AN ANALYSIS OF EMERGENCY MEDICAL SYSTEMS AND THE QUALITY OF EMERGENCY MEDICAL CARE IN RURAL OKLAHOMA

By

LISA DONNINI MILLER

Bachelor of Science
New Mexico State University
Las Cruces, New Mexico
1976

Master of Arts
New Mexico State University
Las Cruces, New Mexico
1978

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
May, 1984

AN ANALYSIS OF EMERGENCY MEDICAL SYSTEMS

AND QUALITY OF EMERGENCY MEDICAL

CARE IN RURAL OKLAHOMA

Thesis Approved:

Gerold O Doeksen
Thesis Adviser

R E Gus Page

Leo P Blakley

Marlys K. Nelson

Robert L Oehrtman

P Larry Claypool

Norman N Durham
Dean of Graduate College

ACKNOWLEDGEMENTS

It is an extremely difficult task to recognize those individuals who have contributed their efforts toward the completion of my studies. Those who have been involved have given an extra degree of effort as events in my life have demanded a great deal of compassion and understanding, which I have received in abundant quantities. To Dr. James Osborn and my many friends in the Department of Agricultural Economics, I thank you for your gifts of concern and support, both emotionally and financially. I am grateful to Dr. Leo V. Blakley, Dr. P. L. Claypool, Dr. Robert L. Oehrtman, R. E. (Gus) Page, and Dr. Marlys Nelson who served on my graduate committee and provided assistance and instruction on the dissertation. A very special thank you to Marlys for her professional guidance as well as the precious friendship she and her husband, Rex, have given me. I would like to express my gratitude to my advisor, Dr. Gerald A. Doeksen, for his commitment to my goal and his assistance in achieving it. I am grateful for the interest of the Oklahoma State Department of Health, exhibited by their financial support in funding this research effort.

To Ginny Gann I will always be grateful, not only for the outstanding assistance provided by the Data Center under her direction, but more importantly for her special friendship. Masoud Morshedi and Lani Vest worked many grueling hours with me, the bright side being the

opportunity to become friends with two such special people. Elton Li, Jerry Warmann and James Alexander have often given of their time and I appreciate each of them. My thanks to Juanita Frazee and Donetta Bantle for their technical assistance, typing expertise and good nature. And to my best friends, H. L. Goodwin and Bill and Gwen Herndon. "What can I say?", thanks for the memories.

For years I have sought the counsel of Dr. Paul Hummer who has given unselfishly of his time. I will always remember him for his wisdom, guidance and friendship.

To my parents, Denny and Elnora Donnini, I express my deepest appreciation for their constant support and understanding. They helped my to see past today and taught me to live for tommorrow. My husband, Robert, has exhibited unending support and constant faith in my abilities. His compassion and understanding have carried me through the most difficult times-toward a bright future.

I dedicate my work to my late husband, Ray Walter, whose memorable passion for life has given me the strength to go on.

TABLE OF CONTENTS

Chapter | Page

Chapter Page

LIST OF TABLES

Table		Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Statement of the Problem

Accidental injury is the leading cause of death in the first half of a person's expected life span and accidental injury and death is the nation's most severe environmental health problem. This was the conclusion of a 1966 National Academy of Science publication which brought to the attention of policymakers and legislators the severity of the problem of traumatic injury and illness (40). Large investments have been made for research into other causes of death, however little had been done to investigate accidental injury and death at the time of the 1966 report.

Federal and State Legislation

Awareness of the problem which was posed by the National Academy of Sciences prompted action at the federal and state levels of government. One of the first efforts to reduce the problem at the national level was the introduction of "The National Highway Safety Act of 1966" (12). This act recognized that the improvement of emergency medical care was one way to reduce the number of deaths resulting from accidental injury. Assistance was provided through the Department of Transportation to purchase ambulance and communications equipment as well as funding for training programs. The state of Oklahoma continues to utilize the federal programs offered and this action has prompted an awareness of the need for quality emergency medical care at the community level.

With the success of early emergency medical care programs and the realization that good quality pre-hospital care does in fact save lives, many advocates of quality emergency care turned their efforts toward other areas of injury and illness. Direction and funding for a systems approach to emergency medical care came from the U.S. Congress through the enactment of the "Emergency Medical Services Act of 1973". This act outlined an approach for care of the patient from the onset of illness, through rehabilitation and to the return of normal activity.

Action at the state level in Oklahoma began in 1967 when the state legislature assigned the task of implementing the provisions of the 1966 federal act to the governor of the state who then appointed a full-time representative for highway safety. The State Department of Health received the responsibility of evaluating and improving emergency medical care in 1968 through an agreement between the Oklahoma Highway Safety Office and the State Commissioner of Health.

Two laws have been developed in the state which have a significant impact on emergency medical care in Oklahoma. The first of these is entitled "The Emergency Medical Services Districts Act" which provides for the formation of EMS districts for purposes of assessment of an ad valorem tax to support the emergency medical service systems. The second law was passed in May of 1977 and was called "The Oklahoma Emergency Medical Services Act." In addition, this act required a comprehensive approach to the provision of emergency medical care in the state. This act was further amended in 1981 to provide for the licensing of all EMS providers in the state.

Many private organizations, other than federal, state and local governments have contributed to the improvement of emergency medical care through grants, funding and training programs.

The Structure of Emergency Medical Systems in Oklahoma

With the passage of the federal highway safety act in 1966 a movement was made toward reducing the number of deaths and injuries which occur on our nations highways. In Oklahoma increasing emphasis was placed on the importance of higher quality emergency medical services (EMS) in reducing the number of fatalities which occur as a result of highway traffic accidents and other medical emergencies in the state of Oklahoma. The state has been involved in an extensive, systematic approach to the challenge of providing good emergency medical service since 1973. At that time the state began training and financial assistance programs through the use of Oklahoma Highway Safety funds based on standards suggested by the U.S. Department of Transportation (12).

The structure of the emergency medical care organization in the state has changed drastically since 1973. The number of EMS systems in Oklahoma fell from 212 in 1973 to 183 in 1981. In the eight year period between 1973 and 1981 the number of EMS services which were operated by funeral homes fell from 124 to 12. The provision of emergency medical care has become categorized as a public service, along with fire and police protection, as more EMS providers are becoming publicly owned and operated.

The total number of ambulance vehicles in operation in the state has fallen from 515 to 322 between 1973 and 1981. This reduction is due to the increased cost of ambulances and basic emergency equipment.

The training of emergency medical technicians (EMTs) and paramedics has improved vastly over this time period. The total number of EMTs trained in 1973 was 629 with 281 of these registered by the National Registry of Emergency Medical Technicians. Over 4,000 had been trained from 1975 through 1980 with funds provided by the Office of Highway Safety.

These changes in emergency medical care equipment, facilities and training along with similar advances in emergency communications, hospitals, public education and public safety are contributing to improved patient care and the provision of cost-efficient emergency medical care. These same changes, along with further developments concerning the environment surrounding emergency medical care in Oklahoma, have created a need for an increased amount of planning and decisionmaking. It is important that policymakers and community leaders be armed with a sufficient amount of information which will enable them to move Oklahoma toward a comprehensive and integrated statewide organization of emergency medical care services.

Objectives of the Study

This study will examine several situations which have been affected by the recent changes in emergency medical services in Oklahoma. The overall objective is to provide decisionmakers with information that will enable them to evaluate the system as it currently exists and to implement change or identify a status quo that will insure the provision of quality emergency medical care in Oklahoma.

The specific objectives of this study are:

1. provide a descriptive analysis of the current structure of the EMS systems in Oklahoma;
2. analyze data relating to recent changes in ambulance licensing laws to determine the effect of these laws within the system;
3. determine the most efficient service areas for EMS systems;
4. suggest locations for first responder teams;
5. project the number of future calls and estimate response times for EMS systems and first responder (FR) teams; and
6. determine which characteristics contribute to the quality of emergency medical care and measure the impact the characteristics have on the level of quality.

Organization of the Study

Chapter II contains a summary of information given by EMS providers when they applied for a license as specified by the 1981 amendment. An analysis is made concerning the structure of the EMS systems as it was at the time the law was enacted and the impact the law had on equipment and training.

Chapter III provides the theoretical background of transportation theory. A version of the transportation model is applied to the Oklahoma EMS system in Chapter IV. The results of the model provide a delineation of the service areas for EMS systems in the state. Five-year projections of the number of ambulance calls and response time estimates for EMS and first responder teams are also presented.

Chapter V summarizes the theoretical approaches utilized in the development of a model to evaluate and predict the quality of EMS systems in the state. Chapter VI demonstrates the use of these techniques as applied to a group of EMS providers in Oklahoma.

The research effort summary, study limitations and further research needs are presented in Chapter VII.

CHAPTER II

EVALUATION OF THE 1981 AMBULANCE LICENSING LAW

Prior to the 1981 Amendment, EMS providers were not required to be licensed. In fact, EMS providers did not have to have trained personnel or any specified equipment. They could legally provide service with a pickup and untrained personnel. The legislature and Governor felt that Oklahomans deserved at least a minimum level of service and passed the 1981 Amendment to the Emergency Medical Care Act.

The act required that, "commencing January 1, 1982, all persons, companies, governmental entities or trust authorities desiring to operate an ambulance shall file with the Commissioner of Health an application for a license to operate such ambulance service" (12). The commissioner is required to notify the applicant within six months that the application has been granted or denied. During that six months time period any service which was in operation on January 1, 1982 could continue to operate. Should the license application be denied the commissioner must specify the reasons for denial. Upon receipt of the notice of denial, the EMS provider is required to remedy the deficiencies specified by the commissioner and reapply for a license within six months during which time the EMS provider is allowed to continue operating.

The commissioner is allowed to grant variances to the standard set of requirements according to the following criteria (12):

1. the safety and well-being of the patients to be served by the EMS service;
2. the availability of trained personnel and medical equipment;
3. the financial ability of the EMS service to meet the minimum standards of the law;
4. the needs of the general populace served by the EMS service; and
5. the comparative number of emergency transport runs made by the EMS service.

A copy of the license application is found in Appendix A. The application requests information concerning the type of EMS service, how it is owned and operated or managed, sources of funding, dispatch methods, number of annual runs, response time, coverage area, level of certification of employees, type of vehicles used and kinds of radio equipment. Guidelines were developed and formulas are used to determine the licensing status of an EMS service based on personnel, equipment, vehicles, and radio equipment.

Policymakers, the Commissioner of Health, State EMS administrators and others interested in the quality of EMS need to know what impact the law had on EMS in Oklahoma. If the amendment did not improve the quality of EMS service, policymakers may desire to expand or revise the amendment. If the amendment improved EMS, they likewise need to know the positive impact. Furthermore, if there are additional ways of improving EMS, they need to be aware of these possibilities.

This section will provide an analysis of EMS systems based on the number of emergency calls they responded to in 1980, the type of service, the kind of ownership the system has and the means of funding under which the service operates. Data are reported based on the 1981 license application with the exception of the number of emergency calls which is based on the number of runs made in 1980 and reported in 1981. A descriptive analysis of the EMS systems in the state is made based on the information obtained from the license application. From these applications, an estimate of deficiencies in equipment and trained personnel was made. Many services which were deficient immediately proceeded to correct these deficiencies.[1] The final impact of the act is the improvement it generated in personnel and equipment.

Descriptive Analysis of Emergency Medical Service Systems

As a result of the 1981 amendment, 187 EMS providers applied for licenses. At the time these applications were made, it was determined from information requested on the application form that 154,162 ambulance runs were made during the previous year (Table 1). Of this number 81,634 calls or 52.95 percent, were emergency calls. The remaining 72,528 calls, or 47.05 percent, were non-emergency transfer calls. Emergency calls are much more critical than non-emergency transfer calls. EMS systems will be analyzed according to the number

---

[1] As of November 1983, only a handful of EMS services had not corrected the deficiencies. The remainder had corrected the deficiencies and were granted a license.

TABLE I

TOTAL NUMBER OF AMBULANCE RUNS IN OKLAHOMA, BY TYPE, 1980

Type of Call	Number	Percent
Emergency	81,634	52.95
Transfer	72,528	47.05
Total	154,162	100

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

of emergency calls.

By grouping services according to the number of emergency calls which they made in 1980, it is shown in Table II that the largest number of services had between 100 and 500 emergency calls. Ninety of the EMS providers or 48.13 percent were in this category. Seventy-two services or 38.50 percent responded to less than 100 calls. The remaining 13.37 percent or 25 applicants were involved in more than 500 emergency ambulance calls.

When examining EMS provider license applicants based on the type of service, the two largest categories within this group are volunteer and government services. As shown from data in Table III, 39 services, or 20.86 percent of the services were reported as being volunteer. Thirty-eight services applied for licensing as being government services but not fire department or police department. This group accounted for 20.32 percent. This indicates that 41.18 percent of the applicants belong to one of these two groups while the remaining 58.82 percent of the applications were received from EMS providers belonging to one of the other eight types of services. The category of funeral homes which were subsidized had only one EMS provider.

Data concerning the type of license applicants classified by owner/operator are found in Table IV. Eighty-one of the 187 applicants, or 43.32 percent, were reported to be city-owned. The remaining 56.68 percent are divided into seven categories. A total of 61 providers, or 32.62 percent were privately-owned or operated by a board or authority.

Many EMS systems in Oklahoma are funded by several different

TABLE II

EMERGENCY MEDICAL SERVICES IN OKLAHOMA, BY NUMBER OF EMERGENCY CALLS, 1981

Number of Emergency Calls	Total Number of Services	Percent
Less than 100	72	38.50
100 - 500	90	48.13
More than 500	25	13.37
Total	187	100

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

TABLE III

EMERGENCY MEDICAL SERVICES IN OKLAHOMA, BY TYPE OF SERVICE, 1981

Type of Service	Total Number Of Services	Percent
Paid Fire Department	25	13.37
Volunteer Fire Department	13	6.95
Law Enforcement	5	2.67
Hospital Based	23	12.30
Private- Not Subsidized	16	8.56
Private Subsidized	16	8.56
Funeral Home- Not Subsidized	11	5.88
Funeral Home- Subsidized	1	.53
Government- Not Fire Department or Police	38	20.32
Volunteer	39	20.86
Total	187	100

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in Jaunary, 1981, by 187 EMS providers.

TABLE IV

EMERGENCY MEDICAL SERVICES IN OKLAHOMA, BY OWNER/OPERATOR, 1981

Owner/Operator	Total Number of Services	Percent
City	81	43.32
County	10	5.34
City/County	4	2.14
Hospital	12	6.42
Authority or Board	29	15.51
Private	32	17.11
Funeral Home	11	5.88
Volunteer	8	4.28
Total	187	100

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

means. For purposes of simplification of data management and reporting, the major source of funding was determined for each EMS system in the state. The majority of EMS providers in the state are funded mostly by charges as shown in Table V. Sixty-nine services, or 36.89 percent of the services applying for licensing were funded in this manner. The number of services operating on a city subsidy was approximately the same as 62 services belong in that group. These two means of funding are utilized by 70.05 percent of the EMS services in the state. At the time of the study, 25 services were supported primarily by ad valorem taxes.

Summary of EMS Systems Upon License Application

Data in Table VI indicate the percentage of EMS applicants which were able to obtain licensing immediately upon application in 1981. Seventy-six, or 40.64 percent of the 187 services were eligible to receive licensing at the time their requests were submitted. The remaining 59.36 percent of the EMS systems were deficient and were not licensed immediately. This group of 111 EMS systems was then required to comply with the licensing requirements before application could be granted.

A breakdown of the results of the 1981 license application by the number of annual runs is shown in Table VII. Of the services with less than 100 emergency calls per year, 68.05 percent were denied. Of those services which have between 100 and 500 calls a year, 43.33 percent were licensed immediately. In the group of EMS providers which handle in excess of 500 calls annually 56.00 percent were licensed upon application leaving 44.00 percent of the services in this category unlicensed.

TABLE V

EMERGENCY MEDICAL SERVICES IN OKLAHOMA, BY SOURCE OF FUNDING, 1981

Source of Funding	Total Number of Services	Percent
Charges	69	36.89
City Subsidy	62	33.16
County Subsidy	7	3.74
Hospital Subsidy	11	5.88
Sales Tax	4	2.14
Utility Assessment	4	2.14
Ad Valorem Tax	25	13.37
Subscription	5	2.68
Total	187	100

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

TABLE VI

TOTAL NUMBER OF EMS LICENSE APPLICATIONS APPROVED AND DENIED, 1981

Status of Application	Total Number	Percent
Licensed	76	40.64
Licensing Denied Due to Compliance Deficiency	111	59.36
Total	187	100

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981 by 187 EMS providers.

TABLE VII

TOTAL NUMBER OF EMS LICENSE APPLICATIONS APPROVED AND DENIED, BY NUMBER OF EMERGENCY CALLS, 1981

Number of Emergency Calls	Total Number	Denied			Approved		
		Number	Percent	Percent	Number	Percent	Percent
Less than 100	72	49	68.05	26.21	23	31.95	12.29
100 - 500	90	51	56.67	27.27	39	43.33	20.86
More than 500	25	11	44.00	5.88	14	56.00	7.49
Total	187	111		59.36	76		40.64

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981 by 187 EMS providers.

Ten of the eleven EMS systems operated by funeral homes without any form of subsidy were denied licensing (Table VIII). In the category of volunteer type of service, which has the greatest number of observations, 61.54 percent were denied a license based on initial application. In the category of government services, 60.53 percent of the EMS providers received licensing immediately.

Data in Table IX show the status of license applications by owner/operator type. The greatest number of EMS systems are owned by city government. Of these services 38.27 percent were in compliance with licensing requirements at the time of application. Of the 32 privately owned EMS services 71.88 percent were unable to become licensed at the time application was made. The largest group of providers in this category were those city-owned services which were denied licensing. They accounted for 26.74 percent of the total number of providers. Of the 29 providers operated by an authority or board 58.62 were granted a license upon application.

Most of the EMS services in the state are funded by either charges or with city subsidy. Approximately 35 percent of the services in each of these categories received licensing immediately upon application as seen in Table X. Of those services which are funded by an ad valorem tax 56.00 percent did not obtain licensing immediately upon request.

Summary Analysis of EMS Systems With Equipment Deficiencies

The American College of Surgeons suggested emergency medical equipment list was adopted as the minimum equipment required for

TABLE VIII

TOTAL NUMBER OF EMS LICENSE APPLICATIONS APPROVED AND DENIED, BY TYPE OF SERVICE, 1981

Type of Service	Total Number	Denied			Approved		
		Number	Percent	Percent of Total	Number	Percent	Percent of Total
Paid Fire Department	25	15	60.00	8.02	10	40.00	5.35
Volunteer Fire Department	13	8	61.54	4.28	5	38.46	2.67
Law Enforcement	5	4	80.00	2.14	1	20.00	.53
Hospital Based	23	11	47.83	5.88	12	52.17	6.42
Private - Not Subsidized	16	9	56.25	4.81	7	43.75	3.74
Private - Subsidized	16	14	87.50	7.49	2	12.50	1.07
Funeral Home - Not Subsidized	11	10	90.91	5.36	1	9.09	.54
Funeral Home - Subsidized	1	1	100	0.53	0	0	0
Government - Not Fire Department or Police	38	15	39.47	8.02	23	60.53	12.30
Volunteer	39	24	61.54	12.83	15	38.46	8.02
Total	187	111		59.36	76		40.64

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981 by 187 EMS providers.

TABLE IX

TOTAL NUMBER OF EMS LICENSE APPLICATIONS APPROVED AND DENIED, BY OWNER/OPERATOR, 1981

Owner/Operator	Total Number	Denied			Approved		
		Number	Percent	Percent Of Total	Number	Percent	Percent Of Total
City	81	50	61.73	26.74	31	38.27	16.58
County	10	4	40.00	2.14	6	60.00	3.21
City/County	4	2	50.00	1.07	2	50.00	1.07
Hospital	12	6	50.00	3.21	6	50.00	3.21
Authority or Board	29	12	41.38	6.42	17	58.62	9.09
Private	32	23	71.88	12.30	9	28.12	4.81
Funeral Home	11	10	90.91	5.35	1	9.09	.53
Volunteer	8	4	50.00	2.13	4	50.00	2.14
Total	187	111		59.36	76		40.64

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

TABLE X

TOTAL NUMBER OF EMS LICENSE APPLICATIONS APPROVED AND DENIED, BY SOURCE OF FUNDING, 1981

Source of Funding	Total Number	Denied			Approved		
		Number	Percent	Percent of Total	Number	Percent	Percent of Total
Charges	69	45	65.22	24.06	24	34.78	12.84
City Subsidy	62	40	64.52	21.39	22	35.48	11.77
County Subsidy	7	3	42.86	1.60	4	57.14	2.14
Hospital Subsidy	11	4	36.36	2.14	7	63.64	3.74
Sales Tax	4	1	25.00	.54	3	75.00	1.60
Utility Assessment	4	2	50.00	1.07	2	50.00	1.07
Ad Valorem Tax	25	14	56.00	7.49	11	44.00	5.88
Subscription	5	2	40.00	1.07	3	60.00	1.60
Total	187	111		59.36	76		40.64

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

licensing (12). Upon application and inspection, equipment not on an ambulance, but required, was specified. The cost of the equipment required to remove these deficiencies was estimated and noted on the application form. Ninety-four of the 111 systems which were denied licensing lacked some of the equipment specified by the American College of Surgeons. A summary of the equipment deficiencies of the EMS systems is found in Tables XI-XIV. Information in these tables includes the total number of services in each category, the total number deficient for licensing, the minimum percentage of the required equipment maintained by the services in each category and the accompanying estimated dollar value of that deficiency, the average percentage and estimated dollar value of the equipment deficiencies in each category and the total estimated dollar value of equipment deficiencies.

