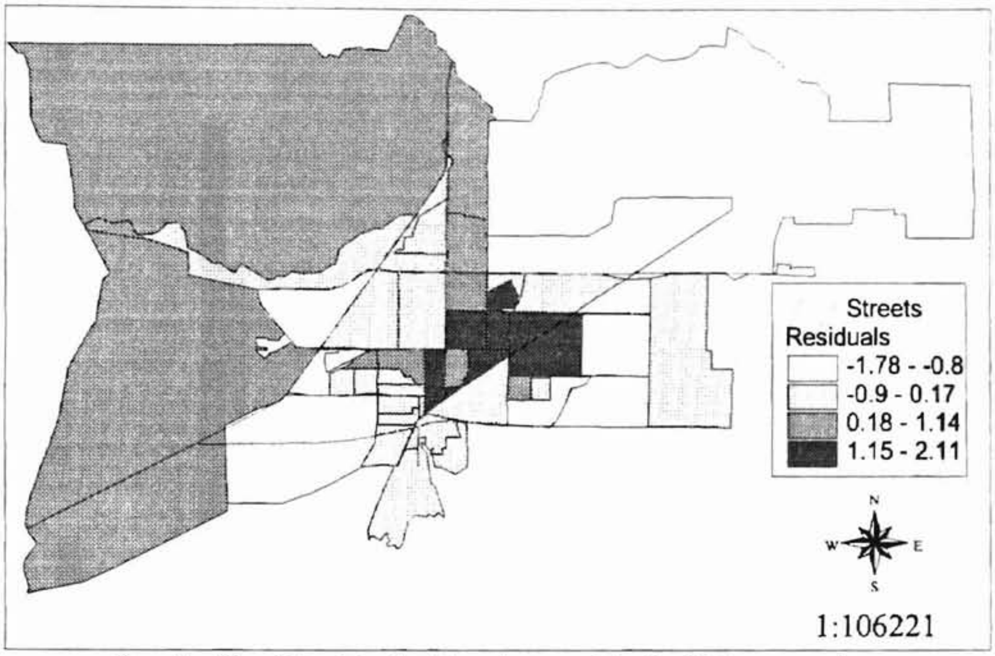
Standardized Residuals: Medical Emergencies Involving Females (17 - 64 yrs).



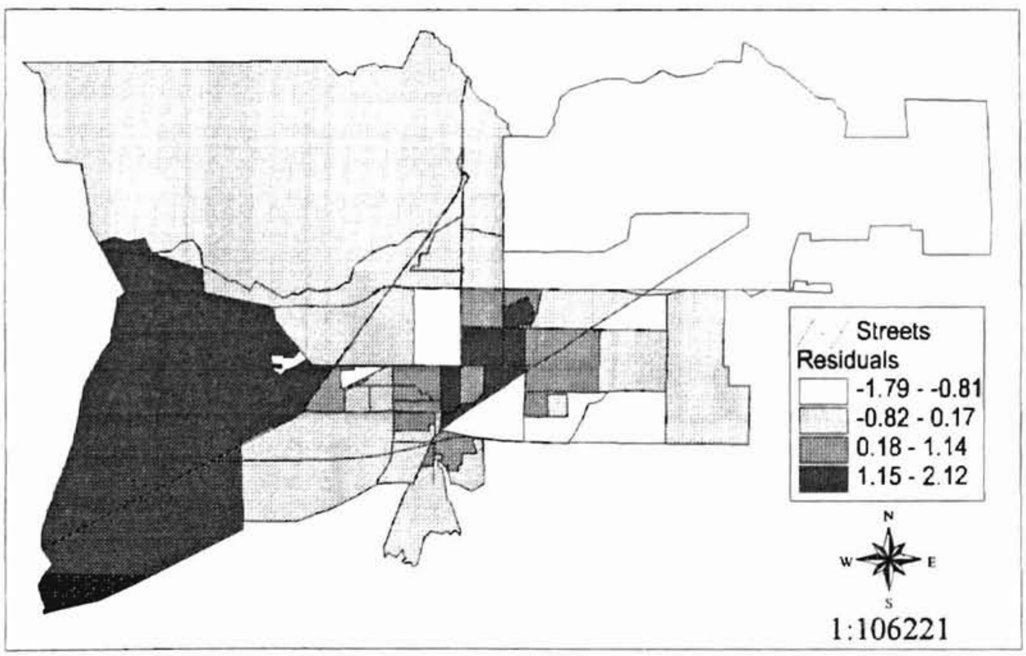
Standardized Residuals: Geriatric Medical Emergencies (>64 yrs).



