A LOCATIONAL ANALYSIS OF NON-METROPOLITAN SECONDARY HOSPITALS IN KANSAS

A Thesis

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By

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Approved by:

Major Professor

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Chapter 1

INTRODUCTION

BACKGROUND

Recently a number of geographers have been interested in medical Geography. My thesis topic fits within the scope of medical geography and is concerned with the optimal location of non-metropolitan Kansas hospitals within their trade areas.

The role of the hospital has evolved with the advancement of medical knowledge and technology. "The hospital's earliest purpose was the protection of the community from the contagiousness of the accursed few - a kind of care which was provided for a sufferer from a slow, crippling, and repulsive killer of unknown and uncontrollable origin."[1] The role of the hospital has changed to the extent that the hospital is maintained for the centralized and expert care of the sick who cannot and/or should not be cared for anywhere else.

As the role of the hospital has changed so must the role of medical geography. Traditionally, medical geography has focused on problems concerning the distribution and spread of disease, problems which remain paramount in developing countries. However, the developed nations of the world face different medical and health care issues than the underdeveloped nation. "The major health concerns include the distribution and maintenance of health care services for a generally healthy population, the care of increasing numbers and proportions of young and very old people, and the protection and improvement of the health and the environment."[2] During the past decade the notion of health planning has received increasing attention in the United States. There is a great opportunity for medical geographical contributions in this area.

Health care in the United States currently faces many crises in cost, quality of care and equitable distribution of types and standards of services offered to the populous. During the past decade many health planning agencies have emerged at the State, regional, and local (usually in urban areas) level. Although progress has been made in this area, in many respects the health care conditions in the United States could be improved. Unfortunately there is a general lack of coordination between the various planning agencies at every level. What is currently needed is to aggregate the efforts of all planning agencies into one master plan on which all planning decisions can be based. A comprehensive plan could be initiated at the regional level first and then possibly on a national level. "Systematic planning to improve existing services and to implement new ones has been gradually gaining momentum under federal government assistance. While current planning efforts remain uncoordinated and fragmentary, the general aim is to move from the present collection of independent, often unrelated health services and facilities toward what is envisaged as a system of health care."[3] A well organized system of health care would aid in reducing medical costs and improve the services offered by reducing service duplication. Mills says, "A major stimulus to the planning of hospital facilities on an area of regional basis is the effect on costs and quality of service of unnecessary duplication."[4] When a hospital develops a program on its own it often fails to meet the minimum standards of patient care due to a lack of adequate human financial resources. As the cost for equipment and personnel rises, the cost of maintaining them also rises. Therefore, if the hospital services of a region were coordinated in a manner which would reduce service duplication, the cost of health care would be reduced and it would cease to rise at the rapid rate which it does today.

According to Armstrong, "A notable lack in most health planning is concern for locational factors, especially regarding resources."[5] It is in this area where medical geographers could make valuable contributions.

"The most comprehensive research by American geographers into urban health problems has been the Chicago Regional Hospital Study."[6] This survey was supported by a grant from the Office of Economic Opportunity to the Chicago Board of Health. The study concentrated on the present state of the provision of health care throughout the city, with an emphasis on how the pattern of health services could be improved to give better care to the less privileged social groups of Chicago. The geographic contribution to the project has been largely based on the premise that, hospitals, like schools and most retail businesses are central services. Because the geographic approach to the Chicago Regional Hospital is derived from the central place theory, the work has consisted partially of building models of optimum hospital size and location and the identification of the hierarchy of hospital services and the classification of hospitals. The gravity model was applied to the patient flows and the distance traveled by patients to the hospitals in an attempt to discover the trade areas of the hospitals.

When attempting to classify hospitals it must be remembered that the hospitals vary in scope as well as in size. Morrill says, "hospital services do not constitute a homogenous output. Some hospitals, typically the smaller ones, have a limited range of facilities and personnel and are able to handle unusual and difficult cases."[7] Therefore, the level of service of a hospital is dependent upon the number of services that it offers.

According to Ron Schmidt, Director of the Kansas Bureau of Health Planning, there is a hierarchy of hospitals which consist of three main levels. The hospitals which offer only a few services usually possess a small trade area, and are known as tertiary hospitals. Those which offer a moderate amount of services (usually including all of those offered by tertiary hospitals) and have a somewhat larger trade area are known as secondary hospitals. Higher level hospitals which offer a large number of specialty services in addition to the services offered at the tertiary and secondary levels are known as primary hospitals. These hospitals serve a very large trade area because they offer many specialized services which cannot be obtained elsewhere within the area they serve.

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Thus, many of the patients that originally go to a small local hospital are sent to a larger hospital if adequate treatment for an illness cannot be obtained at the local one. However, because of the highly specialized nature of the primary hospitals they are few in number, widely dispersed, and usually located in large metropolitan areas.

In addition to the primary hospitals there are also many intermediated size hospitals that perform more services than the tertiary hospitals, but fewer than the primary hospitals. These intermediate hospitals are referred to as secondary hospitals. Their trade areas collectively comprise a large percentage of the primary hospitals trade areas. However, in metropolitan areas it is often difficult to deliniate their true trade areas due to the degree in which they overlap. Many socio-economic and locational factors which are of minimal importance in non-metropolitan areas must be considered before the trade areas can be identified. Some of the more important ones are:

1. The Method by Which the Hospital is Funded: This can determine some of the hospitals patrons. Many patients may go to a private hospital but not to a public hospital, or a public hospital but not to a private hospital.
2. The Hospitals Religious Affiliation: Those of a particular faith will be prone to patronize a hospital supported by their faith before they will support a hospital supported by another faith or a public hospital.
3. The Neighborhood: The neighborhood in which the hospital is located may also affect its trade area. An

inner city hospital will likely have an inner city cliental, whereas, a hospital located in what is perceived as a more desirable neighborhood may draw its patients from many different areas.

4. The Accessibility of the Hospital: A hospital that can be reached by many good routes will have a much better chance of having a large trade area than one which is not linked to the populous by a good transportation network.

5. The Physician: The doctors send their patients to the hospitals where they serve on the medical staff. Thus, if a physician is not on the medical staff of a hospital his patients will go elsewhere even if they reside closer to a hospital where their physician does not serve on the medical staff.

6. Intangibles: There are many intangibles which help to determine the metropolitan hospitals trade areas such as the patient's perception of the quality of service, the friendliness, consideration of the hospital personnel, and the quality of food. In short the atmosphere and the impression the hospital leaves on its patients can help determine its trade area.

Thus, the factors which determine a metropolitan hospitals' trade area are quite complex and the trade areas do not entirely depend upon the hospitals' location within the city.

Although the large hospitals which Morrill speaks of are not located in non-metropolitan areas in Kansas, the state possesses several non-metropolitan secondary hospitals. The complex factors which affect the limits of metropolitan hospital trade areas are virtually non-existent in these areas. The primary reason for this is that the non-metropolitan areas do not possess a sufficient threshold for several hospitals to coexist in close proximity to each other. Thus, the people do not possess the element of choice that is generally present in metropolitan areas when medical care is required, instead they are dependent upon widely dispersed hospitals and must utilize the ones nearest them. The distance between hospitals is often too great for the people to enjoy the luxury of choice when choosing a hospital.

However, quite often the nearest hospitals is disproportionately far from some potential patients while very close to otheres. This raises many questions concerning the location of hospitals within their trade area. Very little work has been undertaken in the past concerning the optimal location of hospitals. Although Richard Morrill and Phillip Kelly have attempted to construct a model dealing with the optimum allocation of services in metropolitan areas, specifically Chicago. They say, "There have been some valiant attempts to deal with the generalized location problem, and with a few simplifications or assumptions, a variety of solutions can be obtained."[8]

In addition to Morrill and Kelly's work Maje Mulivihill, has attempted to test for the optimal location of hospitals in Guatemala City, Guatemala. "Using a capacity-constrained location-allocation model, this study evaluates the locational efficiency of a set of primary health centers in Guatemala City."[9] The results of the study revealed by this model indicate that the ideal distribution of primary health centers departs substantially from the present pattern indicating a need for greater centralization of administration and planning of health care delivery. Although Mulivihills' study was conducted in Guatemala many of the location problems which are paramount in that country are also present in the United States, as we too are in need of a carefully planned health care delivery system.

However, the problem of finding a true optimum is virtually insoluable because of the varying and changing distribution of people, and the fact that most of the hospitals which dot the landscape today were constructed without consideration of location. The Hill-Burton Act of the early 1930's was concerned with providing clinics and hospitals in nearly every community. As a result of such government action, many hospitals are located in such a manner as to provide something less than the most efficient service possible. However, through wise planning and observance of population trends, future facilities may be constructed in such a manner as to maintain an operationally optimal allocation of hospitals, that is, as good as society can achieve. If this is achieved the cost of medical services would cease to rise at the current high rate which we are experiencing today, and the speed with which the patient can be served as well as the quality of service provided would be improved.

These benefits can be at least partially realized if health care is undertaken at the regional level. There is a need for coordination and planning between the metropolitan and the non-metropolitan hospitals. The era of the individual hospital implementing its own policy without regard for the others which surround it must be brought to an end. Whatever argument is used for a hospital formulating its own policy without regard for the needs and the demands of the people is no longer acceptable in today's complex health scene. if in truth, it ever was. One needs only to examine the trends concerning the health field today in order to discern the fallacy of any arguments for not participating in efforts designed for regional health planning. Mills briefly lists the major trends as:

1. An ever-advancing technology, always requiring more extensive and costlier services and facilities which, in turn, demand a wider range of professional skills to staff them, skills already and increasingly in short supply.
2. A significant new dimension in third-party payments (insurance companies) is already resulting and will continue to result in "more looking over the shoulder" to see what our hospitals are doing and how well they are doing it. The cost to third parties vary regionally, depending on the cost of health care in various regions. However, periodic justification of hospital rates is necessary to keep prices in line with regional capabilities and guidelines. The people of regions that are

not as economically well off as people of other regions should not be expected to pay the same price as those in the well to do regions. Thus, regional planning is essential for those not as fortunate as others.

3. Changing patterns in medical practice with greater emphasis on comprehensive care, especially on an ambulatory, outpatient basis, and of medical-social services.

4. A steadily aging population requiring additional and different kinds of services with a greater than ever ability to pay for these services as a result of more widespread federal support legislation.

5. A migratory population with significant changes in the characteristics of the urban setting, all resulting in a changing pattern of needs for services both as to location and character.

6. Development of the extramural program of the hospital through home care.

7. Growth of the hospital "umbrella" to supervise, assist and sponsor allied institutions.

Today, more than ever, each hospital needs a definition concerning its role in the area it serves. This can to a great extent be achieved through comprehensive health care planning. It is nevertheless necessary for each hospital to be aware of the area comprising its trade area before a hospital can become aware of its role in the area it serves.

STATEMENT OF PROBLEM

I plan to identify a secondary level of hospitals in non-metropolitan Kansas. I will map each hospitals' trade areas and hypothesize that such facilities depart significantly from an optimal location within their service areas.

A study of the hierarchy of Kansas hospitals has not been undertaken in Kansas, nor have hospital types and their service areas been identified. Furthermore, the services that differentiate a secondary hospital from a primary hospital or a tertiary hospital have not been identified. This study concerns itself with non-metropolitan hospitals only because most of Kansas is non-metropolitan in nature, as there are only five counties which lie in Standard Metropolitan Statistical Areas. Furthermore, the complex nature of the factors which lead to the development of metropolitan hospital trade areas dictates the use of more sophisticated data than is currently available.

The purpose of this study is:

1. To investigate and define the non-metropolitan secondary hospitals in Kansas.
2. Map their trade areas.
3. Estimate the optimal location of these hospitals.
4. Compare the optimal location of the hospitals with their actual location.
5. If the optimal location of the hospitals vary significantly from the actual location of the hospitals this study will make recommendations concerning the location of future hospitals.

The classification of non-metropolitan secondary hospitals will be based on data from two sources. The Kansas Bureau of Health Planning provides patient origin data on a county by county basis for each hospital. In addition, the Kansas Medical Society has published a list of individual physicians and their specialties for each community. This study will first compile the data concerning the location of the physicians and their specialties. When each physician and his specialty is located it will be possible to locate the communities which possess the highest number of physician specialties, thus possessing the largest number of services. Furthermore, all of the communities that fall within the United States Census Bureau definition of a Standard Metropolitan Statistical Area and their patient origin data will be eliminated. Thus, the remaining communities will be non-metropolitan in nature.

Once a distinction between metropolitan and non-metropolitan hospitals is made, the hospitals which offer a similar number of physician services will appear in clusters with significant breaks between each hospital level. Thus, allowing a differentiation between hospital classification to be made.

1. Trade Areas:

After the secondary hospitals have been identified the origin of patients for each hospital will be surveyed to determine their trade areas. The patient origin data is available on a county by county basis through the Kansas Bureau of Health Planning. Patients using Kansas hospitals who reside in other states are accounted for as out of state, with no distinction made concerning which state they are from.

2. Optimal Location:

After the patient origin data is compiled "The mean center for each trade area will be estimated. To estimate the mean center in the most accurate manner possible, the county centroids will be used. This study recognizes that the optimal location of each hospital will not be based on the relationship to other hospitals in the state, but rather on its centrality within the trade area. However, it is hoped that locating the optimal location will prove an adequate foundation on which to develop further research at a later date. The method used to estimate the mean center is described in Appendix "A".

3. Comparison of Optimal and Actual Locations:

Once the optimal location for each hospital is identified the results will be compared with the actual location of the hospitals. This should be of importance to health planners in formulating future health care policy. If the hospitals are not located in areas of maximum demand for services they are inefficiently located. It is hoped that this study will aid in the implementation of planning decisions which will help improve the Kansas health care delivery system.

JUSTIFICATION

Geography describes and analyzes the spatial organization and spatial interaction of humansand their activity. Within this framework thesis observes the spatial organization of hospitals in Kansas and attempts to analyze and explain this spatial structure by focusing on the nature of hospitals.

The locational work involved in this study assumes that a hierarchy of medical services exists and that the location of these services is determined by the population threshold reuqired by each individual service. There are a few basic services offered at every hospital. The trade areas with a small population should possess only these basic services. However, as the population of a hospital's trade area increases the number of services offered at the hospital should also increase. Therefore, the highly specialized services should be more widely dispersed than the lower level services, because they occur less frequently than the lower level services.

Furthermore, the hospitals possessing a large number of services should have a larger trade area than the hospitals with only a few services, because the people cannot obtain the high level services at every local hospital. Therefore, they must travel farther to obtain the high level services.

