EMERGENCY AMBULANCE UTILIZATION IN THE CITY OF LANSING, MICHIGAN

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JAMES ALAN BREUKER

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ABSTRACT

ESTIMATING EMERGENCY AMBULANCE

UTILIZATION IN LANSING, MICHIGAN

By

James Alan Breuker

This paper sheds some light on the problem of estimating the frequency of occurrences for ambulance runs in the city of Lansing, Michigan. Resources are being wasted and misused every day because of a lack of proper planning in the emergency ambulance field, both in Lansing and throughout the country. Costs for providing emergency ambulance services are continually on the rise and a prudent and systematic way of planning for and utilizing emergency ambulances must be developed.

A relatively simple model, using census data and other data combined by census tract, is developed here. This model allows the user to project probable ambulance use by census tract. Thus, one can tell where emergency ambulances may be needed most and can plan for their locations accordingly. An example of this is the analysis at the end of this paper of the Lansing and Grand Rapids emergency ambulance systems and how the research done in this paper might affect those systems.

By using census tract data in regression analysis, it was found

that a four variable model, developed in this paper, could quite accurately project ambulance runs per person per year in the census tracts of Lansing, Michigan. These variables reflect the fact that, in most cases, ambulance runs have tracts with high percentages of divorced men as their destination. They also have as their destination tracts with high percentages of people of lower educational levels, of lower income and with higher numbers of auto accidents. Of course, all four of these characteristics do not have to be present in every tract with a high ambulance run rate, but usually at least one or a combination of them is. As a result, the four variable model developed has taken on the following form (numerical values have been rounded).

Ambulance runs per person by tract = 1.48 (divorced men per person in each tract) + (-.01)(actual median school years completed in each tract) + .000003 (actual median income for each tract) + .00009 (actual auto accidents for each tract).

All the variables in the equation can be considered measurements of socio-economic class or social disorganization.

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By

James Alan Breuker

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This Thesis is dedicated to my wife, Sharon, without whose help and unfailing support this document could not have been completed.

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A special note of thanks for their help in preparing this thesis goes to:

Dr. Roger Hamlin, my patient advisor, Professor Donn Anderson, whose constructive criticism helped to make this a better paper, Mr. John Kessler, for his continual support, and Mr. Paul Stuhmer, my fellow student, who helped me understand what I did not understand before.

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INTRODUCTION

In recent years, there has been much interest in the field of emergency medicine, especially emergency ambulances. Many studies have noted the effectiveness of advanced equipment and well trained personnel in saving lives and preventing injury.[1] While no one can argue that emergency ambulances have not been beneficial, the question of whether or not they can be more effective must be explored. To cities which operate their own ambulance system, increasing the effectiveness of ambulance service is important if ambulances are to aid the most people for the least cost.

Unfortunately, the methods which many cities use to estimate emergency ambulance utilization are not well formulated. Many cities simply use past trends in ambulance utilization to project future use. While this method is better than no method at all, there is much more to emergency ambulance utilization than just what past trends indicate. Using more scientific methods can be of great importance in helping emergency medical services planners avoid hit and miss solutions to emergency ambulance problems.

This paper is an attempt to help answer the question of where

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[1] "Hospitals on Wheels Replaces Undertaker-Sponsored Ambulances," American City, Vol. 88, May 1973, p. 119. "Paramedics Give Fast, Professional Emergency Care," American City, Vol. 89, March 1974, pp. 55-56.

ambulances should be placed to maximize their effectiveness. The way this paper answers this question is by proposing a computerized model for projecting ambulance utilization by multiple linear regression analysis. The model was then applied to the city of Lansing, using data from Lansing Fire Department, Lansing Police Department, Lansing Traffic Bureau and 1970 Census of Population to gather information by census tract.

The entire emergency medical services system, i.e., emergency rooms, emergency clinics, private ambulance companies, etc., is not considered here; only the ambulance service operated by the Lansing Fire Department. Because of this, data only from Lansing Fire Department was used in analyzing ambulance utilization.

It must be kept in mind that this study is concerned with projecting ambulance runs per person by census tract and, as such, no statement is made or intended on other related issues such as training, equipment, or quality of care. Something will be said concerning location analysis at a later point in the paper.

This study can suggest some answers concerning why ambulances go where they do most often. It can be valuable in helping a municipality analyze its current system. Also, if a city or private ambulance service intends to begin operations in a place which has not had adequate emergency ambulance coverage before, this study can be of aid in deciding where to place ambulances so they can serve the most people for the least cost.

This paper consists of six main parts: Background, Review of Literature and Information Sources, Methodology, Results, Conclusion, and

the Appendices.

The Background section explains some of the historical background of emergency ambulances and how they evolved into what they are today, including some of the legal requirements for operation. Specific history concerning the Lansing ambulance service is also given. An explanation of how the system currently operates is given in this section, too. This part of the paper is meant to help the reader better understand how an emergency ambulance system operates. Thus, the remainder of the paper can take on additional meaning to those who may not be extremely familiar with the workings of an emergency ambulance service.

The section dealing with review of literature summarizes which sources of information were considered in the research for this paper. People from local agencies and organizations were contacted and interviewed and letters were sent to others seeking information on the topic of emergency ambulance utilization by census tract. A library search was also instituted which covered periodicals as well as books. The Council of Planning Librarians bibliographical publications were checked and the Tri-County Council for Emergency Medical Services did a computer bibliography search. Their search included what the Department of Health, Education and Welfare had in its computer bibliography on the topic of emergency ambulance services utilization. The results of the entire search for information are included in the Review of Literature and Information Sources part of the paper.

The Methodology section deals with the process whereby this study was completed. An explanation of how this study was devised as well as how it was carried out is given and a detailed account of which

variables were used in the study is also given. A short outline of the computer process necessary for this study and its effect on the variables and the number of cases (census tracts) used in the study is presented, too. In addition, the process of aggregating variables not found in census data is explained.

The next section of the paper, Results, is concerned with presenting, explaining, and discussing the results obtained by this study. Included in this section is both an explanation of the computer method used and an explanation of the model used to project ambulance runs per person by census tract. After this explanation comes a discussion of the results. Following this discussion, there is a section on some of the problems which this study encountered. The final section analyzes the impact of applying this model to Lansing and Grand Rapids.

The Conclusion summarizes what has been accomplished in this paper and emphasizes the need for more research. Conclusions about the methodology and results are drawn and some implications of this study for future research are stated.

Appendices are included in this paper to help explain the accomplishments of this study. Several of the appendices were compiled by using figures derived from the model and they show how the model can be applied.

This paper was researched during the school years 1974-75 and 1975-76. Much information was gathered from the Lansing Fire Department, Lansing Mercy Ambulance Service, Tri-County Council for Emergency Medical Services, The Office of Health and Medical Affairs--State of

Michigan, Michigan Mid-South Health Systems Agency, Lansing Police Department, and Lansing Traffic Bureau. Background papers were researched and completed during the fall of 1975. Data collection was completed during the spring and summer terms of the 1975-76 school year and the calculation and computation process was done during the summer of 1976. The writing was done in the summer and fall of 1976.

CHAPTER I

BACKGROUND

Introduction

Since this study concerns ambulances, and uses the City of Lansing's ambulance service as a case study, it may be helpful to know more about the general history of ambulances as well as the more specific history of the Lansing service. It can also be helpful to know how the current ambulance service in Lansing operates and how effective it has been. Regulation of ambulance services by federal and state governments is discussed here as is the question of instituting more complete planning methods for an ambulance service.

General Historical and Legal Background

Ambulances have been in existence for quite some time, although the form of today's ambulance system and equipment has changed from the original. Most ambulances were originally associated with wars and were concerned with transporting wounded soldiers to field hospitals. Gradually, the idea of using ambulances spread to the civilian world, also.

Traditionally, the only person to have a vehicle large enough to transport sick or injured comfortably was the mortician or the undertaker.[2] Many morticians began to operate an ambulance service for the

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[2] Mike Amble, interview held in office of Tri-County Council for Emergency Medical Services, September 1975.

benefit of those families which had previously used the mortician's services. The ambulance service quickly spread to include the whole community and funeral homes began to charge for their services. At first, the method of transportation of sick and injured was quite simple. An ambulance would simply go to where the person in need of service was, pick him up, and transport him to a hospital, hoping that he would not die on the way.[3] Any treatment administered to the patient at the scene or enroute to the hospital was usually given by ambulance attendants who had no training or were trained only in Red Cross first aid.[4] The only regulation of the "ambulance industry" pertaining to attendants' qualifications was the requirement that ambulance attendants be trained in advanced Red Cross first aid. This requirement was not enacted into law until 1969.[5] Prior to that time, any training for ambulance attendants was mostly voluntary on the attendant's or their employer's part. The Red Cross advanced first aid requirement still stands, although Michigan Senate Bill 986, passed by the Senate in March of 1976, would require all ambulance attendants to be trained to the basic emergency medical technician, or EMT-1, level. This legislation is expected to be implemented in the near future.

Michigan Public Act 258 of 1968 requires updating of ambulances and equipment. The Michigan Department of Public Health has set up guidelines for ambulance services to follow when purchasing or updating

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[3] Interview held with a former ambulance attendant, Estes-Leadly Funeral Home, Lansing, Michigan, November 1974.

[4] Ibid.

[5] Michigan Public Act 260 of 1969.

their equipment.[6] The federal government has no legislation pertaining to training and equipment for those wishing to use U.S. Government money to purchase new ambulances. The National Academy of Sciences has set up guidelines for training ambulance personnel, but these are not legally required.[7]

New requirements, at least in the State of Michigan, are likely to be enacted in the near future.[8] These requirements mean a greater chance of survival for the medical emergency patient, but they also mean increased cost to the consumer and to those providing the service. In addition to the prospect of increased future regulation and, therefore, increased cost, is the prospect of competition between ambulance services. Ambulance services can advertise and are responsive to public demand for increased quality of care. This, in turn, also means greater cost. As a result, many funeral home services have dropped out of the business since the ambulance service was not their primary business. Some still operate in rural areas where the competition is not as keen, but many in urban areas are phasing out their operations or are getting into it more as a business rather than a sideline.[9] As a

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6 Telephone interview held with Lori Martindale, secretary for the Tri-County Council for Emergency Medical Services, August 1976.