Standardized Residuals: Mental Health Medical Emergencies

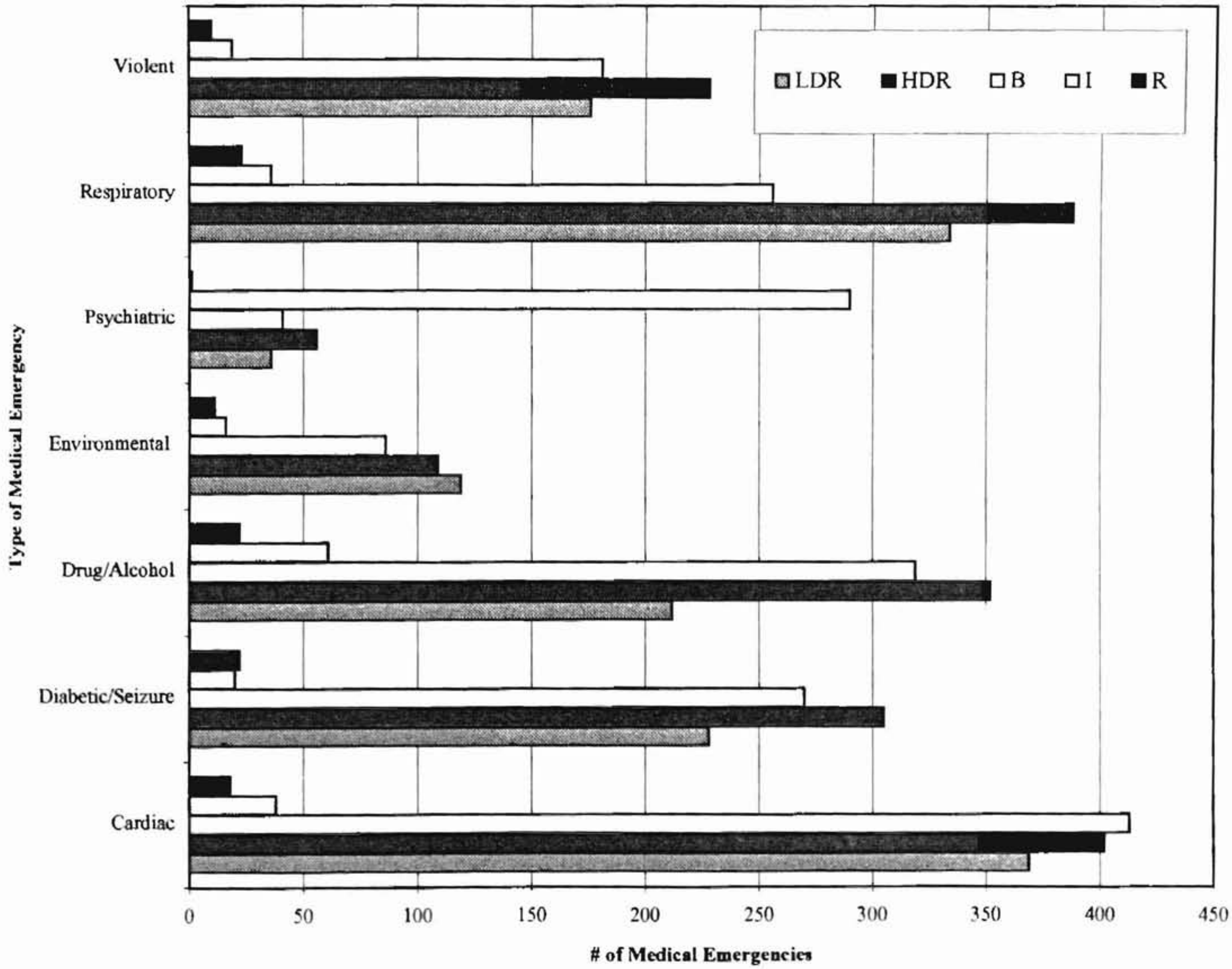