It is important to test for the optimal location of these hospitals and compare those locations with their actual locations, because if they are not of maximum accessibility to everyone in the trade area they are under-utilized and/or costing the public more than is necessary. Furthermore, any differences between the optimal location and the actual location of a hospital can significantly influence the dimensions of the trade area.

This study should aid in the formation of meaningful health care programs in Kansas as well as assist in correcting problems related to misplaced hospitals, because it identifies the optimal location of the hospitals. In addition it is hoped that this study will aid in laying the foundation for future inquiry in the sub-field of medical geography.

EXPECTED RESULTS

The non-metropolitan secondary hospitals in Kansas should be easily discernable. Although, it is possible that the trade areas of the hospitals may somewhat overlap, most of the trade areas should be well defined because the secondary hospitals provide middle level services, thus, they are not numerous and are widely dispersed. It is expected that some of the hospitals will be optimally located within their trade areas, however, it is also possible that some will not be optimally located. This study should identify the hospitals that are optimally located and those that are not.

As a result of identifying the secondary hospitals, the mapping of their trade areas, the testing for the optimal location of the hospitals within their trade areas, and comparing those locations with the actual location this study should aid in the construction of a comprehensive health care plan for Kansas. If nothing more, this study should aid planners in identifying a starting point from which to base decisions concerning the placement of new facilities and services.

THESIS FORMAT

My thesis format will be constructed in the following manner.

Chapter 1. Introduction

Chapter 2. Defining the non-metropolitan secondary hospitals in Kansas and mapping their trade areas.

Chapter 3. Estimating the optimal location of the secondary hospitals.

Chapter 4. Comparing the optimal location of the secondary hospitals with their actual location.

Chapter 5. Summary and Conclusions.

FOOTNOTES

1. Mills, Alden, Functional Planning in General Hospitals, (New York: McGraw-Hill, 1969), p. 4.

2. Armstrong, R.W., "Medical Geography and Health Planning in the United States", Medical Geography Techniques and Field Study, (London: Mathuen and Co., Ltd., 1972), p. 119.

3. Ibid.

4. Mills, Alden, Functional Planning in General Hospitals, (New York: McGraw-Hill, 1969), p. 22.

5. Armstrong, R.W., "Medical Geography and Health Planning in the United States", Medical Geography Techniques and Field Study, (London: Methuen and Co., Ltd., 1972), p. 119.

6. Piercy, Kieth, The Geography of Health and Death and Quality of the Environment in Manhattan, Kansas, M.A. Thesis K.S.U. May, 1971, p. 3.

7. Morrill, R.L., and Kelly, P., "Optimum Allocation of Hospital Services in Chicago", The Annals of Regional Science, 3: pp. 55-66, 1969, 9.57.

8. Ibid.

9. Mulvihill, James, "A Locational Study of Primary Health Services in Guatemala City", The Professional Geographer, 31 (3) 1979, pp. 299-305, p. 299.

Chapter 2

DEFINING KANSAS NON-METROPOLITAN SECONDARY HOSPITALS AND THEIR TRADE AREAS

The purpose of this chapter is to define and identify secondary hospitals in Kansas non-metropolitan areas, and to delineate their trade areas. First, the criteria for identifying secondary hospitals is established. Once the communities which possess secondary hospitals are identified each secondary hospitals' trade area can be identified.

DEFINING THE SECONDARY HOSPITALS

The basis for defining the hierarchy of hospitals in Kansas is the number of physician specialties available in each community. The most recent data available is found in the August 1977 issue of the Kansas Medical Society Journal in which the physicians in every community who belong to the Kansas Medical Society are listed as well as their specialty. This study assumes that each physician practices medicine in the community in which the physician resides. Therefore, the service that a physician provides is listed in that physician's place of residence. Once each physician and his or her specialty is accounted for it is necessary to decide on a method for establishing which non-metropolitan hospitals meet criteria for the secondary level. It is impractical to attempt to determine the dominant hospital in a community which possesses two or more hospitals of similar size and scope, because it is difficult to determine which physician specialties are available at a specific hospital and which are not. Therefore, this study considers these communities as having a secondary hospital node.

For example, in Manhattan, Kansas, there are two hospitals which are comparable in size. Of the 14 physician specialties offered in Manhattan all 14 are offered at both hospitals. That is, both hospitals possess medical staffs which are competent in all 14 specialties making it difficult to arrive at meaningful conclusions concerning the existance of a true dominate secondary hospital in Manhattan. Therefore, Manhattan is considered a secondary node without a dominate secondary hospital.

This study employs two different methods of determining the non-metropolitan secondary hospitals in Kansas. The first method is based on the number of physician specialties in each community. It identifies a logical break point between the number of specialties offered at the secondary hospitals and nodes, and those offered by other types of hospitals. The physician specialty data which this method yields, reveals a cluster of 14 non-metropolitan cities which offer between 10 and 17 different physician specialties. That is, there are no non-metropolitan cities which possess more than 17 physician specialties. Furthermore, a break is found between 8 and 10 specialties. Thus, these 14 secondary hospitals and nodes fall within the logical break points that this method seeks to identify. (See Table 1.)

The second method that is employed attempts to develop an index of specialty hierarchy. The incidence of each physician specialty in Kansas is recorded. Each specialty is ranked and given a numerical value based on the frequency of occurrence within the state. (Appendix B.) For example, the most fre-

Table 1.

Logical Break Point for Non-Metropolitan Secondary Hospitals

Community	Number of Specialties
Arkansas City	6
Atchison	6
El Dorado	6
Winfield	7
Fort Scott	7
Liberal	7
Concordia	8
Coffeyville	10
Dodge City	10
Garden City	10
Emporia	11
Leavenworth	11
Newton	12
Pittsburg	12
Great Bend	13
Hays	14
Manhattan	14
Halstead	14
Hutchinson	16
Lawrence	17
Salina	17

Source: Compiled from Kansas Medical Society Journal, August, 1977.

quently occurring specialty is Family Practice. Thus, it is given a value of 1. Internal Medicine is the second most common specialty found within the state, therefore, it is given a numerical value of 2. This process is repeated until every specialty in Kansas is accounted for. According to the Kansas Medical Society Journal, August, 1977, there are 58 physician specialties which are recognized by the American Medical Association. Of these 58 specialties 49 are found in Kansas. The specialties which are not present in Kansas are not counted in any manner.

An index of this type aides in the identification of higher level hospitals. If Christallers' Central Place Theory is applied to the distribution of medical services, it can be assumed that the higher order specialties occur less frequently and are more widely dispersed than lower order specialties, thus, creating a hierarchy of hospitals. The higher level hospitals have a greater number of physician specialties than the lower order hospitals.

Once the specialties are ranked and a numerical value is assigned to each specialty, the sum of the values for each physician specialty in each community can be determined. (See Table 2.) The totals for each community are found to strongly support the arguement to terminate the lower end of the non-metropolitan secondary hospitals at 10 specialties while leaving the high end at 17. For example, the point totals for cities with 10 or more physician specialties range from 66 to 170 points, while those communities which possess 8 physician specialties

Table 2.

Sum of the Values For Physician Specialties and Logical Break Points

Community	Number of Specialties	Total Points
Arkansas City	6	41
Atchison	6	27
El Dorado	6	44
Winfield	7	42
Fort Scott	7	57
Liberal	7	40
Concordia	8	48
Coffeyville	10	66
Dodge City	10	70
Garden City	10	102
Emporia	11	70
Leavenworth	11	69
Newton	12	98
Pittsburg	12	126
Great Bend	13	100
Hays	14	139
Manhattan	14	115
Halstead	14	174
Hutchinson	16	155
Lawrence	17	170
Salina	17	169

Source: Compiled from Kansas Medical Society Journal, August, 1977.

or less have a point total of 57 or less. However, the gap in the point totals between 8 and 10 specialties would be greater were it not for Fort Scott. Fort Scott possesses only 7 physician specialties yet its point total is 57. The cities of Winfield and Liberal also have 7 physician specialties, however, their point totals are significantly lower than Fort Scott's (42 and 40 respectively). If Fort Scott is treated as a unique entity, the lower point range would be 27 - 48.

As a result of comparing the number of physician specialties in each community with the point value of the specialties, those communities possessing 10 - 17 physician specialties are significantly different in the number of services offered and the scope in which they function to set them apart from those offering 8 or less physician specialties.

As a result of the number of physician specialties in each community and their point totals, the following cities are designated as secondary communities: Coffeyville, Dodge City, Emporia, Garden City, Great Bend, Halstead, Hays, Hutchinson, Lawrence, Leavenworth, Manhattan, Newton, Pittsburg, and Salina.

Most of the secondary hospitals and nodes are clustered in the central part of the state, while two are in the south-western part of the state, two are in the northeast portion of the state, and two are located in the southeast section of the state. (Figure 1.)

Now that the secondary hospitals and nodes have been identified, their trade areas can be mapped.

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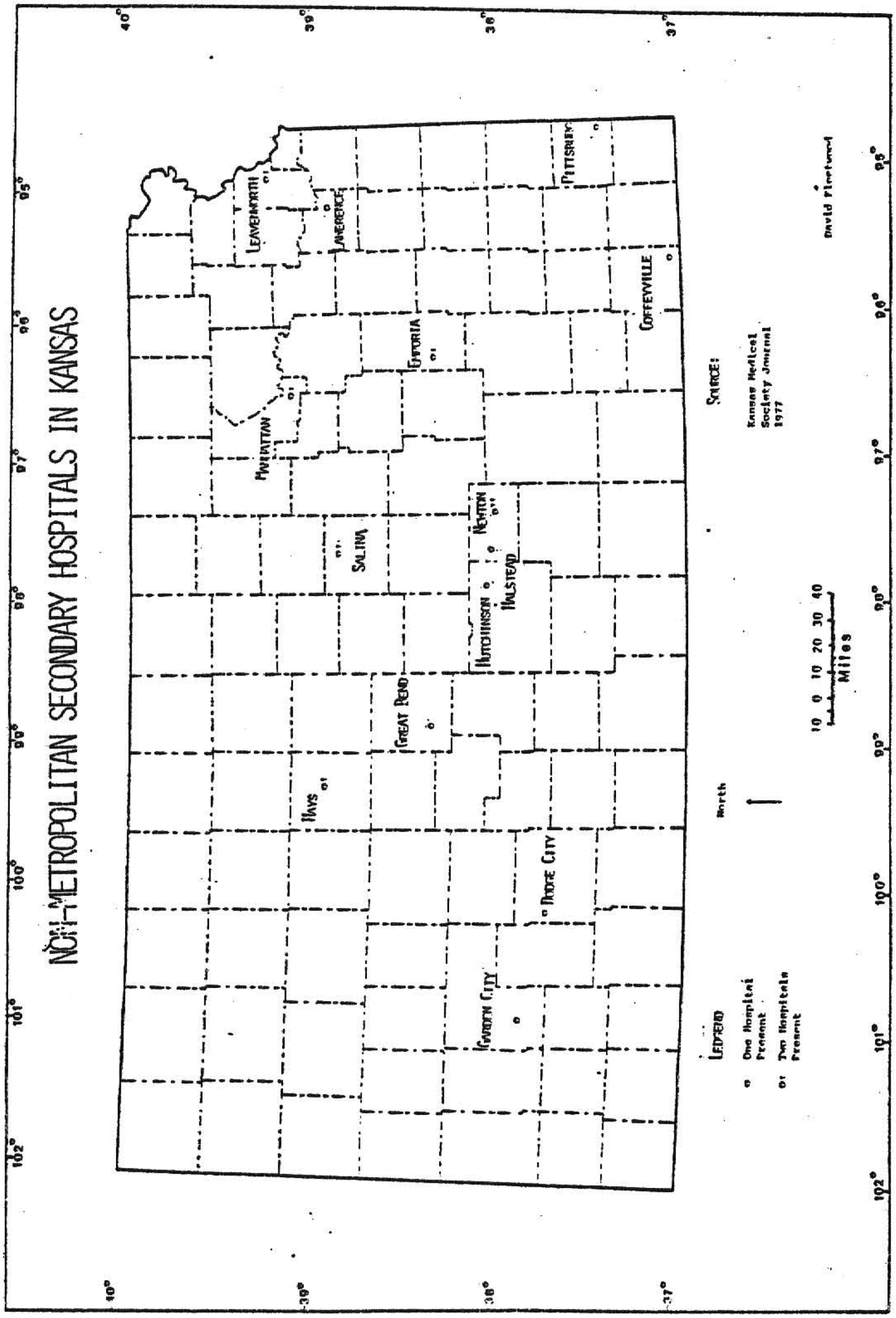
Figure 1.


NON-METROPOLITAN SECONDARY HOSPITALS IN KANSAS
LEAVENWORTH
LAWRENCE
PITTSBURG
COFFEYVILLE
EMPORIA
MANHATTAN
SALINA
NEWTON
HALSTEAD
HUTCHINSON
GREAT BEND
HAYS
DODGE CITY
GARDEN CITY
SOURCE:
Kansas Medical Society Journal 1977
10 0 10 20 30 40
Miles
North
LEGEND
One Hospital Present
Two Hospitals Present
David Fleetwood

MAPPING TRADE AREAS

The patient origin data this study uses to map the trade areas of the secondary hospitals was obtained from the Kansas Bureau of Health Planning. This data is a matrix of patient origins to each hospital for each county and hospital in the state. The data reflects both the total number of patients in each county served by a hospital as well as the percentage of the county population that each hospital serves. The percent of the county population served by each hospital provides a more accurate representation of the true trade areas than the raw numbers, because of population differences in Kansas counties. Therefore, this study uses the percentage data that is available. The 1977 patient origin data is compiled for all of the hospitals except Dodge City, in which case 1977 data does not exist. Therefore, 1976 data is used in place of 1977 data for Dodge City, as it is the most recent data available.

The trade areas of the secondary hospitals and nodes are mapped based on the patient origin data for each hospital. In communities with more than one hospital the data for the hospitals is aggregated in order to provide data for the community as a whole. Since this study is eliminating hospitals within metropolitan areas it is also eliminating patient origin data concerning counties within metropolitan areas. Although there is a possibility that a county within a Standard Metropolitan Statistical Area could fall into a non-metropolitan hospital's trade area, this study assumes that the majority of the people living in these counties will usually patronize the hospitals in their metropolitan area because they are larger in both scope and size, thus they probalby offer all of the services that are offered in non-metropolitan hospitals as well as many higher level services which are not. Therefore, there is little risk of not representing the non-metropolitan secondary trade areas accurately.