7 National Academy of Sciences--National Research Council, Division of Medical Services. Training of Ambulance Personnel and Others Responsible for Emergency Care of the Sick and Injured at the Scene and During Transport, U.S. Government Printing Office, 1968.

8 Michigan Senate Bills 984, 195, 986, and 987, passed by the Michigan Senate in March of 1976.

9 Interview held with a former ambulance attendant, Estes-Leadly Funeral Home, Lansing, Michigan, November 1975.

result of this, some cities are being forced to provide ambulance service themselves or contract for it from commercial services.

Ambulance Service in Lansing: Historical Background

The City of Lansing is required by its current charter to provide ambulance service to its citizens. The charter does not stipulate that the city must run the service. The city must only make sure it is provided. The service could be contracted for, but the city has chosen to provide the service itself.

Lansing's ambulance service was first operated by the police department. In the early 1950's, many patrol beats for policemen were foot patrol beats. Therefore, if a call came for the ambulance, the dispatcher would have to locate a foot patrolman and he would then have to run downtown to the police station, get in the ambulance, and proceed to the aid of whoever was in need. This process took a long time, but at that time the city was much smaller than it is today. In addition, the service provided was simply one of transportation to a hospital or simple resuscitation with an inhalator or oxygen equipment.

As the city grew, the demand for ambulance service did also. Coupled with this, was the demand for upgraded service. Since police are deemed more effective when they are patrolling, the police department did not tie up manpower at the station by permanently assigning men to the ambulance.[10] Therefore, the ambulance service was shifted to the fire department, which had manpower more readily available on a twenty-four hour basis.

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[10] Elmer Weisenber, dispatcher for Lansing Fire Department, interviewed November 1975.

At first, the fire department used the same vehicle and equipment as the police department did and provided the same service also. As demand changed and as new breakthroughs in emergency medicine were brought about, the fire department made every effort to keep in step. Since the department requested federal money for vehicles, it had to meet federal standards and this meant an improvement in equipment. Men also were required to be trained to use the equipment and, because of this, the quality of the ambulance service in Lansing seems to have improved.

The service began with one vehicle and is now operating with four. Three are always in service and one is as a backup. The city has a new "mobile emergency room" on order which is larger than a regular ambulance and is better equipped to handle a greater range of medical emergencies. Lansing is also in the process of implementing paramedics on all its ambulances.[11] The paramedic program enjoys a broad base of public support. Many of the regular firemen have been trained in advanced first aid and the city has plans to train as many as it can to the higher level of Emergency Medical Technician I (a paramedic is an Emergency Medical Technician II).[12]

The city's ambulances are stationed at different fire stations throughout the city. The back-up ambulance is stationed at the downtown station since there is more room there and, since that station's ambulance receives more calls than the others, that is where an

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[11] Interview with Pete Decker, Assistant Fire Chief, Lansing Fire Department, November 1975.

[12] Ibid.

additional ambulance is likely to be used most effectively. The downtown station is also central to the city; therefore, calls from outlying areas can be handled easier and more quickly than if it were stationed elsewhere (see Figure 1 for ambulance locations).

Since the city's ambulances are supposed to respond only in cases of emergencies, the dispatcher must determine if it is a true emergency. If he determines that it is an emergency, he must send out the ambulance nearest to the incident. If he thinks the call is not a true medical emergency, he refers the call to a private ambulance service which responds to it. Ambulances which respond to emergencies also transport the victims to a hospital, unless specifically requested not to do so.

Finances for operating the service come from city revenues as well as federal and state grants for training and equipment. The equipment and training are kept as current as possible. The fire department closely adheres to federal and state guidelines and recommendations concerning training and equipment.

Planning for new vehicles or extended service is not an elaborate process in the city of Lansing, nor is it really necessary yet. Decisions for additional vehicles or manpower seem to be guided by past trends in demand and not according to future projections. Each year the fire department has experienced an increase in the demand for ambulance service (see Figure 2, page 13). The fact that the user pays no direct fee for service (he/she pays through taxes), that the ambulance service enjoys much public support, that the availability of ambulance service is becoming more well known, and that paramedics serve rather than less trained attendants all add to the increasing demand for the service.

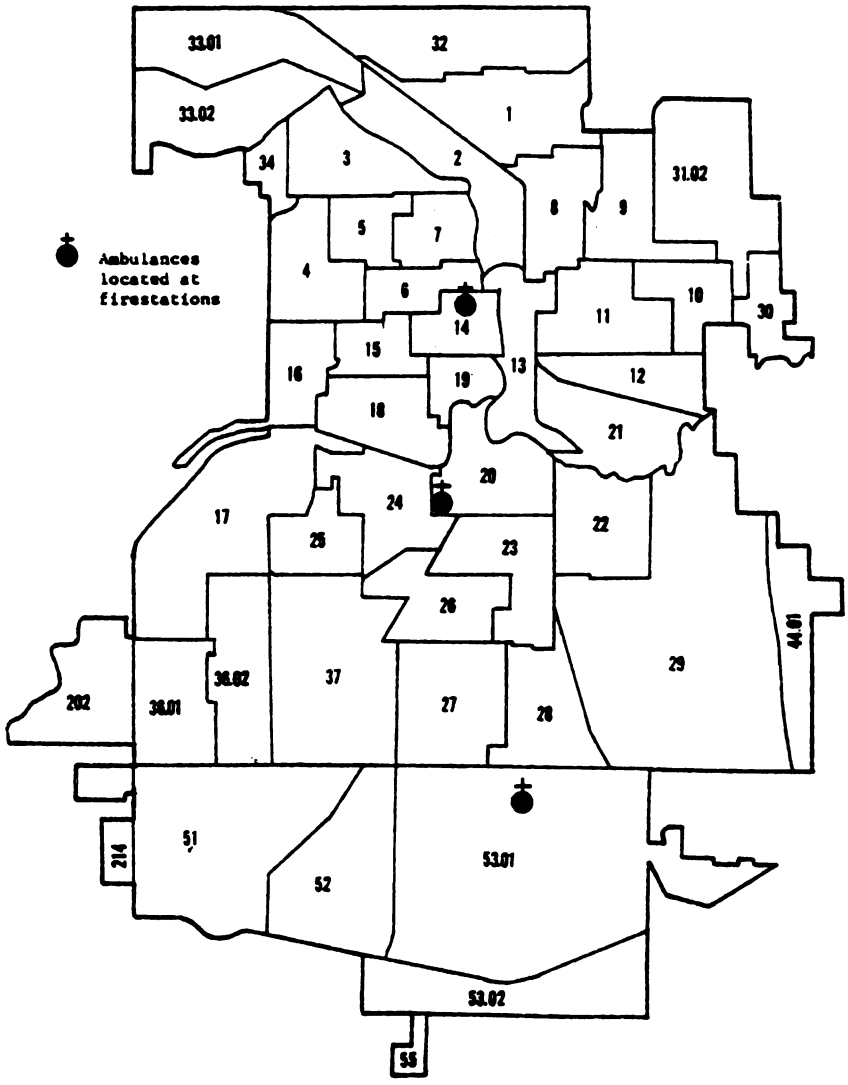

Figure 1

LANSING FIRE DEPARTMENT AMBULANCE LOCATIONS - 1975

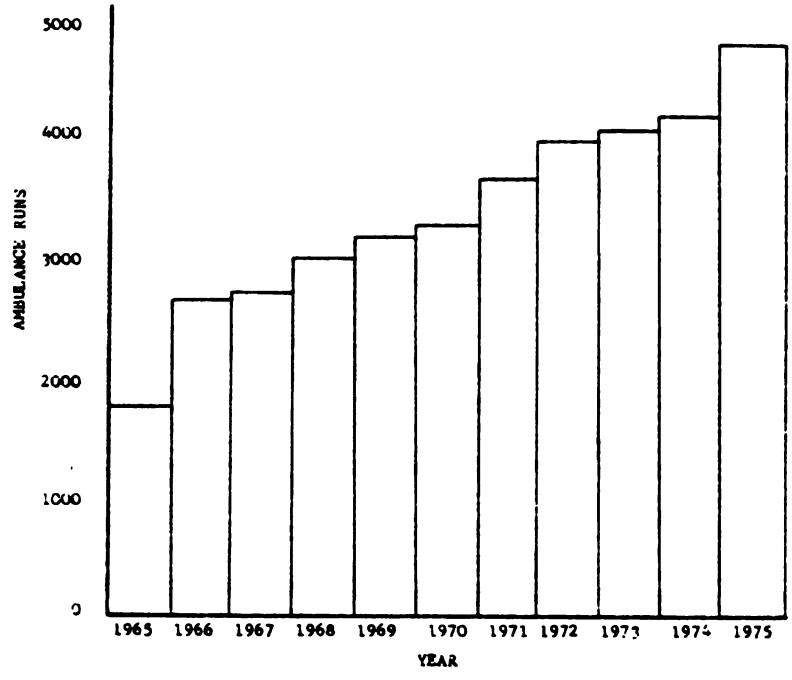

Figure 2

LANSING FIRE DEPARTMENT AMBULANCE RUN INCREASES, 1965-1975

SOURCE: Lansing Fire Department

Population in Lansing is estimated to have increased from 131,114 in 1970 to 131,545 in 1975, or about 2%,[13] while ambulance calls increased from 3,169 in 1970 to 4,671 in 1975 or about 32% (see Figures 2 and 3, pages 13 and 15).[14] This means an increased workload and the city feels it may have to add an additional ambulance to meet increased demand. The question of the location for the additional ambulance is as yet unanswered.