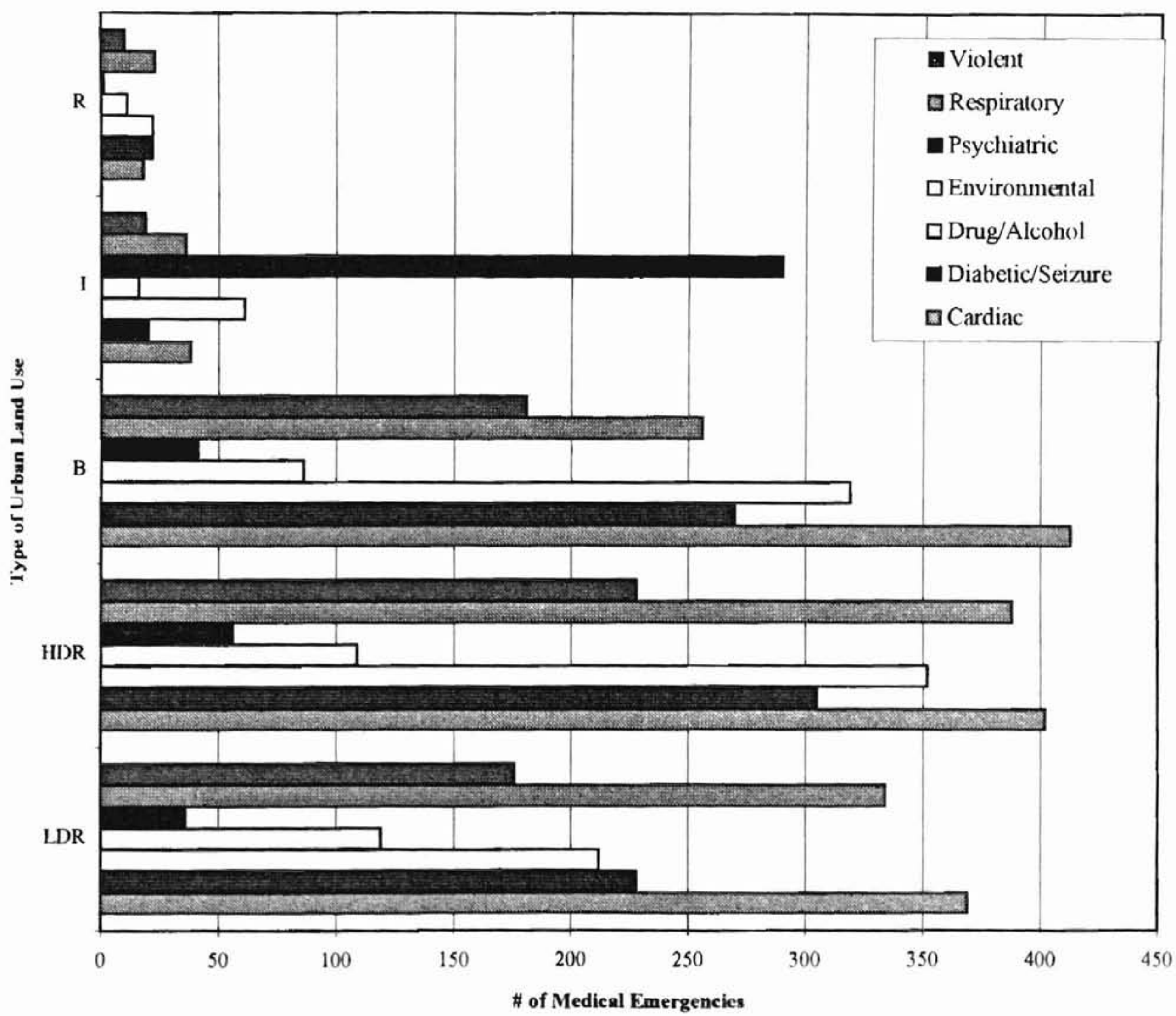
Standardized Residuals: Respiratory Medical Emergencies.