It is first necessary to determine what percentage of a county the secondary hospital and nodes should serve before that county can be considered as part of the hospital or nodes trade area. First the percentage of each county patronizing each of the 14 secondary hospitals or nodes is recorded. After aggregating the data it was found that of the more than 460,000 inpatients (those patients which are admitted to hospitals) served by Kansas hospitals in 1977, twenty one percent were served by the 14 non-metropolitan secondary hospitals and nodes. That is, less than ten percent of the Kansas hospitals were serving more than twenty percent of the patients.

Because of the large percentage of Kansas patients served by the secondary hospitals and nodes, the counties in which ten percent or more of their patients are served by these 14 hospitals and nodes are considered as counties which could be classified as within secondary trade areas. Everyone does not require secondary services. Given, many patients do not require secondary services as many lower level services can be obtained at smaller local hospitals closer to the patients' residence, ten percent is significant percentage of a country's patients and can be used as the threshold for identifying the foundaries of each secondary trade area.

Thus, the criteria for identifying the secondary trade areas is two fold. First, ten percent or more of a county must be served by secondary hospitals or nodes. Second, the secondary hospital or node that serves the greatest portion of the patients in a county is designated as the secondary hospital or node for the county in question. For example, forty six percent of Rook county is served by secondary hospitals or nodes. However, Hays serves forty two percent of the total patients in Rook county, and ninety one percent of the total patients in Rook county, and ninety one percent of the forty six percent that are served by secondary hospitals and nodes. Only nine percent of the secondary trade utilizes other secondary hospitals and nodes. Therefore, Rook county is placed in the Hays trade area.

In sixty six counties at least ten percent of the residents patronize at least one of the secondary hospitals or nodes. However, in four counties, specifically Clark, McPherson, Pratt and Rush counties, this technique fails to place these counties in a specific trade area, as no one county dominates the secondary trade. In Clark county over forty two percent of the secondary trade is served by Dodge City, while over fifty percent is served by Manhattan. Thus, Clark county is included in both the Dodge City and Manhattan trade areas.

In McPherson county competition for the hospital trade is even more intense. Of the patients seeking secondary level care over twenty six percent seek health care in Newton, twenty seven percent in Halstead, nineteen percent in Hutchinson, and almost twenty seven percent in Salina. There is not a dominate secondary community that serves McPherson county, therefore, McPherson county is considered a part of all four trade areas.

In Pratt county forty four percenty of the secondary trade is served by Halstead, while thirty five percent of the trade is taken care of by Hutchinson. Due to the fact that these two cities are in close proximity to each other and neither one commands a clear majority of the Pratt county secondary trade, it is placed in both communities' trade areas.

The situation in Rush county is similar in nature to that of the other three counties. There is no one dominate secondary hospital or node; Hays serves forty eight percent of the secondary trade while Great Bend serves fifty one percent. Therefore, Rush county is considered a part of both Hays and Great Bend trade areas. (See Appendix C.)

The 14 secondary hospitals and nodes form an important segment of the Kansas health care delivery system. "Not only do they serve twenty one percent of the patients in Kansas, but of the 2,346,578 residents of Kansas (1970) 944,999 live within the counties which comprise the secondary hospitals' trade areas."[2] Therefore, forty two percent of the people of Kansas are served by the 14 non-metropolitan secondary hospitals and nodes.

The secondary hospitlas and nodes are not only important to non-metropolitan Kansas, but to metropolitan Kansas as well. The non-metropolitan secondary hospitals and nodes case the patient load in the metropolitan hospitals by providing higher level services to people who would otherwise seek health care in the metropolitan areas.

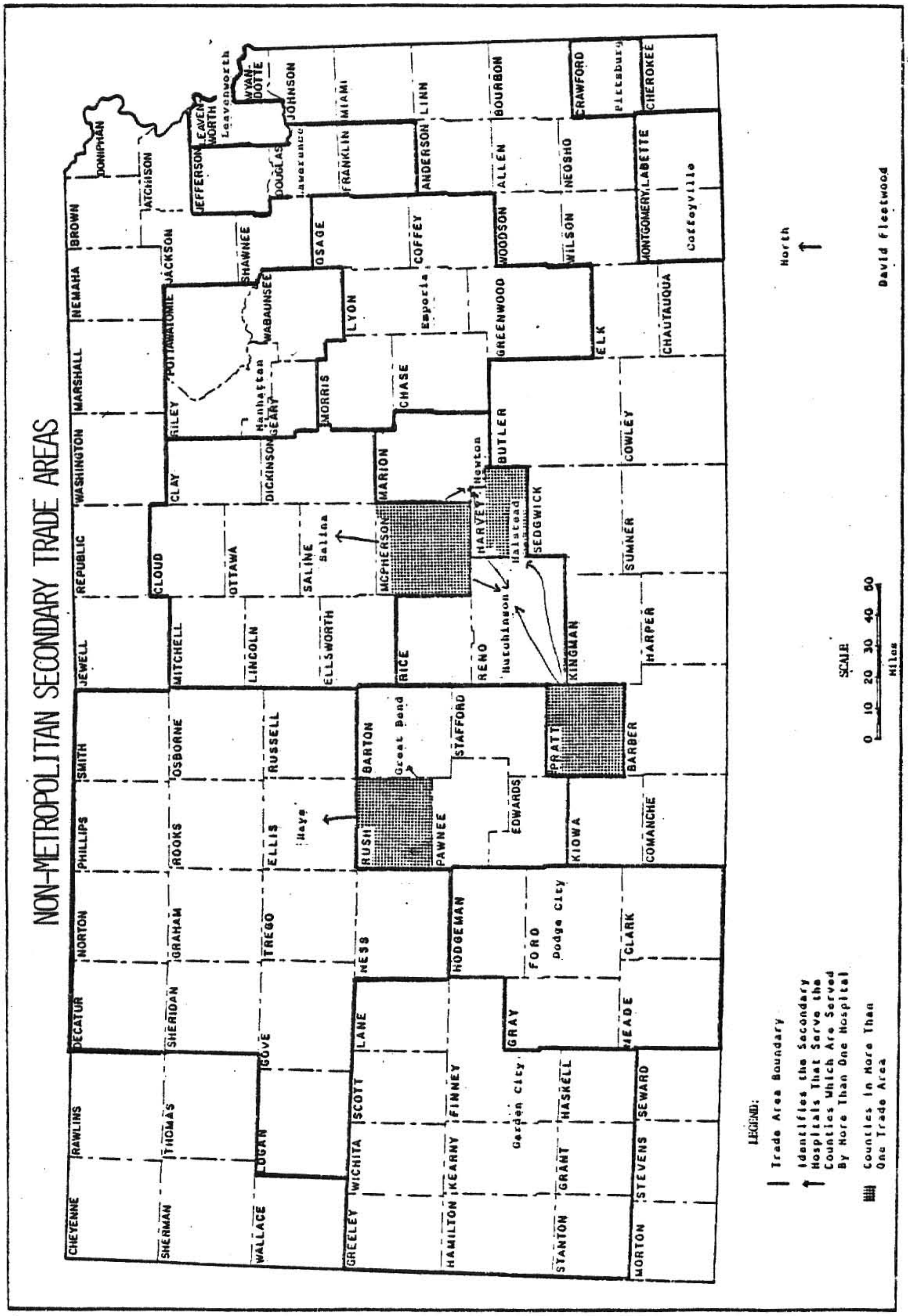
CHARACTERISTICS OF TRADE AREAS

The secondary trade areas vary markedly across the state. The trade areas in the east appear to be quite small when compared to the trade areas of the western part of the state. In the central portion of the state the trade areas are somewhat larger in both areas and the number of counties within the trade areas than those in eastern Kansas. In the western portion of the state the trade areas are quite large in both areas and the number of counties that comprise the trade areas. This can be attributed to a greater population density in the eastern part of the state which drops markedly with increased longitude.

Christaller's, Central Place Theory aids in explaining this phenomena when it is applied to the location of hospitals. Christaller says that a certain population threshold is necessary for each service. Low order services require low population thresholds, while high population thresholds are required for high level services.

Furthermore, the higher level services tend to locate in the same place, as few areas meet their minimum threshold. Thus, the high population density of eastern Kansas meets the minimum thresholds for ithe secondary services much easier than the sparse population of western Kansas. Therefore, the trade areas in eastern Kansas are small but numerous. How-

Figure 2


NON-METROPOLITAN SECONDARY TRADE AREAS
CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
POTTAWATOMIE
JACKSON
ATCHISON
JEFFERSON
LEAVENWORTH
Leavenworth
WYANDOTTE
JOHNSON
WALLACE
LOGAN
GOVE
TREGO
ELLIS
Hays
RUSSELL
LINCOLN
OTTAWA
DICKINSON
GEARY
Manhattan
WABAUNSEE
SHAWNEE
DOUGLAS
Lawrence
MIAMI
FRANKLIN
OSAGE
LYON
Emporia
MORRIS
SALINE
Salina
ELLSWORTH
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
Great Bend
RICE
MCPHERSON
MARION
CHASE
COFFEY
ANDERSON
LINN
HAMILTON
KEARNY
FINNEY
Garden City
HODGEMAN
PAWNEE
STAFFORD
RENO
Hutchinson
HARVEY
Newton
Halstead
BUTLER
GREENWOOD
WOODSON
ALLEN
BOURBON
STANTON
GRANT
HASKELL
GRAY
FORD
Dodge City
EDWARDS
PRATT
KINGMAN
SEDGWICK
ELK
WILSON
NEOSHO
CRAWFORD
Pittsburg
MORTON
STEVENS
SEWARD
MEADE
CLARK
COMANCHE
KIOWA
BARBER
HARPER
SUMNER
COWLEY
CHAUTAUQUA
MONTGOMERY
Coffeyville
LABETTE
CHEROKEE
LEGEND:
Trade Area Boundary
Identifies the Secondary Hospitals That Serve the Counties Which Are Served By More Than One Hospital
Counties in More Than One Trade Area
SCALE
0 10 20 30 40 50
Miles
North
David Fleetwood

ever, in western Kansas the population density is comparatively sparse. Thus, a larger trade area is necessary in order to provide a minimum threshold for the secondary services. Furthermore, the secondary hospitals and nodes of western Kansas are farther apart than their eastern peers. "For example, there are only four secondary hospitals and nodes in western Kansas (Dodge City, Garden City, Great Bend and Hays), and they serve only 269,385 patients. However, the four secondary hospitals and nodes of central Kansas (Newton, Hutchinson, Halstead and Salina) serve 348,352 patients, which is an additional 78,967. The secondary hospitals and nodes of eastern Kansas serve the largest number of potential patients, 419,665, however, the trade areas of eastern Kansas are among the smallest of the secondary hospitals."[3] (Figure 2.) In addition, the secondary hospitals and nodes of eastern Kansas are not as widely distributed as those of western Kansas. This is due to the presence of more large hospitals which are present because of the larger number of people living in this section of the state.

In general, the number of people served by secondary hospitals decreases westward, although the size of their trade areas increases. This phenomena is attributed to the decrease in population density with increased longitude.

FOOTNOTES

1. *Kansas Medical Society Journal*, August, 1977.

2. Kansas Bureau of Health Planning, *1977 Patient Origin Data*, (unpublished).

3. Ibid.

Chapter 3

ESTIMATING THE OPTIMAL LOCATION

DEFINING AN OPTIMAL LOCATION

Now that the secondary hospitals, secondary nodes, and their trade areas have been identified it is now possible to estimate the optimal location for each secondary hospital and node within its trade area. This is desirable because it can aid planners in making decisions concerning the distribution of new services and facilities by illustrating the efficiency of service based on the location and distribution of current hospitals relative to those served by each hospital.

The purpose of this chapter is to identify the optimal location of the secondary hospitals within their trade areas. The optimal location of the secondary hospitals and nodes is defined as the mean center of the trade area population. "The mean center is the point within the trade area which minimizes the sum of the squared distance to all people within the trade area."[1]

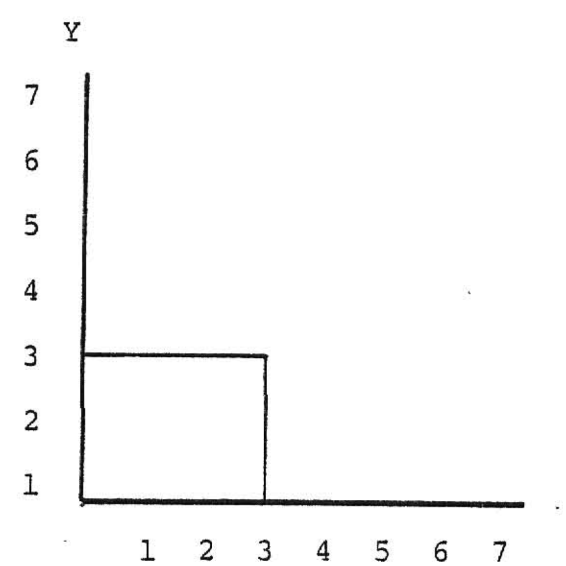
The county subdivisions, as defined by the, "General Population Characteristics - Kansas", 1970 Census of Population, and their population are used to estimate the mean center of the trade areas. In order to identify the mean center it is necessary to construct a grid overlay with an X and a Y axis (see Appendix A). "Using a map of Kansas with minor civil divisions and townships, the Y axis of the grid overlay is placed directly over the western boundary of each individual trade area and the X axis is placed directly over the southern boundary of each trade area."[2] Once the X and Y axes are established it is possible to establish the mean center.

CENTROIDS WITHIN THE TRADE AREAS

This study assumes that the geographic center of population for each county subdivision is the population center of that subdivision. When a grid overlay is placed over the map it is possible to assign an X and Y value to the centroid. The value of the X tier on the grid overlay which most accurately represents the position of the centroid is given as the X value. The value of the Y tier which most accurately represents the position of the centroid is given as the Y value. (See Figure 1.)

Figure 3.

County Centroid Values



The X value of the centroïd is 3 and the Y value of the centoid is 3. Thus, X = 3, Y = 3.

The tiers on the grid overlay are 1/2 inch wide, representing three files on the map of Minor Civil Divisions and Townships of Kansas. When the procedure in Figure 3 is repeated for each county subdivisions the following formula can be used to estimate the mean center:

$$CX = \frac{\sum X_i \ w_i}{W} \qquad CY = \frac{\sum Y_i \ w_i}{W}$$

(CX, CY) = the mean coordinate.

X_i = the location of the population centroid for each county subdivision within the trade area in relationship to the X axis.

w_i = the 1970 population of each county subdivision.

Y_i = the location of the centroid for each county subdivision within the trade area in relationship to the Y axis.

W = the 1970 population of the entire trade area in question.