Data in Table XI show that the EMS systems which had less than 100 emergency calls in 1980 maintained an average of 93.09 percent of the required equipment at the time application was made. However, at least one operator in this category had only 25 percent of the equipment which was required. Although those EMS services with more than 500 calls maintained an average of 95.67 percent of the required equipment at least one EMS service required an expense of $2,211.60 in order to comply with licensing requirements. The largest average estimated dollar value of equipment deficiency is also found in this group. The group in the intermediate range of calls had the greatest estimated dollar value of equipment deficiency which was approximately $23,000. The group with the greatest number of emergency calls had only about a fourth as many services but had an estimated dollar value

TABLE XI

ACS* EQUIPMENT MAINTAINED AND EQUIPMENT DEFICIENCY OF UNLICENSED SERVICES BY NUMBER OF EMERGENCY CALLS, 1981

Number of Emergency Calls	Number of Services	Number Unlicensed Due To Equipment Deficiency	ACS Equipment Maintained		Estimated Deficiency		Total Estimated Deficiency
			Minimum	Average	Maximum	Average	
			-----percent----		------dollars------		----dollars----
Less than 100	72	37	25	93.09	811.15	423.43	15,666.90
100 - 500	90	46	70	96.36	1393.60	499.35	22,969.84
More than 500	25	11	70	95.67	2211.60	1097.92	12,077.10
Total	187	94					50,713.84

*The standard set of equipment required on board emergency medical vehicles as suggested by the American College of Surgeons

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

TABLE XII

ACS* EQUIPMENT MAINTAINED AND EQUIPMENT DEFICIENCY OF UNLICENSED SERVICES BY TYPE OF SERVICE, 1981

Type of Service	Total Number of Services	Total Number Deficient	ACS Equipment Maintained		Estimated Deficiency		Total Estimated Dollar Value of Deficiency
			Minimum	Average	Maximum	Average	
			-----percent----		------dollars------		
Paid Fire Department	25	15	70	94.56	1395.40	550.39	8255.80
Volunteer Fire Department	13	7	84	96.62	650.00	443.51	3104.55
Law Enforcement	5	4	86	94.80	667.35	425.44	1881.75
Hospital Based	23	11	79	96.30	975.00	477.42	5251.55
Private- Not Subsidized	16	7	83	96.53	2211.00	950.89	6656.20
Private-Subsidized	16	9	86	96.63	1057.10	543.24	4889.10
Funeral Home-Not Subsidized	11	5	57	85.73	803.00	515.78	2578.89
Funeral Home-Subsidized	1	1	84	84.00	453.90	453.90	453.90
Government-Not Fire or Police	38	14	92	98.00	975.00	531.48	7440.65
Volunteer	39	21	25	92.00	823.00	485.79	10,201.45
Total	187	94					50,713.84

*The standard set of equipment required on board emergency medical vehicles as suggested by the American College of Surgeons

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

TABLE XIII

ACS* EQUIPMENT MAINTAINED AND EQUIPMENT DEFICIENCY OF UNLICENSED SERVICES BY OWNER/OPERATOR, 1981

Owner/ Operator	Number of Services	Number Unlicensed Due To Equipment Deficiency	ACS Equipment Maintained		Estimated Deficiency		Total Estimated Deficiency
			Minimum	Average	Maximum	Average	
			-----percent-----		------dollars------		----dollars----
City	81	47	25	93.94	1395.40	501.86	23,410.30
County	10	4	71	95.90	726.00	344.00	1376.00
City/County	4	2	87	92.75	602.00	563.50	1127.00
Hospital	12	6	79	95.33	975.00	597.76	3568.65
Authority or Board	29	10	87	98.17	975.00	512.78	5145.75
Private	32	16	83	96.58	2211.60	719.34	11,509.30
Funeral Home	11	5	57	85.73	803.00	551.78	2758.89
Volunteer	8	4	92	97.71	823.00	454.49	1817.95
Total	187	94					50,713.84

* The standard set of equipment required on board emergency medical vehicles as suggested by the American College of Surgeons

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

TABLE XIV

ACS* EQUIPMENT MAINTAINED AND EQUIPMENT DEFICIENCY OF UNLICENSED SERVICES, BY SOURCE OF FUNDING, 1981

Source of Funding	Number of Services	Number Unlicensed Due to Equipment Deficiency	ACS Equipment Maintained		Estimated Deficiency		Total Estimated Deficiency
			Minimum	Average	Maximum	Average	
			-----percent----		------dollars------		----dollars----
Charges	69	35	25	92.07	2211.60	543.02	19,005.49
City Subsidy	62	35	70	95.94	1395.40	515.34	18,036.90
County Subsidy	7	3	92	97.71	975.00	650.00	1950.40
Hospital Subsidy	11	4	86	96.09	1057.10	790.59	3162.35
Sales Tax	4	1	96	99.00	975.00	975.00	975.00
Utility Assessment	4	2	83	93.75	492.35	408.68	817.35
Ad Valorem Tax	25	13	84	97.12	975.00	470.49	6116.35
Subscription	5	1	96	99.20	325.00	650.00	650.00
	187	94					50,713.84

* The standard set of equipment required on board emergency medical vehicles as suggested by American College of Surgeons

Source: Applications for licensing submitted to the Oklahoma Commissoner of Health in January, 1981, by 187 EMS providers.

of equipment deficiency totalling almost half that of the services in the intermediate range.

Data in Table XII summarizes the equipment status of the EMS services and the associated estimate of the value of equipment deficiencies for the ten different types of EMS systems in the state. Volunteer EMS services maintained as low as 25 percent of the equipment which was required. This group maintained 92 percent of the equipment required, on the average, and the average estimated dollar value of the equipment deficiency in this group was $485.79. This same group required, by far, the largest total estimated dollar value of equipment for compliance than any other category totalling $10,201.45. Government services maintained 98 percent of the required equipment on the average with an average estimated dollar value of equipment deficiency of $531.48.

When examining equipment deficiencies by the type of owner/operator it is shown in Table XIII that the city-owned services had as little as 25 percent of the required equipment on board. This same group had an average percentage of 93.94 and an estimated average dollar amount of deficiency of $501.86. It also had a relatively high total estimated dollar value of deficiency of $23,410.30. Hospital-owned services had a relatively high average dollar value of equipment deficiency which was $597.76, although the total estimated dollar value of equipment deficiency in that group was not excessively high.

Among the EMS services which utilized charges as their major source of funding, on the average, 92.07 percent of the required equipment was carried on board as seen in Table XIV. In this same category as little as 25 percent was maintained by some service or services. It was found that in this group the maximum dollar value of equipment deficiency was as high as $2,211.60. This same group had a total estimated dollar value of equipment deficiency of $19,005.49, the largest of any other category of funding sources. The large number of services in this category resulted in an average deficiency of $543.02. Those funded by sales tax had the highest average dollar deficiency, $975.

Summary Analysis of EMS Systems With Personnel Deficiencies

A formula based on the number of calls received by an EMS system was used to determine the number of personnel required by each service for licensing. Each EMS system is required to have a registered EMT on each emergency call. Personnel of the State Health Department made an estimate of the number of EMTs each service needed. A summary of the number of EMTs registered at the time of application and the average and total number of additional EMTs required for compliance with licensing requirements, by different categories, is presented in Tables XV - XVIII.

As shown in Table XV the largest number of EMTs were employed by those services responding to between 100-500 calls in 1980. This group was estimated to need 88 additional EMTs to meet compliance regulations. This group required 2.94 additional EMTs, on the average, while those services responding to more than 500 calls required an average of 4.34 additional EMTs to obtain licensing. The group which responded to less than 100 emergency calls in 1980

TABLE XV

REGISTERED* AMBULANCE PERSONNEL AT THE TIME OF LICENSE APPLICATION AND NUMBER REQUIRED FOR LICENSING BY NUMBER OF EMERGENCY CALLS, 1981

Number of Emergency Calls	Number of Services	Number Unlicensed Due to Personnel Deficiency	Number of Registered EMT's at Time of Application	Number of Additional EMT's Required for Licensing	
				Average	Total
Less than 100	72	35	196	2.12	74
100 - 500	90	30	529	2.94	88
More than 500	25	6	350	4.34	26
Total	187	71	1075		188

*Emergency Medical Technicians which are certified and registered with the National Registry of Emergency Medical Technicians

Source: Applications for licensing submitted to the Oklahoma Commissoner of Health in January, 1981, by 187 EMS providers.

TABLE XVI

REGISTERED* AMBULANCE PERSONNEL AT THE TIME OF LICENSE APPLICATION AND NUMBER REQUIRED FOR LICENSING REQUIREMENTS BY TYPE OF SERVICE, 1981

Type of Service	Number of Services	Number Unlicensed Due to Personnel Deficiency	Number of Registered EMT's at Time of Application	Number of Additional EMT's Required for Licensing	
				Average	Total
Paid Fire Department	25	7	208	2.29	16
Volunteer Fire Department	13	4	49	1.75	7
Law Enforcement	5	1	30	6.00	6
Hospital Based	23	5	129	2.40	12
Private-Not Subsidized	16	7	94	5.00	35
Private-Subsidized	16	13	48	2.93	38
Funeral Home-Not Subsidized	11	6	11	2.67	16
Funeral Home-Subsidized	1	1	0	3.00	3
Government-Not Fire or Police Department	38	9	346	1.89	17
Volunteer	39	18	160	2.12	38
Total	187	71	1075		188

* Emergency Medical Technicians which are certified and registered with the National Registry of Emergency Medical Technicians

Source: Applications for licensing submitted to the Oklahoma Commissoner of Health in January, 1981, by 187 EMS providers.

TABLE XVII

REGISTERED* AMBULANCE PERSONNEL AT THE TIME OF LICENSE APPLICATION AND NUMBER REQUIRED FOR LICENSING BY OWNER/OPERATOR, 1981

Owner/ Operator	Number of Services	Number Unlicensed Due to Personnel Deficiency	Number of Registered EMT's at Time of Application	Number of Additional EMT's Required for Licensing	
				Average	Total
City	81	28	387	2.33	65
County	10	3	42	1.67	5
City/County	4	2	37	1.50	3
Hospital	12	3	71	2.67	8
Authority or Board	29	7	353	1.72	12
Private	32	20	147	3.55	71
Funeral Home	11	6	11	2.67	16
Volunteer	8	2	27	4.00	8
Total	187	71	1075		188

* Emergency Medical Technicians which are certified and registered with the National Registry of Emergency Medical Technicians

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

TABLE XVIII

REGISTERED* AMBULANCE PERSONNEL AT THE TIME OF LICENSE APPLICATION AND NUMBER REQUIRED FOR LICENSING BY SOURCE OF FUNDING, 1981

Source of Funding	Number of Services	Number Unlicensed Due to Personnel Deficiency	Number of Registered EMT's at Time of Application	Number of Additional EMT's Required for Licensing	
				Average	Total
Charges	69	31	330	2.78	86
City Subsidy	62	25	322	2.84	71
County Subsidy	7	2	67	1.50	3
Hospital Subsidy	11	2	33	2.50	5
Sales Tax	4	1	36	2.00	2
Utility Assessment	4	1	16	2.00	2
Ad Valorem Tax	25	8	149	2.13	17
Subscription	5	1	122	2.00	2
Total	187	71	1075		188

* Emergency Mecical Technicians which are certified and registered with the National Registry of Emergency Medical Technicians

Source: Applications for licensing submitted to the Oklahoma Commissioner of Health in January, 1981, by 187 EMS providers.

required an average of 2.12 additional employees for compliance.

Personnel requirements classified by the type of EMS system are shown in Table XVI. Government services which were not associated with fire or police departments had the largest number of EMTs at the time license application was made. This same group of EMS systems also required a relatively small number of additional EMTs for license compliance. On the average, services in this category required 1.89 additional EMTs to obtain licensing. Private EMS systems which were not subsidized required an additional 35 EMTs which results in an average of 5.00 per service. The one funeral home which was subsidized had no registered EMTs at the time of application and was required to obtain three before licensing could be obtained.

Data in Table XVII show that privately owned and operated EMS systems required the addition of 71 EMTs to the 147 which were employed by these services at the time licensing application was made. This figure results in an average deficiency of registered personnel of 3.55 for private services. Services operated by an authority or board required the addition of an average of 1.72 registered EMTs in each service or a total of 12 to the 353 already employed.

The personnel requirements for EMS services based on the source of funding utilized is shown in Table XVIII. Those services operating with a county subsidy had 67 employees when they applied for licensing. The EMS systems in this group were required to hire an additional three employees to obtain licensing. On the average this required each service to hire 1.50 additional EMTs. Those services which operate through charges were required to increase their personnel from 330 to 416, or an average increase of 2.78 employees in each service.

Summary

The analysis provides some insight as to the results of the licensing procedure. The data show about half of the EMS systems were readily licensed based on the guidelines of the 1981 amendment.

The enactment of the licensing law had an impact on the purchase of additional equipment and training of additional EMTs. Ninety-four applicants were denied licensing status due to equipment deficiencies. These systems had to invest $50,714 in additional equipment to correct the deficiencies. A change was also necessary in the employment of personnel. At the time licensing became required there were a total of 1,075 registered emergency medical technicians employed in the state. Upon receipt of the applications the Department of Health determined the status of each applicant and prepared a notation on the application outlining the deficiencies of those services which were denied licensing. Analysis of these applications indicated the need for an additional 188 registered EMTs to bring the 71 deficient services into compliance with their personnel requirements.

Enactment of the 1981 Amendment to "The Emergency Medical Care Act" of Oklahoma was intended to upgrade the quality of emergency care in the state. At the conclusion of the one year period most emergency medical services were licensed. These services were able to obtain licensing by upgrading their equipment and facilities or training personnel. Those services which were later able to receive licensing based on exceptions granted by the Commissioner of Health will continue to be monitored.

CHAPTER III

THE TRANSPORTATION MODEL USED TO DELINEATE EMS SYSTEM AREAS AND FIRST RESPONDER SITES

It is assumed that a major determinant of the quality of emergency medical care is the amount of time required to reach the site of a medical emergency. The ability of an EMS service to rapidly reach the site of the emergency rapidly reduces the amount of time which passes before the patient is stabilized and transported to a hospital for care. It is assumed that with a reduction in response time the chances of mortality increase. Response times depend greatly on the service area which an EMS system serves. It is possible that the boundaries which are delineated by the emergency medical service may not be the most efficient. The effect of this inefficiency is two-fold. First, the EMS provider may not be reaching the site of the emergency as rapidly as another EMS provider might be able to. The impact of this situation is hypothesized to be a reduction in the quality of emergency medical care. The second ramification of the inappropriate delineation of EMS systems boundaries is related to the creation of EMS districts. State Amendment 522 allows for the creation of EMS districts funded by ad valorem taxes. It is important that these districts be formed to accurately reflect the area which is or should be served. For example, Seiling, Oklahoma, created an EMS district which serves the Seiling school district in Dewey county. However, all emergency calls occurring in southwestern Major county and southeastern Woodward county are responded to by the Seiling EMS service. To reflect the Seiling service area, the southwestern part of Major county and southeastern part of Woodward county should have been in the Seiling EMS district. Residents in southwestern Major county and southeastern Woodward county are paying ad valorem EMS taxes to other services which are not responding to their emergencies. The delineation of accurate EMS system areas is necessary to prevent districts from being formed which do not serve those given areas.

The objective of this portion of the study is to provide local decisionmakers and EMS planners with the most efficient delineation of EMS service areas for the state and identify possible first responder sites. An adaptation of a transportation model along with data related to locations of services, quantity of service demanded, population projections and mileages will be used to delineate EMS system areas. The study will also project the number of EMS calls for 1985 to 1990. The delineations will be for EMS systems providing either basic life support (BLS) or advanced life support (ALS). Basic life support is the minimum level of emergency care which is licensed in Oklahoma. Advanced life support (ALS) or paramedic service is provided by only a few. Another important level of service is first responder (FR) sites. These systems are utilized due to the need created by the existence of many remote areas which have a small number of calls and cannot afford an expensive BLS level service. The idea behind first responder locations is to have volunteers who will respond to an emergency in the remote area in which they live and stabilize the patient until the ambulance arrives from a BLS or ALS system.

The remainder of this chapter will 1) summarize the transportation model; 2) review selected rural development applications; and 3) summarize the model used in this study. The EMS system areas, first responder sites and data related to response time and number of calls are presented in Chapter IV.

The General Transportation Model

The study of spatial allocation is generally defined to mean the study of the flow of goods over geographical space. A fundamental spatial allocation problem is known as the transportation problem. Scotts' (46) explanation of the transportation problem involves the definition of a simple economic system composed of the following ingredients:

1. a set of geographically distinct points or regions which produce some commodity;
2. a set of geographically distinct points or regions which consume the same commodity; and
3. a given unit cost for transportation of the commodity from any producer to any consumer.

A transportation model then designates an assignment of flows of the commodity from producers to consumers so that the total costs of transportation within the system are minimized. The constraints of such a model are that the suppliers productive capacity cannot be exceeded and that the demands of all consumers must be met.

The model can be defined as having the following elements. Under the assumption that the transportation model involves the movement of a single set of homogeneous goods, the sources of the goods are designated as i where i = 1, 2, 3, ..., n. There are m demand points for the good where the destinations are j = 1, 2, 3, ..., m. The magnitude of flow from i to j is x_{ij} and the cost of transporting one unit from supply point i to demand point j is t_{ij}. The total cost of transporting the goods from i to j becomes $t_{ij}\ x_{ij}$. S_i will denote the supply of the good at i and D_j the demand for the good at point j.

The basic objective of the transportation model is to minimize the cost of transporting the commodity. The objective is expressed mathematically as:

$$\text{minimize} \qquad Z = \sum_{i=1}^{n} \sum_{j=1}^{m} t_{ij}\ x_{ij} \qquad \text{Equation (3.1)}$$

subject to the constraints:

$$\sum_{j=1}^{m} x_{ij} \leq S_i \qquad \text{Equation (3.2)}$$

which states that the total shipments out of the i^{th} source must always be less than or equal to the supply at the i^{th} source; and:

$$\sum_{i=1}^{n} x_{ij} = D_j \qquad \text{Equation (3.3)}$$

which states that the total shipments into the j^{th} destination must equal total demand. The flow of the good cannot be specified as a negative number and the following constraint therefore applies:

$$X_{ij} \geq 0 \qquad \text{Equation (3.4)}$$

The basic transportation model has been adapted and applied to a wide variety of problems. This method of programming was originally developed to schedule the optimum allocation of cargo vessels. When certain fixed transportation requirements are met it is possible to minimize the distance of ships travelling in ballast. Heady (26) points out that the method may be used to determine least-cost sources of materials to a marketing or processing firm, for plants which produce at different locations with sales or consuming points at other locations, and also to show how output "should" flow for a provider to remain competitive and minimize costs. The model can be adapted in many ways to problems of comparative advantage or interregional competition.

Spatial models of transportation or transshipment problems have been used extensively in the discipline of agricultural economics. They have very often been adapted to problems of the livestock industry (4, 27, 36).

Applications of Transportation Models to Problems in Rural Development

The application of transportation models to rural development problems is both frequent and diverse. Variations of transportation algorithms lend themselves to many of the problems faced by researchers in dealing with questions concerning rural areas. The applications may be valuable due to the geographic nature of rural areas and the sparsity of population which generally requires an emphasis on the most efficient movement of factors.

Holland and Barittelle (24) used both linear and separable programming models in a study involving the consolidation of rural schools. The researchers combined the objective of minimization of the cost of transporting students in the rural areas with a cost minimization problem involving the internal costs of operation of the schools. Three planning horizons were investigated with each successive horizon involving an increasing degree of variability of the factors involved. The results of the study indicated that some consolidation proved to be cost minimizing. However, due to the trade-off between the costs of operation of the schools and transportation costs, the total savings attributed to consolidation were small.

The location of small, rural, satellite health care clinics was analyzed in a study by Hardy, Marshall and Faris (22). It was determined that health care problems in rural areas are compounded by the difficulty which patients have in commuting to medical services which are great distances from the rural areas. Location of these satellite clinics was assumed to increase the accessibility of health care to rural residents. The algorithm used in this study identified possible location sites with the objective of minimizing the distance which must be travelled by rural residents to reach health care facilities.

The linear programming model was used to determine the optimum locations of emergency medical service facilities in a study by Oehrtman, Broeckelman and Doeksen (42). The study discusses both open and closed transportation systems with applications of both. The study employed the open transportation model to determine the optimum location of emergency vehicles of two EMS systems in Woods County, Oklahoma. This type of problem involves the movement of a vehicle from the point of origin to the demand point and on to more points before returning to the point of origin. This is the case of an EMS system which must transfer a patient to a hospital or nursing home before returning to the point of origin. Minimization of total vehicle miles was the objective of a study which involved the open transportation system and the movement of the vehicle from its origin and returning again to its origin. This particular analysis involved a possibility of nine different locations and forty demand areas.

Another application of the open transportation system was the determination of possible locations of emergency vehicles in Okmulgee County, Oklahoma. Eight locations for vehicles were suggested with 23 demand areas. The analysis was conducted by weighing the costs and benefits of an additional facility location.

The closed transportation model involves minimization of one-way mileage and does not account for a second point of delivery. The study used a version of the closed transportation system to evaluate the alternative locations of a second fire station in Okmulgee County, Oklahoma. The authors pointed out that when the objective of the study is to minimize the average response time or minimize the maximum response time of the emergency vehicle, the system can be analyzed as a closed transportation system since the number of miles travelled after the patient is picked up does not affect response time.

Another study concerning emergency medical services in Oklahoma involved the use of a linear programming model to designate service areas for basic life support and first responder locations. The study by Selassie, Doeksen and Oehrtman (47) involved a four county area in Northwestern Oklahoma. The model utilized in the study delineated these service areas by allowing the closest ambulance services to respond to emergency calls in the designated demand areas. This objective minimized the response time required to reach the site of the emergency.

Research conducted by Schmidt, Oehrtman and Doeksen (45) merged the use of budget analysis and transportation analysis to aid in the planning of rural emergency medical services in Latimer County, Oklahoma. This type of analysis had not been conducted prior to this study. The objectives involved determining the optimum locations of EMS services taking into account some measures of the quality of the service provided based on maximum and average response times in addition to determining the operating costs at the locations.

Daberkow and King (11) utilized response time and service time as standards of effectiveness in illustrating the application of a location algorithm of branch and bound programming in determining optimal size, number and location of emergency medical service facilities in rural areas of Northern California. The analysis of EMS delivery in a rural environment involved the objectives of minimizing the total costs of providing EMS care under different standards of effectiveness, determining the trade-offs between total costs and different standards of effectiveness and analyzing the financial feasibility of providing EMS as standards of effectiveness and demand for services change.

The Transportation Model Used in This Study

The computerized transportation procedure algorithm designated as GLOSS (Generalized Location Optimization Selection System) is used in this study to assign the demand areas or townships to EMS systems and first responder origins in such a way as to minimize one way transportation mileage (42). The transportation procedure model is used to optimize a linear objective function with respect to a specific type of restraint. In a generalized form, the model can be stated as follows:

Minimize an objective function of the form

$$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij} \qquad \text{Equation (3.5)}$$

subject to the constraints

$$\sum_{j=1}^{n} X_{ij} = a_i \quad \text{where } i = 1,2,\ldots,m \qquad \text{Equation (3.6)}$$

$$\sum_{i=1}^{m} X_{ij} = b_j \quad \text{where } j = 1,2,\ldots,n \qquad \text{Equation (3.7)}$$

$$X_{ij} \geq 0 \qquad \text{Equation (3.8)}$$

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j \qquad \text{Equation (3.9)}$$

where:

m = the number of locations of ambulance service facilities (origins);

n = number of locations of ambulance facility users (destinations);

a_i = ambulance service capacity at the i^{th} ambulance service facility;

b_j = amount of ambulance services demanded by the j^{th} location of ambulance service users (number of annual calls);

X_{ij} = amount of ambulance services to be supplied by the facility at location i to each user location j;

C_{ij} = cost of supplying one unit of ambulance service from ambulance facility location i to each user location j (one way mileage used as a proxy for "cost"); and

$C_{ij}X_{ij}$ = cost of supplying X_{ij} units of ambulance services from ambulance facility location i to any user at location j.

The following assumptions of the transportation model must be satisfied in order for the transportation problem to be solved.

1. Services being provided by each of the various facility location origins are homogeneous. In other words, availability of services at each origin will equally satisfy the demands in any service user location (equation 3.6).
2. Service capacities at various origins and demands at various locations of service users are known and total demand must equal total capacity (equation 3.9). When discrepancies occur between service capacity and user demand, a dummy service capacity or user demand vector is used to produce equality. This dummy vector is used to signify unused capacities or unsatisfied demands.
3. Costs of providing services by any one origin to the other locations of service users are known and are independent of the amount of services provided. That is, it is assumed that a constant per-unit-cost-of-service is provided between locations.
4. There is an objective function to be optimized (equation 3.5).
5. The activities cannot be executed at negative levels (equation 3.8).

The function utilized in this study to determine the boundary delineations for EMS systems and first responder sites is to minimize average response time to reach an emergency. This objective is based on the idea that service users, decisionmakers, and policymakers partially identify quality of emergency medical service with response time.

To adapt the general transportation model for use with this objective certain modifications are made. Each location of an ambulance facility user (destination) is given a value equal to the frequency of all calls. This means that an ambulance travels to each user location as many times as necessary to handle the number of calls for each user location or destination. The facility location(s) with the smallest solution value(s) (i.e., $\sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij}X_{ij}$) represents the optimum solution(s) and location(s) which minimize the average response time.

CHAPTER IV

DELINEATION OF EMS SYSTEM AREAS AND IDENTIFICATION OF FIRST RESPONDER SITES

The transportation model described in the previous chapter is employed to delineate boundaries for the EMS systems in Oklahoma. Possible locations for first responder sites are also determined in this portion of the study.