In order for the city to plan more accurately for future utilization of its ambulance system, it should use more comprehensive and scientific methods. Using other data besides past trends can be of great importance in helping emergency medical services planners avoid hit and miss solutions to emergency ambulance problems. Relying on past trends of continual increase in demand may not be an adequate indicator of future use.

Cost

Like many other services today, the cost of ambulance service is increasing and it uses resources that possibly could be utilized better in another area if proper foresight is used in planning. However, the ambulance industry has not been stabilized by implementation of uniform standards and, as a result, costs have not leveled off.[15] Lansing

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[13] The 1970 figure was obtained from the Census while the 1975 figure is a projection estimated by the Tri-County Regional Planning Commission. It was obtained during a telephone interview in June 1976.

[14] These figures are from a telephone inquiry to L.F.D. in February 1977.

[15] Telephone interview with Rod Palmer, owner of Lansing Mercy Ambulance Service, October 1976.

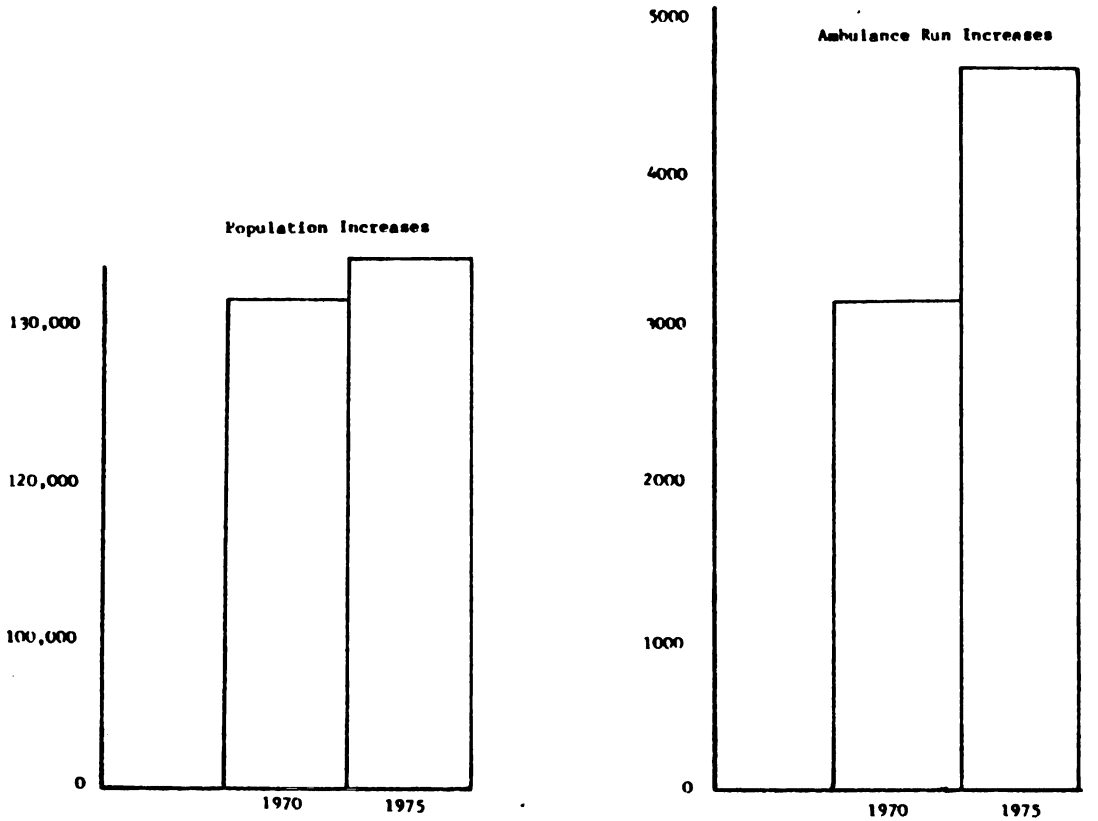

Figure 3

INCREASES IN POPULATION AND AMBULANCE RUNS, 1970-1975

SOURCE: Tri-County Regional Planning Commission and Lansing Fire Department

Mercy Ambulance Service, for example, experienced about a 33% increase in cost from 1975-1976 or an increase in their base rate from $35 to $50.[16] In view of this, utilizing resources to the optimum with foresight is imperative. More complete planning for emergency ambulance runs is proposed in this paper. Thus, by using this method both to analyze present needs as well as to get a grip on future needs, the resources in an emergency ambulance system can be put to good use.

Summary

Ambulance service in Lansing has come a long way. It now operates with a much higher level of efficiency and expertise than it did in the past. The ambulance service enjoys a high degree of public support and this also has increased its effectiveness. However, the cost of providing service and the increased demand for that service necessitates a more comprehensive means of planning for emergency ambulances and their utilization.

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[16] Ibid.

CHAPTER II

REVIEW OF LITERATURE AND INFORMATION SOURCES

Introduction

This chapter explains what sources were consulted in gathering information for this thesis. The search for information included library sources such as books and periodicals, local community sources such as agencies, commissions and councils serving Lansing and the surrounding area, and agencies and offices operated by the State of Michigan. Letters seeking information were also sent to people not in the immediate area who might be helpful in gathering information for this paper.

Local Sources of Information

This study was conceived after several months of working with and doing research on the emergency ambulance system in the tri-county (Clinton, Eaton, and Ingham Counties, Michigan) area. In working and talking with people at the Lansing and East Lansing Fire Departments, Michigan Mid-South Health Systems Agency, Tri-County Council for Emergency Medical Services, Office of Health and Medical Affairs for the State of Michigan, and the owner of one of the commercial ambulance services in the city, it became apparent that a study of the nature of this one would be beneficial. Therefore, after consulting with Dr. Roger Hamlin of the School of Urban Planning, Mr. John Kessler, Director of Planning at Michigan Mid-South Health Systems Agency, and

others,[16] it was decided that a study of emergency ambulances and how their utilization might be projected using readily available census data would be beneficial to the parties involved and the field of emergency medical services planning.

Literature and Library Search

To learn as much about studies of this type as possible and to become further familiarized with the subject area, a search of literature was instituted. The search for similar studies included a library search of the Education Index from July 1965 to May 1976. No literature was found which would have a direct bearing on this paper. The topics which were searched in the Education Index and in all the following potential sources of information were: "Medical Services," "Emergency Squad Personnel," "Ambulances," "Rescue Squad," and "Medical Workers." Much the same topics were investigated in the Reader's Guide.

The Reader's Guide to Periodical Literature was checked under topics which might relate to this study, also. Volumes from 1965 to May of 1976 were covered. Articles on the ambulance systems of Houston, Texas, Los Angeles, California, and Jacksonville, Florida were found, but none mentioned how these systems were planned or utilized.[17]

Research (Resources) in Education sourcebooks were also examined. The period 1968 through May of 1976 was covered. This search produced

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[16] Dr. Harry Perlstadt, Department of Sociology, M.S.U., Mr. Mike Amble, Executive Secretary, Tri-County Council for Emergency Medical Services, and Mr. Kenneth Malkowski, formerly a health planner and now a transportation planner for the State of Michigan.

[17] "Hospitals on Wheels," American City 88(May 1973):119. "Paramedics Give Fast...," American City 89(March 1974): 55-56. "The Best Ambulance Service," Reader's Digest 104(March 1974): 95-98.

a selected bibliography, published by the U.S. Government, on emergency health services.[18] Unfortunately, this bibliography dealt with the general topic only and offered no clues for additional reading and research on the topic of emergency ambulance utilization and distribution.

The Current Index to Journals in Education was searched. The period from 1969 to May of 1976 was covered and no similar studies were found here either.

Council of Planning Librarians planning bibliographies which pertained to emergency medical or health services were also researched. Those searched were: #100--Planning For Locational Change in the Delivery of Medical Care, #134--Health Manpower Planning, #168--Health Planning, #233--Health Planning Applications of Operations Research and Systems Analysis, #261--Physicians Assistants, #392--Comprehensive Health Planning, #475--Planning Medical Care, #493--Emergency Medical Services in Metropolitan Areas, #586--Health Services, #593--The Health Component in Community Development, and #690--Police and Fire. This search produced nothing which would relate to emergency ambulance utilization by census tract. Some general background sources were found and these have been included in the "General References" section of the Bibliography.

Mr. Kenneth Malkowski, Health Planner for the Office of Health and Medical Affairs, State of Michigan, was consulted concerning possible

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[18] National Academy of Sciences--National Research Council, Division of Medical Sciences. Recent Publications on Ambulance Services, Washington, D. C.: NRC-NAS, June 1970.

sources of information.[19] He supplied material from his personal files[20] (these are included in the bibliography) and supplied a book which was very useful in this study. This was a draft copy of the book entitled "Methods for Determining and Projecting the Needs and Demands for Emergency Medical Services: An Anotated Bibliography," prepared by Arthur Young and Company for the Division of Comprehensive Health Planning, Health Resources Administration, Department of Health, Education and Welfare.[21] This book proved its usefulness by providing an up to date list of research in emergency medical services. In addition, this book is an anotated bibliography and a short summary of each article listed was given. This made it much easier to judge which potential sources of information were the most valuable. The Fitzsimmons and the Aldrich, et al., studies, cited and discussed on pages 22 and 25 were found in this book. Some general background references also were found and these have been included in the "General References" section of the Bibliography.

The Tri-County Council for Emergency Medical Services also did a

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[19] Interview held at the Office of Health and Medical Affairs, State of Michigan, Lansing, Michigan, June 1976.