MARGIN OF ERROR

When using the technique of estimating the mean center to identify the optimal location, a certain amount of error is possible depending upon the width of the tiers on the grid overlay. Hart says the mean center of a phenomena can be one half of a tier off from the true mean center and still represent the mean center accurately. However, as the tier width increases the possibility of error also increases. For example, a grid overlay possessing a tier width of one half inch would be more accurate than one possessing a tier width of one inch, because the mean center may vary only one half of a tier width. Thus, a tier width of one inch may vary one half inch and yet remain statistically accurate. However, a tier width of one half inch may vary only one fourth of an inch before it is no longer statistically accurate. Therefore, a small tier width is more desireable than a large tier width when attempting to accurately estimate the mean center of any phenomena. As this study uses a grid overlay with one half inch tiers, (representing three miles) the mean center may deviate by a maximum of $\pm$ 1 1/2 miles in any direction from the approximate mean center.

In addition, as the number of subdivisions increases the chance for error in locating the mean center decreases. The larger number of subdivisions more accurately represents the location of patient residence than a small number of subdivisions. This study made use of 1,213 county subdivisions in estimating the mean center for the 14 non-metropolitan secondary hospitlas. (See Table 3.)

However, the accuracy of this method becomes suspect if the counties are not contiguous because the distance between the non-contiguous counties and the contiguous counties distorts the location of the mean center. Furthermore, the greater the distance between the non-contiguous counties, the larger the error will be. Therefore, this method of determining the optimal location is most accurate when the counties are contiguous.

Table 3.

Number of County Subdivisions in Each Trade Area

Trade Area	Number of County Subdivisions
Coffeyville	34
Dodge City	50
Emporia	88
Garden City	61
Great Bend	86
Halstead	47
Hays	261
Hutchinson	105
Lawrence	39
Leavenwroth	11
Manhattan	61
Newton	71
Pittsburg	13
Salina	291

Source: Compiled from "General Population Characteristics - Kansas", 1970 Census of Population.

DESCRIPTION OF THE OPTIMAL LOCATIONS

Once the mean center for each trade area is identified it is possible to identify the hospitals and nodes which are otpimally located and those which are not. However, one important question remains. At what point does a hospital case to be optimally located? This study modifies Hart's method of identifying the mean center somewhat in order to accurately represent the operational optimal location of the secondary hospitals and nodes. For example, when the mean center is not located in any community, but is located in a field some distance from any settlement instead, it is necessary to compensate