Data and Procedures

The state was divided into eight regions. The division into these eight regions is for purposes of data management only and has no relevence to lines of demarcation for any other purpose. Figure 1 shows the division of the eight regions in the state. Figures 2-9 depict the individual regions. In addition, Tulsa and Oklahoma counties are eliminated from this study as they are serviced by AmCare organizations.

Data required for the eight regions include:

1. an estimate of where EMS calls would originate;
2. the number of emergency medical service calls received from these areas;
3. locations of current EMS providers;
4. possible locations of first responder sites; and
5. mileage from each emergency location to each possible EMS system or first responder.

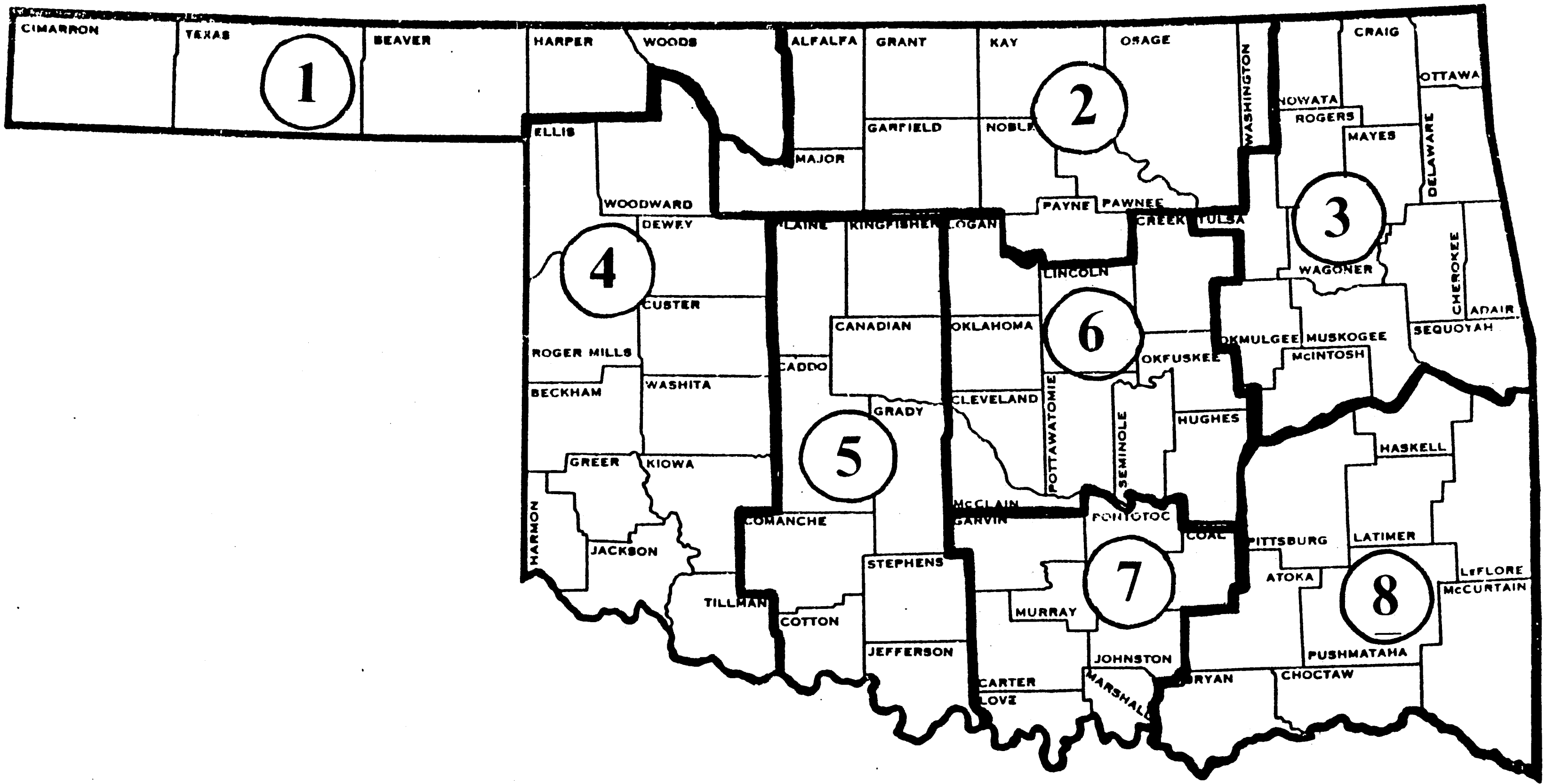


FIGURE 1. EMS Study Areas in Oklahoma

Origins of EMS Demand

The eight areas used in the study were subdivided along township lines which are generally six miles square. An example of this is shown for area 1 in Figure 2. Each of these townships serve as a destination or demand point for a rural ambulance service

Estimate of Calls

The number of emergency medical service calls generated in each demand area had to be estimated. The number of calls was obtained from primary surveys[2] or from the Oklahoma Ambulance Services Registry (43). This registry is published annually by the Emergency Medical Division of the State Health Department.

For purposes of long-term planning, it is useful to predict future calls that might by received by a service. This was accomplished through the use of a demographic model which takes current population and projects population using birth rates, death rates and migration rates (13). Then using local emergency medical service utilization rates derived from survey data, an estimate of EMS calls was projected by demand area (or township) for 1985 and 1990.

Location of EMS Providers

The 1981 Registry of Ambulance Services (43) was used to identify the locations of current EMS Systems. In several cases there were

---

[2] Primary surveys of over seventy-five percent of all EMS systems have been completed by the Oklahoma State University Extension Service. An analysis of the location of calls is part of the survey.

services accidentally omitted from the registry but these were added to the study. These sites are shown in the maps in Figures 2-9. Each of these existing EMS services are the supply points used in the transportation model.

Possible First Responder Sites

The population of small communities and the distance from an emergency vehicle in an EMS system were the determining factor as to whether or not a community was identified as a first responder site. For each first responder site, the estimated number of calls expected in 1985 and 1990 was projected. This provides decisionmakers with a tool to determine whether or not they wish to organize a first responder system in their community based on the expected number of calls and distance from an emergency vehicle in an EMS system.

Mileage Matrix

Once the EMS system location points and the demand areas were located it was possible to develop a mileage matrix to be used in the computer algorithm. The matrix contained the one-way road mileages from all locations of emergency vehicles in an EMS system and first responder sites to the center of all of the demand points in the state. This one-way mileage is used as a proxy for the response time of emergency vehicles answering emergency medical service calls.

The Transportation Procedure

The computerized transportation procedure utilized these data to determine the assignment of demand areas to EMS systems and suggested first responder sites in such a way as to minimize the average mileage traveled to reach the site of an emergency in the townships delineated as demand points. It is assumed that by minimizing the average mileage a faster response time will be achieved by the responding ambulance service. The projected number of calls by township was used to determine the expected number of calls for all EMS systems and first responder sites for 1985 and 1990 based on the delineations of the service area.

The number of emergency medical service calls received by each EMS system in 1981 are shown in Tables XIX-XXVI. In addition, the projected number of calls for 1985 and 1990 are listed for all of the EMS system and suggested first responder locations. Also determined by the transportation model and shown in the tables is the maximum mileage travelled by a service and the average mileage each service would travel in response to emergency medical service calls in their designated service area based on the boundary delineations.

Results

Area 1

Area 1 includes Beaver, Cimarron, Harper, Texas and Woods counties in Northwest Oklahoma. This service area is shown in Figure 2. The results of the study for this area are found in Table XIX. These five counties contain 240 townships (or demand areas). There are a total of 11 EMS systems in operation in this area. These services are listed in Tables XIX and indicated with an asterisk. The area serviced by the Guymon EMS system had a total of 383 emergency

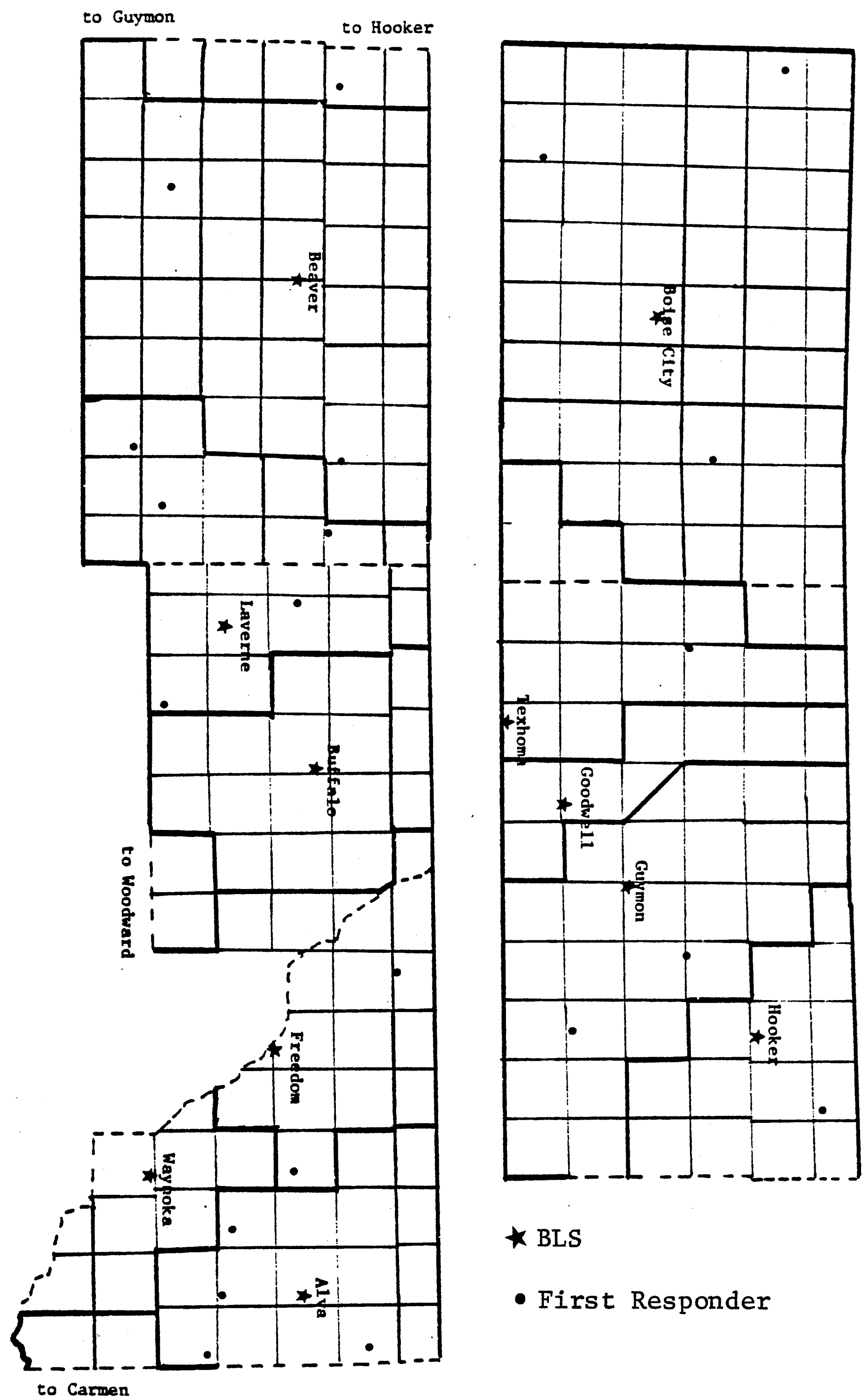


FIGURE 2. EMS Service Area Delineation, Area 1

medical service calls in 1981, not including hospital-to-hospital transfers. The model projected that the number of calls from within the service area would jump to 412 in 1985 and further increase to 443 in 1990. Population projections do not indicate an increase in the number of calls received in Buffalo between 1981 and 1985. The population projections, indicate a reduction in the number of calls from 52 to 49 in the period between 1985 and 1990.

Also included in Table XIX are the suggested locations of first responder sites. There are 21 of these locations in area 1. The locations of these sites are listed in Table XIX and are those services which are not indicted by an asterisk. Because these services are suggested and not in actual operation there are no calls listed for 1981. If there had been a team at the location, they would have stabilized the patient until the emergency vehicle from the EMS system could have arrived on the scene. For example, the first responder site at Tyrone, in Texas County, could receive 42 calls in 1985. This number would increase to 45 in 1990. These calls would also be serviced by the EMS system at Hooker. As shown in Figure 2 this EMS system serves the area including Tyrone.

The EMS service at Guymon would travel a maximum of 34.00 miles and an average of 4.87 to respond to calls within its service area in 1985. The maximum and average distances travelled by the services in this Panhandle region of the state are relatively large due to the sparse population distribution and lower number of EMS providers which serve this portion of the state.

The maximum and average distances travelled to respond to calls is also shown for the suggested first responder sites based on the

TABLE XIX

ESTIMATED MILEAGE AND NUMBER OF SERVICE CALLS IN AREA 1 BY EMS SYSTEM

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
BEAVER					
*BEAVER	150	164	34.00	14.16	176
BALKO		15	18.00	7.98	25
FORGAN		21	4.00	3.03	24
GATE		8	7.00	3.38	9
KNOWLES		5	9.00	5.27	6
SLAPOUT		10	12.00	7.00	11
TURPIN		15	10.00	6.61	34
CIMARRON					
*BOISE CITY	136	152	38.00	11.29	147
FELT		9	9.00	4.78	9
KENTON		7	13.00	7.07	7
KEYES		29	13.00	4.28	29
HARPER					
*BUFFALO	52	52	25.00	9.88	49
*LAVERNE	100	99	28.00	8.99	98
MAY		4	8.00	4.25	4
ROSSTON		6	7.00	4.17	6
TEXAS					
*GOODWELL	51	55	32.00	5.02	59
*GUYMON	383	412	34.00	4.87	443
*HOOKER	80	85	26.00	9.19	92
*TEXHOMA	120	126	37.00	10.07	140
FOUR CORNERS		10	17.00	7.40	12
HARDESTY		13	15.00	6.17	14
OPTIMA		10	3.00	3.00	11
TYRONE		42	4.00	3.10	45

TABLE XIX (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
WOODS					
*ALVA	344	333	25.00	4.83	321
*FREEDOM	43	41	34.00	10.23	41
*WAYNOKA	142	139	22.00	5.02	139
AVARD		4	3.00	3.00	4
CAPRON		7	6.00	3.86	7
CORA		4	6.00	4.50	4
DACOMA		13	3.00	3.00	13
HOPETON		6	5.00	4.00	6
LOOKOUT		6	9.00	5.67	6

* INDICATES BLS SERVICE
OTHER LOCATIONS ARE SUGGESTED FIRST RESPONDER SITES

1985 projections. If a first responder team were to locate in Cimarron County at Kenton, they could be called to respond at a location as far as 13.00 miles from Kenton. On the average they would travel 7.07 miles. The EMS system located at Boise City would also be responding to these calls. However, the EMS service at Boise City would be travelling as far as 38.00 miles to reach a call and help could be provided on the scene much more rapidly by a first responder team.

Based on the results of the model it is often necessary that these service area boundaries cross the lines of the area division. Two examples of this situation are found in area 1. Two townships which are located in the southeastern corner of Harper county are actually served by the EMS system which operates out of Woodward. This service is located in Woodward County which is found in area 4. Two other townships located in southeastern Woods County are serviced by an EMS system which is in area 2. Calls received from this 72 square mile region would be answered by the Carmen EMS system from Alfalfa County.

Area 2

Ten counties in Northcentral Oklahoma comprise area 2. These counties are Alfalfa, Garfield, Grant, Kay, Major, Noble, Osage, Pawnee, Payne and Washington. Area 2 has a total of 302 destinations or townships which are served by 25 EMS systems and 52 suggested first responder locations. The map showing the service area delineations is found in Figure 3. Table XX contains the mileages and number of calls for this area. The table indicates that Garfield County is

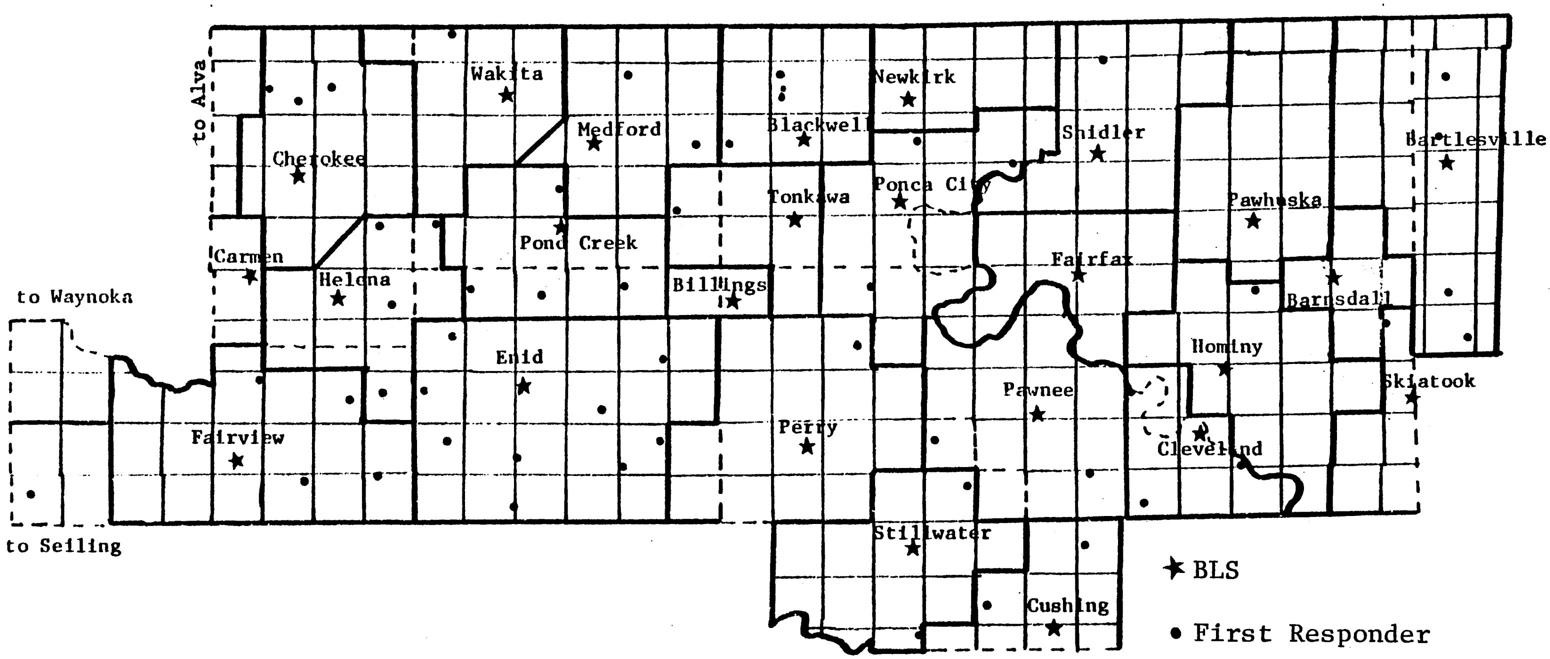


FIGURE 3. EMS Service Area Delineation, Area 2

TABLE XX

ESTIMATED MILEAGE AND NUMBER OF SERVICE CALLS IN AREA 2 BY EMS SYSTEM

		1985			
EMS BY COUNTY	1981 CALLS	CALLS	MAXIMUM DISTANCE	AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
ALFALFA					
*CARMEN	65	65	14.00	4.15	64
*CHEROKEE	198	198	22.00	6.49	196
*HELENA	169	170	18.50	9.34	172
BYRON		5	7.00	4.19	5
BURLINGTON		8	8.00	3.84	8
DRIFTWOOD		4	3.50	3.19	4
GOLTRY		12	3.50	1.72	12
JET		15	6.00	4.47	15
GARFIELD					
*ENID	2,600	2,764	28.00	10.67	2,993
BISON		5	3.00	3.00	6
CARRIER		15	3.00	3.00	16
COVINGTON		20	11.00	3.77	21
DOUGLAS		5	7.00	5.93	6
DRUMMOND		15	3.00	3.00	15
FAIRMONT		17	5.00	3.42	18
GARBER		41	8.00	3.58	45
HILLSDALE		5	3.00	3.00	5
HUNTER		11	4.00	3.24	14
KREMLIN		12	7.00	4.51	13
LAHOMA		15	7.00	3.25	16
WAUKOMIS		50	30.00	5.52	54
GRANT					
*MEDFORD	57	56	23.00	6.70	54
*POND CREEK	88	92	28.00	13.51	91
*WAKITA	37	36	19.00	7.88	37

TABLE XX (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
DEER CREEK		5	11.00	4.40	5
JEFFERSON		5	3.00	3.00	5
LAMONT		15	6.00	3.40	15
MANCHESTER		4	8.00	5.14	4
NASH		10	4.00	3.20	10
RENFROW		2	3.00	3.00	2
KAY					
*BLACKWELL	577	593	17.00	4.00	601
*NEWKIRK	95	97	23.00	4.23	99
*PONCA CITY	1,699	1,728	27.00	5.07	1,791
*TONKAWA	200	205	14.00	4.57	211
BRAMAN		15	6.00	3.39	16
KAW CITY		16	3.00	3.00	17
KILDARE		8	4.00	1.97	8
NARDIN		5	3.00	3.00	5
MAJOR					
*FAIRVIEW	250	253	26.00	8.92	295
AMES		10	6.00	3.67	11
CHESTER		5	16.00	6.19	6
CLEO SPRINGS		20	5.00	3.57	22
ISABELLA		2	6.00	4.05	3
MENO		5	6.00	4.80	6
RINGWOOD		12	8.00	3.96	13
NOBLE					
*BILLINGS	15	15	5.00	3.18	17
*PERRY	312	334	28.00	6.42	366
MARLAND		10	6.00	3.60	11
MORRISON		25	4.00	3.23	27
RED ROCK		11	7.00	3.76	13

TABLE XX (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
OSAGE					
*BARNSDALL	164	186	10.00	3.50	220
*FAIRFAX	176	203	15.00	4.66	235
*HOMINY	232	263	15.00	12.14	305
*PAWHUSKA	450	516	21.00	4.56	599
*SHIDLER	75	86	24.00	6.09	101
*SKIATOOK	310	353	35.00	7.40	412
AVANT		20	6.00	3.36	23
GRAINOLA		5	3.00	3.00	6
WYNONA		30	3.00	3.00	35
PAWNEE					
*CLEVELAND	508	597	14.00	8.92	651
*PAWNEE	500	583	18.00	7.08	625
BLACKBURN		5	3.00	3.00	5
JENNINGS		15	3.00	3.00	16
MARAMIC		5	3.00	3.00	5
RALSTON		20	3.00	3.00	22
WESTPORT		10	3.00	3.00	11
PAYNE					
*CUSHING	666	719	16.00	6.04	807
*STILLWATER	1,446	1,560	16.50	3.81	1,742
GLENCOE		27	18.00	6.77	30
PERKINS		40	3.00	3.00	45
RIPLEY		20	3.00	3.00	22
YALE		50	4.00	3.10	56

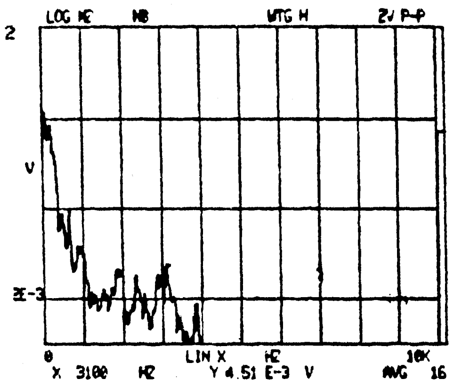
TABLE XX (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
WASHINGTON					
*BARTLESVILLE	1,829	2,003	31.00	4.77	2,225
COPAN		29	6.00	3.28	57
DEWEY		96	3.00	3.00	111
RAMONA		15	4.00	3.09	17
VERA		8	4.00	3.09	9

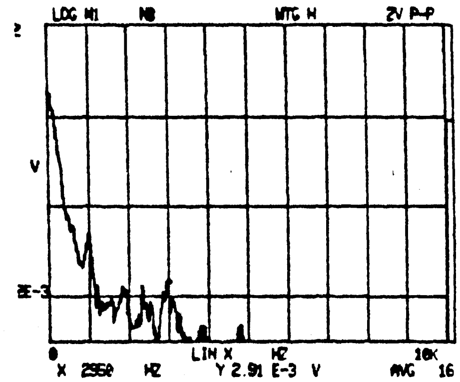
+ A PORTION OF THIS SERVICE AREA IS IN TULSA COUNTY WHICH IS NOT REPRESENTED IN THIS STUDY.