[20] Thomas P. Dekar, "A Simulation Model of Response Characteristics of the Detroit Emergency Medical Service" (Ph.D dissertation, University of Detroit, 1976). Idem, "Proposal for Dissertation Involvement with Emergency Medical Service Division of Detroit Fire Department" (Proposal for Ph.D dissertation, University of Detroit, September 1973). State Health Planning Advisory Council Task Force on Health Personnel and the Office of Health and Medical Affairs, Bureau of the Budget, State of Michigan, "Pharmacy Personnel Requirements in Michigan; A Preliminary Report," draft copy, April 1976.

[21] Arthur Young and Company, "Methods for Determining and Projecting the Needs and Demands for Emergency Medical Services: An Anotated Bibliography," draft copy, 1975.

computer check of the sources it has available in its computer bibliography. Its computer bibliography is connected with the computer bibliography on emergency medical services at the Department of Health, Education and Welfare in Washington, D.C. Nothing was found there about projecting emergency ambulance use by census tract data.[22]

In addition to the above, a letter was sent to several people who might have some additional knowledge in the field and who might be willing to share it or suggest further sources of information. A copy of this letter is shown in Appendix A. The names of these people were gathered from interviews of the people previously mentioned, references in periodicals consulted, and from replies received from others to whom the letter was sent.

Sources encountered through this mail survey did not directly relate to projecting emergency ambulance run rates by census tract using socio-economic data. Some of the suggested articles dealt with relating emergency room visits to socio-economic data,[23] but not ambulance use. Therefore, these articles were consulted and their relationship to ambulance utilization was considered.

Geoffry Gibson has written an interesting book entitled Emergency Medical Services in the Chicago Area in which he discusses the state of

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[22] Interview held with Mr. Mike Amble, Executive Secretary, Tri-County Council for Emergency Medical Services, June 1976.

[23] Jacobs, A.R., J.W. Garett, and R. Warsinger, "Emergency Department Utilization in an Urban Community: Implications for Ambulatory Care." Journal of the American Medical Association, Vol. 216, no. 2, April 2, 1971, pp. 307-312. Berman, J.I. and Luck, E., "Emergency Services: Patients Ethnic Backgrounds Affect Utilization," Hospitals, vol. 45, July 16, 1971, pp. 64-8.

the Chicago E.M.S. system.[24] While he goes into how each vehicle is utilized and how well the equipment is used, no attempt is made to determine if the utilization rates can be estimated or projected or how this might be done. There are other studies of this nature also which, unfortunately, do not discuss using data outside the ambulance system itself to estimate calls. Rather, these studies analyze data gathered from inside the system, such as response time, to point the way toward increased efficiency.[25] Studies of these types are noted here because they were reviewed in order to give the author some idea of what they did, how they did it, and whether or not they have a bearing on studies similar to the one presented here. The general format of these studies (hypothesis, research, collecting data, testing, and results) is roughly the same as the format of the thesis presented here. On the other hand, their intent is different from the character of this study. They look at ambulance utilization from the standpoint of how each vehicle and its personnel can be used better in the location it is in. The current location of the vehicles is assumed as appropriate. These studies attempt to focus on utilization efficiency using factors such as time spent on runs, equipment used on runs and number of personnel needed. This study proposes a method of evaluating ambulance location and utilization efficiency by collecting census tract information which

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24 Geoffry Gibson, Emergency Medical Services in the Chicago Area (Chicago, Illinois: Center for Health Administration Studies, University of Chicago, 1970).

25 J.A. Fitzsimmons, "A Methodology for Emergency Ambulance Deployment," Management Science, vol. 19, no. 6, February 1973, pp. 627-636.

relates to socio-economic data and using that data to project ambulance runs per person in census tracts. Thus, the location of ambulances can be planned so that those who use and need an ambulance most can be served the fastest.

Summary

Many possible sources of information concerning emergency ambulance utilization were consulted. Very little was found about projecting ambulance utilization through the use of census tract data. Other studies were found which used factors such as response time, but the use of socio-economic factors in projecting ambulance run rates has not been incorporated into the methodology for any study except the Aldrich, et al., one in which emergency ambulance use in Los Angeles is scrutinized. This study is discussed at greater length in the last chapter of this paper.

CHAPTER III

METHODOLOGY

Introduction

The topic for this paper was worked out with community leaders in the field of emergency ambulance services while the methodology for doing this study evolved from several months of work in the area of emergency ambulance services, from a related study done in Los Angeles, California, and from assistance given by Dr. Roger Hamlin, School of Urban Planning and Landscape Architecture, Michigan State University, and Mr. Paul Stuhmer, a fellow student.

Study Development

Developing a technique to project ambulance runs per person by any means can be of great value to a city or ambulance service in planning for the future. Therefore, since there is much information concerning the population of Lansing gathered by census tract in the decennial U.S. Census, it was decided that attempting to project ambulance usage by utilizing this data would be a beneficial achievement which could be adequately accomplished.

This decision was arrived at with Mr. John Kessler from Michigan Mid-South Health Systems Agency and Mr. Ken Malkowski, health planner for the State of Michigan. Mr. Malkowski and Mr. Kessler suggested that something could be done on ambulance utilization since this was an

understudied subject, especially in the Lansing area. The author then decided to do a preliminary study of ambulance utilization in the Lansing area. In the process of doing this, it was discovered that the Lansing Fire Department had begun to keep records on ambulance runs by census tract. With this in mind and knowing that there was much information in the Census, a brief study was undertaken to see if there might be a relationship between tracts with high ambulance calls and tracts with certain types of socio-economic characteristics such as low median school years completed, low median income, and a high rate of persons over 65 years of age. Simple visual observations indicated that there did seem to be some sort of relationship between ambulance runs and certain census information. It was then decided that the technique would be expanded and a model developed which might help one project ambulance runs using readily available census tract data.

Having decided to use census tract data, the next step was to choose which census tract data to use. Some suggestions as to who uses an ambulance most, which neighborhoods the ambulance goes to most often and who uses other emergency medical services most often were gathered from talks with L.F.D. paramedics[26] as well as from printed studies.[27]

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[26] L.F.D. paramedics Bill Wilson and Roy Zigler and Lansing Mercy Ambulance Service employees were asked where ambulances seem to go most often and who they most often picked up. Their answers indicated that it seemed that most runs went to lower socio-economic class neighborhoods and also there seemed to be a lot of runs to pick up people of older ages, most of them women.

[27] Carole Aldrich, John Hisserich, and Lester Lave, in their study entitled "An Analysis of the Demand for Emergency Ambulance Service in an Urban Area," American Journal of Public Health, vol. 61, no. 6, June 1971, pp. 1156-1169, note that children and elderly, single men (including unmarried, separated, and divorced), and non-whites generate more calls than their counterparts. Barry King and Ellis Sox in "An

Whenever these suggestions coincided with available census data or data that might be easily aggregated into census tract format, it was included as a variable in this study. Usually census data could be found which coincided with these suggestions or closely paralleled them.[28] Other variables were chosen because they seemed to suggest that they may have some bearing on ambulance use, e.g., the number of housing units per tract with no car available may indicate why so many people call an ambulance when one is needed rather than drive to the hospital.

Variables

The method used to analyze the variables is multiple linear regression. This method allows the user to establish the variables in a list from the most important to the least important. Inter-relationships between variables are considered and, when the computer is used, one can calculate the chance that a correct answer will result if a certain piece of data is used in an equation. The multiple linear regression technique develops a set of values which can be placed in a multiple linear regression equation. These values in the equation can then be used to develop a model which projects, in this case, emergency ambulance use per person by census tract. A more complete explanation of this computer method is given in the first section of Chapter Four.

Emergency Medical Services System--An Analysis of Workload," Public Health Reports, Vol. 82, no. 11, November 1967, pp. 995-1008, and A.R. Jacobs, J.W. Garett, and R. Wersinger in "Emergency Department Utilization in an Urban Community: Implications for Ambulatory Care," Journal of the American Medical Association, vol. 216, no. 2, April 2, 1971, pp. 307-312, also indicate that various socio-economic factors influence use of emergency medical facilities.

[28] If census data did not directly coincide with a desired variable, then two or more census categories were combined which gave the desired

Table I indicates which variables were used in this study. The dependent variable is ambulance runs and is explained a little later in the text. The independent variables are listed following the dependent one. Most of the variables have been changed so they represent a rate or per person description. This was done to standardize the variables in each census tract as much as possible, i.e., the fact that a certain tract may have a high number of divorced males may lead one to form a certain opinion about the tract. When that factor is changed to a rate, it may be less visible than in other tracts. Rates automatically account for the amount of population in a tract and its influence on certain variables or characteristics. Actual median income in each tract and actual median school years completed in each tract are used, since these are already in "per person" form. As they are, they indicate the relative poverty or wealth of a census tract. The unemployment variable is also a rate, but is calculated with the total number of people in the work force over 16 years of age as the denominator and not all people in the tract as the denominator because not all people in a tract necessarily want to be in the work force. The housing variable was intended to give some idea of the number of crowded and/or below standard houses in each tract. This variable was calculated by adding dwelling units with 1.01 persons per room or more in each tract to the number of dwelling units lacking some or all plumbing facilities in each tract and dividing by twice the number of households. Another variable which is not calculated on a per capita basis is the "One Adult Headed Family" variable. This variable was computed by

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variable, e.g., women over 65 + men over 65 = persons over 65.