Figure 4

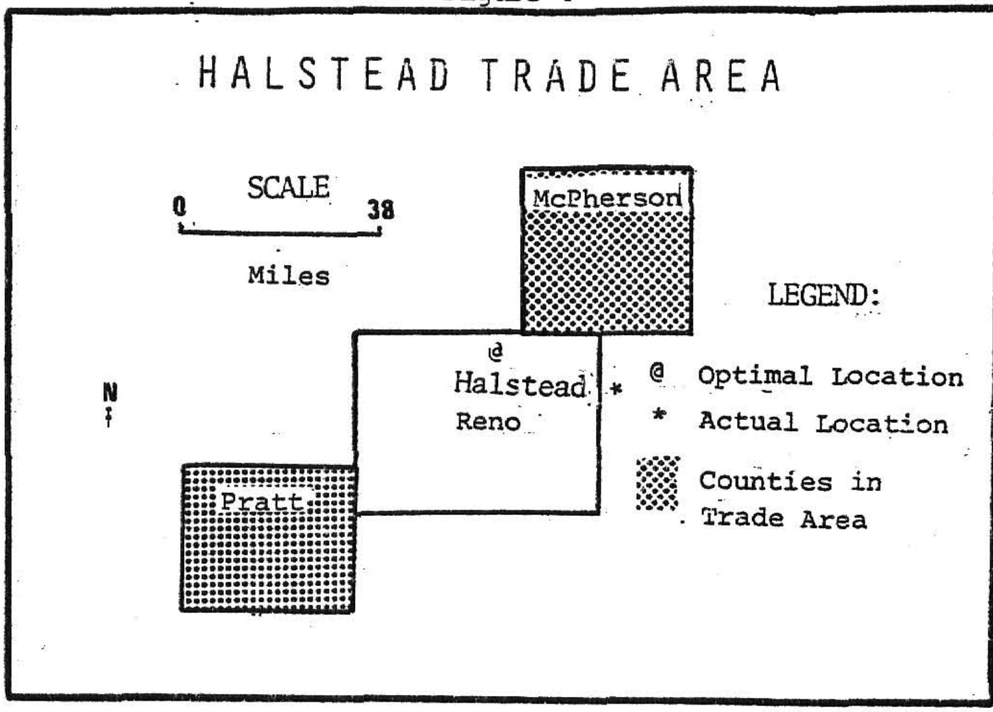


Figure 5

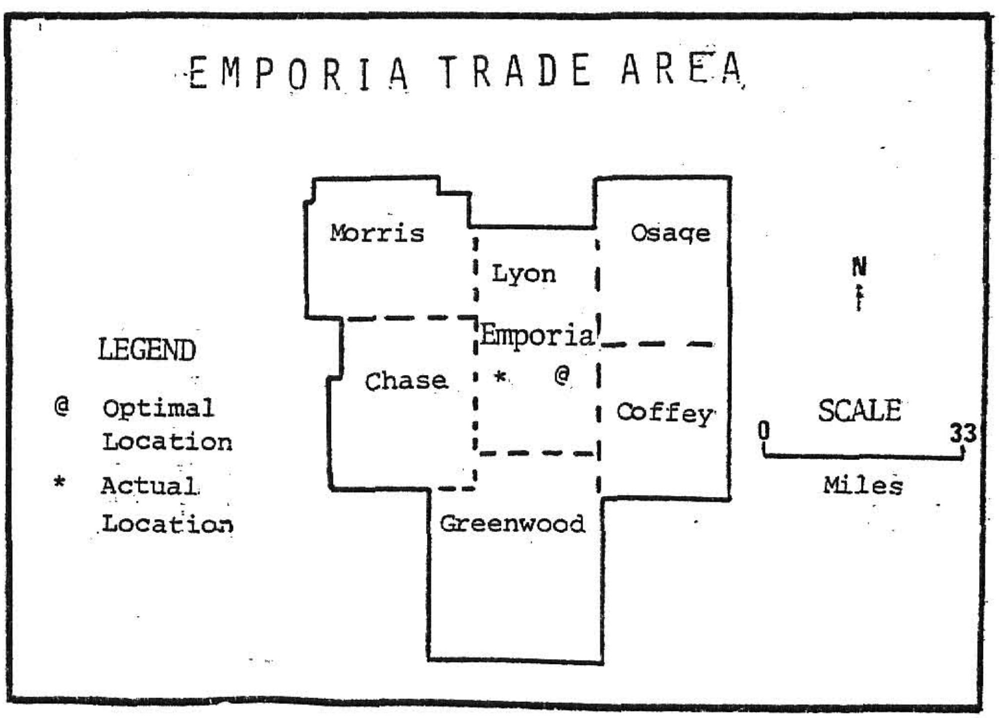


Figure 6

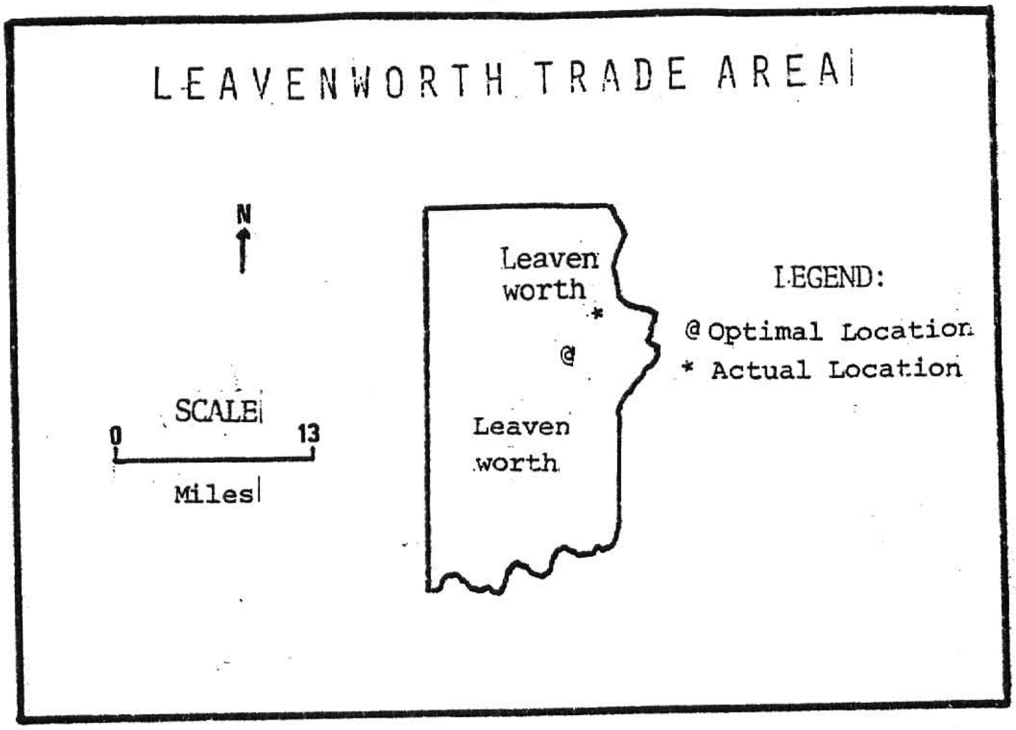


Figure 7

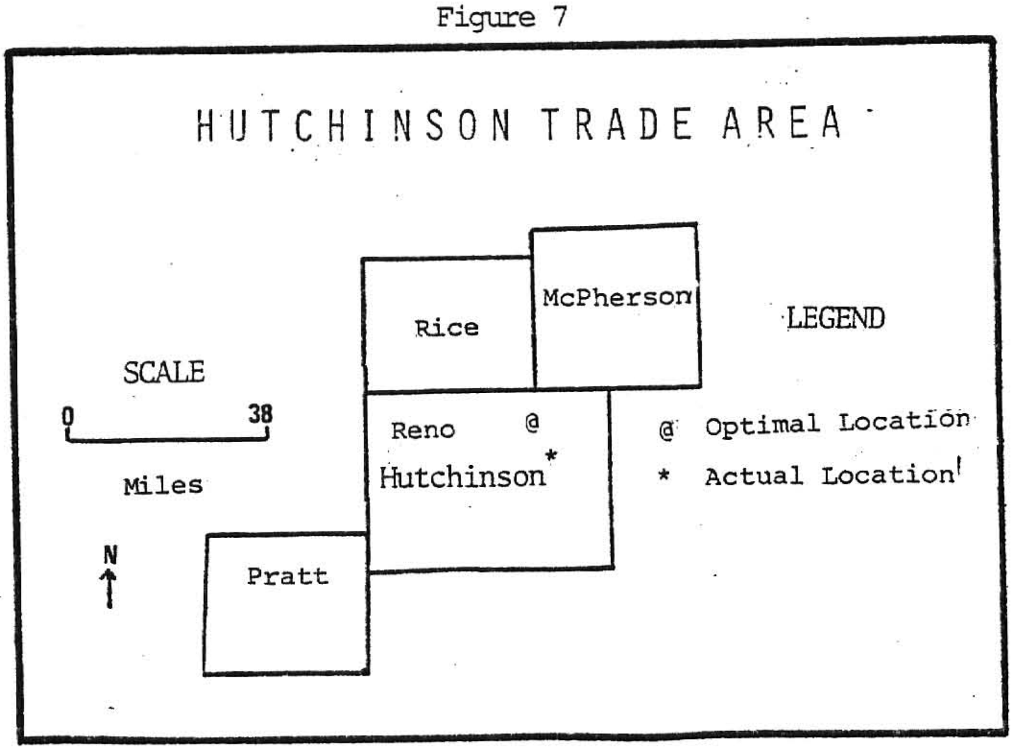


Figure 8

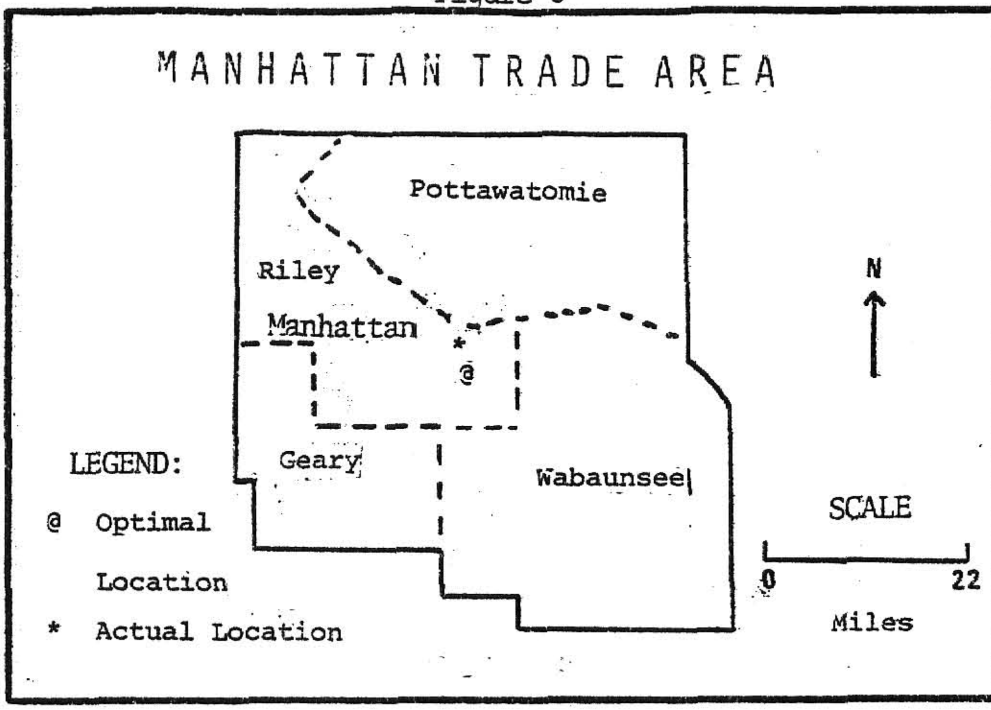


Figure 9

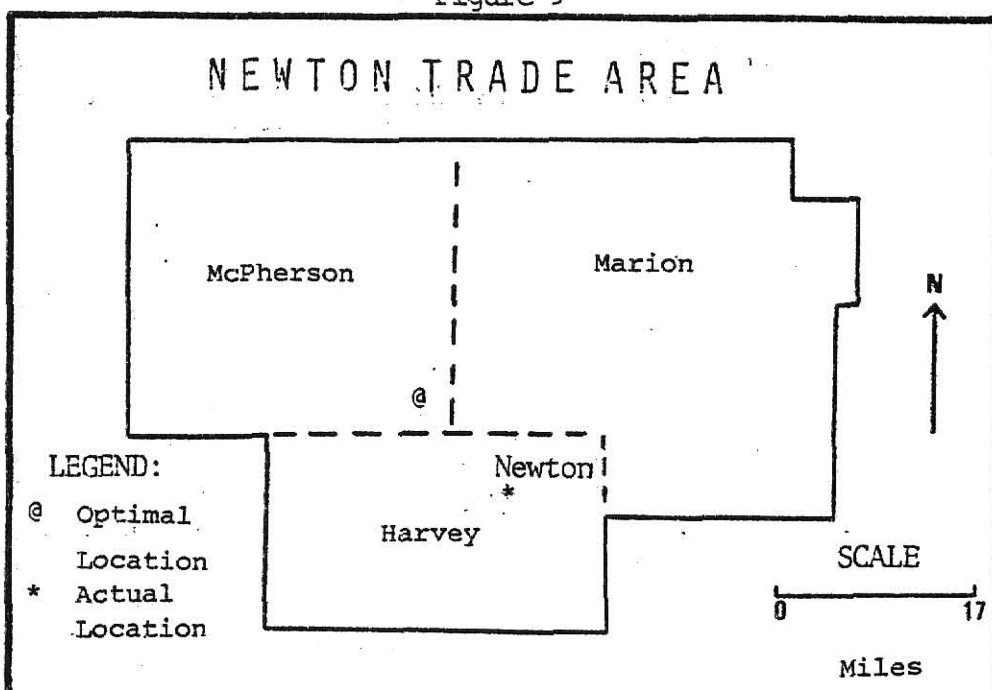


Figure 10

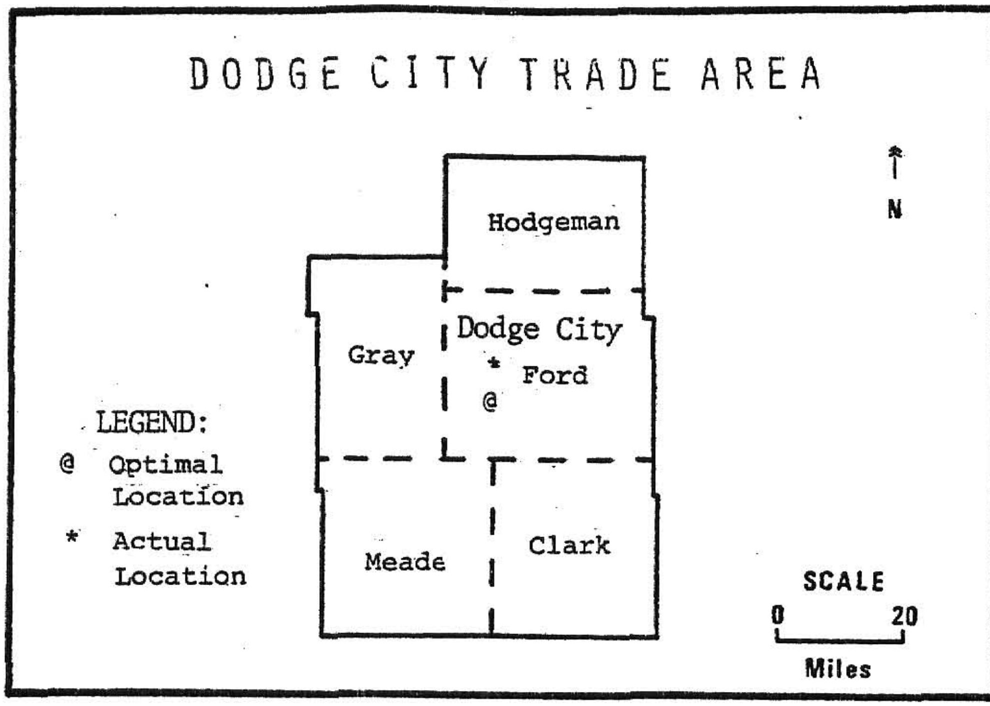


Figure 11

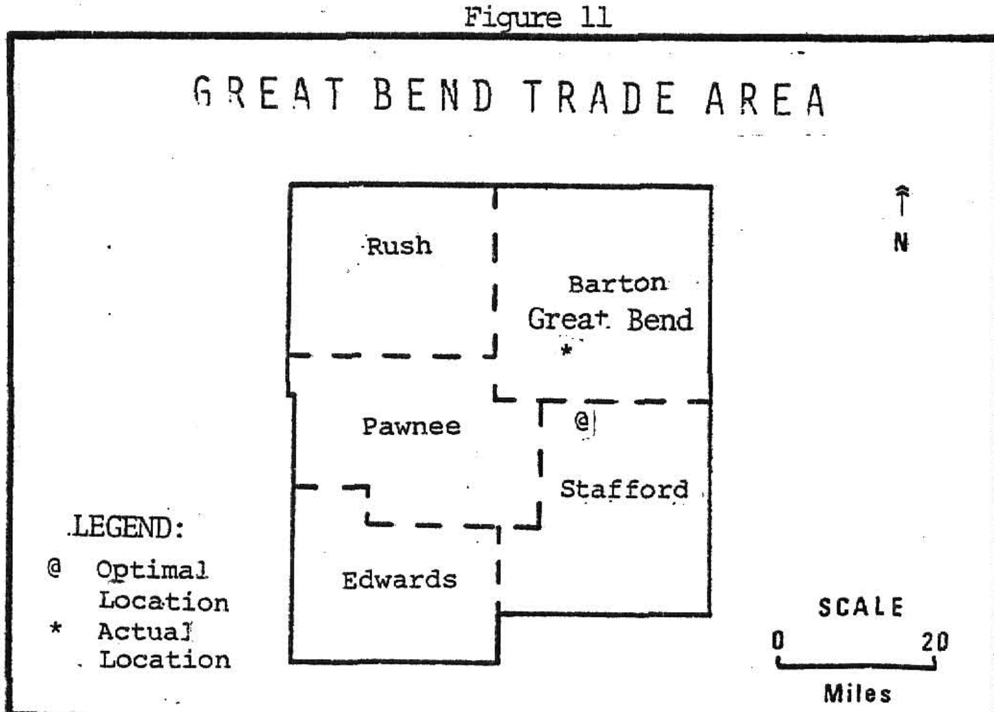


Figure 12

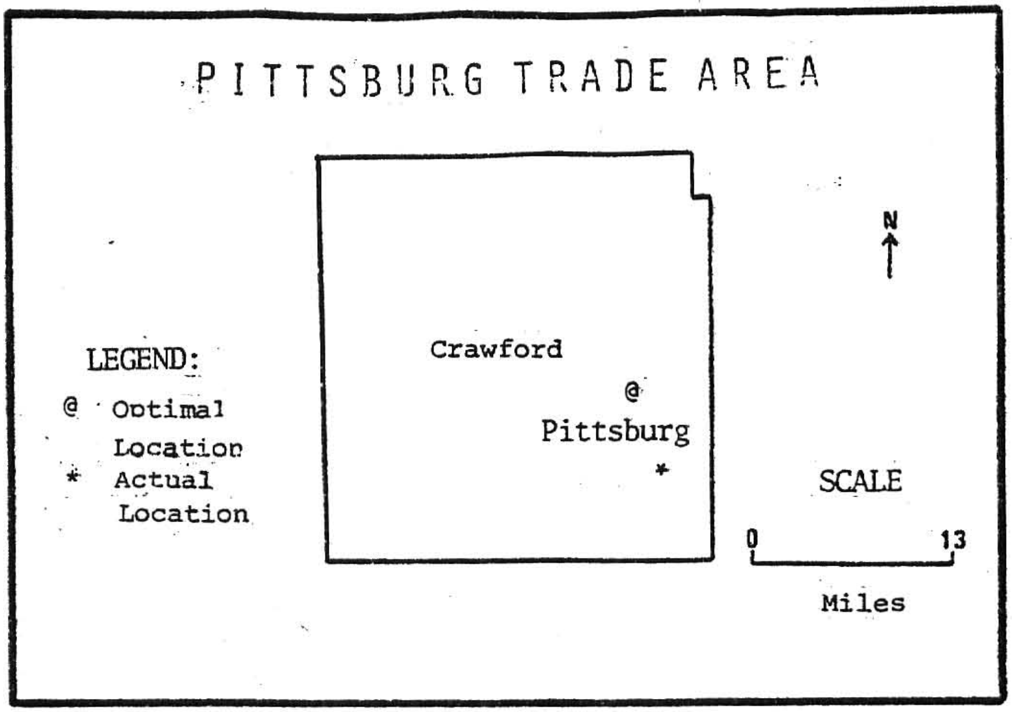


Figure 13

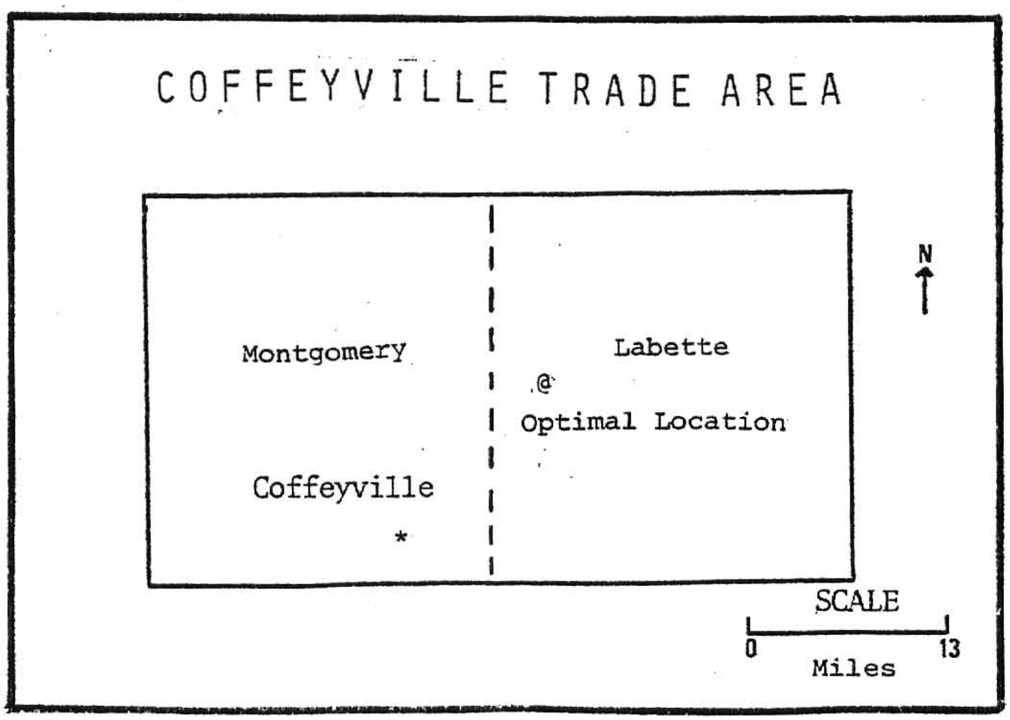


Figure 14

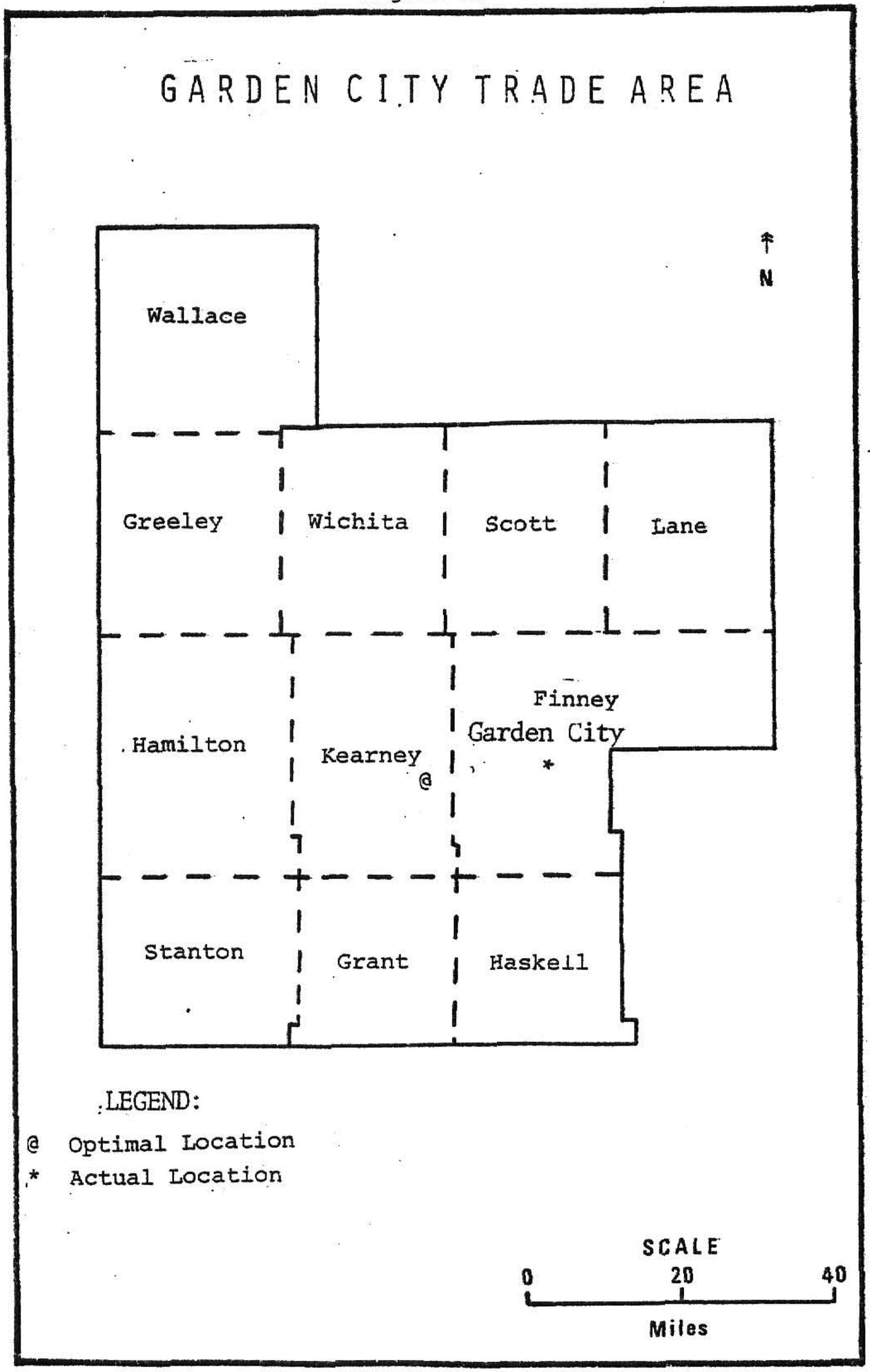

GARDEN CITY TRADE AREA
N
Wallace
Greeley
Wichita
Scott
Lane
Hamilton
Kearney
Finney
Garden City
Stanton
Grant
Haskell
LEGEND:
@ Optimal Location
* Actual Location
SCALE
0
20
40
Miles