* INDICATES BLS SERVICE

OTHER LOCATIONS ARE SUGGESTED FIRST RESPONDER SITES.

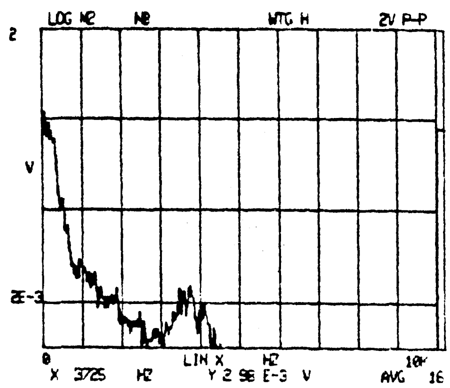


Pitch

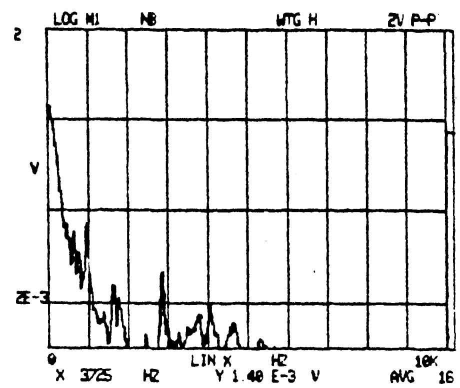


Roll

Head No. 1



Pitch



Roll

Head No. 2

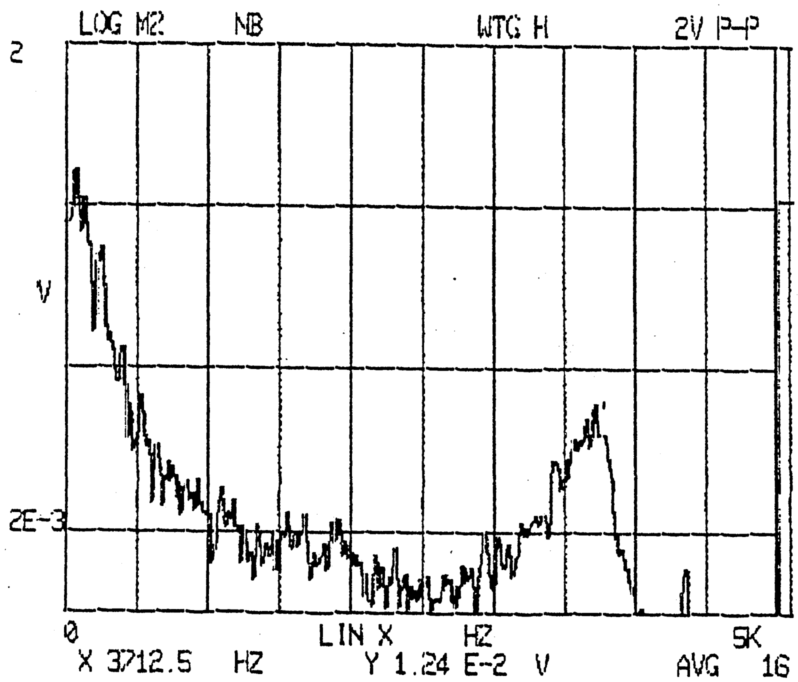
Figure 25. Pitch and Roll Spectra of Two Production Heads

be caused by a number of factors such as differences in the chamfer of the stylus and minor variations in the stiffness, mass, or boundary conditions of the stylus/gimbal system. Because of the relatively small size of the stylus/gimbal system, the eigenvalues and eigenvectors are rather sensitive to small variations in the above mentioned parameters.

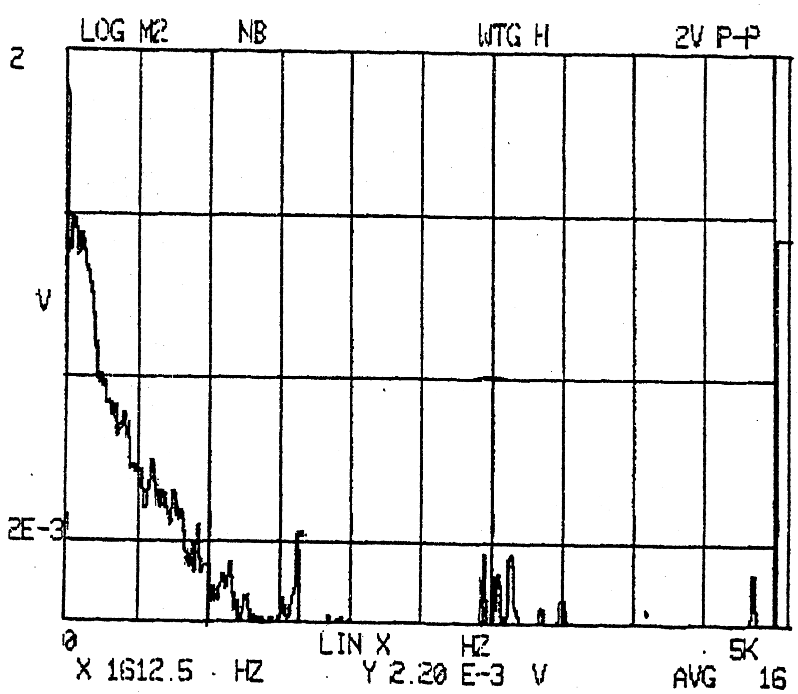
Frequency Response of Production Head

A production head was examined in the frequency domain using the L-RBA system. A typical plot of the frequency spectrum is shown in Figure 26. These data were taken at the outside track position and at 300 RPM which is the factory-set drive speed. The dominant peak in the high-frequency portion of the pitch rotation spectrum occurs at 3712 Hz with a zero-to-peak rotational amplitude of 60.3(-6) degrees. The dominant high-frequency roll motion occurs at 1612 Hz with an amplitude of 10.7 (-6) degrees.

Inspection of the frequency spectra of Figure 26 reveals that low-frequency motions are two orders of magnitude larger than the high-frequency components. The low-frequency components must correspond to motions that occur as the stylus follows waves in the flexible disk. The high-frequency modes consist of a relative motion between the stylus and disk surfaces and thus are at least partially responsible for excessive media wear. Note that the high-frequency broad-band excitation is not as evident in the roll direction as it is in the pitch direction. This is the expected result as the friction-type forcing function acts essentially in the pitch direction. Tables X and XI contain data taken for the dominant high-frequency mode in the pitch and roll directions, respectively. It is evident from these data that some frequency shift



Pitch Spectrum



Roll Spectrum

Figure 26. Pitch and Roll Spectra for Production Head, Drive Speed 300 RPM, Outside Radial Track

TABLE X

DOMINANT HIGH-FREQUENCY PITCH MODE OF THE PRODUCTION HEAD AT 300 RPM DRIVE SPEED IN THE OUTSIDE, MIDDLE, AND INSIDE RADIAL TRACK POSITIONS

Radial Track Position	Mode Frequency (Hz)	Amplitude (Degrees)
Outside	3712	60.30(-6)
Middle	3500	26.90(-6)
Inside	3425	29.00(-6)

TABLE XI

DOMINANT HIGH-FREQUENCY ROLL MODE OF THE PRODUCTION HEAD AT 300 RPM DRIVE SPEED IN THE OUTSIDE, MIDDLE, AND INSIDE RADIAL TRACK POSITIONS

Radial Track Position	Mode Frequency (Hz)	Amplitude (Degrees)
Outside	1612	10.70(-6)
Middle	1612	7.14(-6)
Inside	1612	14.50(-6)

occurs in the pitch modes when radial track position is changed. This is possibly due to an increased disk stiffness and enforced buckling deformation in the disk as a result of hub/disk interference that are present at the inside track position. This would result in different boundary conditions as well as a change in the forcing functions. From Figure 26 it can be seen that the 1612 Hz roll mode has a much narrower bandwidth as compared with the 3712 Hz pitch mode. Also, the roll mode does not exhibit a significant frequency shift when radial track position is changed.

A test was performed to determine the effects of media velocity on the amplitude of a high-frequency pitch mode. This test was performed at the outside radial track position. The pitch mode that was examined occurs near 3550 Hz. The numerical results of this examination are given in Table XII and a plot of these data is shown in Figure 27. It is seen that the vibrational amplitude increases with increasing media velocity. It appears that this mode begins to go somewhat unstable at a media velocity of about 75 inches per second. At 75 inches per second, the mode frequency began to shift upward from the 3550 Hz value typical of all lower media velocities. The frequency had shifted to 3675 Hz at the uppermost test velocity of 110.6 inches per second. The media velocity at the factory-set drive speed of 300 RPM in the outside track position is approximately 69 inches per second; thus when at the outside track the stylus is operating near the unstable or transition range of this 3550 Hz mode.

Frequency Response of Experimental Head Designs

The experimental head designs AD-2, AD-3, and AD-4 were tested to

TABLE XII

AMPLITUDE OF 3550 HZ PITCH MODE
OF THE PRODUCTION HEAD FOR
VARIOUS MEDIA VELOCITIES

Media Velocity (Inches/Second)	Pitch Amplitude (Degrees)
13.8	8.9(-6)
20.7	9.8(-6)
27.7	10.4(-6)
34.6	12.1(-6)
41.5	13.7(-6)
48.4	15.3(-6)
55.3	20.2(-6)
62.2	20.3(-6)
69.1	25.8(-6)
76.0	28.0(-6)
82.9	39.0(-6)
89.9	55.9(-6)
97.8	50.1(-6)
103.7	56.9(-6)
110.6	60.7(-6)

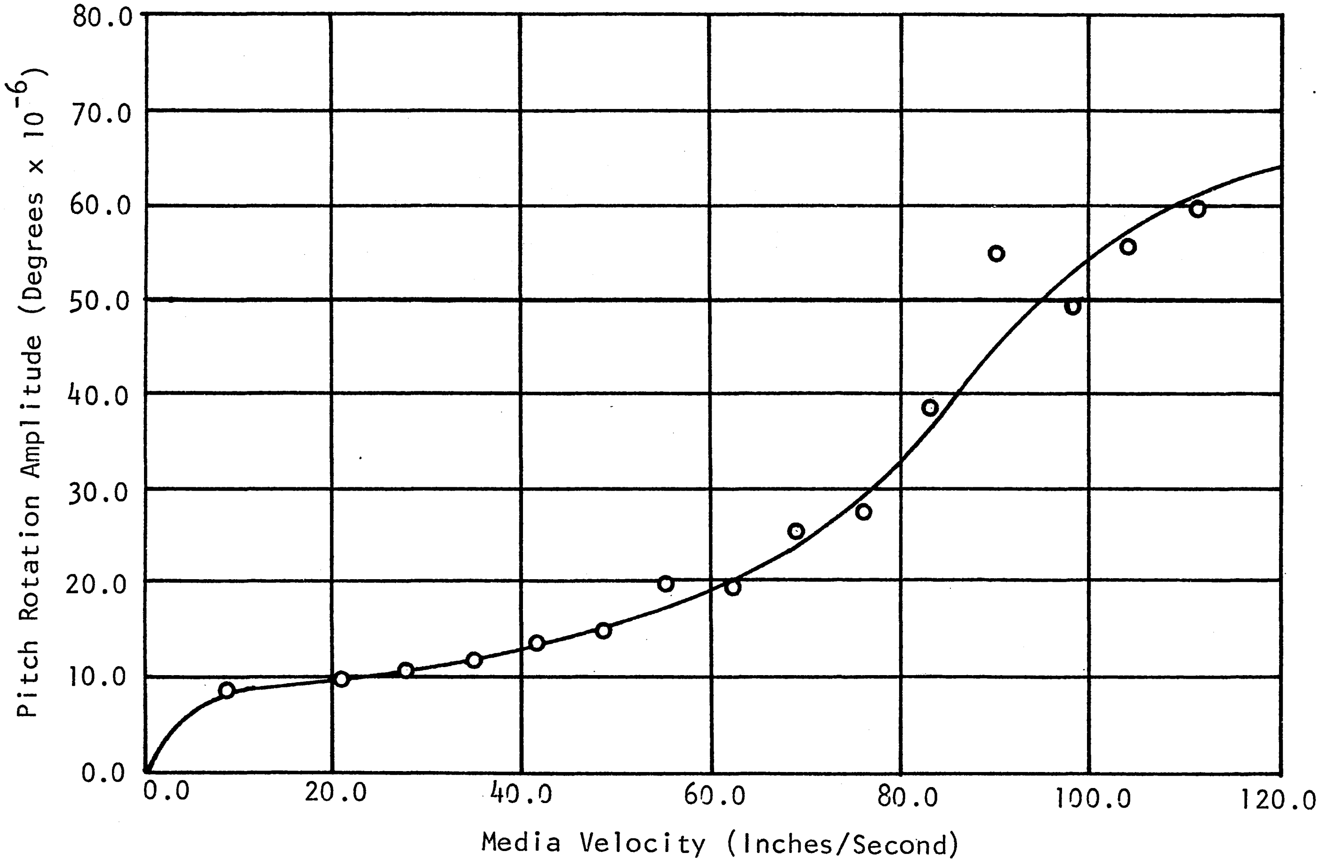


Figure 27. Pitch Rotation Amplitude Versus Media Velocity, 3550 Hz Pitch Mode, Outside Radial Track

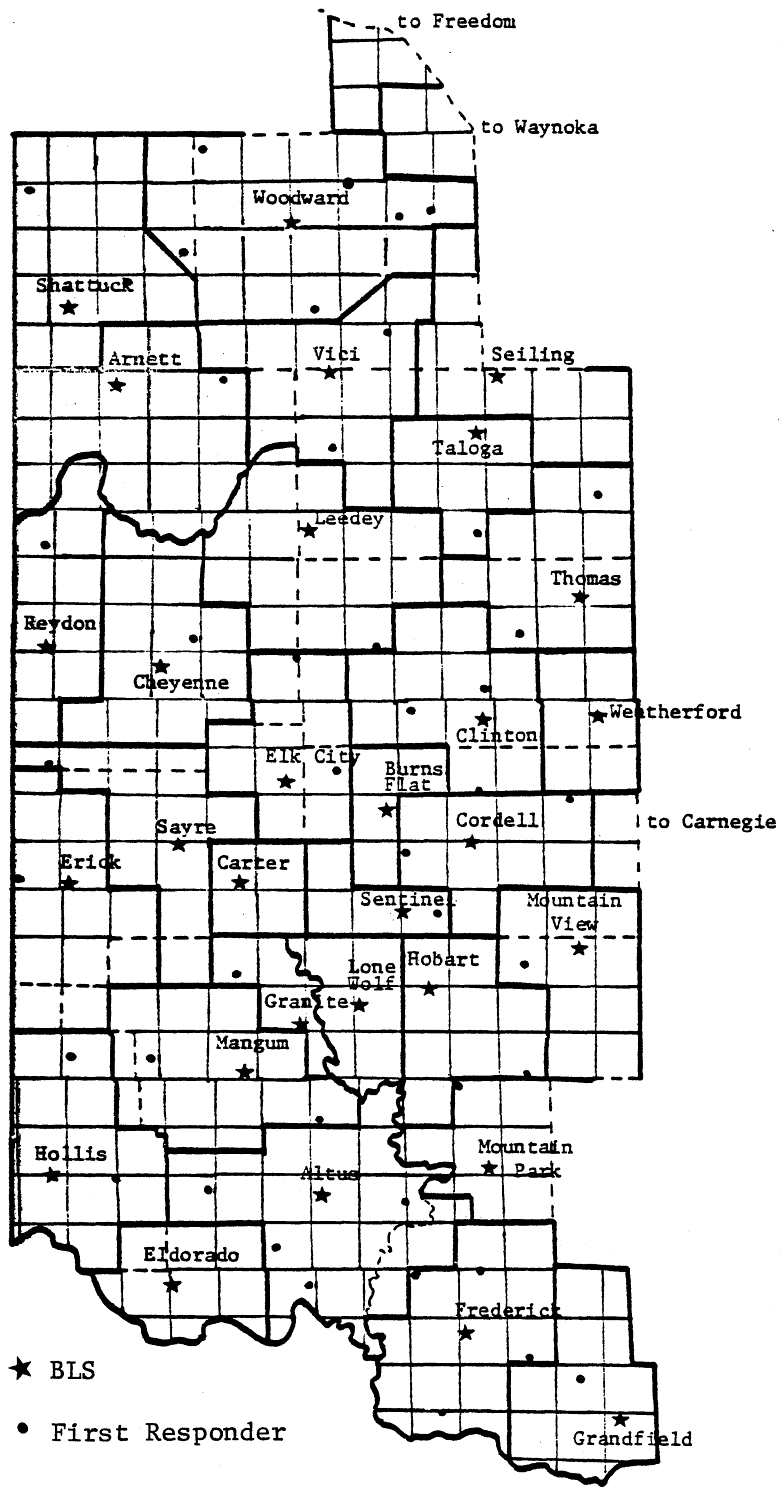


FIGURE 5. EMS Service Area Delineation, Area 4

TABLE XXII

ESTIMATED MILEAGE AND NUMBER OF SERVICE CALLS IN AREA 4 BY EMS SYSTEM

		1935			
EMS BY COUNTY	1981 CALLS	CALLS	MAXIMUM DISTANCE	AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
BECKHAM					
*CARTER	30	32	9.00	4.39	35
*ELK CITY	700	790	18.00	12.74	877
*ERICK	129	139	21.00	4.92	153
*SAYRE	345	374	30.00	4.46	416
TEXOLA		10	3.00	3.00	11
CUSTER					
*CLINTON	700	740	22.00	4.56	801
*THOMAS	137	145	24.00	7.49	152
*WEATHERFORD	300	317	12.00	3.84	340
ARAPAHO		30	10.00	3.00	33
BUTLER		26	8.00	3.38	28
CUSTER CITY		21	3.00	3.00	22
STAFFORD		11	4.00	2.45	12
DEWEY					
*LEEDEY	42	45	22.00	8.73	46
*SEILING	134	142	44.00	7.32	150
*TALOGA	55	56	31.00	7.04	59
*VICI	101	110	17.00	6.65	116
CAMARGO		22	6.00	3.73	22
OAKWOOD		21	5.00	4.43	21
PUTNAM		13	4.00	3.23	14
ELLIS					
*ARNETT	30	31	24.00	10.05	33
*SHATTUCK	112	117	26.00	6.51	123
CATESBY		5	8.00	5.20	5
FARGO		21	6.00	3.57	22
GAGE		27	10.00	8.90	28
HARMON		6	5.00	4.00	6

TABLE XXII (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
GREER					
*GRANITE	97	93	16.00	4.38	83
*MANGUM	323	310	21.00	6.49	290
REED		8	4.00	3.31	12
WILLOW		8	7.00	4.00	7
HARMON					
*HOLLIS	261	248	31.00	5.89	237
GOULD		4	3.00	3.00	3
VINSON		13	5.00	3.62	12
JACKSON					
*ALTUS	1,100	1,117	22.00	5.90	1,134
*ELDORADO	50	51	12.00	4.69	52
BLAIR		29	5.00	3.41	30
DUKE		21	5.00	3.16	21
ELMER		10	7.00	5.10	10
HEADRICK		19	3.00	3.00	19
OLUSTEE		23	4.00	3.09	24
KIOWA					
*HOBART	286	288	20.00	4.09	291
*LONE WOLF	80	82	10.00	4.68	82
*MOUNTAIN PARK	196	199	20.00	5.73	202
*MOUNTAIN VIEW	90	93	43.00	26.77	96
COOPERTON		5	4.00	3.42	5
GOTEBO		20	6.00	3.30	20
ROOSEVELT		16	6.00	3.81	16
ROGER MILLS					
*CHEYENNE	125	133	20.00	3.79	136
*REYDON	60	62	27.00	9.80	64

TABLE XXII (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
DURHAM		6	14.00	6.83	7
HAMMON		23	6.00	3.09	25
STRONG CITY		3	4.00	3.33	3
SWEETWATER		14	8.00	4.79	15
TILLMAN					
*FREDERICK	425	423	17.00	4.68	421
*GRANDFIELD	88	87	19.00	5.48	86
DAVIDSON		22	3.00	3.00	22
HOLLISTER		6	3.00	3.00	6
LOVELAND		9	7.00	5.67	9
MANITOU		8	10.00	4.75	8
TIPTON		56	7.00	3.47	57
WASHITA					
*BURNS FLAT	145	154	9.00	3.87	166
*CORDELL	196	233	16.00	5.39	259
*SENTINEL	60	63	14.00	4.35	67
BESSIE		18	3.00	3.00	19
CANUTE		27	6.00	3.26	29
CORN		18	3.00	3.00	19
DILL CITY		27	6.00	3.57	29
ROCKY		14	4.00	3.29	15
WOODWARD					
*WOODWARD	959	1,109	22.50	4.96	1,317
FORT SUPPLY		20	12.00	4.00	23
MOORELAND		50	8.00	3.45	60
MUTUAL		10	6.00	3.43	13
QUINLAN		5	8.00	4.77	6
SHARON		10	3.00	3.00	11