Table 1

VARIABLES USED IN COLLECTING DATA

Variable Name	Variable Code Name	Description
Dependent Variable:		
Ambulance Runs	Runs	Number of Ambulance Runs by Lansing Fire Department per Capita Per Year in Each Census Tract
Independent Variables:		
Females	Female	Number of Females Per Capita in Each Census Tract
Persons Under 10 Years Old	Kids	Number of Persons Under 10 Years Old Per Capita in Each Census Tract
Females Over 65 Years Old	Oldfem	Number of Females Over 65 Years Old Per Capita in Each Census Tract
Males Over 65 Years Old	Oldmen	Number of Males Over 65 Years Old Per Capita in Each Census Tract
Median Income	Income	Actual Median Income In Each Census Tract
Police Calls for Service	Cops	Number of Police Calls for Service Per Capita in Each Census Tract
Non Whites	Minor	Number of Non-Whites Per Capita in Each Census Tract
Median School Years Completed	Skool	Actual Median School Years Completed Per

Table 1 -- Continued

Variable Name	Variable Code Name	Description
Independent Variables:		
		Census Tract
Unemployment	Unem	Number of Unemployed Males and Females in the Labor Force Over 16 Years Old Per Capita in Each Census Tract
Auto Accidents	Crash	Number of Actual Auto Accidents in Each Census Tract
Divorced Females	Divfem	Number of Divorced Females Over 14 Years Old Per Capita in Each Census Tract
Divorced Males	Divmen	Number of Divorced Males Over 14 Years Old Per Capita in Each Census Tract
Housing	Hous	1.01 Persons Per Room or More in a Dwelling Unit Plus the Number of Dwelling Units Lacking Some or All Plumbing Facilities Per Twice the Number of Households in Each Census Tract
One Adult Headed Families	Singfam	Numbers of Families With Only One Adult As Head Per Total Number of Households with Heads in Each Census Tract
No Available Auto	Nocar	Numbers of Housing Units With No Auto Available Per Total Number of Housing Units Available in Each Census Tract
Poverty Level	Poverty	Number of Families Below

Table 1 -- Continued

Variable Name	Variable Code Name	Description
Independent Variables		
		the Census Poverty Level Per Family in Each Census Tract
Persons Over 65 Years Old	Oldfolks	Persons Over 65 Years Old Per Capita in Each Census Tract

combining the number of families with only one adult as head and dividing by the total number of households in each tract with heads. Thus, a rate is arrived at, but not a per capita one. The "No Available Auto" variable is also not a per capita variable. It is calculated by dividing the number of housing units with no auto available to them by the total number of housing units in each tract.

1970 Census of the Population data was used for all variables except three. These are: "Runs" (ambulance runs), "Cops" (police calls for service), and "Crash" (actual number of auto accidents). The "Runs" variable data was collected directly from the Lansing Fire Department records. Their computer requires data to be tabulated by census tract, so it was a very simple matter to acquire the runs per census tract for 1975 and then calculate the variable using 1970 census tract population figures. "Cops" was a bit more difficult to calculate and the police department was very accommodating in helping to provide information. First, since the police keep records by reporting district, it was necessary to get records of all police calls for service from each reporting district. This data was not readily available and a special request for this data for 1975 was made. When the results returned, they were listed by police reporting district. Next, since reporting districts are smaller than the census tracts, they had to be aggregated into groups which approximated the census tracts. In most cases, reporting districts could be grouped so that several together would exactly make up a census tract. In the instances where some reporting districts had to be split, they were divided into thirds or quarters by visually estimating from a map comparing reporting districts to census tracts.

Thus tract 1 might be comprised of reporting areas 1,2,3, and 1/3 of 4. Police calls for service were assigned to tracts in the same manner with tract 1 getting all the calls for service from reporting districts 1,2,3, and 1/3 of the calls from 4. In this way, police calls for service were assigned to all the tracts and the variable was then calculated using 1970 census figures. The "Crash" variable was obtained by using data on where all accidents occurred in the city in 1975. This data was gathered from the City of Lansing, Traffic Engineering Department. Each location on this list was then plotted on a census tract map and the totals for each tract were then tallied up and recorded. The actual number of accidents by census tract make up the "Crash" variable. The mixing of 1970 and 1975 data is discussed in the Problems section of the Results chapter.

The independent variables were chosen because they were suggested as being important either by employees of Lansing Fire Department and/or Lansing Mercy Ambulance Service or were suggested in the Aldrich, et al., study (see footnotes 26 and 27). These variables are: "Females," "Persons Under 10 Years Old," "Females Over 65 Years Old," "Males Over 65 Years Old," "Non-Whites," "Divorced Females," "Divorced Males," "Persons Over 65 Years Old," "One Adult Headed Families," "Housing," "Auto Accidents," and "Unemployment". "Females Over 65 Years Old," "Males Over 65 Years Old," and "Persons Over 65 Years Old" may seem like the same variables, but were all included to see if both males and females over 65 influenced ambulance runs or whether it was just the males or just females of this group who were the most influential.

In a preliminary study which the author did on the Lansing-East

Lansing ambulance system, it was felt that, given the seeming prevalence of ambulance runs to tracts which represented lower socio-economic class, it might be of interest to include median income and median school years completed variables. These variables also tended to relate to the ambulance run data and, therefore, were included in this study. The "Poverty" variable was included as another type of economic variable. Median income, if it relates to ambulance runs, can show a trend toward higher ambulance use with an increase or decrease in median income, but the "Poverty" variable can indicate whether or not there may be an increase or decrease in ambulance runs at a certain income level. The 1969 poverty level, used in the 1970 Census, ranged from $6,116 for a non-farm family with a male head and seven persons to $1,487 for a single female, 65 years old and over, living on a farm. The poverty level for a non-farm family of four with a male head was $3,745.

The "One Adult Headed Families" variable and the "No Available Auto" variable were included in this study because these variables may be helpful in explaining the occurrence and location of ambulance runs. The Aldrich, et al., study indicates that single women (including unmarried, separated, and divorced) usually make less use of ambulances than do unmarried, separated or divorced males. The "One Adult Headed Families" variable was included to see if a family might have some influence on the tendency of single adults, especially males, to use the ambulance more.

The "No Available Auto" variable was included since a predominance of households in a census tract without an auto available to them might

be helpful in explaining why many ambulance runs go to certain tracts. Because these households would have no other means of transportation to a hospital if a medical emergency arose, they might be more inclined to call an ambulance.

Professor Keith Honey, School of Urban Planning and Landscape Architecture, Michigan State University, suggested that a crime indicator be included in the study to see if crime may influence ambulance runs. Therefore, the "Police Calls for Service" variable was included in the study.

Census Tracts Used

Data was collected only for the tracts which fire department ambulance run data coincided with. Ambulances respond to calls from Lansing tracts 1-30, 31.02, 32, 33.01, 33.02, 34, 36.01, 36.02, 37, 38.01, 44.01, 51, 52, 53.01, 53.02, 55, 202, 214, and 238. Insufficient census data existed for tracts 30, 55, 214, and 238, because of very low population base or the segment of these tracts which fall within the city limits had a very low population base. Therefore, these tracts were eliminated by the computer in its calculations when the "pair-wise deletion" command was not specified. This command tells the computer to make the calculations commanded using all cases and to simply skip over the cases of missing data which some tracts had. Therefore, if this command was used, all remaining tracts (44 of them without 30, 55, 214, and 238) would be used in these calculations. When "Pair-wise deletion" is not specified, the computer eliminates all tracts with any missing data. In this case, tracts 14, 35, and 44.01 are eliminated also, since these tracts had at least one variable which could not be calculated due to

missing data. Thus, the computer makes its calculations on 41 cases (tracts) in this instance. When calculations are made in this manner, the results are more accurate, since the calculations are made on data which is complete. The reliability of results when the other method is used cannot be guaranteed and it is suggested that "Pair-wise deletion" not always be used.[29]

The regression equation was calculated using 41 census tracts or about 85% of the tracts which city ambulances respond to (see figure 4). The elimination of three tracts of the 44 (14, 34, and 44.01) eliminates about 6% of the ambulance runs for 1975. The results, then, are based on approximately 94% of the runs generated in 1975.

It should be noted here that those tracts which were eliminated by the computer in the computation process (14, 34, and 44.01) had high ambulance runs per person ratios as well as high ratios for some other variables. This may have had a bearing on the ultimate results, but these tracts were missing data and, to insure the accuracy of the general equation, had to be eliminated. It is unfortunate that tract 14 was eliminated, especially since that is the downtown area tract and every city has a downtown area which should be included in calculations of this type. However, the tracts which were used in the calculations most likely represent a cross section of what the city of Lansing is generally like. The downtown area most likely has a much larger ambulance run rate because few people live there but many people work and

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[29] Norman H. Nie, C. Hadlai Hull, Jean G. Jenkins, Karin Steinbrenner, and Dale H. Bent, Statistical Package for the Social Sciences, second edition, version 6.0, (McGraw-Hill, Inc., 1975), p. 353.