Figure 15

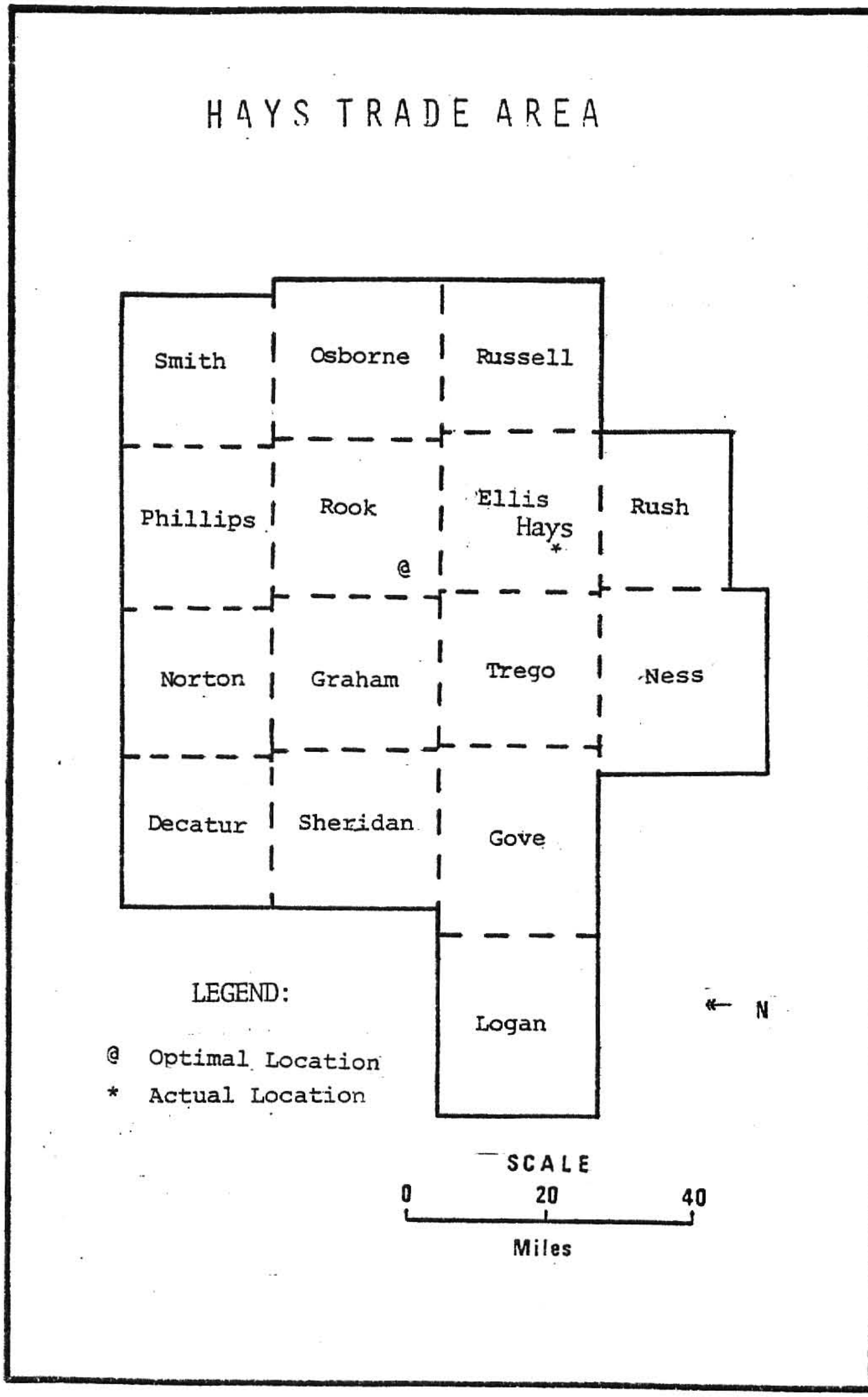

HAYS TRADE AREA
Smith
Osborne
Russell
Phillips
Rook
Ellis
Hays
Rush
Norton
Graham
Trego
Ness
Decatur
Sheridan
Gove
Logan
LEGEND:
@ Optimal Location
* Actual Location
N
SCALE
0
20
40
Miles

Figure 16

SALINA TRADE AREA

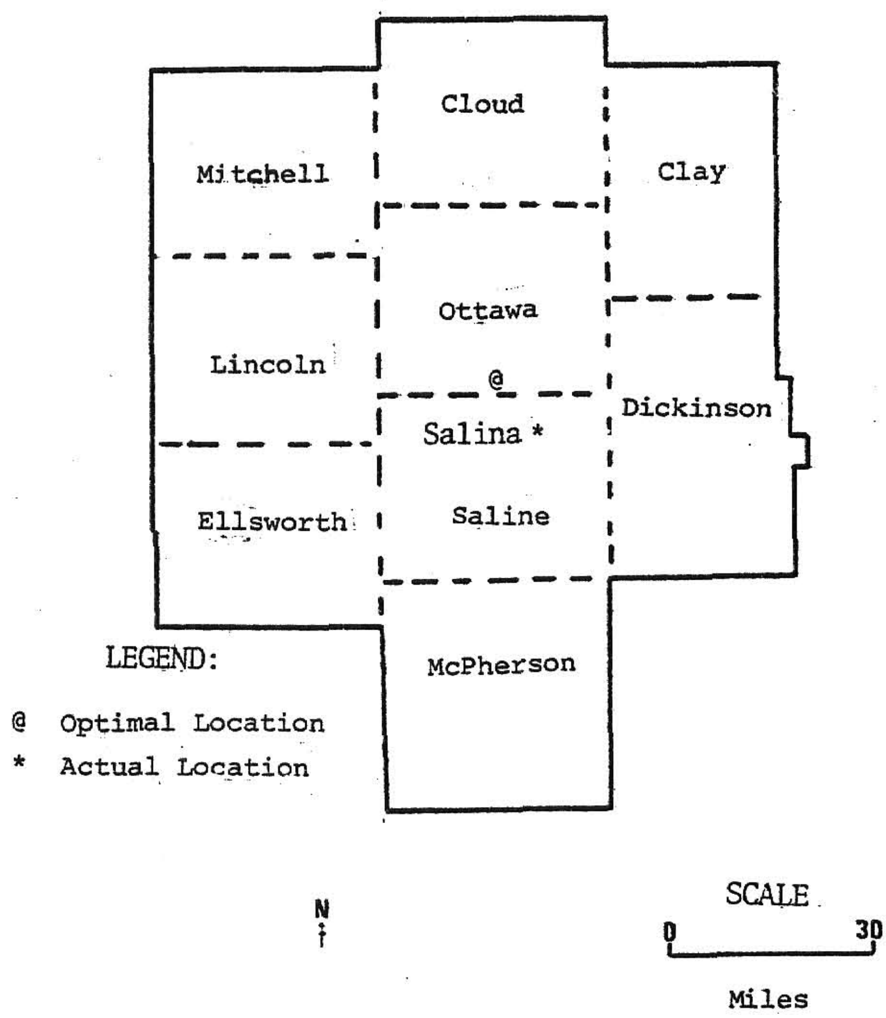
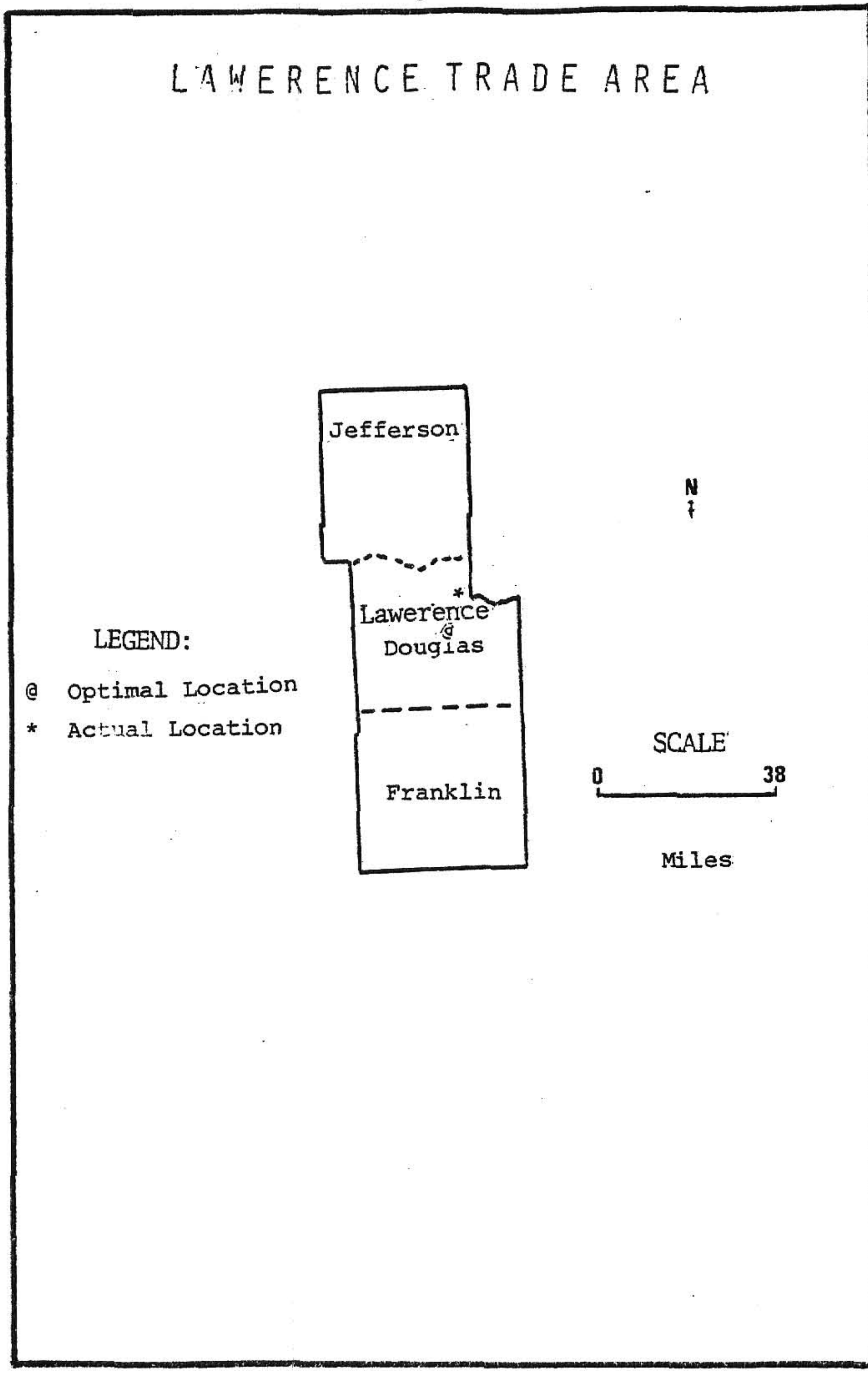


Figure 17


LAWERENCE TRADE AREA
Jefferson
N
Lawerence
Douglas
Franklin
LEGEND:
@ Optimal Location
* Actual Location
SCALE
0
38
Miles

for this variation. If the secondary hospital or node in question is located in the settlement closest to the mean center the hospital or node will be considered optimally located. It is impractical to build a hospital in a field some distance away from any of the populous and then supply that hospital with utilities, transporation routes, and other items essential to its operation. Furthermore, the hospital would not serve any of the populous well because everyone would have to travel some distance to reach it. However, if the secondary hospital or node is located in a settlement the problems concerning the utilities and transportation routes would be greatly reduced, and the problem would be eliminated for at least some of the populous. Therefore, if the secondary hospital or node is found to be located in the settlement nearest the mean center it is considered optimally located.

None of the 14 secondary hospitals or nodes are located at the exact mean center. This can be partially attributed to the fact that in 13 of 14 cases, the mean center is located in a field within the hospital's trade area. The Halstead trade area possesses the one mean center that is in a community.

Using the preceding criteria, 8 of the 14 secondary hospitals and nodes are optimally located. (Table 4.)

NON-CONTIGUOUS TRADE AREAS

There are two secondary trade areas that are not contiguous. They are Halstead and Manhattan. Manhattan is found to be unique among the secondary hospitals and nodes. It is optimally located within its trade area when on the contiguous

Table 4.

Optimally and Sub-Optimally Located Secondary Hospitals and Nodes

Optimally Located Hospitals and Nodes	Sub-Optimally Located Hospitals and Nodes	Distance from the optimal Location to The Actual Location
Dodge City	Coffeyville	17 Miles
Emporia	Garden City	13 Miles
Hutchinson	Great Bend	11 Miles
Lawrence	Hays	27 Miles
Leavenworth	Halstead	33 Miles
Manhattan	Newton	16 Miles
Pittsburg		
Salina		

counties within its trade area are used in the formula to test for the mean center. However, Clark county which is in extreme southwest Kansas is a part of the Manhattan trade area, as fifty percent of the Clark county secondary trade patronizes Manhattan. The patients from Clark county are not served by both Manhattan hospitals, but rather they are treated only at St. Mary Hospital. Given the close proximity of Clark county to Dodge City (which shares Clark county with Manhattan, serving forty eight percent of the patients) and its extreme distance from Manhattan, it is assumed that the patients in Clark county patronize St. Mary for cultural reasons and not for reasons of practicality. Given the extreme distance between Clark county and Manhattan it is quite possible there is an error in the data set. However, efforts to prove this have been futile. If Dodge City cannot accommodate these people, Wichita would be a much more logical place to receive treatment than would Manhattan, as it possesses many more physician specialties, and is closer to Dodge City than Manhattan.

Furthermore, Clark county's distance from Manhattan artificially distorts the true mean center of the trade area substantially southwest of Manhattan. If the distorted mean center is treated as the optimal location, a hospital located at that location would fail to serve any portion of the trade area in an efficient manner. Therefore, Clark county is not included in testing for the mean center of the Manhattan trade area.