* INDICATES BLS SERVICE

OTHER LOCATIONS ARE SUGGESTED FIRST RESPONDER SITES

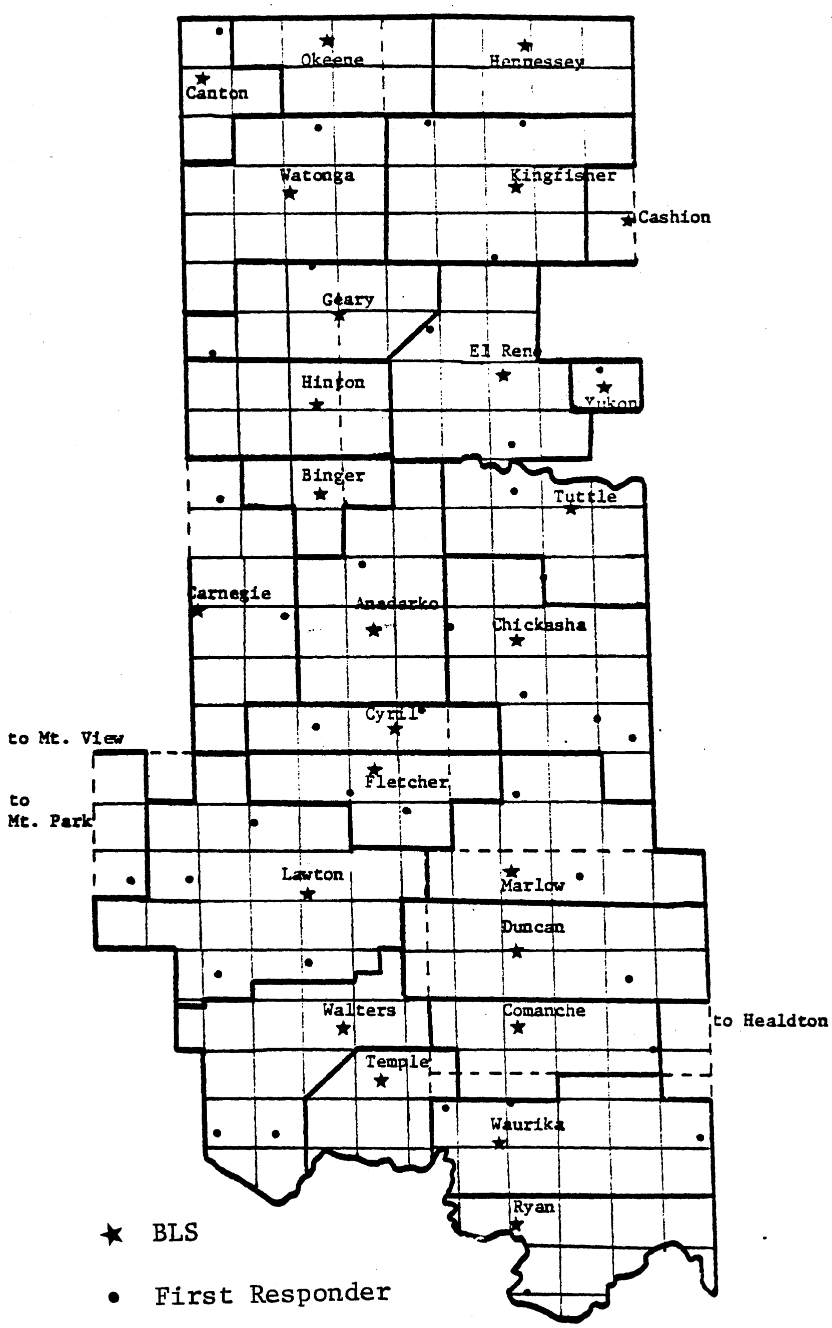


FIGURE 6. EMS Service Area Delineation, Area 5

TABLE XXIII

ESTIMATED MILEAGE AND NUMBER OF SERVICE CALLS IN AREA 5 BY EMS SYSTEM

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES	----	
BLAINE					
*CANTON	186	198	8.00	4.88	212
*GEARY	122	136	16.00	6.56	160
*OKEENE	118	125	15.10	4.78	134
*WATONGA	290	308	18.00	4.53	331
GREENFIELD		19	3.00	3.00	21
HITCHCOCK		19	5.00	3.53	20
HYDRO		44	4.00	3.30	46
LONGDALE		36	3.00	3.00	39
CADDO					
*ANADARKO	800	827	25.00	5.34	864
*BINGER	57	59	7.00	4.24	61
*CARNEGIE	429	443	32.00	10.44	466
*CYRIL	339	355	15.00	6.06	373
*HINTON	177	187	20.00	7.82	201
APACHE		50	5.00	3.21	53
CEMENT		31	3.00	3.00	33
EAKLY		16	3.00	3.00	17
FORT COBB		29	4.00	3.25	31
GRACEMONT		19	4.00	3.26	20
CANADIAN					
*EL RENO	1,066	1,362	13.00	3.69	1,853
*YUKON	633	808	3.00	3.00	1,102
CALUMET		20	4.00	3.02	27
UNION CITY		26	3.00	3.00	35
COMANCHE					
*FLETCHER	250	266	15.00	6.79	296
*LAWTON	2,884	3,055	25.00	3.97	3,296

TABLE XXIII (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
CACHE		55	7.00	3.33	60
ELGIN		27	3.00	3.00	29
FAXON		10	7.00	3.52	11
GERONIMO		27	4.00	3.16	28
INDIAHOMA		13	8.00	3.74	15
MEDICINE PARK		20	4.00	3.05	21
STERLING		25	3.00	3.00	27
COTTON					
*TEMPLE	97	101	11.00	4.04	105
*WALTERS	254	265	24.00	7.03	278
DEVOL		12	16.00	7.69	12
RANDLETT		16	5.00	3.28	17
GRADY					
*CHICKASHA	1,248	1,412	20.00	4.89	1,646
*TUTTLE	344	389	16.00	6.99	454
ALEX		29	3.00	3.00	30
AMBER		21	3.00	3.00	24
BRADLEY		10	13.00	5.92	11
MINCO		54	9.00	3.97	63
NINNEKAH		40	3.00	3.00	47
RUSH SPRINGS		54	9.00	3.82	63
VERDEN		20	3.00	3.00	23
JEFFERSON					
*RYAN	132	132	19.00	5.98	141
*WAURIKA	200	200	25.00	12.06	216
ADDINGTON		12	3.00	3.00	13
HASTINGS		18	3.00	2.94	19
RINGLING		56	10.00	3.52	60
TERRAL		5	3.00	3.00	6

TABLE XXIII (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
KINGFISHER					
*CASHION	64	69	6.00	4.49	76
*HENNESSEY	285	298	25.00	6.10	317
*KINGFISHER	449	470	19.00	5.65	503
DOVER		32	7.00	3.67	34
LOYAL		14	6.00	4.50	15
OKARCHE		45	7.00	3.79	54
STEPHENS					
*COMANCHE	231	250	17.50	5.48	282
*DUNCAN	780	855	24.00	4.49	958
*MARLOW	329	363	20.00	7.10	414
BRAY		21	8.00	4.31	24
LOCO		8	4.50	4.75	9
VELMA		29	9.00	3.85	[illegible]

* INDICATES BLS SERVICE

OTHER LOCATIONS ARE SUGGESTED FIRST RESPONDER SITES

Lawton had a total of 2,884 emergency medical service calls in 1981. This number is projected to increase by 6 percent to 3,055 in 1985 and by almost 8 percent to 3,296 during the following five year period. Services in this area may travel a minimum of several miles to a maximum of 32.00 miles to respond to a call. However, the latter distance is not travelled frequently as the average distances travelled within this area are much lower. There are several townships in the eastern part of this region which are served by Oklahoma County. This county is not included in the study because the emergency service is provided by AmCare. As seen in Figure 6 several of the townships in the western part of this region are served by the EMS systems out of Mountain View and Mountain Park which are located in area 4.

Area 6

The counties in area 6 are Cleveland, Creek, Hughes, Lincoln, Logan, McClain, Okfuskee, Pottawatomie, and Seminole. This area has 25 EMS systems and 40 suggested first responder locations. These locations serve a total of 255 townships or destinations. These counties are shown in Figure 7. Table XXIV shows the EMS and first responder systems emergency medical service calls and distances. An example is the EMS system at Holdenville which had a total of 594 emergency calls in 1981. This number is expected to increase to 617 in 1985 to 651 in 1990. This service has a maximum distance of 32.00 miles and an average distance of 8.30 miles to travel within its service area. The first responders in this area travel a maximum of 11 miles out of Stuart but many first responders travel a distance as

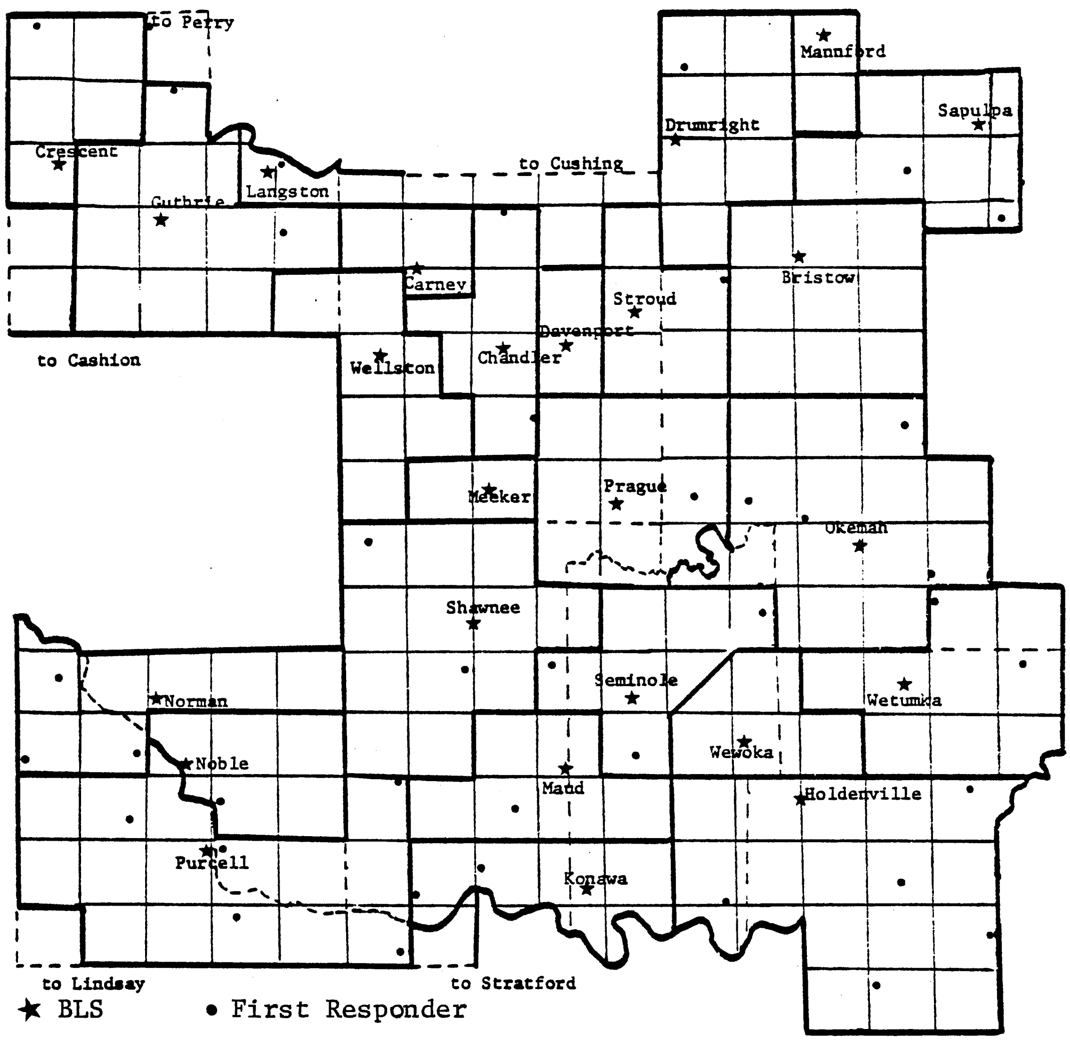


FIGURE 7. EMS Service Area Delineation, Area 6

TABLE XXIV

ESTIMATED MILEAGE AND NUMBER OF SERVICE CALLS IN AREA 6 BY EMS SYSTEM

		1985			
EMS BY COUNTY	1981 CALLS	CALLS	MAXIMUM DISTANCE	AVERAGE DISTANCE	1990 CALLS
			---- MILES	----	
CLEVELAND					
*NOBLE	184	229	8.00	3.26	303
*NORMAN	2,377	2,932	17.00	4.57	3,831
LEXINGTON		50	5.00	3.30	66
SLAUGHTERVILLE		56	4.00	3.05	75
CREEK					
*BRISTOW	443	493	17.00	4.65	570
*DRUMRIGHT	568	634	15.00	5.62	730
*MANNFORD	191	213	10.00	3.47	245
*SAPULPA	1,365	1,524	15.00	3.95	1,753
DEPEW		26	3.00	3.00	30
KELLYVILLE		37	3.00	3.00	43
MOUNDS		32	3.00	3.00	37
OILTON		45	3.00	3.00	52
HUGHES					
*HOLDENVILLE	594	617	32.00	8.30	651
*WETUMKA	288	297	15.00	6.99	310
CALVIN		22	3.00	3.00	23
DUSTIN		20	3.00	3.00	21
GERTY		10	10.00	5.28	10
LAMAR		9	6.00	3.43	10
STUART		17	11.00	5.62	18
LINCOLN					
*CARNEY	69	79	3.00	1.78	92
*CHANDLER	287	304	8.00	4.15	378
*DAVENPORT	87	98	3.00	2.55	114
*MEEKER	115	130	3.00	3.00	152
*PRAGUE	303	340	13.00	4.91	384

TABLE XXIV (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
*STROUD	228	258	8.00	3.36	300
*WELLSTON	255	291	14.00	5.59	339
AGRA		14	4.00	3.11	16
SPARKS		23	3.00	2.45	27
LOGAN					
*CRESENT	165	185	15.00	5.52	211
*GUTHRIE	908	1,018	15.00	4.16	1,169
*LANGSTON	19	21	12.00	4.17	25
COYLE		10	3.00	3.00	10
MARSHALL		10	8.00	3.81	11
MERIDIAN		5	7.00	4.40	6
MULHALL		11	3.00	3.00	13
ORLANDO		8	5.00	3.34	9
McCLAIN					
*PURCELL	737	855	24.00	8.42	1,036
BLANCHARD		75	7.00	4.93	80
BYARS		26	6.00	3.91	32
GOLDSBY		28	3.00	3.00	33
NEWCASTLE		120	3.00	3.00	145
WASHINGTON		29	3.00	3.00	35
WAYNE		24	8.00	4.25	29
OKFUSKEE					
*OKEMAH	428	438	13.00	5.77	447
BOLEY		28	4.00	3.21	28
CASTLE		5	3.00	3.00	5
CLEARVIEW		10	3.00	3.00	10
OKFUSKEE		12	7.00	4.86	13
PADEN		23	5.00	3.49	23
WELEETKA		42	3.00	3.00	43

TABLE XXIV (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
POTTAWATAMIE					
*MAUD	42	45	16.00	6.59	49
*SHAWNEE	2,598	2,848	10.50	4.84	3,207
ASHER		27	3.00	3.00	30
EARLSBORO		13	3.00	3.00	15
McLOUD		120	3.00	3.00	135
ST. LOUIS		9	3.00	3.00	10
TECUMSEH		150	4.00	3.06	169
TRIBBEY		19	7.00	5.44	22
WANETTE		24	5.00	3.56	27
SEMINOLE					
*KONOWA	208	222	14.00	6.42	239
*SEMINOLE	724	758	13.00	4.48	802
*WEWOKA	483	507	10.00	3.72	534
BOWLEGS		28	3.00	3.00	30
CROMWELL		24	6.00	4.09	25
SASAKAWA		20	3.00	3.00	22

* INDICATES BLS SERVICE
OTHER LOCATIONS ARE SUGGESTED FIRST RESPONDER SITES

short as three miles. Several townships in Logan County are served by Perry which is in area 2 and by Cashion which is in area 6.

Area 7

Area 7 is found in the southcentral portion of the state. The counties included are Carter, Coal, Garvin, Johnston, Love, Marshall, Murray and Pontotoc. This area has a total of 181 townships which are being served by 16 EMS systems. In addition, it is suggested that there be 31 first responder locations. Several counties have only one EMS system. An example found in Table XXV is Coalgate in Coal County. Coalgate had 259 emergency calls in 1981. The projected number for 1985 is an increase of 10 calls to 269. The area is projected to have a decrease in the need for emergency medical service calls in 1990 as this number drops to 248. Love, Marshall and Murray counties each have one service. The first responders in this area travel a short distance to respond to calls relative to areas such as the northwestern portion of the state. The maximum distance travelled by a first responder team is 20 miles and the average is much less. This same geographical situation applies to the EMS system. Figure 8 shows the service area delineations of these 8 counties.

Area 8

The southeastern portion of the state is represented by area 8 and the service area delineations can be found in Figure 9. The counties included in this area are Atoka, Bryan, Choctaw, Haskell, Latimer, LeFlore, McCurtain, Pittsburg and Pushmataha. The area has

TABLE XXV

ESTIMATED MILEAGE AND NUMBER OF SERVICE CALLS IN AREA 7 BY EMS SYSTEM

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
CARTER					
*ARDMORE	1,251	1,348	18.00	3.98	1,478
*HEALDTON	439	474	19.00	11.17	522
*LONE GROVE	190	201	15.00	4.40	226
DICKSON		31	15.00	3.53	34
GRAHAM		8	3.00	3.00	9
RATLIFF CITY		22	3.00	3.00	24
SPRINGER		23	8.50	3.44	25
WILSON		43	4.00	3.07	48
COAL					
*COALGATE	259	269	27.00	11.80	248
CENTRAHOMA		8	3.00	3.00	39
LEHIGH		11	3.00	3.00	12
TUPELO		22	6.00	3.56	24
GARVIN					
*ELMORE CITY	127	135	18.00	7.17	142
*LINDSAY	400	427	20.00	5.03	466
*MAYSVILLE	161	171	6.00	4.25	182
*STRATFORD	116	124	14.00	7.37	135
*PAULS VALLEY	577	613	17.00	4.10	660
*WYNNEWOOD	91	98	13.00	3.71	104
PAOLI		22	8.00	4.53	24
JOHNSTON					
*TISHOMINGO	454	508	19.00	8.32	449
BROMIDE		6	3.00	3.00	6
CONNERVILLE		4	3.00	3.00	5
MANNSVILLE		20	4.00	3.35	23
MILBURN		12	8.00	3.50	13

TABLE XXV (Continued)

		1985			
EMS BY COUNTY	1981 CALLS	CALLS	MAXIMUM DISTANCE	AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
MILL CREEK		18	5.00	3.00	20
WAPANUCKA		20	4.00	3.10	23
LOVE					
*MARIETTA	407	461	22.00	8.25	531
LEON		9	10.00	5.77	10
OVERBROOK		9	3.00	3.00	9
THACKERVILLE		119	4.00	3.30	137
MARSHALL					
*MADILL	677	777	17.00	7.89	909
KINGSTON		33	3.00	3.00	39
LEBANON		12	3.00	3.00	14
LITTLE CITY		10	3.00	3.00	12
NEW WOODVILLE		17	3.00	3.00	20
MURRAY					
*SULPHUR	800	835	17.00	6.36	892
DAVIS		81	5.00	3.01	87
DOUGHERTY		5	3.00	3.00	5
HICKORY		4	3.00	3.00	4
JOY		5	3.00	3.00	5
PONTOTOC					
*ADA	1,358	1,510	23.00	5.11	1,582
*ALLEN	85	92	12.00	5.89	100
BYNG		28	3.00	3.00	31
FITTSTOWN		11	7.00	5.19	12
ROFF		15	9.00	3.42	16
STONEWALL		25	3.00	3.00	27
VANOSS		8	3.00	3.00	9

* INDICATES BLS SERVICE

OTHER LOCATIONS ARE SUGGESTED FIRST RESPONDER SITES

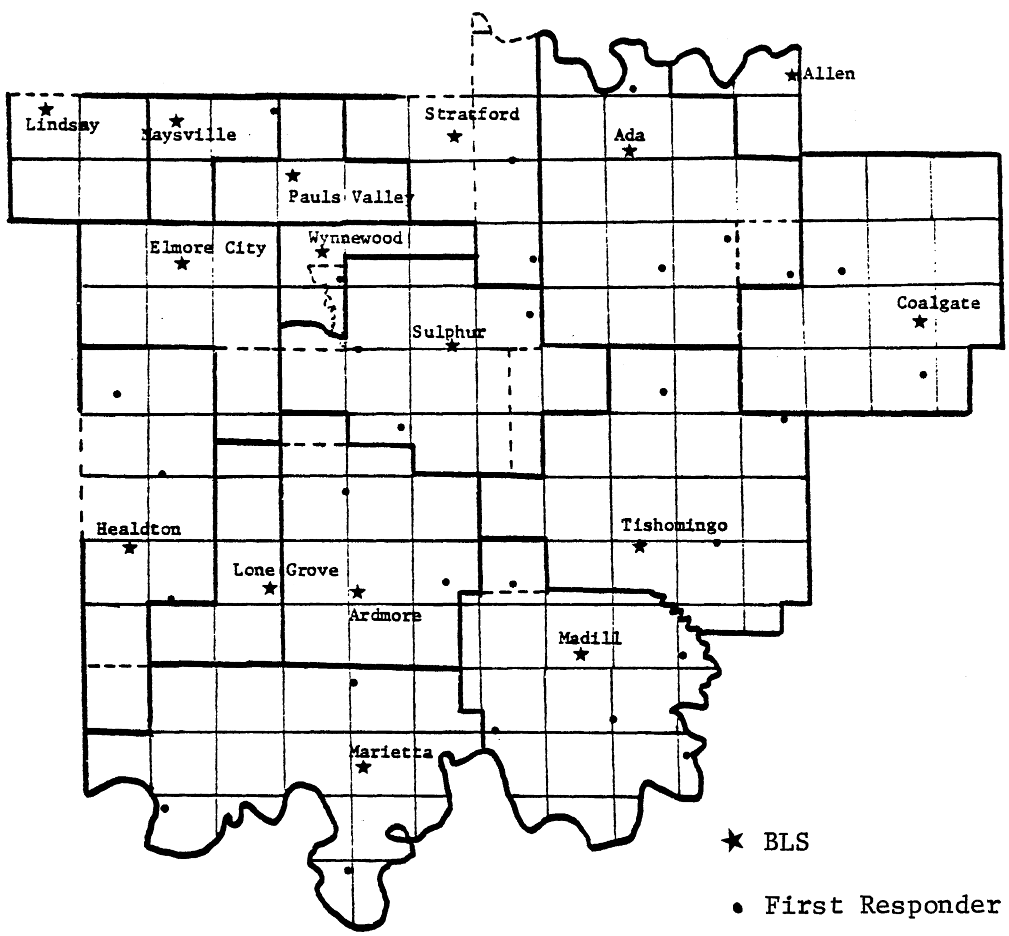


FIGURE 8. EMS Service Area Delineation, Area 7

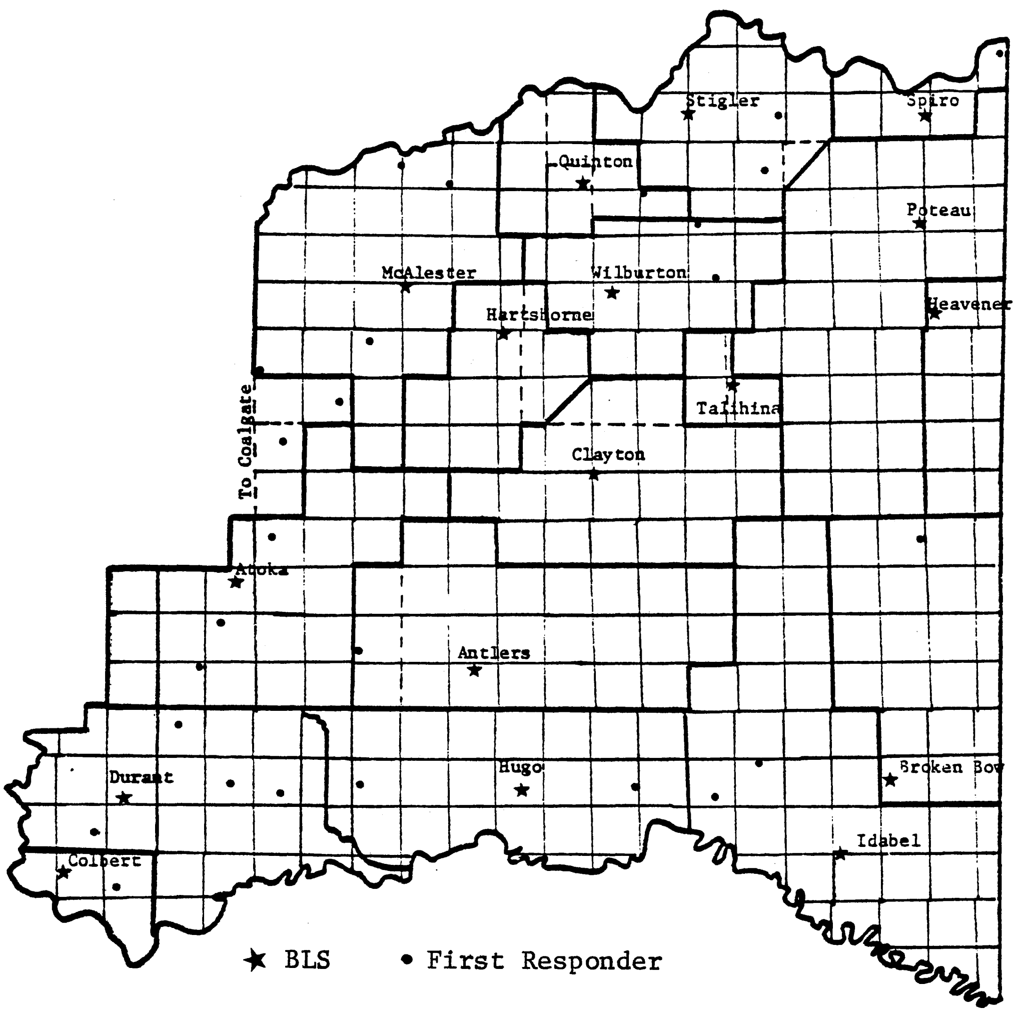


FIGURE 9. EMS Service Area Delineation, Area 8

17 EMS systems and 25 suggested first responder sites which serve 329 townships or destinations. Data in Table XXVI show the number of calls, projections and mileages for this area. Spiro, in LeFlore County had 346 emergency calls in 1981. This number is expected to increase to 433 by 1990. The EMS service at Spiro travels a maximum distance of 13.00 miles to respond to an emergency medical service call and an average distance of 7.11 miles. First responders would travel a maximum of 25.00 miles out of Smithville to respond to an emergency medical service call in McCurtain County. The EMS system at Broken Bow would also respond to the calls received at Smithville. The maximum distance for this service to travel is 49.00 miles. Four townships in the western part of this area are served by the EMS service out of Coalgate in area 7.