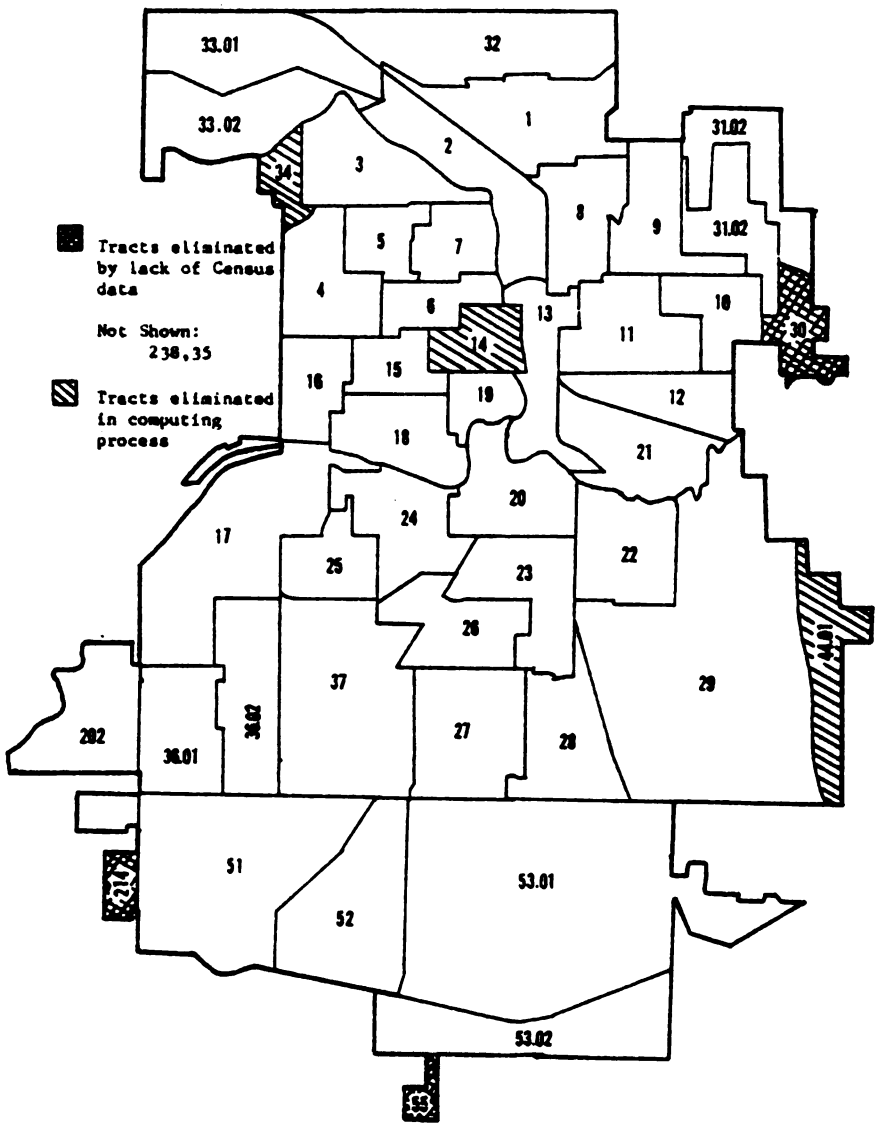

Figure 4

LANSING CENSUS TRACTS NOT INCLUDED IN STUDY

shop there. Another type of model better suited to projecting downtown ambulance run rates must be developed before the downtown run rate in Lansing can be accurately projected. The Lansing Model developed here is more suitable for making projections for residential areas.

Summary

This study makes use of census tract information for variables for the multiple regression equation developed here. These variables were chosen by examining related studies and interviewing emergency medical personnel in the area.

Once the variables were chosen, information was gathered on them for each census tract in the Lansing area. Only variables about which complete information on all suggested variables could be gathered were used.

Multiple regression techniques were then used to analyze the variables and develop a computer model which could be applied to all census tracts and accurately project ambulance calls for any area on a census tract basis.

CHAPTER IV

RESULTS

Introduction

This study was carried out with the intent of using census tract data to project ambulance utilization by census tract. The last chapter noted the variables which were included in this study and chapter four discusses these variables, how they influenced this study, and which ones were used in the model and why. A short discussion of the statistical method used by the computer in making calculations is given here to indicate how the correlations and the final regression equation were arrived at. These, as well as some weaknesses of this study, are elaborated on in this chapter.

The final section of this chapter is a brief application of the results of the research done in this paper. The cities of Lansing and Grand Rapids, Michigan are used as subjects for application of the results.

Computer Method

The computer method used is SPSS (Statistical Package for the Social Sciences), which was developed at Northwestern University.[30] The SPSS stepwise, multiple regression analysis technique is the method most often used when there are a large number of independent variables.

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[30] Ibid.

In stepwise regression analysis, the computer calculates a simple correlation coefficient between the dependent variable and the independent variables. The computer then selects the independent variable with the highest correlation and, using this variable, computes a regression equation.

In the next step, the partial correlation coefficient between the dependent variable and the rest of the independent variables is computed. The partial correlation coefficient is the correlation coefficient between two variables when the effects of other variables have been accounted for. The computer then selects the highest of these and calculates a multiple regression equation using the two selected independent variables.

The SPSS program continues in this step by step manner until all the independent variables have been entered into the equation or the computer stops entering variables because their ability to explain additional variation is insignificant. This limit is already set in the SPSS package. The results of each step are printed after each step is completed and they are summarized in a summary table at the end of the computer run.

Correlations

By observing the "Simple R" column in Table 2, one can view the correlation coefficients between the dependent variable "Runs" and the independent variables. This correlation coefficient is known as a simple correlation coefficient and represents the correlation between only two variables--the dependent one and the particular independent one. The partial correlation coefficient is calculated by the computer when

Table 2

MULTIPLE REGRESSION SUMMARY TABLE

Step	Variable	F. Value	Significance	R Square	Simple R
1	Divmen	113.31840	0	.74396	.86253
2	Skool	7.45845	.010	.78597	-.65238
3	Income	8.64200	.006	.82649	-.53045
4	Crash	6.23848	.017	.85212	.60630
5	Oldmen	5.60297	.024	.87253	.20492
6	Unem	2.62389	.115	.88166	.34903
7	Divfem	1.56660	.220	.88702	.59438
8	Hous	.73115	.399	.88955	.76110
9	Poverty	.98814	.328	.89296	.50732
10	Nocar	1.46830	.235	.89795	.68619
11	Oldfem	1.84073	.185	.90404	.17923
12	Singfam	.34316	.563	.90520	.31782
13	Kids	.58429	.451	.90721	-.19308
14	Oldfolks	.55328	.464	.90915	.20419
15	Minor	.10591	.748	.90953	.18995
16	Cops	.11374	.739	.90996	.77217
17	Female	.06963	.794	.91023	-.18189

Dependent Variable . . Runs

it is ranking the independent variables in order of importance. As mentioned previously, partial correlation coefficients are calculated taking into account the influence of the other independent variables on the one being calculated. This gives a different answer than a simple correlation coefficient and explains why the variables in Table 2 are not listed in order of decreasing Simple R's. The partial correlation coefficient is a more accurate representation of the relationship between variables, but the simple correlation coefficient can be used to get a general idea of how variables relate to each other.

Significance also figures in the ranking of the variables by the computer. The significance figure indicates the chance that calculations using a variable could be faulty. The first four variables in Table 2 have the best significance values. The worst of these four is "Crash" which would have a 1.7% chance of giving a faulty answer if it were used in an equation.

If one notices which variables have the highest cross correlation with other variables indicated in Table 3, page 42, the ones which represent some manner of social disorganization seem to stand out. Income relates inversely to all the variables except "Skool". The divorced male and female problem relates highly with other problems such as poor housing and high police calls for service. Unemployment relates with high ratios of single person headed families. In short, many social problems seem to be inter-related and compound themselves in certain tracts. This is somewhat logical, since the nature and consequences of social problems often seem to cause people who have these problems to locate near one another for economic or social reasons.

Table 3

CORRELATION COEFFICIENTS

	Runs	Female	Kids	Oldfem	Oldmen	Income	Cops
Female	-.18189						
Kids	-.19308	-.17713					
Oldfem	.17923	.52403	-.66197				
Oldmen	.20492	.28437	-.54335	.85457			
Income	-.53045	-.02023	.00726	-.32018	-.40376		
Cops	.77217	-.12423	-.14532	.15079	.21807	-.66833	
Minor	.18995	.04493	.14173	-.07482	-.06405	-.43649	.33474
Skool	-.65238	.17657	-.18806	-.13261	-.33965	-.75199	-.50842
Unem	.34903	-.07279	.17040	-.00073	.16065	-.54095	.56241
Crash	.60630	-.05803	-.21093	.36497	.38281	-.43420	.63642
Divfem	.59438	.29792	-.49217	.63171	.53818	-.62150	.57708
Divmen	.86253	-.07216	-.40414	.35384	.34247	-.64311	.81264
Hous	.76110	-.21132	.04125	-.01926	.06526	-.68057	.81968
Singfam	.31782	.09473	.32366	.08366	.23311	-.70464	.38775
Nocar	.63619	.33917	-.44787	.61178	.52701	-.68434	.66811
Poverty	.50732	.16319	.06582	.14825	.22651	-.77429	.64287
Oldfolks	.20419	.51625	-.63379	.96607	.91706	-.34967	.20319

Table 3 -- Continued

Skool	-.37278				
Unem	.37661	-.62783			
Crash	.05973	-.41506	.26155		
Divfem	.23739	-.39140	.31027	.36250	
Divmen	.22870	-.55938	.38428	.52309	.77979
Hous	.26948	-.72242	.65215	.41277	.47976
Singfam	.73593	-.72215	.57021	.14999	.36256
Nocar	.38786	-.45992	.32765	.39182	.87878
Poverty	.63230	-.71178	.54705	.29870	.55381
Oldfolks	-.01891	-.20933	.07891	.37999	.60821
	Minor	Skool	Unem	Crash	Divfem
House	.77638				
Singfam	.29613	.49514			
Nocar	.82288	.55530	.45802		
Poverty	.57738	.68627	.79510	.68868	
Oldfolks	.36623	.03062	.13051	.63049	.21775
	Divmen	Hous	Singfam	Nocar	Poverty

With this in mind, it is interesting to see that the ambulance run rate correlates negatively with high median income (-.53). These are simple correlations and can be seen in Table 3. The ambulance run rate correlates positively with high police call rates (.77), high incidences of divorced males (.86) and females (.59), more than average housing problems (.76), and a high "No Auto Available to Household" rate (.64). The "Poverty" variable also correlates highly with "Runs" (51). Unemployment correlated with high ambulance runs at about the .35 level while the "Single Person Headed Families" Variable correlated at about the .32 level. The characteristics with high correlations could be associated with social disorganization and lower socio-economic class. In effect, what this means to emergency ambulance planners is that census tracts which exhibit evidence of social disorganization or low socio-economic class will be the ones which also require the most ambulance service.

Other variables did not correlate highly with the "Runs" variable. The "Female" variable correlated at the -.18 level, "Kids" correlated at the -.19 level, "Oldfem" correlated at .18, "Oldmen" at..20, and "Oldfolks" correlated at the .20 level. These are not as significant as the previous correlations, but it is important to note that none of them came out with .00 correlation, below the .10 mark or above the -.10 mark.