Given the information concerning the Manhattan trade area, Manhattan should be treated as optimally located, or at the very least as a special case, and not labeled as non-optimally located because of the unique circumstances involved in its trade area.

The Halstead trade area is also non-contiguous. There are only two counties in its trade area, McPherson county and Pratt county. They are less than fifty miles apart and separated by only one county (Reno county). However, Halstead is located in Harvey county, which is not in its trade area. This discrepancy can be attributed to the fact that patient origin data is available only by county, and the majority of Harvey county's patients utilize Newton instead of Halstead. Therefore, the optimal location for the trade area is figured using the two non-contiguous counties because of the distance between them is not great, thus, the deviation is minimal.

This study acknowledges that any solid conclusions concerning the Halstead trade area cannot be accepted without reservations. However, the fact that Halstead is not located in its own trade area supports the conclusion that it is sub-optimal in nature.

PATTERNS OF OPTIMALLY LOCATED SECONDARY HOSPITALS

Very distinct patterns emerge with respect to the distribution of optimally located secondary hospitals in Kansas. The secondary hospitals and nodes of eastern Kansas appear to be optimally located within their trade areas with the exception of Coffeyville. However, those hospitals and nodes located in central and western Kansas are not optimally located with the exceptions of Dodge City and Salina.

In addition, the size of the trade area appears to influence the efficiency of the secondary hospitals and nodes. The trade areas of eastern Kansas encompass less area than their western counterparts. This can be attributed in part to the greater population density in eastern Kansas. The greater the population of an area, the greater the need for higher level hospital services because of the increased number of people. Therefore, there is a greater need for facilities that provide these services. In eastern Kansas it appears that this demand has been met by providing several secondary hospitals and nodes in this region.

The situation in western Kansas varies markedly from that of eastern Kansas. The trade areas of western Kansas are sparsely populated, thus, there is not as large a demand for secondary services per unit area as there is in eastern Kansas.

Furthermore, there are fewer cities in which to locate a secondary hospital. In this situation a hospital may serve much of its trade area simply because there is no other hospital which provides higher level services within a reasonable distance. Thus, the trade area may be very large, but the secondary hospital or node may not be optimally located.

Table 5.

Population Density by Trade Area

Secondary Hospital or Node	Population	Area	Population Density
Coffeyville	65,742	1,282	51.27
Dodge City	27,573	4,785	7.85
Emporia	59,156	17,384	3.40
Hays	197,404	26,565	7.43
Halstead	34,834	1,625	21.44
Hutchinson	107,919	3,610	29.28
Garden City	52,282	8,837	5.92
Great Bend	54,788	3,785	14.48
Manhattan	107,947	3,566	30.27
Newton	103.799	2,979	4.84
Pittsburg	37,850	598	3.29
Salina	139,640	6,696	0.85
Lawrence	89,884	1,558	6.69
Leavenworth	53,340	466	4.46

Source: Figures taken from or compiled from, "General Population Characteristics - Kansas", 1970 Census of Population.

The hospitals and nodes of western Kansas are not found to be optimally located as often as their eastern peers. The following generalizations concerning optimal location of Kansas non-metropolitan secondary hospitals and nodes can be made:

1. The larger the trade area, the less likelihood that the hospital will be optimally located.

2. More densely populated trade areas are more likely to have hospitals or nodes that are optimally located.

3. The north-south location of a secondary hospital or node does not influence whether it is optimally located to the extent that its east-west location does.

4. Incidence of sub-optimal secondary hospitals and nodes increases westward.

FOOTNOTES

1. Hart, J.F., "Central Tendancy in Geographical Distributions", Economic Geography, Vol. 30, (1954), pp. 48-59, p. 48.

2. Map, "United States Department of Commerce", Minor Civil Divisions and Townships, May 14, 1940.

Chapter 4

COMPARING THE OPTIMAL AND ACTUAL LOCATIONS

The purpose of this chapter is to compare the distance the population must travel to the actual location of the non-optimally located hospitals with the distance the patients must travel to the estimated mean center of the trade area (the optimal location). The results of the comparison are then tested to determine if the difference between the optimal and actual locations are significant.

METHODS USED TO SHOW SIGNIFICANT DIFFERENCE

This study employs two methods for comparing the distance the patients in sub-optimal trade areas must travel to the actual location of the secondary hospitals or nodes with the distance they must travel to the actual location. The first method used identifies the standard distance of both the actual and optimal locations. The second method tests for a significant difference between the actual location of a hospital or node and its optimal location is the t Test.

Standard Distance

The standard distance measures the deviation of distances about the location in question in much the same manner as the standard deviation about the mean. Approximatley sixty eight percent of the population is located within one standard distance of the point in question if the population distribution is random.

The formula for the standard distance of both the actual and optimal location is as follows.

$$\frac{(CX - X_i)^2 + (CY - Y_i)^2}{N}$$

CX = the location of the hospital (either the actual or the optimal location) on the X axis of a grid overlay placed over a map.

X_i = the mean X coordinate reflecting the center of each county subdivision "(as recognized by the United States Census Bureau)"[1] within the trade area to the loation of the hospital (either the actual or optimal location).

CY = the location ofthe hospital (either the actual or the optimal location) on the Y axis of a grid overlay placed over a map.

Y_i = the coordinate reflecting the center of each county subdivision "(as recognized by the United States Census Bureau)"[2] within the trade area to the location of the hospital (either the actual or optimal location).

N = the total number of county subdivisions within the trade area.

Standard distance about actual location. The geographic distribution of secondary hospitals and nodes with large and small standard distances about the actual location is similar in many ways to the distribution of the secondary hospitals and nodes with large and small trade areas, i.e., the large trade areas are generally located in western Kansas. The large trade areas are more likely to possess a large standard distance than the small trade areas because of the larger area that they encompass and the low population density of the western trade areas. A low population density in a large trade area requires a much larger radius about the hospital or node in order to encompass sixty eight percent of the populous (approximately one standard distance than would be necessary in a small densely populated trade area. Therefore, a large standard distance about an actual location is more likely in western Kansas than in eastern Kansas.

For example, Hays and Garden City, both located in western Kansas, possess large trade areas. In addition they both have a large standard distance about the actual location of the secondary hospital node, 45.94 and 41.35 miles respectively. However, Coffeyville, located in southeast Kansas, possesses a small trade area as well as a small standard distance about the actual location (24.61 miles).

As the trade areas of western Kansas are generally both larger and more sparsely populated than those of eastern Kansas, the standard distance of secondary hospitals and nodes in western Kansas are generally larger than those of eastern Kansas. However, there are instances where noticeable differences exist between the size of a trade area and its relationship to the size of the standard distance about the actual location of the secondary hospital or node.

A case in point where a noticeable difference exists between the size of a trade area and the size of the standard distance about the actual location of a secondary hospital or node is Great Bend. Although Great Bend is located in central

Kansas and possesses a fairly large trade area it possesses the smallest standard distance of the non-optimally located hospitals (18.69 miles). However, there are several secondary hospitals or nodes with smaller trade areas located east of Great Bend (Figure 2.). Of these hospitals and nodes Coffeyville and Newton possess a smaller standard distance (24,61 and 27.35 miles respectively).

In addition to Great Bend, Halstead, a secondary hospital whose trade area is not contiguous, also possess a noticeable difference in the relationship of trade area size and the size of the standard distance. Halstead possesses one of the smallest trade areas among the secondary hospitals and nodes, but the largest actual standard distance of the non-optimally located hospitals (46.84 miles). However, Halstead is west of several relatively small secondary trade areas, and east of several large secondary trade areas (see Figure 2.).

The generalization that the standard distance increases westward as does the trade area size is not applicable for Great Bend of Halstead. However, it must be noted that the Halstead standard distance may seem somewhat larger than it actually is due to distortion caused by the counties of the trade area not being contiguous.

<u>The standard distance about the optimal location</u>. It is possible to identify more definite geographic trends concerning the standard distance about the optimal location of the secondary hospitals and nodes than is possible concerning their actual locations. For example, Garden City and Hays in western

Kansas have large trade areas and the largest standard distances about their optimal location (33.42 and 33.40 miles respectively). Furthermore, Coffeyville in eastern Kansas possesses the smallest standard distance about an optimal location (10.88 miles). Great Bend and Newton in central Kansas have standard distances between the two extremes, 17.62 and 17.11 miles respectively. However, Halstead remains unique as it possesses a standard distance of 32.32 miles, which is large for its longitude.

With the exception of Halstead the standard distance about the mean center of the non-optimally located secondary hospitals and nodes increases westward across the state. As with the actual locations the larger and more sparsely populated the trade area the larger the standard distance of the optimal location. However, a more definite relationship exists between the size of the trade area and the standard distance of the optimal location as compared to that between the size of the trade area and the standard distance of the actual location. The only discrepancy in the pattern among the optimal locations is Halstead, and that discrepancy is questionable because the trade area is not contiguous. However, among the actual locations, Halstead is joined by Great Bend in deviating from the pattern.

In each trade area the standard distance of the optimal location is less than that of the actual location (see Table 6.).

Table 6.

A Comparison of the Actual and Optimal Standard Distances

Hospital	Actual Standard Distance	Optimal Standard Distance
Coffeyville	24.61 Miles	10.88 Miles
Halstead	46.84 Miles	32.32 Miles
Newton	27.25 Miles	17.11 Miles
Great Bend	18.69 Miles	17.62 Miles
Garden City	41.35 Miles	33.42 Miles
Hays	45.95 Miles	33.40 Miles

This is an expected result as the mean center of the trade area should minimize the distance the residents must travel to obtain medical services at the secondary hospital or node. Thus, there is a likelihood that the hospitals could be located in such a manner as to serve their respective populations in a more efficient manner. It is necessary to determine if the actual location differs significantly from the optimal location before a determination can be made as to whether the hospitals can be located in such a manner as to serve their populations in a more efficient manner.

TESTING FOR SIGNIFICANT DIFFERENCE

The second method this study uses in testing for a significant difference between the actual location of a hospital or node and its optimal location is the t Test. The t Test compares two different means to see if they are from the same population. The following is the formula for the t Test.

$$t = \frac{X_1 - X_2}{\sqrt{\frac{S_1}{N-1} - \frac{S_2}{N-1}}}$$

Assuming that the distance from the hospital to the centroid of a county subdivision is the average distance the population of a county must travel to the hospital, the above formula can be used to determine if the difference between the actual location and the optimal location is significant.

X_1 = The average distance to the actual location of the hospital for county subdivisions within a trade area.

X_2 = The average distance from the optimal location to each county subdivision within the trade area.

S_1 = The standard deviation of X_1.

S_2 = The standard deviation of X_2.

N = The number of centroids in the hospital's trade area.

With the aid of a t Table the results of this formula will make it possible to determine certain probabilities for t. For the purposes of this study it will aid in determining if the difference between the optimal location and the actual location is significant. "However, in order to use the table, it is necessary to know one constant in order to be able to define the t distribution exactly. This constant is called the Degrees of Freedom."[3] The degrees of freedom were calculated by subtracting one each from the total number of county subdivisions in the trade area for both the actual and optimal location of each secondary hospital and node in question ($N_1 + N_2 - 2$).

This study conducts the t Test at the ninety five percent confidence level. At this confident level a t score of greater than 1.645 is required to show a significant difference between the actual location and the optimal location of the hospitals and nodes.

Of the six sub-optimal hospitals three are located at points significantly different from their optimal location and three are not (see Table 7.).

Table 7.

Results of t Tests

Hospital	t Value	Significant (Yes or No)
Coffeyville	1.30	No
Halstead	4.79	Yes
Newton	2.43	Yes
Great Bend	1.57	No
Garden City	1.52	No
Hays	2.85	Yes

Of the three that possess an optimal location significantly different from their actual location, Halstead is questionable because its trade area is not contiguous. When the true optimal location is in doubt the findings concerning the trade area are also in doubt.

There does not seem to be a pattern concerning the geographic location of those hospitals which are located at significantly different points than the optimal location or those which are not located at significantly different points. Halstead and Newton are located in central Kansas while Hays is located in western Kansas. However, the distance the population must travel to the secondary hospitals or nodes actual trade area differs significantly from the optimal location in each instance. Furthermore, the distance the population must travel to the actual location does not differ significantly from the optimal location for Coffeyville; which is located in eastern Kansas, and Great Bend; which is located in central Kansas.

In addition there is no discernable pattern concerning trade area size and the hospitals which are located at significantly different locations than their optimal location. Furthermore, no pattern exists between trade area size and those hospitals or nodes which are not located at significantly different locations than their optimal location. For example, Hays, located in western Kansas, possess an extremely large trade area, and the difference its population must travel between the optimal location and the actual location is significant. However, Newton, located in central Kansas, possesses a small trade area, yet the different between its actual and optimal location is also significant.

Similar differences are also found among those secondary hospitals and nodes which are located at points not significantly different from their optimal location. Coffeyville which possesses a small trade area and is located in southeast Kansas, is in this group of hospitals, as is Garden City, which possess a substantially larger trade area in western Kansas. Thus, there does not seem to be a pattern concerning the location of secondary hospitals and nodes which are not located at a significantly different location than their optimal location in Kansas.

Thefollowing generalizations can be made when comparing the actual location of the secondary hospitals with their optimal location.

1. The large trade areas of western Kansas are more likely to possess a larger standard distance about both the acutal location and the optimal location.
2. The standard distance about the actual locations is larger than the standard distance about the optimal location, indicating that the hospitals could be more efficiently located (Table 6.).
3. When testing for a significant difference between the actual and optimal locations, three hospitals and nodes are found to differe significantly from their optimal locations. They are Halstead, Hays and Newton.
4. There does not seem to be a pattern concerning the location of the hospitals which are located at significantly different points from the optimal location or those which are not located at significantly points.

FOOTNOTES

1. "General Population Characteristics - Kansas", 1970 Census of Population, published by the U.S. Department of Commerce, Bureau of the Census, pp. 112-126.

2. Ibid.

3. Korin, Basil, Statistical Concepts for the Social Sciences, p. 196.

Chapter 5

SUMMARY AND IMPLICATIONS FOR FUTURE RESEARCH

FINDINGS

This study has identified a non-metropolitan secondary level of hospitals in Kansas. In addition many interesting aspects of the Kansas health care delivery system are revealed. It defined the existance of 14 non-metropolitan secondary hospitals and nodes in Kansas, based on the number of physician specialties in each community and their position in the hierarchy of physician specialty. Furthermore, the trade area for each secondary hospital and node were mapped using patient origin data that identifies the number of patients in each county utilizing each hospital. This study also revealed that more than one fifth of Kansas inpatients were served by the 14 secondary hospitals and nodes. In addition, forty two percent of Kansas residents lived within non-metropolitan secondary trade areas. Therefore, the non-metropolitan secondary hospitals and nodes are an important segment of the Kansas health care delivery system.