Summary

The analysis in this portion of the study provides EMS planners and decisionmakers with the information needed to suggest efficient service areas for emergency medical service systems in the State. Once these EMS system areas are organized it is imperative that the emergency medical resources within the service area be organized in the most efficient manner to insure rapid response times. These resources include the number of crews to have on duty, and the location of first responders. A model, based on queueing theory, for determining the optimum number of crews to have on duty at various times of the day is outlined in a study by Sellassie, Doeksen and Oehrtman (47). The study recognizes the nature of emergency calls is such that the equipment and personnel are idle a great deal of the

TABLE XXVI

ESTIMATED MILEAGE AND NUMBER OF SERVICE CALLS IN AREA 8 BY EMS SYSTEM

		1985			
EMS BY COUNTY	1981 CALLS	CALLS	MAXIMUM DISTANCE	AVERAGE DISTANCE	1990 CALLS
			---- MILES	----	
ATOKA					
*ATOKA	301	320	28.00	8.77	346
CANEY		6	8.00	3.85	7
FARRIS		4	6.00	4.27	4
STRINGTOWN		28	3.00	3.00	30
TUSHKA		8	3.00	3.00	9
WARDVILLE		4	3.00	3.00	4
BRYAN					
*COLBERT	287	310	14.00	5.64	338
*DURANT	1,960	2,105	31.00	6.94	2,310
ACHILLE		22	10.00	5.01	24
BENNINGTON		19	19.00	5.63	21
BOKCHITO		22	12.00	5.21	24
CADDO		40	7.00	4.32	43
CALERA		40	3.00	3.00	44
CHOCTAW					
*HUGO	654	683	29.00	9.66	727
BOSWELL		21	7.00	3.73	22
FORT TOWSON		25	12.00	5.59	27
HASKELL					
*STIGLER	411	442	20.00	8.22	477
KEOTA		20	8.00	4.04	22
KINTA		12	4.00	3.15	15
McCURTAIN		22	6.00	3.44	24
LATIMER					
*WILBURTON	200	212	23.00	7.47	230
RED OAK		23	11.00	6.31	25

TABLE XXVI (Continued)

EMS BY COUNTY	1981 CALLS	1985 CALLS	1985 MAXIMUM DISTANCE	1985 AVERAGE DISTANCE	1990 CALLS
			---- MILES ----		
LEFLORE					
*HEAVENER	254	280	46.00	9.00	318
*POTEAU	1,111	1,226	47.00	14.84	1,389
*SPIRO	346	382	13.00	7.11	433
*TALIHINA	89	98	14.00	3.94	111
ARKOMA		69	9.00	3.38	78
McCURTAIN					
*BROKEN BOW	349	385	49.00	8.14	439
*IDABEL	1,118	1,232	48.00	12.98	1,396
SMITHVILLE		17	25.00	12.65	19
VALLIANT		33	10.00	3.16	38
WRIGHT CITY		33	18.00	5.22	37
PITTSBURG					
*HARTSHORNE	245	262	30.00	5.33	280
*McALESTER	1,336	1,414	25.00	6.31	1,517
*QUINTON	187	200	15.00	7.48	213
ASHLAND		5	7.00	3.77	5
CROWDER		21	3.00	3.00	23
INDIANOLA		11	6.00	4.46	12
KIOWA		27	12.00	3.91	29
SAVANNA		27	3.00	3.00	29
PUSHMATAHA					
*ANTLERS	453	500	31.00	8.27	561
*CLAYTON	144	162	34.00	13.28	176

* INDICATES BLS SERVICE
OTHER LOCATIONS ARE SUGGESTED FIRST RESPONDER SITES

time. The decision to add additional crews or emergency vehicles in a service area depends on the number of times that an emergency call is received. This study presents a methodology to estimate the number of times a year that multiple calls are received. The use of these methods in conjunction with this analysis can provide a comprehensive plan for developing highly efficient EMS systems in Oklahoma. The location of first responders is a function of the number of calls and the desired response time. Again, local decisionmakers must decide on the level of service given within the level of available funds.

CHAPTER V

TECHNIQUES UTILIZED TO ASSESS THE QUALITY OF EMERGENCY MEDICAL CARE

This study has addressed two situations which affect the quality of emergency medical services in the state of Oklahoma. First, an analysis of the structural characteristics of EMS systems in Oklahoma based on their licensing requirements was presented. That portion of the study assumed that emergency medical service is improved by the requirements which must be met to obtain a license. Second, the study developed guidelines for providing the most efficient service area boundaries for EMS systems based on highway mileage, usage and population projections. Likewise, locations of first responders were suggested. The goal of service area delineation and suggestion of first responders sites is to minimize response time. Given this information, it would be valuable to determine what affect some additional characteristics have on the quality of emergency medical service.

Policy makers, community planners and legislators would benefit from information on characteristics which contribute to improved emergency medical care. Such information could be used to identify changes in or additions to current laws which would improve the quality of emergency care. Statistical information concerning these characteristics and quality variables could also provide the basis for requesting the funding or assistance necessary to improve the quality of emergency medical care.

The final portion of this study is devoted to identification of factors which contribute to the quality of emergency medical care in Oklahoma. This will be accomplished by the development of a method which utilizes information available on licensing applications, information related to the characteristics of the service, and a variable related to the quality of emergency medical care. Quality of emergency medical service is extremely difficult to measure. This study will utilize the number of highway fatalities per thousand highway injuries which an EMS service has as a measure of the quality of the emergency care provided by that service. This measure is utilized given the assumption that good quality medical care can reduce the number of fatalities which occur as the result of accidents or medical emergencies.

The analysis will be accomplished through the use of two techniques. These include discriminant analysis and ordinary least squares regression. The purpose of this chapter is to summarize the theory behind these approaches and the situations to which they apply.

Discriminant Analysis

Discriminant analysis is used when it is desirable to statistically distinguish between two or more groups. The researcher collects a set of "discriminating variables" which measure characteristics on which the groups are expected to differ. Discriminant analysis attempts to weight and linearly combine the discriminating variables so that the groups are forced to be as statistically distinct as possible (41).

The Basic Assumptions

Discriminant analysis utilizes the basic assumptions which follow (32):

1. the units of analysis, or data cases, should be members of two or more mutually exclusive groups;
2. the discriminating variables must be measured at the interval or ratio level of measurement to assure proper calculation in mathematical equations;
3. there is no limit on the number of discriminating variables as long as the total number of observations exceeds the number of variables by two;
4. no variable may be a linear combination of other discriminating variables;
5. the population covariance matrices are equal for each group; and
6. it is assumed that each group is drawn from a population with a multivariate normal distribution.

The Discriminant Function

Given m samples with $n_1, n_2, \ldots, n_m$ observations on the random variables $x_1, x_2, \ldots, x_k$, new individuals can be allotted to the correct population group using the following function (10):

$$D_{ij} = \alpha_{ij} + X\beta_{ij} \quad i_{ij} = 1, 2, \ldots, m \text{ but } i \neq j$$

Equation (5.1)

where

X = the column vector of observations on the k x's for a given individual;

α = a constant to be estimated; and

β = a vector of k constants to be estimated.

If all the functions defined by the above equation are known and if the value of the vector X for a specific individual is known, this individual should be classified into that group, i, for which

$D_{ij} > \log_e [q_j/q_i]$ for all i and j, $i \neq j$ Equation (5.2)

where q_i and q_j are the a priori probabilities of drawing a new observation from group i and j respectively (5).

The constants in Equation 5.1 can be estimated by:

$\hat{\beta}_{ij} = S^{-1} (\overline{X}_i - \overline{X}_j)$, and Equation (5.3)

$\hat{\alpha}_{ij} = -0.5 (\overline{X}_i + \overline{X}_j)' \hat{\beta}_{ij}$ Equation (5.4)

where S is the k-square matrix of variances and covariances over all m samples having elements of the form

$$s_{uv} = \frac{1}{N - m} \sum_{i=1}^{m} \sum_{t=1}^{n_i} (X_{itu} - \overline{X}_{iu}) (X_{itv} - \overline{X}_{iv}) \qquad \text{Equation (5.5)}$$

$$u, v = 1, 2, \ldots, k$$

where:

$N = \sum_{i=1}^{m} n_i = n_1 + n_2 + n_3 \ldots + n_m$ (sum of the observations in m samples)

X_i, X_j = the column vectors of means of the k x's for samples i and j; and

$\overline{X}_{iu}$, $\overline{X}_{iv}$ = the means of variables u and v over all samples.

Once the discriminant function is obtained along with the classification rule (Equation 5.2) it can be used to classify each individual in the sample. One group of observations can be used to develop the classification rule. From that point, additional groups of observations can be classified based on the results of the classification rule. If relevant, the size and sign of the estimated coefficients, then $\hat{\beta}_{ij}$, can be utilized to determine the importance of the variables as with multiple regression analysis (20).

Selected Applications of Discriminant Analysis

Discriminant analysis was used by Bromley to aid rural communities in Wisconsin in determining their economic development "comparative advantage". It was recognized that there exist dominant forces which cause a rural area to achieve a degree of increased economic activity in the form of either tourism or industry. A group of 20 variables were identified as having a bearing on a county's advantage as being a recreation area or industrial area. Discriminant analysis enabled researchers to indicate which of the variables that were measured had the greatest impact on placing a county in either of these groups. It is possible for a county to strengthen it's comparative advantage in an area of economic development by concentrating efforts on a certain area. Alternatively, if the planners of the county were unsatisfied with being "assigned" to one group they were then aware of the areas of development which must be abandoned and those which must be strengthened in order to attract the other, more satisfactory, type of business to their area.

Lovejoy utilized discriminant analysis in a study involving employment predictions (37). The author points out that previous studies to determine employment needs in an area were concerned basically with distances to employment, population characteristics and the number of jobs. The author perceives a need to match these kinds of data with information concerning the desires and characteristics of both the local population and incoming industries. Discriminant analysis was used to determine whether and which local rural residents would obtain employment with a new energy development in Utah. The discriminant function utilized was one which distinguished those employed at a similar facility located elsewhere and those unemployed in the vicinity of the new plant location. The results of the classification of those employees at the existing location could then be used to assign categories of employment possibility to those unemployed workers who might be applying for positions at the new plant location.

Discriminant analysis was used to examine the characteristics of members of artificial livestock breeding cooperatives in Pennsylvania (20). The members were questioned as to their opinion of the proposed merger of two cooperatives. Their responses were either in favor of, opposed to, or undecided about the merger. The discriminating characteristics were related to the age and income of the member as well as various information about the member's farm and livestock herd. Hallberg examined the characteristics as to their importance in distinguishing the opinion of the member towards the merger. The authors were then able to determine the characteristics of members who opposed or were in favor of the merger.

Ordinary Least Squares Regression

The simple linear regression model assumes that the true state of stochastic interrelationships between variables can be represented by a linear equation of the following form:

$$Y_i = \alpha + \beta X_i + \varepsilon_i \quad i = 1, 2, \ldots, n \qquad \text{Equation (5.6)}$$

where Y_i is a dependent variable whose variation is explained by the explanatory variables X_i, i =1, 2,...,n. The stochastic disturbance is ε, and α and β are the regression parameters. The subscript i refers to the i^{th} observation. The values of the variables X and Y are observable, but those of ε are not. Y is an nxl vector of observed values on the dependent variable, X is an nxk matrix of observations on the independent variables, β is a kxl vector of unknown parameters and u is an nxl vector of unknown disturbances where k is the number of explanatory or independent variables in the equation and n is the number of observations in the sample (26). With least squares the estimator for β, $\hat{\beta}$, is chosen to minimize the sum of squared deviations of the observed values from their means. The estimator $\hat{\beta}$ derived in this manner is given in the matrix form as:

$$(X^1X)^{-1} X^1Y \qquad \text{Equation (5.7)}$$

The model yields an unbiased estimator with the lowest variance of all linear unbiased estimators when the following set of basic assumptions hold:

1. ε_i is normally distributed;
2. $E(\varepsilon_i) = 0$;
3. $E(\varepsilon_i\ ) = \sigma^2$; and
4. $E(\varepsilon_i \varepsilon_j) = 0 \ i \neq j$;

The first two assumptions state that, for each value X_i, the disturbance is normally distributed around zero. The third assumption concerns homoskedasticity and means that every disturbance has the same variance σ^2 whose value is unknown. The fourth assumption requires that the disturbances be non-autoregressive. The second and the fourth assumptions imply that the disturbances are uncorrelated (33).

The estimators obtained through ordinary least squares (OLS) regression possess these desirable properties. Hypotheses about the regression model may also be tested and an estimate of the impact of the effect that the explanatory variables have upon the dependent variable is obtained (31).

Distinction Between OLS Regression and Discriminant Analysis

The basic distinction between regression analysis and discriminant analysis lies in the form of the criterion variable (44). Regression analysis uses a weighted combination of values on various predictor variables to predict or estimate an object's value on a quantitative criterion variable when given it's values on each of the predictor variables. The criterion variable is continuously scaled. In discriminant analysis a "discriminant" function is used. This function is a weighted combination of those predictor variable values used to "classify" an object into two or more criterion groups. The function assigns an object a value on the quantitative criterion variable (28).

Discriminant analysis uses group membership as the criterion and makes all comparisons between groups and none within groups. This differs from regression in that there is no basis for between group comparison. Discriminant analysis is used when the task of classification or grouping is required while regression analysis is utilized when there is no basis for comparison between groups based on the classification variable.

Discriminant analysis is used in this study to classify observations into one of two groups based on a criterion variable and the use of a cut-off point to develop a dichotomous grouping. Regression analysis is then used to study the relationship between predictor variables and the continuously scaled criterion variable.

CHAPTER VI

ASSESSING THE QUALITY OF EMERGENCY MEDICAL CARE

This study employs the use of discriminant analysis as a tool to classify EMS systems based on the quality of emergency medical care they provide. The number of highway fatalities per 1000 highway injuries is used to group the EMS systems into "high" and "low" groups. An EMS system which falls into the "low" group is assumed to provide a better level of emergency care than an EMS system belonging to the group with a high number of fatalities per 1000 injuries. The dichotomy for this grouping is determined by using the mean and median number of fatalities per 1000 injuries as cut-off points in two applications of discriminant analysis. This analysis provides a guideline for determining how an EMS system will perform based on selected characteristics.

The analysis is extended with ordinary least squares (OLS) regression to determine the effects that explanatory variables have on the number of fatalities per 1000 injuries. The analysis develops a model to test hypotheses related to changes in the explanatory variables and the effects these changes have on the direction of change in the quality variable.

Development of this classification procedure and a determination of the characteristics which influence the quality of emergency medical care may aid in the improvement of EMS systems in Oklahoma. The pre-determination of quality may afford state licensing officials the means to improve the quality of an EMS system by requiring upgrading of equipment or services or by implementing policy changes. Local decisionmakers may identify characteristics which can be improved or adopted at little cost to improve EMS in their community.

Description of the Variables and Related Hypotheses

Quality measures of an effective EMS system are difficult to find and measure. The ultimate goal of an EMS system is to reduce the number of deaths. Highway fatalities per 1000 highway injuries is a quality variable which was obtainable for EMS systems in Oklahoma. For this reason, the number of fatalities per 1000 injuries which occur in an EMS system area is utilized as the measure of quality. The dependent variable is identified in the model specification by FAT/INJ.

The variables chosen to explain differences in the quality of EMS were gathered from information obtained in the Registry of Ambulances (43). Listed below are the variables utilized in the model. Following each definition is a brief explanation of the hypothesis behind each variable.

<u>Category of Licensing</u>

CATD = 1 if the EMS system was unable to obtain licensing immediately upon application

= 0 if the EMS system was licensed immediately upon application

It is assumed that an EMS system which was properly equipped and manned would obtain licensing immediately and would provide good quality ambulance care. Therefore, it is hypothesized that those EMS systems which obtained licensing at the time of application would have a lower number of fatalities per 1000 injuries while those which were not would have a greater number of fatalities per 1000 injuries in that service area.

Type of Service

TYPED1 = 1 type of EMS service is paid fire department, law enforcement or government

= 0 otherwise

TYPED2 = 1 type of EMS service is hospital based

= 0 otherwise

TYPED3 = 1 type of EMS service is private or funeral home

= 0 otherwise

TYPED4 = 1 type of EMS service is volunteer

= 0 otherwise

Due to the availability of equipment, personnel and professional guidance, it is hypothesized that an EMS system which is hospital-based would be in a position to provide a better level of emergency care relative to other types of services.

Owner/Operator Status

OWNOPD1 = 1 EMS service owned and/or operated by a city, county, city and county, authority or board

= 0 otherwise

OWNOPD2 = 1 EMS service owned and/or operated by a hospital
= 0 otherwise

OWNOPD3 = 1 EMS service owned and/or operated privately or by a funeral home

= 0 otherwise

OWNOPD4 = 1 EMS service operated on a volunteer basis

= 0 otherwise

Owner/operator status is similar to the type of service. Again it is hypothesized that an EMS service which is operated by a hospital would have access to the resources which would enable that EMS system to provide better medical care in relation to an EMS system which is owned and operated under other conditions. Therefore, a hospital operated EMS is hypothesized to have fewer fatalities per 1000 injuries.

Source of Funding

FUNDD1 = 1 EMS service is funded principally by city subsidy
= 0 otherwise

FUNDD2 = 1 EMS service is funded principally by county subsidy

= 0 otherwise

FUNDD3 = 1 EMS service is funded principally by hospital subsidy

= 0 otherwise

FUNDD4 = 1 EMS service is funded principally by sales tax

= 0 otherwise

FUNDD5 = 1 EMS service is funded principally be utility assessment

= 0 otherwise

FUNDD6 = 1 EMS service is funded principally by ad valorem tax

= 0 otherwise

FUNDD7 = 1 EMS service is funded principally by subscription

= 0 otherwise

FUNDD8 = 1 EMS service is funded principally by charges

= 0 otherwise

Any relationship between the means by which an EMS system is funded and the quality of service it provides is hard to determine due to the many different types of funding situations which exist. However, due to the administrative environment which provides an ad valorem tax for funding of ambulance services, it is assumed that a service which functions under this type of system would have a reliable and consistent flow of funding. It is assumed that the proper equipment could be maintained and personnel could be retained due to the security of funds. Therefore it is hypothesized that a service funded by an ad valorem tax will have a higher quality of emergency care or lower fatalities per 1000 injuries.

Medical Director

DIRECTD = 1 if EMS system retains a medical director

= 0 otherwise

An EMS system which has a medical director would be assumed to have resources, in the form of technical guidance, training and management skills, which would be unavailable in EMS systems without a director. It is hypothesized that EMS systems which have a director would then have a lower number of fatalities per 1000 injuries in their service area.

EMS Council

COUNCILD = 1 if EMS system operates under the guidance of an EMS council

= 0 otherwise

Operation of an EMS system under the direction of an EMS council offers organization and direction which may not exist in the absence of an EMS council. It is hypothesized, based on this, that an EMS system operating under the direction of a council would exhibit a higher degree of quality than other EMS systems.

Ambulance Personnel

REG1 = the total number of ambulance personnel licensed and registered with the National Registry of Emergency Medical Technicians per number of emergency medical calls

NONREG1 = the total number of ambulance personnel which are not licensed Emergency Medical Technicians per number of emergency medical calls

It is assumed that the more personnel which an EMS system has per number of calls it receives the more effective it will be in providing emergency care. The number of registered and non-registered ambulance personnel per number of calls are included as variables. However, it is assumed that the number of registered technicians per number of emergency medical calls would have a greater impact on reducing the number of fatalities per 1000 injuries than the number of non-registered personnel.

Equipment

EQUIP = percentage of the equipment required by the American College of Surgeons (ACS) carried on board the ambulance

The equipment utilized in the treatment of patients with emergency illness or injury is vital. The availability of or the failure to carry the proper amount of equipment could contribute to or detract from the effectiveness of the care provided. It is hypothesized that the number of fatalities per 1000 injuries is inversely related to the percentage of ACS equipment which an EMS system maintains.

Emergency Calls

CALLS = annual number of emergency medical service calls to which the EMS system responds

It is assumed that an EMS system required to respond to a great many calls will not only receive an increased level of experience in dealing with various types of medical emergencies but will also be more readily available and prepared to respond to a call. In general, it is hypothesized that an EMS system with a high number of calls will have a lower number of fatalities per 1000 injuries.

Population Density

POP = population per square mile in the EMS system area

It is observed that in an area which is densely populated the EMS system service area is smaller than a sparsely populated area. Because it would probably take less time to deliver a patient to a hospital facility in a densely populated area, the quality of emergency care provided in this area may be better. The number of fatalities per 1000 injuries should be reduced by the ability to hospitalize the patient more rapidly.

Response Time

AVGMILE = average number of miles travelled by the EMS system in response to medical emergencies

MAXMILE = maximum number of miles travelled by the EMS system in response to medical emergencies

The average and maximum number of miles travelled by an EMS system can be used as a proxy for response time. An EMS system which has short average and maximum response times is hypothesized to have a lower number of fatalities per 1000 injuries relative to an EMS system which has longer response times.

Miles of Roadway

MILES = total number of miles of state and federal roadway within the EMS system service area

It is hypothesized that the number of fatalities would increase in a service area which has a large amount of state and federal roadway miles within its boundaries. This would be attributed to the increased amount of traffic in a service area, both on and off the highway.

Drinking Drivers

DRUNK = total number of accidents within the EMS service area which involved drinking drivers

Due to the increased interest in reducing the number of drinking drivers on the highway and the direct relationship between highway accidents and drinking drivers, this variable is included. It will be used to test the hypothesis that more fatal injuries occur as a result of accidents caused by drinking drivers. Therefore, an area which has a high number of alcohol-related accidents is expected to have a higher number of fatalities per 1000 injuries due to the severity of the resulting injuries.

Results of Discriminant Analysis

The objective of this portion of the study is to develop a classification system for EMS systems based on the quality of the emergency medical care they provide. Discriminant analysis was used to classify the EMS systems into two categories based on whether they had a number of fatalities per 1000 injuries that was above or below a cut-off point. Two applications of variables will be analyzed. One will use the mean number of highway fatalities per 1000 highway injuries of all EMS systems while the other will use the median as the cut-off point to divide the observations into "high" and "low" groups. It is hypothesized than an EMS system with a "low" number of fatalities per 1000 injuries is able to provide better quality emergency care than an EMS system with a "high" number of fatalities per 1000 injuries.