Before the reliability of any variables can be established, their significance figures must be checked. Just a high correlation does not necessarily insure importance. The significance figures of the 17 variables in this study indicate that only the "Divmen", Skool", "Income",

and "Crash" variables can be used if one wishes to remain above the 98% mark for significance. Reasons why particular variables show a higher correlation and are more significant than others cannot be determined without additional investigation. The similarity between the variables with the highest correlation in their relation to social disorganization has been noted, however.

The Equation

If one looks at the summary tables on the following pages, one can see the results of entering all 17 variables into the equation to try to explain the variation. The computer notes each step and the amount of variation which this model accounts for is noted after the last variable entered (R^2 = .91023). Thus, looking at the last R^2 figure in Table 2, one can see that by entering all the B values listed in Table 4, plus the constant, into an equation for each tract, one can account for more than 91% of the variation in runs between census tracts. The B value is calculated by the computer and is used to calculate a multiple regression equation of the type $Y = a + B_1x_1 + B_2x_2 + B_3x_3 + \ldots + B_nx_n + \text{error}$. The Y value is the actual ambulance runs per person and the B values are those which have been calculated to help estimate the actual number of ambulance runs per person. The x values represent the variable values (per person in each census tract) which the B values must be multiplied with to obtain the Y estimate. In the case of a four variable model, there will be four B values and four x values for each census tract.

Table 4 also lists the standard error. This is a statistical

Table 4

SUMMARY TABLE I OF MODEL VARIABLES

Variable	B	Std Error B	F - - - - - - - Significance
Divmen	1.4789729	.17593088	70.670198
Skool	-.97766304E-02	.23436607E-02	17.401589
Income	.29145308E-05	.89019443E-06	10.719328
Crash	.89608806E-04	.35876588E-04	6.2384848
(Constant)	.94634204E-01	.24600982E-01	14.797604

measurement of dispersion which, in this case, applies to the B value. It indicates that the B value may fluctuate a certain amount, but on the average, the B value will be the B value stated in the table.

It must be noted that if all 17 variables were used in the equation, the significance factor would be quite high. Since the higher the significance factor becomes, the greater the chance of error, some of the variables entered at the end of the equation are rather questionable.

Because variables representing social disorganization correlate highly with the ambulance run rate, it is likely that these variables could be used to project the ambulance run rate for census tracts and could then prove of value to emergency ambulance system planners. However, there are many variables which could be chosen to represent social disorganization or low socio-economic class. The author has chosen 17 and these have been listed and discussed in a previous chapter. Because 17 is still quite a cumbersome number to work with when doing calculations using a regression equation, it was decided to limit the equation to the four most significant variables. In addition, the first four variables account for 93.6% of the total variation which the entire equation could account for. Therefore, by adding the last thirteen variables only 6.4% more variation is accounted for. The significance of the first four variables is also such that it makes them reliable enough to base calculations on (the worst one of the top four is "Crash" which has a 98.3% chance of being accurate if used in an equation).

It was decided that the first four variables would be used in making up the model for projecting ambulance demand per person by census tract.

The equation, then, consists of these four variables:

"Divmen" (divorced males over 14 years old per person in each tract in 1970).

"Skool" (median school years completed in each census tract in 1970).

"Income" (median income in each census tract in 1970).

"Crash" (actual automobile accidents which occurred in a tract during 1975).

The B values and their standard errors are listed in Table 4. The significance and R^2 statistics listed in Table 5 for this equation indicate what has been previously stated concerning the reliability and importance of these figures.

Given the B values listed in Table 4, the equation for any census tract would look like this:

Let Y = Ambulance calls per person in any given tract.

Y = 1.48(Divmen) + (-.01)(Skool) + .000003(Income) + .00009 (Crash) + .09463, the constant.

(Numbers are rounded to two decimal places or at the first non-zero integer after the decimal.)

Substituting the values for census tract 1, Lansing, Michigan, the equation becomes:

Y = 1.48(.0138) + (-.01)(11.3) + .000003(9710) + .00009(43) +.09463

= .020424 + (-.113) + .02913 + .00387 + .09463

= .035054 (without rounding error, the actual number is .03672138)

runs per thousand persons in tract 1 for 1975, since the data is assumed to be based on 1975. The runs per year, or Y estimate for the year, is:

Table 5

SUMMARY TABLE II OF MODEL VARIABLES

Step	Variable	F Value	Significance	Multiple R	R Square	Simple R
1	Divmen	113.31840	0	.86253	.74396	.86253
2	Skool	7.45845	.010	.88655	.78597	-.65238
3	Income	8.64200	.006	.90912	.82649	-.53045
4	Crash	6.23848	.017	.92310	.85212	.60630

Dependent Variable . . Runs

.035054 x 2763, the actual population of tract 1 = 96.85 runs for 1975. The actual number of runs for 1975 was 96. When this figure is corrected for rounding error, the estimated runs, or Y estimate, actually is 101.46. Some of the previous figures give different results than the computer does because they are rounded here for the sake of illustration. The actual Y estimates for all tracts considered in this study are given in Figure 5. For complete results for all tracts, see Appendix B. Figure 5 was drawn by the computer to show how far off the Y estimates were from the actual runs per person figure for each tract. See the list of conversions from observation to census tract in Table 6 to determine which observation refers to which tract.

The four variables in the final regression equation all have rather high simple correlation coefficients between them, the highest being between the"Skool" and "Income" variables (.75188). The lowest correlation between any of the top four variables is -.41506, which is the coefficient between the "Skool" and "Crash" variables. This is an inverse relationship, but the absolute value is what matters. The remainder of the correlation coefficients are somewhere between .75 and .41. The high correlation among the top four variables indicates that they are not completely independent of each other. High correlation between variables also signifies that they are indicators of social disorganization and/or socio-economic poverty. However, the four variables in the equation are effective in projecting the ambulance run rate by census tract. The correlation between them should be kept in mind when the results are being considered, though.

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* * * * * * * * * * * * * * * * * * * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * * * * * * * * * * * * * * * *

OBSERVATION      Y VALUE          Y ESTIMATE          RESIDUAL          -2SD                    0.0                    +2SD

    1.          .3470033E-01      .3672139E-01      -.2021387E-02                  :          I
    2.          .8473003E-01      .9976274E-01      -.2503041E-02                    :        I
    3.          .2960000E-01      .2084710E-01       .1247099E-02                 .           I
    4.          .2150003E-01      .2766365E-01      -.6163650E-02                  .         I
    5.          .3720033E-01      .3145513E-01       .5744871E-02                    .      I
    6.          .3610000E-01      .4438018E-01      -.4280077E-02                  .        I
    7.          .3550000E-01      .4027191E-01      -.4771909E-02                  .        I
    8.          .5900000E-01      .4552533E-01       .1247467E-01                      .    I
    9.          .2990003E-01      .3971186E-01      -.3011861E-02                  .        I
   10.          .2170000E-01      .2531522E-01      -.3615222E-02                  :        I
   11.          .3220003E-01      .3549528E-01      -.3295281E-02                  :        I
   12.          .3390000E-01      .4011748E-01      -.6217482E-02                  .        I
   13.          .9120033E-01      .8826620E-01       .2933796E-02                     .     I
   14.    CASE DELETED DUE TO MISSING DATA.
   15.          .6650000E-01      .5746321E-01       .3517886E-02                       .   I
   16.          .3380000E-01      .2392360E-01       .1487640E-01                          . I
   17.          .1200003E-01      .2012296E-01      -.3622964E-02                  .        I

   18.          .3900000E-01      .5427452E-01      -.1627452E-01  R                       I
   19.          .8330000E-01      .7685867E-01       .6441328E-02                       .   I
   20.          .5120003E-01      .5542186E-01      -.4221864E-02                    .      I
   21.          .2500000E-01      .3611640E-01      -.1111640E-01                 .         I
   22.          .1450000E-01      .1985777E-01      -.5357770E-02                  .        I
   23.          .2020000E-01      .2666970E-01      -.6469695E-02                  :        I
   24.          .3130000E-01      .3351160E-01      -.2211496E-02                    :      I
   25.          .2090000E-01      .2181253E-01      -.9125253E-03                    .      I
   26.          .3290003E-01      .2370431E-01       .4195008E-02                       .   I
   27.          .3710000E-01      .2823732E-01       .8812680E-02                         . I
   28.          .2570000E-01      .2674454E-01      -.9554552E-03                    .      I
   29.          .2120000E-01      .2747838E-01      -.6273838E-02                  .        I
   30.          .7600000E-02      .1663277E-01      -.9032770E-02                .          I
   31.          .2410000E-01      .3291026E-01      -.8810261E-02                  :        I
   32.          .3060000E-01      .2418288E-01       .1441712E-01                          . I
   33.          .1470000E-01      .2009496E-01      -.5329496E-02                    .      I
   34.    CASE DELETED DUE TO MISSING DATA.
   35.          .1610000E-01      .1862588E-01      -.2515880E-02                    .      I
   36.          .2390000E-01      .1416346E-01       .9736543E-02                       .   I
   37.          .3130000E-01      .3194362E-01      -.6436202E-03                    .      I
   38.          .1280000E-01      .1309723E-01      -.2972392E-03                    .      I
   39.    CASE DELETED DUE TO MISSING DATA.
   40.          .3500000E-01      .3409428E-01       .9057160E-03                    .      I
   41.          .1890000E-01      .1787010E-01       .1029904E-02                    .      I
   42.          .4820000E-01      .3880575E-01       .9394247E-02                       .   I
   43.          .4450000E-01      .2714192E-01       .1735808E-01                             I R
   44.          .3000000E-01      .2256238E-01       .7437620E-02                       .   I