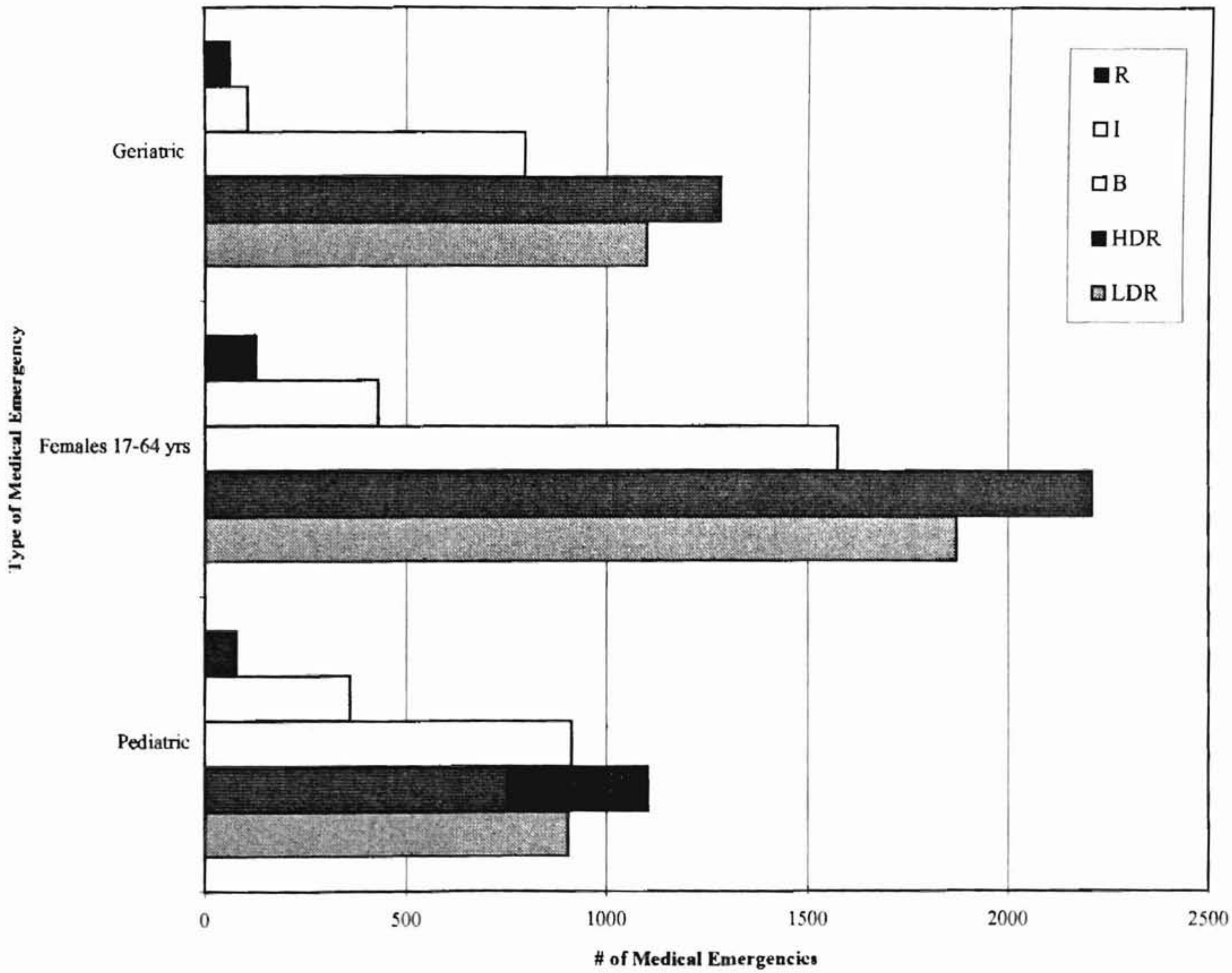


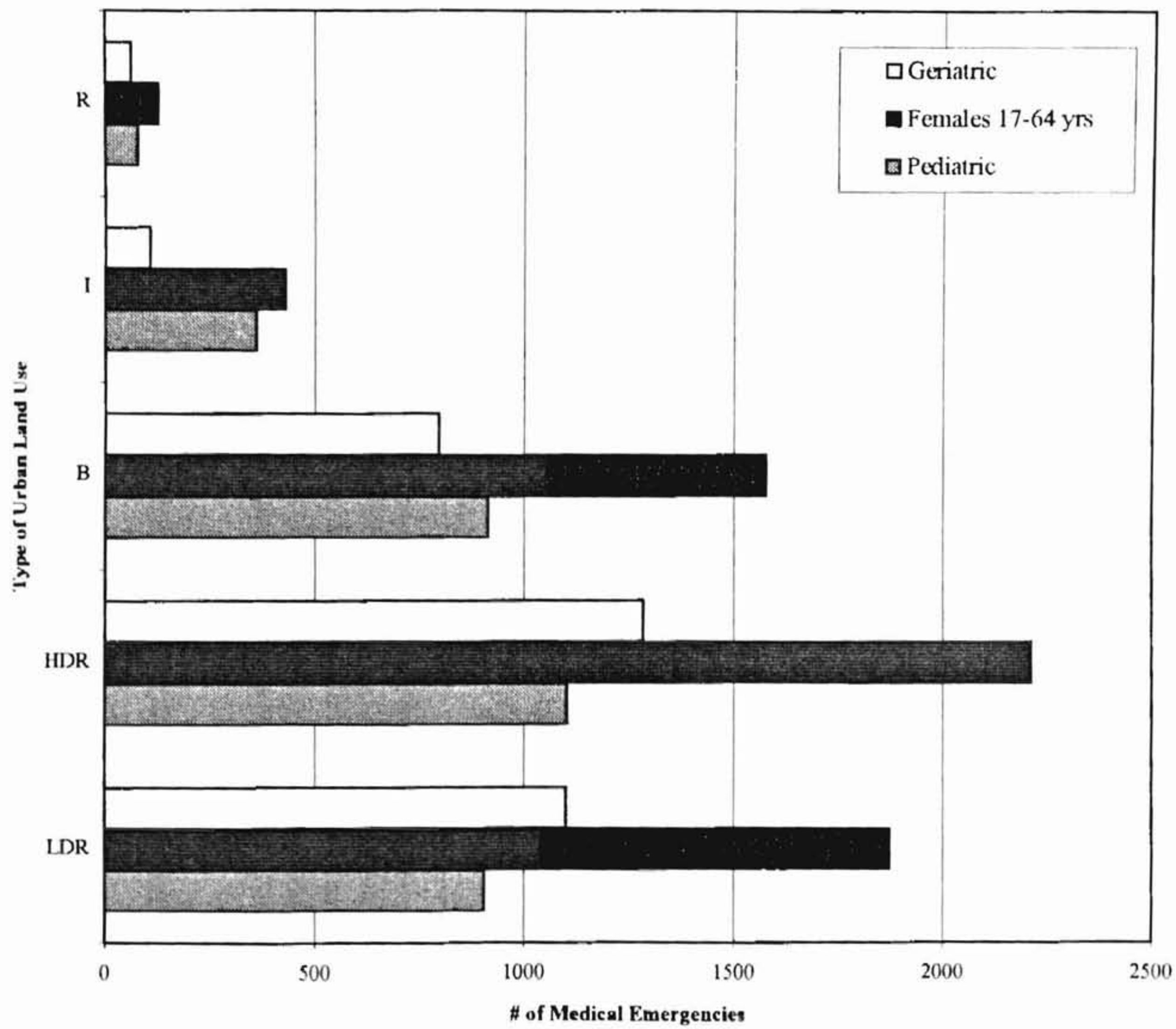
Standardized Residuals: Medical Emergencies Resulting from Acts of Violence.

APPENDIX G


LDR
HDR
B
I
R
Violent
Respiratory
Psychiatric
Environmental
Drug/Alcohol
Diabetic/Seizure
Cardiac
Type of Medical Emergency
0
50
100
150
200
250
300
350
400
450
# of Medical Emergencies


Violent
Respiratory
Psychiatric
Environmental
Drug/Alcohol
Diabetic/Seizure
Cardiac
Type of Urban Land Use
R
I
B
HDR
LDR
0
50
100
150
200
250
300
350
400
450
# of Medical Emergencies


Geriatric
Females 17-64 yrs
Pediatric
Type of Medical Emergency
R
I
B
HDR
LDR
0
500
1000
1500
2000
2500
# of Medical Emergencies


Geriatric
Females 17-64 yrs
Pediatric
R
I
B
HDR
LDR
Type of Urban Land Use
0
500
1000
1500
2000
2500
# of Medical Emergencies

2

VITA

Timothy Scott Hayes

Candidate for the Degree of

Master of Science

Thesis: UTILIZATION AND PATTERN ANALYSIS OF AN EMERGENCY MEDICAL SERVICES SYSTEM: A GIS AND SPATIAL ANALYTICAL APPROACH

Major Field: Geography

Biographical:

Education: Graduated from Armijo High School, Fairfield, California in June 1986; received a Bachelor of Arts degree in Geography from the University of California, Davis, California 1994. Completed the requirements for the Master of Science degree with a major in Geography at Oklahoma State University in May 1998.

Experience: Employed as a volunteer fire fighter from 1983-1986 and 1988-1991 with Suisun Fire Protection District and Fairfield Fire Department respectively; employed as an Emergency Medical Technician from 1986-1995 with Medic Ambulance Service; employed as a Geographic Information Systems Manager/Analyst with Medical GIS Consulting from 1994-1996.

Professional Memberships: Association of American Geographers