The SAS DISCRIM package was used to classify the EMS systems into groups based on the number of fatalities per 1000 injuries and the characteristics of the discriminating variables (1). The results of the classification procedure which utilized the median number of fatalities per 1000 injuries in the procedure are found in Table XXVII while the results based on the mean number are found in Table XXVIII.

Use of the median number of fatalities per 1000 injuries resulted in the correct classification of 50 of the 86 systems belonging to the group of "low" fatalities per 1000 injuries, or 58.14 percent of the EMS systems in this category. This results in the misclassification of 36 or 41.86 percent of the EMS systems into the "low" group which actually belong in the "high" group. Of those EMS systems which have a total number of fatalities per 1000 injuries greater than the median, 81 of the 86 were properly classified in the "high" group. The discriminant procedure properly classified 94.19 percent of the EMS system in the "high" category leaving only 5 services or 5.81 percent of the group classified improperly. By examining the columns in Table XXVII which indicate the percentages of the total number of observations it is seen that 29.07 percent of the services were properly classified as being in the "low" group and 47.09 were properly classified in the "high" group. This indicates that a total of 76.16 percent of the services were properly classified while the remaining 23.84 were misclassified.

TABLE XXVII

CLASSIFICATION OF EMS SYSTEMS BY DISCRIMINANT ANALYSIS USING MEDIAN NUMBER OF FATALITIES PER 1000 INJURIES

Fatalities/1000 Injuries	Number* In Group	Number and Percent of Observations in Group at Left Classified Into Group Below					
		Low Number of Fatalities/1000 Injuries			High Number of Fatalities/1000 Injuries		
		Number	% of group	% of total	Number	% of group	% of total
Low	86	50	58.14	29.07	36	41.86	20.93
High	86	5	5.81	2.91	81	94.19	47.09
Total	172						

* Indicates the number of ambulance services which belong in this group

TABLE XXVIII

CLASSIFICATION OF EMS SYSTEMS BY DISCRIMINANT ANALYSIS USING AVERAGE NUMBER OF FATALITIES PER 1000 INJURIES

Fatalities/1000 Injuries	Number* In Group	Number and Percent of Observations in Group at Left Classified Into Group Below					
		Low Number of Fatalities/1000 Injuries			High Number of Fatalities/1000 Injuries		
		Number	% of group	% of total	Number	% of group	% of total
Low	111	71	63.96	41.28	40	36.04	23.25
High	61	5	8.20	2.91	56	91.80	32.56
Total	172						

* Indicates the number of ambulance services which belong in this group

The overall results of the discriminant procedure using the mean number of fatalities per 1000 injuries (Table XXVIII) are less accurate than use of the median number. A total of 73.84 percent of the observations are properly classified while 26.16 percent are misclassified. The difference in the number of observations in each group results in an improved classification of the services in the "low" group which is outweighed by more severe misclassification of the "high" group. The "low" group of EMS systems has an increase in number by 25 totalling 111 services. Seventy-one of the services, or 63.96 percent, in this group are properly classified while 36.04 percent of the services are classified improperly. A reduction in the number of services classified properly in the "high" category results from the loss of 25 observations in this category when the mean is used. Fifty-six services, or 91.80 percent are classified properly. The number misclassified in the "high" group remains at 5 but is now 8.20 percent of that group. It is apparent that the change in the number of observations in each group is directly related to the number in that group which is classified properly.

Results of Ordinary Least Squares Regression

Ordinary least squares (OLS) regression was used with the same set of explanatory variables utilized in the discriminant analysis. While the discriminant function uses the binary variables of the "high" and "low" number of fatalities per 1000 injuries, the regression analysis employs the continuous form of this variable. The

OLS analysis determines which variables utilized in the discriminant analysis contribute most in explaining variability in the quality of emergency medical service. OLS regression also allows tests of significance of separate variables to be performed, thereby testing hypotheses previously outlined.

The general form of the model tested is:

FAT/INJ = f (CATD, TYPED1, TYPED2, TYPED3, OWNOPD1, OWNOPD2, OWNOPD3, FUNDD1, FUNDD2, FUNDD3, FUNDD4, FUNDD5, FUNDD6, FUNDD7, DIRECTD, COUNCILD, REG1, NONREG1, EQUIP, CALLS, POP, AVGMILE, MAXMILE, MILES, DRUNK)

Equation (6.1)

Because the model will include an intercept, one of the categories in each of the groups of binary variables is omitted to avoid obtaining an exact linear relationship between the variables and the intercept.

The SAS procedure SYSREG was used to obtain the results of the regression procedure for the following model (1):

$$\begin{aligned}\text{FAT/INJ} = {} & \beta_0+\beta_1\text{CATD} + \beta_2\ \text{TYPED1} + \beta_3\ \text{TYPED2} + \beta_4\ \text{TYPED3} + \beta_5\ \text{OWNOPD1} \\ & +\beta_6\text{OWNOPD2} + \beta_7\ \text{OWNOPD3} + \beta_8\ \text{FUNNDD1} + \beta_9\ \text{FUNDD2} \\ & +\beta_{10}\ \text{FUNDD3} + \beta_{11}\ \text{FUNDD4} + \beta_{12}\ \text{FUNDD5} + \beta_{13}\ \text{FUNDD6} \\ & +\beta_{14}\ \text{FUNDD7} + \beta_{15}\ \text{DIRECTD} + \beta_{16}\ \text{COUCILD} + \beta_{17}\ \text{REG1} \\ & +\beta_{18}\ \text{NONREG1} + \beta_{19}\ \text{EQUIP} + \beta_{20}\ \text{CALLS} + \beta_{21}\ \text{POP} \\ & +\beta_{22}\ \text{AVGMILE} + \beta_{23}\ \text{MAXMILE} + \beta_{24}\ \text{MILES} + \beta_{25}\ \text{DRUNK}\end{aligned}$$

Equation (6.2)

This form of the equation was used to determine the significance of the variables based on the following hypothesis and the alternative:

H_0 : $B_0 = B_1 = B_2 = \ldots = B_{25} = 0$

H_A : not the null hypothesis

Inclusion in the model of all of the variables which were perceived to be relevant resulted in a model exhibiting an R^2-value of .2929 indicating that the model explained 29 percent of the variability in the dependent variable. However, the model contained only one variable which was significant at the 10 percent level on the basis of t-tests (17). In addition, the signs of the parameters were not in agreement with the hypothesized relationships. A listing of the variables and their associated coefficient values is found in Appendix C.

Through the process of performing all possible regressions, the following model was determined to be the most useful in explaining the number of fatalities per 1000 injuries occurring in an EMS system.

$$\begin{aligned} \text{FAT/INJ} = \underset{(4.96)}{73.0391} &- \underset{(1.96)}{0.0210}\ \text{CALLS} - \underset{(1.60)}{0.2109}\ \text{POP} \\ &+ \underset{(2.19)}{2.907}\ \text{AVGMILE} - \underset{(1.49)}{14.6630}\ \text{CATD} \\ &- \underset{(.57)}{79.2098}\ \text{REG1} - \underset{(.88)}{81.2394}\ \text{NONREG1} \end{aligned} \qquad \text{Equation (6.3)}$$

The model has an R^2-value of .1215. The t-values obtained in the analysis are reported in parentheses below the estimates of the coefficients. These t-values are examined to test the hypotheses on the coefficients obtained for the explanatory variables. The t-values for the intercept and the coefficients of CALLS, POP, AVGMILE and CATD indicate a rejection of the hypotheses that the values are equal to zero. The t-values obtained for the coefficients on REG1 and NONREG1 are not sufficient to reject this hypothesis. This indicates that neither the number of registered employees nor the total number of non-registered employees is relevant in explaining the number of fatalities within each service area.

The F-ratio for the model is 3.80. A test of significance utilizing this value indicates rejection of the hypothesis that $B_0 = B_1 = B_2 = B_3 = B_4 = B_5 = B_6 = 0$ for the overall model. The reason for the contradiction to the results of the t-test for REG1 and NONREG1 is the fact that the separate contributions of the variables REG1 and NONREG1 to the explanation of the variation of FAT/INJ are weak, whereas their joint contribution, which cannot be decomposed, is quite strong (25).

It is also noted that the values of the coefficients on the variables REG1 and NONREG1 are very close and of the same sign. This is an indication that neither variable has a relatively predominant influence on the dependent variable contrary to the hypothesized relationship. This justifies the combination of these two variables to obtain an explanatory variable accounting for the total number of personnel in each EMS system, TOTEMP1 (TOTEMP1 = REG + NONREG/CALLS). When the two variables which account for the number of ambulance personnel are replaced by a variable whose value is the combined value, the following OLS regression equation is determined.

$$\begin{aligned} \text{FAT/INJ} &= \underset{(5.21)}{73.0886} - \underset{(1.97)}{0.0211\,\text{CALLS}} - \underset{(1.63)}{0.2111\,\text{POP}} \\ &= \underset{(2.20)}{2.9065\ \text{AVGMILE}} - \underset{(1.60)}{14.7019\ \text{CATD}} \\ &\quad - \underset{(1.16)}{80.5698\ \text{TOTEMP1}} \qquad \text{Equation (6.4)} \end{aligned}$$

This model results in the same R^2-value of .1215. This model also enables the rejection of the hypothesis that $B_1 = B_2 = B_3$

$= B_4 = B_5 = 0$ based on an F-ratio which is 4.59. In addition, the variables are acceptable at the 10 percent level of significance with the exception of TOTEMP1 and CATD.

Although the model exhibits a relatively low R^2-value, it does explain the direction of the relationships which are included in the model. As hypothesized, the total number of calls, population per square mile and the number of ambulance personnel are inversely related to the number of fatalities. The average number of miles travelled in response to a medical emergency is directly related to the dependent variable.

A very important hyothesized relationship is not confirmed by the model. The value of the intercept is 73.0886. Because of the binary nature of the CATD variables, the intercept measures the mean number of fatalities per 1000 injuries for those EMS systems which were licensed. The value of the intercept is reduced by 14.7019 and becomes 58.3867 when this variable is equal to one, indicating the category as being "not licensed". The model, therefore, indicates that the number of fatalities per thousand injuries is actually higher in the "licensed" category. While this situation opposes the hypothesized relationship it can be illustrated by examining some frequencies in the raw data. The average number of fatalities per thousand injuries in the "licensed" category is 67.54. The average number in the "unlicensed" category falls to 59.24. This may explain the results obtained in the regression analysis and the contradiction to the hypothesized relationship.

The magnitude of the change in the dependent variable caused by each of the significant variables would be valuable in the analysis of the classification procedure of discriminant analysis. The model indicates that an increase in population per square mile by 100 results in a reduction in fatalities per 1000 injuries by 21. The number of fatalities per 1000 injuries is increased by almost three per year when average response time is increased due to an increase in average mileage of one mile. The model also shows that with an increase of 100 calls, the number of fatalities per 1000 injuries is reduced by two.

Summary

A method to properly classify an EMS system in the manner described, used in conjunction with regression analysis to determine which variables are important in the classification process, may aid policymakers and EMS planners. The goal of this analysis is to properly classify a "large" number of the observations. The proportion classified correctly to make the method acceptable as a planning tool must be a completely subjective decision as there are no decision criteria available. The analysis should be examined in conjunction with the results of the regression procedure to arrive at a conclusive decision concerning the acceptability of the method as an analytical approach to estimating the quality of emergency medical care.

Before the model is used it should be noted that multicollinearity is present in the data. The correlation coefficients are presented in Appendix B. The correlation matrix indicates that a high degree of association exists between the variables related to the mileages which the EMS system must travel in response to an emergency and the number of miles of state and federal roadway in the service area. Another example of the degree of correlation within the model is shown in the association between the number of calls an EMS system receives a year and the population within that service area. The number of calls is also highly correlated with the number of miles of state and federal roadway in the service area.

A high degree of correlation will create multicollinearity within the model which could contribute to the insignificant regression results (33). This correlation among the explanatory variables could cause large variances in the regression coefficients. The acceptance region for the hypotheses is wide in the presence of this correlation. This weakens the power of the tests of significance.

As more and better data become available policymakers may be interested in repeating this analysis to determine if results will better support the hyothesis presented. More pertinent variables may also be determined and included in later analyses.

CHAPTER VII

SUMMARY AND CONCLUSIONS

In recent years federal and state legislaturesn have enacted laws which indicate their awareness of the importance of emergency medical care in reducing the number of deaths resulting from accidents and other medical emergencies. These laws led to changes in the structure of the emergency medical care system in Oklahoma. This study attempted to examine some of the areas of emergency medical care which have been affected by recent changes and to measure the impact these changes have on the quality of EMS care. It is assumed throughout the study that the quality of emergency medical care is affected in various ways. Specifically, by legislation affecting the operations of emergency medical care systems, by the ability of an EMS system to respond to an emergency as rapidly as possible, and by the emergency care that is provided by the system which responds to an emergency.

The first portion of the study is a descriptive analysis of the information provided on the license applications required of EMS providers beginning in January of 1982. The study determined that based on the licensing requirements enacted on that date less than half of the EMS providers in the state were able to obtain licensing. The study also examined the deficiencies of providers. The deficiencies which existed required that EMS providers in the state acquire additional equipment valued at $50,000.00 to comply with equipment regulations. It was also shown that the number of emergency medical technicians in the state had to be increased by over seventeen percent due to the requirements of the new laws governing emergency medical care services. These changes to indicate that the law affected the areas of personnel and equipment which are assumed to affect the quality of emergency medical care.

The second portion of the study utilized a computerized transportation algorithm to determine the most efficient service areas for EMS providers in the state. The underlying assumption is that a reduction in the response time of an emergency vehicle increases the probability of survival of the victim of an emergency. Based on the number of calls from demand areas, and highway mileages the model determined the boundaries of the service areas that would minimize the average response time of emergency vehicles to the site of an emergency, In addition, the number of calls the EMS services would receive in the future was predicted. Suggestions were also made as to the locations of first responder sites based on the distance of the location from an EMS service and the projected number of calls in the area.

An attempt was also made to develop a method to classify EMS systems based on the quality of emergency care they provide. The number of highway fatalities per 1000 highway injuries which occur in a service area was chosen as the variable to measure quality. Discriminant analysis was used to group the services into "high" and "low" numbers of fatalities per 1000 injuries based on the characteristics of the EMS system. Approximately 76 percent of the EMS systems were classified properly when the median number of fatalities per 1000 injuries was used as the cut-off point for the "high" and "low" groups. Ordinary least squares regression was then used to determine which variables utilized in the classification procedure contribute most in explaining the quality of emergency medical care. It was found that the population per square mile in a service area and the number of calls received by an EMS system are inversely related to the number of fatalities per 1000 injuries in that area. This measure of the quality of emergency care was found to increase as the average response time of emergency vehicles increased. Regression analysis was also used to test hypotheses relating to the direction of effect the explanatory variables have on the dependent variable and to determine the significance of the variables included in the model.

The results of the study can be used by EMS planners and local decisionmakers to aid in the development of policies which directly affect the provision of quality emergency medical care to the residents of rural areas in Oklahoma.

Limitations of the Study

The limitations of the study are related to the availability of good data which is appropriate for determining the quality of emergency medical care. In conducting this study it became evident that there is a limited amount of data which are appropriate to the task of determining the quality of emergency medical care. EMS systems currently maintain a record of the emergency calls which they make. Enactment of the 1981 Amendment to the Emergency Medical Care Act may further improve the quality of record keeping. However, no record is maintained which follows the progress of the trauma patient from the time the emergency occurs through the health care system to recuperation or alternatively to the death of the trauma victim. It would be valuable to maintain records concerning response times and treatment administered in addition to hospital records on the patient. This kind of information could be used to judge the treatment which was administered without the benefit of diagnosis by a physician. The data could be used to indicate where and what kind of equipment and training are required to improve emergency medical care. The availability of this additional information would make in possible to utilize other variables in the model. The techniques utilized in this study could be applied to a model which had less association between the variables. Reduction of the degree of multicollinearity in the model could result in improving the tests of significance.

Expansion of the time period of the study would allow more accurate estimates of the values of some of the variables. The extreme values would be balanced out over an extended time period adding to the reliability of the data.

Suggestions for Future Study

Improvements in the type and quality of data maintained by EMS providers could be used to show that good quality emergency medical care saves lives. National, state and local leaders as well as EMS planners need this proof to justify the allocation of additional funds for training, equipment and research and to influence the passage of laws which improve the quality of emergency medical care.

A previous study involving EMS systems in Massachusetts and West

Virginia has presented conclusive statistical results concerning the probability of survival of cardiac patients who have received emergency medical care (49). The researchers developed an analytical model which relates cardiac mortality to rural community, patient and EMS system characteristics. Research of this type would be valuable in upgrading the quality of rural emergency medical care in Oklahoma.

Development of further study should involve the collection of data which would allow the determination of the probability of survival of victims of trauma in rural areas in Oklahoma. This would require that data collection begin at the time the trauma is reported and that the surviving patient's recovery is monitored for several months to insure accurate reporting of the recovery. The data could be used to obtain the probability of survival of a patient based on the characteristics of the EMS system involved. The research could also be used to measure the effectiveness of higher quality medical care in the form of advanced life support or paramedic training. The impact of first responders on the probability of a patients survival could also be measured.

The information provided by studies which deal with the quality of emergency medical care can assist policymakers and legislators in the decisionmaking process. When justification of funding and training needs are available in the form of statistical evidence these decisionmakers have the increased ability to implement policy which will improve the quality of emergency medical care in the rural areas of Oklahoma. This action can improve the probability of reducing the number of deaths which occur as a result of emergency illness or injury.

Selected Bibliography

(1) Barr, Anthony J., James H. Goodnight, John P. Sall and Jane T. Helwig. A User's Guide to SAS-1979. Raleigh, North Carolina: SAS Institute, Inc., 1979.

(2) Bontrager, Sharon, Gerald A. Doeksen and Linda Crowley. Oklahoma Emergency Medical Service Training in 1980. Stillwater, Oklahoma: Oklahoma State University Department of Agricultural Economics, AE Report 8216, July, 1981.

(3) Bontrager, Sharon, Gerald A. Doeksen and Robert L. Oehrtman. Emergency Medical Service Training in Oklahoma: Current and Future Needs. Stillwater, Oklahoma: Oklahoma State University Department of Agricultural Economics AE Report 8214, July, 1981.

(4) Bowser, Max F. and John W. Goodwin. Optimum Distribution Patterns for Feeder Cattle. Stillwater, Oklahoma: Oklahoma Agricultural Experiment Station Technical Bulletin T-123, June, 1968.

(5) Brandow, G. E. and A. K. Potter. "An Application of the Linear Discriminant Function." Rural Sociology. Volume 18, No. 4, December, 1953, pp. 321-327.

(6) Brennan, Michael J. Preface to Econometrics. Cincinnati, Ohio: South-Western Publishing Company, 1973.

(7) Bromley, Daniel W. "The Use of Discriminant Analysis in Selecting Rural Development Strategies." American Journal of Agricultural Economics. Vol. 50, No. 2 (May, 1971), pp. 319-322.

(8) Cacoullos, T. Discriminant Analysis and Applications. New York: Academic Press, 1973.

(9) Committee on Allied Health. Emergency Care and Transportation of the Sick and Injured. Menasha, Wisconsin: George Banta Company, 1977.

(10) Cooley, W. W. and P. R. Lohnes. Multivariate Procedures for the Behavioral Sciences. New York: John Wiley, 1962.

(11) Daberkow, S. G. and G. A. King. "Response Time and the Location of Emergency Medical Facilities in Rural Areas: A Case

Study." American Journal of Agricultural Economics. Vol. 59, No. 3, (August, 1977), pp. 467-477.

(12) Doeksen, Gerald A., Leonard G. Anderson, Jr. and Vanessa Lenard. A Community Development Guide for Emergency Medical Services. Stillwater, Oklahoma: Oklahoma State Cooperative Extension Service, 1981.

(13) Doeksen, Gerald A., Barbara Broeckelman, Vanessa Lenard and Leonard Anderson Jr. "Other Computer Models Used in EMS Planning." (Paper to EMS Administration Workshop, Orlando, Florida, March 22-23, 1982).

(14) Doeksen, Gerald A., Vanessa Lenard, Barbara Broeckelman and Leonard Anderson Jr. "Emergency Medical Service Budgeting: An Effective Decisionmaking Tool." (Paper to EMS Administration Workshop, Indianapolis, Indiana, October 30-31, 1981.)

(15) Doeksen, Gerald A. and Vanessa Lenard. Financing Rural EMS Systems in the 80's. Stillwater, Oklahoma: Oklahoma Agricultural Experiment Station, Professional Paper 1443, 1983.

(16) Doeksen, Gerald A., James R. Nelson and Robert L. Oehrtman. "An Overview of Programs and Tools to Assist Local Decision Makers with Economic Planning for Community Services." (Paper to Southern Regional Science Association, Charleston, South Carolina, April 13-15, 1983.)

(17) Draper, N. R. and H. Smith. Applied Regression Analysis. New York: John Wiley and Sons, Inc., 1966.

(18) Eisenbeis, Robert A. and Robert B. Avery. Discriminant Analysis and Classification Procedures. Lexington, Massachusetts: Lexington Books, 1972.

(19) Goldstein, Matthew and William R. Dillon. Discrete Discriminant Analysis. New York: John Wiley and Sons, 1978.

(20) Hallberg, Milton C. "Multiple Discriminant Analysis for Studying Group Membership." University Park, Pennsylvania: Pennsylvania State University Agricultural Experiment Station Bulletin 775, February, 1971.

(21) Hallberg, Milton C. and W. R. Kriebel. "Designing Efficient Pickup and Delivery Route Systems by Computer." Agricultural Experiment Station Bulletin 782. University Park, Pennsylvania: Pennsylvania State University, June, 1972.

(22) Hardy, William E., Jr., J. Paxton Marshall and J. Edwin Faris. "Determining Locations for Rural Medical Clinics: A Model and It's Use." Southern Journal of Agricultural Economics. Vol. 5, No. 2 (December, 1973), pp. 165-173.

(23) Heady, Earl O. and Wilfred Candler. Linear Programming Methods. Ames, Iowa: The Iowa State University Press, 1973.

(24) Holland, David W. and John L. Baritelle. "School Consolidation in Sparsely Populated Rural Areas: A Separable Programming Approach." American Journal of Agricultural Economics. Vol. 57, No. 4 (November, 1975), pp. 567-575.

(25) Huang, David S. Regression and Econometric Methods. New York: John Wiley and Sons, Inc., 1970.

(26) Johnston, J. Econometric Methods. New York: McGraw-Hill Book Company, 1963.

(27) Judge, G. G. and T. D. Wallace. Spatial Price Equilibrium Analyses of the Livestock Economy. Stillwater, Oklahoma: Oklahoma Agricultural Experiment Station Technical Bulletin, TB-78, 1959.

(28) Kachigan, Sam Kash. Multivariate Statistical Analysis. New York: Radius Press, 1982.

(29) Kendall, M. A. The Advanced Theory of Statistics, Vol. 2. London: Charles Griffin and Company, 1948.

(30) Kendall, Maurice and Alan Stuart. The Advanced Theory of Statistics, Vol. 3. London: Charles Griffin and Company, 1976.

(31) Kennedy, Peter. A Guide to Econometrics. Cambridge, Massachussets: The MIT Press, 1981.

(32) Klecka, William R. Discriminant Analysis. Sage University Paper Series, Quantitative Analysis in the Social Sciences, 19. London: Sage Publications, Inc., 1980.

(33) Kmenta, Jan. Elements of Econometrics. New York: Macmillan Publishing Co., Inc., 1971.

(34) Lachenbruch, Peter A. Discriminant Analysis. New York: Hafner Press, 1975.

(35) Lindeman, Richard H., Peter F. Merenda and Ruth Z. Gold. Introduction to Bivariate and Multivariate Analysis. Glenview, Illinois: Scott, Foresman and Company, 1980.

(36) Liu, Charles V. and Donald A. West. A Spatial Analysis of Beef Feeding and Slaughtering with Emphasis on the South. Southern Cooperative Series, Bulletin No. 177, 1973.