Using the technique of estimating the mean center, the optimal location for each secondary hospital and node was identified. If the secondary hospital or node was located in the community nearest the actual mean center, the node was considered optimally located. If it was not located in the community nearest the actual mean center, the two centers were compared to determine if they were significantly different.

The following secondary hospitals and nodes were found to be optimally located: Dodge City, Emporia, Hutchinson, Lawrence, Leavenworth, Manhattan, Pittsburg and Salina.

Two techniques were used to compare the actual location of the secondary hospitals and nodes with their optimal locations. The first technique identified the standard distance of the optimal location and the standard distance of the actual location. Sixty seven percent of the populous should live within one standard distance of the location in question.

The t Test was then applied in an attempt to test for a significant difference between the mean distance of the county subdivisions to the actual location, and the mean distance of the county subdivisions to the optimal location. The results revealed that there are three non-metropolitan secondary hospitals and nodes in Kansas that were not optimally located, in that there is a significant difference between the actual location and the optimal location. The three were, Halstead, Hays, and Newton. Halstead was sub-optimal by twenty miles, Hays was sub-optimal by twenty five miles, and Newton was sub-optimal by eleven miles. However, Halstead was questionable because its trade area was not found to be contiguous, therefore, the results concerning its trade area were not totally reliable. However, the fact that Halstead was not located within its trade area further supports the conclusion that it was not optimally located within its trade area.

IMPLICATIONS

This study is limited to non-metropolitan secondary hospitals in Kansas. However, the findings differ from much of the previous research undertaken in otherplaces, i.e., previous studies in other parts of the country and the world indicate a greater percentage of hospitals are non-optimally located than the Kansas non-metropolitan secondary hospitals. The percentage of optimally located hospitals should be greater in this study because the focus is on the optimal location within the trade area only, not taking into account the location of other hospitals within the region, as many researchers have done in the past. Thus, the hospitals are not optimal or sub-optimal in relatioship to other hospitals, but rather only within their trade areas.

Although it may be desireable to undertake a study comparing the actual and optimal location of hospitals while taking into account the location of other hospitals, the patient origin data for such a study would require greater detail than is presently available in Kansas. However, a study of this nature would enable the researcher to more accurately define the trade area foundaries of the secondary hospitals and the smaller hospitals within secondary trade areas. Thus, the location of the smaller hospitals could be taken into account when testing for the optimal location of secondary hospitals.

However, in order to more fully understand the Kansas health care delivery system a study similar to this one could be undertaken for both primary and tertiary hospitals including hospitals and data in metropolitan areas as well as non-metropolitan areas. When the data for the entire state is collected and placed in aggregate form a statewide study could be undertaken to map the trade areas for all the hospitals and test for their optimal location taking into account the effects one hospital has on another.

Furthermore, the gravity model could be used to predict future hospital utilization. If past utilization patterns are studied future trends can be predicted by observing patient flow patterns and applying the gravity model to them. A study of this nature would aid health planners in making planning decisions because it would allow them to predict, with a high degree of accuracy, future health care needs for the state.

PROBLEMS WITH THE METHODOLOGY

Although the techniques used in this study are proven geographical and statistical techniques, there are some problems with the methodology when applied to Kansas health care. Specific problems concern identifying the trade areas, the patient origin data, and the method used in testing for the optimal location.

When identifying the secondary hospitals and nodes this study is unable to accurately place Fort Scott in any grouping. Therefore, it is treated as a unique case, illustrating that there are some hospitals that are not primary, secondary or tertiary in nature. Perhaps a study of several midwest states would reveal four levels in the hierarchy of hospitals in the region.

The patient origin data provides information on only a county by county basis. Any trade area boundaries that actually terminate in the interior of a county are not revealed by this data. Therefore, there is a need to generate more specific patient origin data, such as patient origin data by zip code. Zip code tabulation would allow the research to more accurately identify the residence of the patients because many of the communities within each county possess different zip codes. Little additional money or research would be required to collect this information because each patient treated at a hospital is required to provide their address and zip code in order to receive billing for services rendered.

The term optimal location is an illusive term that can be defined in many ways. This study defines it as the mean center of a trade area. However, the technique of locating the mean center of a trade area is accurate so long as the counties within the trade area are contiguous. A certain amount of accuracy is lost when the counties are not contiguous. The accuracy diminishes with increased distance between the non-contiguous counties. Furthermore, the technique of estimating the mean center does not allow for variations in the transportation network. The distance is measured in actual miles without regard for the transportation network.

CONCLUSIONS

Of the 14 non-metropolitan secondary hospitals and nodes in Kansas, only Hays, Halstead and Newton are not optimally located within their trade area. The remaining eleven of the secondary hospitals and nodes are optimally located within their trade areas. Therefore, the majority of the non-metropolitan secondary hospitals in Kansas are optimally located within their trade areas.

Non-metropolitan secondary hospitals play an important role in the Kansas health care delivery system by providing higher level care than is generally available to non-metropolitan areas. Furthermore, the non-metropolitan secondary trade areas serve sixty six of one hundred and one non-metropolitan counties in Kansas (five counties are metropolitan in nature). However, there are large regions in southeast, southcentral, northeast and northcentral Kansas that are not served by Kansas non-metropolitan secondary hospitals. Although many of these counties may be served by secondary hospitals in other states it appears that there is a need for additional optimally located secondary services for much of non-metropolitan Kansas.

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APPENDIX A

The Mean Point

The mean, or average, is defined statistically as the sum of the values of all unites divided by the total number of units. The algebraic sum of deviations from the mean is zero. The mean point of an arial distribution is the center of gravity or folcrum, if each unit of the distribution is considered to have equal weight on a rigid level plane or uniform weight. The point at which this hypothetical plane would balance is the center of gravity, or mean point of the distribution.

The mean point may be located gy determining the intersection of two lines along each of which the hypothetical plane would balance. These lines might be likened to the fulcra of balanced seesaws; the sum of values on either side of the line, when multiplied by the r distance from it, is equal. The following procedure is suggested for locating the mean point:

1. Draw a base line along one side of the distribution.
2. Determine the sum of deviations from this base line, as follows:

   a. Draw a series of equi-distant lines parallel to the base line. The area between each two of these parallel lines is a "tier". Narrower tiers produce more accurate results; the possible error in the location of the mean point, as outlined later, is half of the width of one tier.

   b. Number the first tier "1", and assign consecutive odd numbers to the midpoints of each subsequent tier.

The assignment of consecutive numbers (instead of consecutive odd numbers) to each tier necessitates the use of tier mid-values (0.5, 1.5, 2.5, etc.) in all computations.

c. Add the total value of working units in each tier and multiply this total value by the tier number to obtain the "tier moment".

d. Add the tier moments to determine the sum of all deviations from the base line.

3. Divid the sum of all deviations by the total value of the distribution (3,460,000 people in Georgia in 1950). The result is the distance (in tiers) of the fulcral line, along which the distribution will balance, from the base line. Draw the fulcral line in its proper location, 32.2 tiers north of the base line, keeping in mind the fact that lines separating tiers have even numbers and tier midpoints have odd numbers.

4. Draw a second base line. Although the second base line may be drawn at any angle to the first, the location of the mean point is facilitated if the two base lines are at right angles, which ensures that the two fulcral lines will also intersect at right angles.

5. Determine the sum of deviations from the second base line by the same procedure used in step 2.

6. Divid the sum of deviations by the total value of the distribution, and draw the second fulcral line at its proper distance of 20.7 tiers from the second base line.

This procedure ensures that the sum of variations along either fulcral line is zero, so the distribution will balance along either line. The intersection of the two fulcral lines is the point at which variations are zero, the point at which the distribution would balance, or the mean point.

PROPERTIES

The following properties characterize the mean point, and indicate its applications and limitations:

1. The mean point is the center of gravity of the distribution.
2. The algebraic sum of rectangular deviations from the mean point is zero.
3. The mean point may be treated algebraically, i.e., the mean point of the population of the United States could be accurately located if the mean point of population of each of the 48 states was known and properly weighted.
4. The mean point is greatly affected by extreme items.
5. The mean point is influenced by any movement within the distribution.

USES

The mean point is best used in dynamic analyses of distributions, such as the study of areal shifts. The best known example of such use is the decennial calculation of the mean point of United States population by the Bureau of the Census. Other areal shifts which have been analyzed by use of the mean point include shifts of coal mining in the Appalachian bituminous coal fields, shifts in the domestic lumber and timber supply, and shifts in United States agriculture and manufacturing. This use of the mean point reflects its extreme sensitivity to movements within the distribution.

APPENDIX B

Ranking of Physician Specialties

Specialty	Rank
Family Practice	1
Internal Medicine	2
General Surgery	3
Psychiatry	4
Obstetrics and Gynecology	5
Pediatrics	6
Radiology	7
Anesthesiology	8
Ophthalmology	9
Urology	10
Orthpedic Surgery	11
Pathology	12
Cardiovascular Disease	13
Thoracic Surgery	14
Dermetology	15
Neurology	16
Otolaryngology	17
Child Psychiatry	18
Ear, Nose and Throat	19
Gastroenterology	20
Plastic Surgery	21
Allergy	22
Administrative Medicine	23
Neurological Surgery	23
Pulmonary Diseases	25
Emergency Medicine	26
Diagnostic Roentgenology	26
Hematology	28
Pediatric Allergy	29
Rheumatology	29
Gynecology	29
Neuropsychiatry	32
Nephrology	33

APPENDIX B Continued

Ranking of Physician Specialties

Specialty	Rank
Therapeutic Radiology	33
Public Health	35
Pediatric Neurology	36
Physicial Medicine and Rehabilitation	36
General Preventive Medicine	36
Pediatric Cardiology	39
Osteopathy	39
Occupational Medicine	39
Nuclear Medicine	39
Clinical Pharmacology	39
Aviation Medicine	39
Clinical Gernontology	45
Endocrinology	45
Genetics	45
Insurance Examination	45
Neoplastic Disease	45

Source: Compiled from the Kansas Medical Society Journal, August, 1977.

APPENDIX C

Secondary Trade Areas

Community	Trade Area	Percent of County Secondary Trade
Coffeyville	Labette	49.67%
	Montgomery	97.47%
Dodge City	Clark	42.85%
	Gray	63.73%
	Hodgeman	48.99%
	Meade	80.13%
	Ford	65.06%
Emporia	Chase	83.73%
	Greenwood	82.86%
	Lyon	98.86%
	Morris	52.86%
	Osage	84.16%
	Coffey	95.75%
Hays	Ellis	95.40%
	Gove	87.10%
	Graham	85.98%
	Logan	77.54%
	Ness	43.82%
	Norton	61.55%
	Osborne	60.22%
	Phillips	85.50%
	Rook	90.51%
	Rush	44.11%
	Russell	57.69%
	Sheridan	80.98%
	Smith	54.33%
	Trego	86.88%
	Decatur	67.07%
Halstead	Pratt	42.75%
	McPherson	26.96%
Hutchinson	McPherson	18.96%
	Pratt	33.88%
	Reno	87.14%

APPENDIX C Continued

Secondary Trade Areas

Community	Trade Area	Percent of County Secondary Trade
	Rice	53.32%
Garden City	Finney	93.36%
	Greeley	68.04%
	Hamilton	88.50%
	Haskell	80.20%
	Kearney	87.48%
	Grant	51.17%
	Lane	74.63%
	Scott	68.92%
	Stanton	54.03%
	Wallace	57.43%
	Wichita	61.78%
Great Bend	Barton	91.63%
	Edwards	56.66%
	Pawnee	83.09%
	Rush	50.18%
	Stafford	55.34%
Manhattan	Clark	50.72%
	Geary	66.96%
	Pottawatomie	95.56%
	Riley	98.06%
	Wabaunsee	72.20%
Newton	Harvey	77.62%
	McPherson	26.13%
	Marion	79.23%
Pittsburg	Crawford	99.43%
Salina	Clay	50.49%
	Dickinson	91.39%
	Ellsworth	57.06%
	Lincoln	95.50%
	McPherson	26.54%
	Mitchell	83.73%

APPENDIX C Continued

Secondary Trade Areas

Community	Trade Area	Percent of County Secondary Trade
	Ottawa	98.85%
	Saline	98.22%
	Cloud	92.91%
Lawrence	Douglas	99.59%
	Franklin	88.96%
	Jefferson	81.43%
Leavenworth	Leavenworth	94.98%

Source: Compiled from Patient Origin Data supplied by the Kansas Bureau of Health Planning.

A LOCATIONAL ANALYSIS OF NON-METROPOLITAN SECONDARY HOSPITALS IN KANSAS

AN ABSTRACT OF A MASTERS THESIS

Presented to

the faculty of the graduate school

Kansas State University

In partial fulfillment of the

Master of Arts Degree in Geography

BY

David Fleetwood

March 21, 1980

* Abstract

The purpose of this study is to identify the non-metropolitan secondary hospitals in Kansas, map their trade areas, identify their optimal location, and test for significant difference between the actual location and their optimal location. My hypothesis is that non-metropolitan secondary hospitals in Kansas significantly differ from their actual locations.

Fourteen non-metropolitan secondary hospitals and nodes are identified based on the number of physician specialties offered in each community and the physician specialties frequency of occurrance (a hierarchy of physician specialty). Those hospitals offering a similar number of physician specialties tend to cluster together. The non-metropolitan secondary hospitals are clustered between an upper break point of seventeen physician specialties and a lower break point of ten specialties.

Using patient origin data supplied by the Kansas Bureau of Health Planning the trade areas for each secondary hospital and node are mapped. The optimal location for each trade area is then tested by estimating the mean center of the population of each trade area. This technique is very reliable when the counties within the trade areas are contiguous.

Two methods are used to compare the actual location of the trade areas with their optimal locations. The first technique identifies and compares the standard distance of each trade areas' actual and otpimal location. Sixty eight percent

of the population will fall within one standard distance of the location in question if the distribution is normal.

The second method employs the t Test to compare the mean distance of the trade area population to the actual location with the mean distance to the optimal location. The t Test reveals three non-metropolitan secondary hospitals and nodes possess an optimal location that differs signficantly from the actual location. The three hospitals and nodes are: Hays, Halstead, and Newton. Therefore, the majority of the non-metropolitan hospitals and nodes in Kansas are optimally located within their trade areas.

* Taken from John Fraser Hart's, CENTRAL TENDENCY IN AREAL DISTRIBUTIONS.