(37) Lovejoy, Stephen B. "Employment Predictions in Social Impact Assessment: An Analysis of Some Unexplored Variables." Socio-Economic Planning Science Journal. Vol. 17, No. 2 (1983), pp. 87-93.

(38) Mayes, Anne C. and David G. Mayes. Introductory Economic Statistics. New York: John Wiley and Sons, 1976.

(39) Menkhaus, D. J. and R. M. Adams. "Forecasting Price Movements: An Application of Discriminant Analysis." Western Journal of Agricultural Economics. Vol. 6, No. 2. (December, 1981), pp. 229-238.

(40) National Academy of Sciences. National Research Council, Accidental Death and Disability: The Neglected Disease of Modern Society. Washington, D.C., 1966, p. 5.

(41) Nie, Norman H., C. Hadlai Hull, Jean G. Jenkins, Karen Steinbrenner, Dale H. Bent. Statistical Package for the Social Sciences, Second Edition. New York: McGraw-Hill Book Company, 1970.

(42) Oehrtman, Robert L., Barbara Broeckelman and Gerald A. Doeksen. An Adaptation of a Computerized Transportation Location Model to Problems in Rural Development. Stillwater, Oklahoma: Oklahoma State University Department of Agricultural Economics AE Report 8066, May 1980.

(43) Oklahoma State Department of Health, Emergency Medical Services Division. 1981 Oklahoma Ambulance Services Registry. Oklahoma City, Oklahoma, 1982.

(44) Rulon, Phillip J. "Distinctions Between Discriminant and Regression Analyses and a Geometric Interpretation of the Discriminant Function." Harvard Educational Review. Vol. 21, No. 2 (Spring, 1951), pp. 80-90.

(45) Schmidt, Joseph F., Robert L. Oehrtman, and Gerald A. Doeksen. "Planning Ambulance Services for a Rural Emergency Medical Service District." Southern Journal of Agricultural Economics. Vol. 10, No. 1. (July 1978), pp. 126-133.

(46) Scott, Allen J. An Introduction to Spatial Allocation Analysis. Washington, D.C.: Commission on College Geography, Resource Paper No. 9, 1977.

(47) Selassie, Haile-Mariam-Gebre, Gerald A. Doeksen and Robert L. Oehrtman. An Analysis of Current and Future Needs for Emergency Medical Service in Oklahoma. Stillwater, Oklahoma: Oklahoma State University Department of Agricultural Economics AE Report 8210. 1982.

(48) Steel, Robert G. D. and James H. Torrie. Introduction to Statistics. New York: McGraw-Hill Book Company, 1976.

(49) Sytkowski, Pamela A., Joseph Stokes, Ralph B. D'Agostino, Albert J. Belanger, and Kevin S. Bettencourt. "Testing a Model to Assess the Effectiveness of Emergency Medical Services in Rural Areas." (Unpublished Report.) Department of

Medicine, Boston University School of Medicine; Department of Mathematics, Boston University; Boston City Hospital. Supported by a grant from the Department of Health and Human Services; Washington D.C., 1983.

(50) Thisse, Jacques-Francois and Henry G. Zoller. Location Analysis of Public Facilities. Amsterdam: North Holland Publishing Company, 1983.

(51) Tweeten, Luther and George L. Brinkman. Micropolitan Development Ames, Iowa: The Iowa State University Press, 1976.

APPENDIXES

APPENDIX A

STATE OF OKLAHOMA REQUEST FOR

AMBULANCE PROVIDER LICENSE

Oklahoma State Department of Health
Emergency Medical Service
1000 Northeast 10th Street
P.O. Box 53551
Oklahoma City, Oklahoma 73152

REQUEST FOR AMBULANCE PROVIDER LICENSE
State of Oklahoma

FOR OFFICE USE ONLY
Approved ________ Denied ________
License Number: ________

DATE OF APPLICATION

PLEASE TYPE

NAME OF SERVICE	PROVIDER NUMBER
MAILING ADDRESS	ADMINISTRATOR/DIRECTOR
STREET ADDRESS CITY STATE ZIP	EMERGENCY PHONE ( ) — BUSINESS PHONE ( )

1 TYPE OF SERVICE/OPERATOR

(Check one only)

- ☐ Paid Fire Dept.
- ☐ Volunteer Fire Dept.
- ☐ Law Enforcement
- ☐ Hospital Based
- ☐ Private *(not subsidized)*
- ☐ Private *(subsidized)*
- ☐ Funeral Home *(not subsidized)*
- ☐ Funeral Home *(subsidized)*
- ☐ Governmental *(not fire or police)*
- ☐ Volunteer *(not fire or police)*
- ☐ Other *(specify)* ________

2 SERVICE IS OWNED/MANAGED

(Check one only)

- ☐ City
- ☐ County
- ☐ City/County
- ☐ Hospital
- ☐ Authority or Board
- ☐ Private
- ☐ Funeral Home
- ☐ Volunteers
- ☐ Other *(specify)* ________

3 SERVICE FUNDED *(Check all that apply)*

- ☐ Charges
- ☐ City Subsidy
- ☐ County Subsidy
- ☐ Hospital Subsidy
- ☐ Sales Tax
- ☐ Utility Assessment
- ☐ Ad Valorem Tax (522)
- ☐ Subscription
- ☐ Donations
- ☐ Other ________ *(specify)*

4 CHARGES AND RATES

Emergency Call Base Rate: ________

Transfer Call Base Rate: ________

What is Approximate Collection Rate: ________%

5 PRIMARY METHOD OF DISPATCH *(Check only one)*

- ☐ PROVIDER (Ambulance units are dispatched through the providers own base station)
- ☐ CENTRAL (Ambulance units are dispatched through centrally operated base station. In addition to ambulance units, this base station dispatches for fire, police, etc.)
- ☐ REGIONAL (Ambulance units from several different providers are dispatched through a multiple city/county base station)

6 BASE STATION RADIO *(Check all that apply)* ☐ None

FREQUENCIES: 155.340 ☐ 155.280 ☐ UHF (Med I thru Med 8) YES ☐ NO ☐ OTHER ________

7 THIS RADIO IS CAPABLE OF THE FOLLOWING *(Check all that apply)*

- ☐ No Radio
- ☐ Dispatch to Ambulance
- ☐ Dispatch to Hospital
- ☐ Dispatch to Fire/Police
- ☐ Other *(specify)* ________

8 HOSPITALS *(By Encoder Number)*

Primary ________ Secondary ________

9 ANNUAL RUNS

Total number of emergency runs made by your service between Jan. 1, 19___ to Dec. 31, 19___

Total number of transfer runs made by your service between Jan 1, 19___ to Dec. 31, 19___

Emergency ________ Transfer ________

10 CURRENT LEVEL OF CERTIFICATION
(Please enter numbers only)

	Full Time	Part Time
No Current Certification	___	___
Advanced First Aid Card	___	___
First Responder Certificate	___	___
National Registry EMT-Basic	___	___
State Registry EMT-Advanced	___	___
State Registry EMT-Advanced/ Cardiac	___	___
National Registry EMT-Paramedic	___	___
TOTAL	___	___

11 AVERAGE RESPONSE TIME
Average Response Time for Emergency Runs ________ min.

COVERAGE AREA
Using the Enclosed Map, Outline the Primary Coverage Area.
Does Service Provide 24-Hour Coverage? Yes ☐ No ☐

12 DOES YOUR COMMUNITY HAVE AN EMS COUNCIL?

☐ Yes ☐ No If Yes, Chairperson's Name & Address

____
Name
____
Address
____

ODH Form No. 604
(Rev. 9/1981)

13 ARE YOUR ADVANCED PERSONNEL UNDER MEDICAL CONTROL? Yes ☐ No ☐

WHO IS YOUR MEDICAL DIRECTOR? *Name* ______________________

Address ______________________

14 VEHICLE	TYPE I	TYPE II	TYPE III	RR LIMOUSINE	VAN AMBUL	SUBURBAN	CARRY ALL	STATION WAGON	MODIFY HEARSE	RESCUE/OTHER
EMERGENCY										
TRANSFER										

15 EMERGENCY VEHICLE CHECKLIST

INSTRUCTIONS: Complete one checklist for each **emergency** vehicle. DO NOT complete this checklist for transfer or non-emergency vehicles. Additional checklists are attached.

1. MANUFACTURER ______________________ 2. YEAR ______________ 3. TAG ______________

4. TYPE VEHICLE (check one only)

- ☐ Type I (KKK-1822) Modular
- ☐ Type II (KKK-1822) Van
- ☐ Type III (KKK-1822) Mod. Van
- ☐ Suburban
- ☐ Van
- ☐ Raised Roof
- ☐ Hearse
- ☐ Station Wagon
- ☐ Carryall
- ☐ Other (specify) ______________

5. RADIO FREQUENCIES (Check all that apply)

☐ 155.340 ☐ 155.280 ☐ UHF Med 1-8 ☐ Other (specify) ______________

6. THIS RADIO IS CAPABLE OF THE FOLLOWING: (Check all that apply)

- ☐ No Radio
- ☐ Ambulance to Ambulance
- ☐ Ambulance to Hospital
- ☐ Ambulance to Fire/Police
- ☐ Ambulance to Dispatcher
- ☐ Other (specify) ______________

7. ESSENTIAL EQUIPMENT (Check each item carried aboard this vehicle)

- ☐ Portable Suction Apparatus
- ☐ Bag-mask Ventilation Unit
- ☐ Oropharyngeal Airways
- ☐ Safety Pins
- ☐ Burn Sheets
- ☐ Traction Splint
- ☐ Inflatable Splints
- ☐ Mouth-to-Mouth Ventilation Airways
- ☐ Portable Oxygen Equipment
- ☐ Mouth Gags
- ☐ Universal Dressings
- ☐ Sterile Gauze Pads
- ☐ Bandages
- ☐ Aluminum Foil
- ☐ Adhesive Tape
- ☐ B/P Cuff/Stethoscope
- ☐ Spine Board (long)
- ☐ Spine Board (short)
- ☐ Triangular Bandages
- ☐ Obstetrical Kit
- ☐ Shears
- ☐ Poison Kit
- ☐ Pneumatic trousers (MAST)

8. ADVANCED LIFE SUPPORT EQUIPMENT (Check each item carried aboard this vehicle)

- ☐ Cardiac Monitor/Defibrillator
- ☐ Intubation Equipment/Esophageal Obturator
- ☐ Drug Kit
- ☐ IV Fluids
- ☐ IV Kit
- ☐ Respirator

9. RESCUE & EXTRICATION EQUIPMENT (Check each item carried aboard this vehicle)

- ☐ Wrench - 12" adj.
- ☐ Screw Driver - 12" Phillips
- ☐ Screw Driver - 12" Regular
- ☐ Hacksaw
- ☐ Double Action Tin Snip (Min. 8")
- ☐ Triangular Reflectors/Battery Operated Flares
- ☐ Goggles (2)
- ☐ Ropes (2)
- ☐ Bolt Cutter
- ☐ Hammer - 5 lb.
- ☐ Wrecking Bar
- ☐ Fire Ax
- ☐ Pliers - 10"
- ☐ Shovel
- ☐ Hard Hat
- ☐ Crowbar
- ☐ Portable Hydraulic Power Jack & Spreader Tool

16

EXTRICATION EQUIPMENT ON BOARD? Yes ☐ No ☐

ACCESS TO EXTRICATION EQUIPMENT? Yes ☐ No ☐

EXTRICATION PROVIDED BY: ______________________

17 Signature of this document constitutes verification of statement.

____

Signature of person completing this form

18 RETURN TO:

OKLAHOMA STATE DEPARTMENT OF HEALTH
EMS DIVISION
P.O. BOX 53551
OKLAHOMA CITY, OKLAHOMA 73152

APPENDIX B

CORRELATION COEFFICIENTS
OF VARIABLES USED IN THE MODEL

CORRELATION COEFFICIENTS / N = 172

	CATD	TYPED1	TYPED2	TYPED3	OWNOPD1	OWNOPD2	OWNOPD3	FUNDD1	FUNDD2	FUNDD3	FUNDD4	FUNDD5	FUNDD6
CATD	1.00000	-0.09587	-0.08508	0.16024	-0.09323	-0.05654	0.17216	0.03600	-0.02663	-0.17210	-0.12290	-0.04283	-0.04212
TYPED1	-0.09587	1.00000	-0.26600	-0.41181	0.53550	-0.20396	-0.37984	0.21419	0.03980	-0.12466	0.05313	0.05313	0.17416
TYPED2	-0.08508	-0.26600	1.00000	-0.21531	-0.16386	0.69956	-0.19859	-0.21360	0.01306	0.51445	0.06028	-0.05754	0.10608
TYPED3	0.16024	-0.41181	-0.21531	1.00000	-0.71309	-0.11429	0.92236	0.08333	0.01699	-0.14344	-0.08909	0.00000	-0.23250
OWNOPD1	-0.09323	0.53550	-0.16386	-0.71309	1.00000	-0.38087	-0.70932	0.10195	-0.02922	-0.12395	0.11584	0.03550	0.26738
OWNOPD2	-0.05654	-0.20396	0.69956	-0.11429	-0.38087	1.00000	-0.15227	-0.17461	0.05242	0.49292	-0.04412	-0.04412	-0.11515
OWNOPD3	0.17216	-0.37984	-0.19859	0.92236	-0.70932	-0.15227	1.00000	0.11192	0.03216	-0.13231	-0.08217	0.01081	-0.21444
FUNDD1	0.03600	0.21419	-0.21360	0.08333	0.10195	-0.17461	0.11192	1.00000	-0.15856	-0.19126	-0.11878	-0.11878	-0.30999
FUNDD2	-0.02663	0.03980	0.01306	0.01699	-0.02922	0.05242	0.03216	-0.15856	1.00000	-0.05117	-0.03178	-0.03178	-0.08294
FUNDD3	-0.17210	-0.12466	0.51445	-0.14344	-0.12395	0.49292	-0.13231	-0.19126	-0.05117	1.00000	-0.03834	-0.03834	-0.10005
FUNDD4	-0.12290	0.05313	0.06028	-0.08909	0.11584	-0.04412	-0.08217	-0.11878	-0.03178	-0.03834	1.00000	-0.02381	-0.06214
FUNDD5	-0.04283	0.05313	-0.05754	0.00000	0.03550	-0.04412	0.01081	-0.11878	-0.03178	-0.03834	-0.02381	1.00000	-0.06214
FUNDD6	-0.04212	0.17416	0.10608	-0.23250	0.26738	-0.11515	-0.21444	-0.30999	-0.08294	-0.10005	-0.06214	-0.06214	1.00000
FUNDD7	-0.05277	-0.06858	-0.07090	0.03659	0.01074	-0.05436	-0.02487	-0.14635	-0.03916	-0.04724	-0.02934	-0.02934	-0.07656
DIRECTD	0.37403	-0.04194	-0.15969	0.04046	-0.00283	-0.13717	0.06285	0.14553	-0.04880	-0.27275	-0.09190	-0.01442	-0.17244
COUNCILD	0.19[illegible]40	-0.15624	0.04770	-0.00735	-0.01017	0.04116	0.03889	0.05206	0.00487	-0.00190	0.01571	-0.06875	-0.32637
REG1	-0.29239	-0.06634	-0.03822	-0.25879	0.17253	-0.00374	-0.23620	0.00845	-0.03410	0.09420	0.06506	-0.02325	0.00847
NONREG1	0.09111	-0.13448	-0.08649	-0.10728	-0.03636	-0.04404	-0.09782	-0.05514	-0.06944	-0.06581	-0.06904	-0.02797	0.12791
EQUIP	-0.38255	0.10737	0.05010	-0.04026	0.11314	0.02339	-0.00227	0.08932	0.06653	0.06391	0.07109	-0.01566	0.09928
CALLS	-0.15560	0.13391	0.08217	0.17323	-0.10948	0.05414	0.15051	0.00118	0.06824	0.07421	0.04377	0.01390	0.01488
POP	-0.12606	0.02731	0.01137	0.17828	-0.16268	0.05821	0.17596	0.12131	-0.05814	0.01506	-0.02754	-0.00430	-0.16386
AVGMILE	-0.02238	0.03031	-0.01451	-0.00345	0.10679	-0.09696	0.01397	-0.12481	0.05994	-0.03574	-0.01743	-0.11039	0.30322
MAXMILE	-0.07869	0.12462	0.04343	-0.03888	0.13646	-0.04253	-0.01465	-0.09740	0.16503	0.00116	0.11209	-0.05156	0.33414
MILES	-0.16288	0.23142	0.08983	0.01742	0.08746	0.01956	0.00349	-0.07108	0.29852	0.03418	-0.01753	-0.11226	0.34305
DRUNK	0.03956	-0.06670	0.00826	0.02677	0.02033	-0.00596	0.00571	-0.01350	-0.03062	0.17939	-0.15508	0.09561	-0.01094

CORRELATION COEFFICIENTS / N = 172

	FUNDD7	DIRECTD	COUNCILD	REG1	NONREG1	EQUIP	CALLS	POP	AVGMILE	MAXMILE	MILES	DRUNK
CATD	-0.05277	0.37403	0.19340	-0.29239	0.09111	-0.38255	-0.15560	-0.12606	-0.02238	-0.07869	-0.16288	0.03956
TYPED1	-0.06858	-0.04194	-0.15624	-0.06634	-0.13448	0.10737	0.13391	0.02731	0.03031	0.12462	0.23142	-0.06670
TYPED2	-0.07090	-0.15969	0.04770	-0.03822	-0.08649	0.05010	0.08217	0.01137	-0.01451	0.04343	0.08983	0.00826
TYPED3	0.03659	0.04046	-0.00735	-0.25879	-0.10728	-0.04026	0.17323	0.17828	-0.00345	-0.03888	0.01742	0.02677
OWNOPD1	0.01074	-0.00283	-0.01017	0.17253	-0.03636	0.11314	-0.10948	-0.16268	0.10679	0.13646	0.08746	0.02033
OWNOPD2	-0.05436	-0.13717	0.04116	-0.00374	-0.04404	0.02339	0.05414	0.05821	-0.09696	-0.04253	0.01956	-0.00596
OWNOPD3	-0.02487	0.06285	0.03889	-0.23620	-0.09782	-0.00227	0.15051	0.17596	0.01397	-0.01465	0.00349	0.00571
FUNDD1	-0.14635	0.14553	0.05206	0.00845	-0.05514	0.08932	0.00118	0.12131	-0.12481	-0.09740	-0.07108	-0.01350
FUNDD2	-0.03916	-0.04880	0.00487	-0.03410	-0.06944	0.06653	0.06824	-0.05814	0.05994	0.16503	0.29852	-0.03062
FUNDD3	-0.04724	-0.27275	-0.00190	0.09420	-0.06581	0.06391	0.07421	0.01506	-0.03574	0.00116	0.03418	0.17939
FUNDD4	-0.02934	-0.09190	0.01571	0.06506	-0.06904	0.07109	0.04377	-0.02754	-0.01743	0.11209	-0.01753	-0.15508
FUNDD5	-0.02934	-0.01442	-0.06875	-0.02325	-0.02797	-0.01566	0.01390	-0.00430	-0.11039	-0.05156	-0.11226	0.09561
FUNDD6	-0.07656	-0.17244	-0.32637	0.00847	0.12791	0.09928	0.01488	-0.16386	0.30322	0.33414	0.34305	-0.01094
FUNDD7	1.00000	0.04589	-0.08471	-0.01267	-0.05901	-0.00742	0.14274	0.11510	-0.04166	-0.10107	-0.07611	0.11033
DIRECTD	0.04589	1.00000	0.35472	-0.15105	0.08908	-0.05825	-0.11980	-0.03287	-0.06214	-0.21531	-0.19566	0.00545
COUNCILD	-0.08471	0.35472	1.00000	-0.07122	0.03443	-0.06873	-0.01280	0.03971	-0.08686	-0.12059	-0.12276	-0.07221
REG1	-0.01267	-0.15105	-0.07122	1.00000	0.20986	0.19713	-0.28704	-0.24558	0.06769	0.11285	-0.09121	0.06631
NONREG1	-0.05901	0.08908	0.03443	0.20986	1.00000	-0.05235	-0.27136	-0.10444	0.03755	-0.11238	-0.21534	0.08114
EQUIP	-0.00742	-0.05825	-0.06873	0.19713	-0.05235	1.00000	0.05451	-0.01329	0.05761	0.20472	0.22436	0.05063
CALLS	0.14274	-0.11980	-0.01280	-0.28704	-0.27136	0.05451	1.00000	0.57514	-0.04787	0.16147	0.51535	0.11317
POP	0.11510	-0.03287	0.03971	-0.24558	-0.10444	-0.01329	0.57514	1.00000	-0.23200	-0.28352	-0.02733	-0.01516
AVGMILE	-0.04166	-0.06214	-0.08686	0.06769	0.03755	0.05761	-0.04787	-0.23200	1.00000	0.63300	0.38946	-0.08298
MAXMILE	-0.10107	-0.21531	-0.12059	0.11285	-0.11238	0.20472	0.16147	-0.28352	0.63300	1.00000	0.58772	-0.06126
MILES	-0.07611	-0.19566	-0.12276	-0.09121	-0.21534	0.22436	0.51535	-0.02733	0.38946	0.58772	1.00000	-0.00325
DRUNK	0.11033	0.00545	-0.07221	0.06631	0.08114	0.05063	0.11317	-0.01516	-0.08298	-0.06126	-0.00325	1.00000

APPENDIX C

PARAMETER ESTIMATES AND T-RATIOS OF VARIABLES INCLUDED IN THE OLS REGRESSION MODEL

VARIABLE	PARAMETER ESTIMATE	T-RATIO
INTERCEPT	60.2366	1.56
CATD	- 3.4475	0.41
TYPED 1	3.2483	0.34
TYPED 2	0.9934	0.06
TYPED 3	8.7525	0.41
OWNOPD 1	1.4518	0.09
OWNOPD 2	-11.9634	0.53
OWNOPD 3	- 4.1443	0.18
FUNDD 1	3.1233	0.36
FUNDD 2	-16.8993	0.94
FUNDD 3	-17.3825	0.95
FUNDD 4	-10.6795	0.46
FUNDD 5	9.7222	0.43
FUNDD 6	- 5.2887	0.40
FUNDD 7	-21.8512	1.15
DIRECTD	- 6.0813	0.76
COUNCILD	6.8313	0.82
REG 1	48.6353	0.74
NONREG 1	88.4970	1.22
EQUIP	- 0.2115	0.52
CALLS	- 0.0025	0.26
POP	- 0.0066	0.08
AVGMILE	1.3554	1.05
MAXMILE	0.3567	0.64
MILES	0.0436	0.30
DRUNK	-12.9734	5.52

VITA

Lisa Donnini Miller

Candidate for the Degree of

Doctor of Philosophy

Thesis: AN ANALYSIS OF EMERGENCY MEDICAL SYSTEMS AND THE QUALITY OF EMERGENCY MEDICAL CARE IN RURAL OKLAHOMA

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Des Moines, Iowa, December 29, 1955, the daughter of Faust Lawrence and Elnora Martin Donnini.

Education: Graduated from Tom J. Mayfield High School, Las Cruces, New Mexico, in May 1973; received the Bachelor of Science degree in Home Economics Business from New Mexico State University in July, 1976; received the Master of Arts degree in Economics from New Mexico State University in July, 1978; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in May, 1984.

Professional Experience: Graduate Teaching Assistant, New Mexico State University, September 1976 to May 1978; Research Assistant, New Mexico State University, June to August 1977 and June to August 1978; Graduate Research Assistant, Oklahoma State University, September 1978 to June 1982; Cost-Return Analyst, Oklahoma State University, July 1982 to June 1983.

Organizations: American Agricultural Economics Association, Southern Agricultural Economics Association, Western Agricultural Economics Association.