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
       R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED          41.
NUMBER OF 2 S.D. OUTLIERS         2. OR   4.88 PERCENT OF THE TOTAL
```

Figure 5

Y ESTIMATE CALCULATIONS AND COMPARISON OF ESTIMATES TO ACTUAL

Table 6

OBSERVATION-CENSUS TRACT

Observations 1-29 are equivalent to census tracts 1-29. The rest of the conversions are listed in this table.

Observation	Census Tract
30	31.02
31	32
32	33.01
33	33.02
34	34
35	36.01
36	36.02
37	37
38	38.01
39	44.01
40	51
41	52
42	53.01
43	53.02
44	202

Discussion of Results

One of the values of this study is that it makes use of readily available census data to project emergency ambulance use. With the exception of a few variables, all the data was collected from the census books. Of the four variables in the final equation, only the "Crash" variable was not collected from the census information and even if this variable were eliminated from the equation, the amount of variation accounted for would drop from 85.2% to 82.6%. Therefore, it is conceivable that someone using this equation with only census data could still remain fairly accurate in his projections. To carry this argument one step further, if one looks again at Table 2, it can be noted that the "Divmen" variable alone accounts for nearly 73.4% of the variation. The correlation between the ambulance run rate and the "Divmen" variable is also the highest of all the variables. Because of this, it is possible to just use this one census variable and still make projections which are reasonably accurate.

The methodology for doing the Lansing study stands out. It can be applied to any other study in any other area of the country which has an emergency ambulance system. This is not to say that all the variables will be the same, only the process whereby those variables are chosen. Consulting providers of ambulance care, seeking out similar research in related fields, such as emergency room studies, and corresponding with and interviewing local experts in the emergency medicine field can give one an idea of what information is valuable for consideration in a specific area.

A study was located which was similar to the Lansing one, "An

Analysis of the Demand for Emergency Ambulance Service in an Urban Area," by John Hisserich, Lester Lave, and Carole Aldrich.[31] It was done in the Los Angeles, California area. It also used census data (1960, since the study was completed before 1970) as well as some other variables involving geographical and commercial areas. Actually, demand was estimated by several different models based on just auto accidents, other accidents, illnesses, dry runs, cardiacs and poisonings. Aldrich, et al. claim that using their model, 92.7% of the variation can be accounted for (the Lansing model accounts for 85.2% of the variation). The Los Angeles study includes 632 census tracts and uses 37 variables and 7 different models for estimation of per capita ambulance runs. Aldrich, et al., note that demand increases near recreational areas due to auto accidents. They also note that there is an increase in demand near commercial areas due to the great movement of people through these areas. Industrial areas tend to be safer because of increased industrial safety legislation, they say. Areas devoted to transportation, such as shipyards, train yards, and airports, generate few calls for service because most are served by special ambulance services.

A more complex model, such as the Aldrich one, may be necessary for larger cities, while one the size of the Lansing model may be more feasible for cities approximately the size of Lansing.

Another publication, "How Change Can Make Us Ill," which relates to this study, was printed by the Cooperative Extension Service, Michigan

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[31] Carole Aldrich, et al., "An Analysis of the Demand for Emergency Ambulance Service in an Urban Area," American Journal of Public Health, 61(6): 1156-1169.

State University.[32] It notes the relationship between illness and patterns of social and familial disorganization, including divorce. The article notes that social disorganization facilitates the occurrence of general medical problems. This conclusion also lends support to the conclusion drawn in this paper that social disorganization leads to more emergency medical problems.

From what has been done in this study, one fact which emergency ambulance planners should be aware of stands out: Ambulance runs in Lansing tend to be concentrated in areas of above average social disorganization, i.e., areas with a high crime rate, low income, low median school years completed and a high number of divorced persons. This fact is true for the Lansing area and may be true for many other areas also, although it must be proven. Since the data is all peculiar to the Lansing area, the results are also. However, given the socially disorganized areas which usually present themselves in every city, it can be reasonably surmised that the pattern of ambulance calls in these areas will be similar to the pattern of ambulance calls in like areas of Lansing.

General Problems and Assumptions

In addition to the problems previously mentioned in the text, there are several additional ones which should be noted here in order to keep this study in perspective. The first is the fact that data sets were gathered from different years. Since 1970 census data and 1975 fire

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[32] Thomas H. Holmes, M.D., T. Stephenson Holmes, M.D., "How Change Can Make Us Ill," Cooperative Extension Service, M.S.U., Extension Bulletin E-1009, August 1976.

department, police department, and traffic bureau data was used, the results may not be as accurate as they would be if the data were all from the same year. This may cause the overall estimate for total runs for the entire city to be down because the tracts which have the most runs per capita are those near downtown (see Figure 6) and tracts near the center of cities have traditionally been losing population. The computer calculations, however, treat the data as if it were all from the same year. The data was collected from only two years, so discrepancies should be at a minimum. This problem is peculiar to the Lansing case study and will not reflect on any other similar case study unless there is a like discrepancy in data collection years. This discrepancy in no way detracts from the methodology used for this study. New and more current data can easily be inserted into the model when available so as to periodically update and improve the projection coefficients.

Another problem related to using census information is that the census is only taken every ten years (every five years after 1980). Census material used in calculating between census variables would have to be estimated, which could be a complex procedure if yearly figures were desired to make calculations as accurate as possible. The other alternative is to assume that the variables will change at an even year to year rate between censuses. One may have to rely on past census to census rates to get an idea of what year to year trends are.

A third potential weakness of this study is that fire department data by census tract was available only for the year 1975. Thus, no averages could be taken nor could any sort of time study be done to find out if the model this proposes is accurate. It is unknown whether or

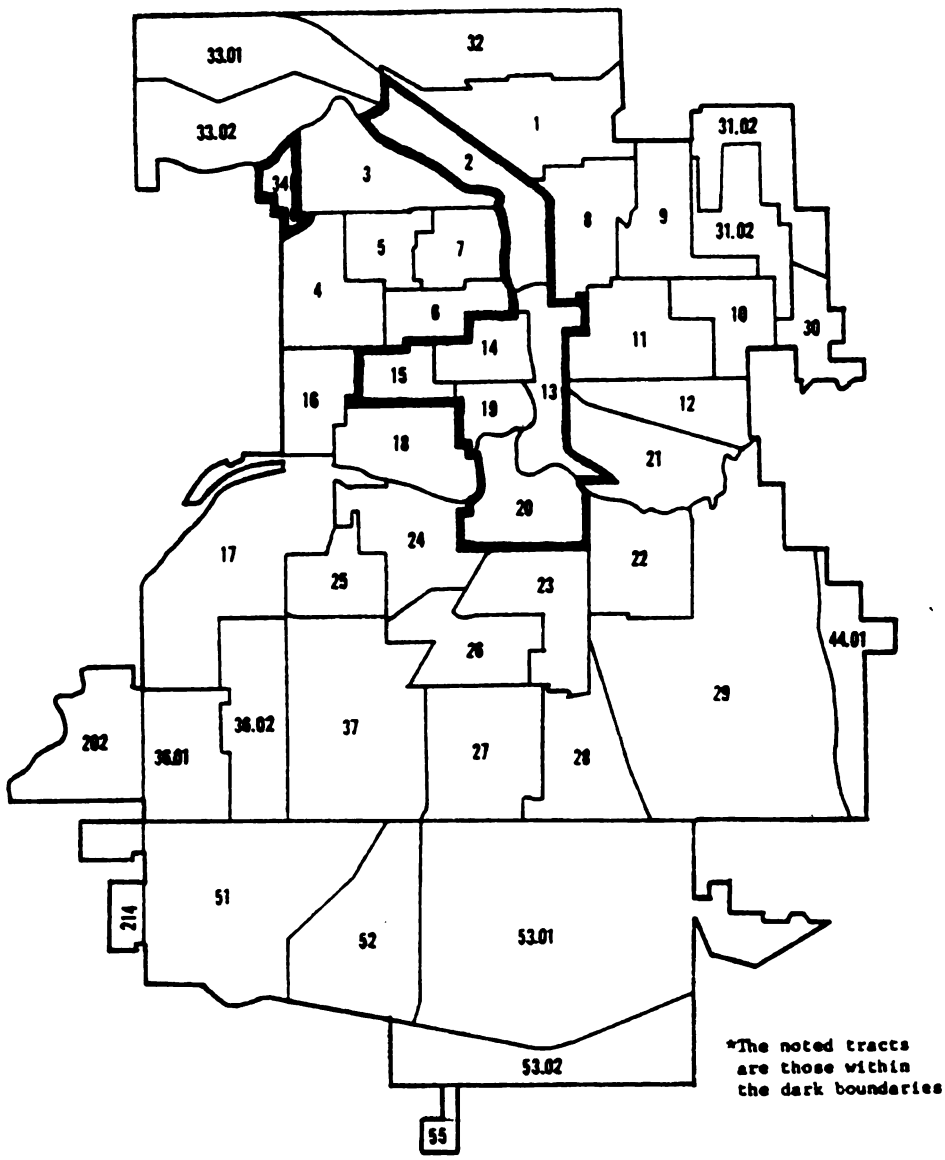

Figure 6

LANSING CENSUS TRACTS WITH 50 OR MORE AMBULANCE CALLS PER 1000 PERSONS, 1975 *

not 1975 was an unusual year for ambulance runs to certain census tracts, but, judging from total run comparisons on a year to year basis, 1975 does not appear to be out of the ordinary.

This study also presents a problem because it has no way of accounting for climatological factors such as seasonal changes. Weather in Michigan could have a great effect on ambulance utilization and vehicle placement.

Another problem is that it is very difficult to account for psychological factors in the population. The introduction of paramedics on the ambulances and the subsequent good press which they received may have temporarily influenced the number of ambulance runs for 1975, since paramedics were introduced mostly during 1974. This may affect the results of this study since it used 1975 data.

Other ways of handling medical emergencies are assumed to remain constant for the period this study is considering and they must be assumed to remain constant during any period of time over which this model is applied. Methods of handling medical emergencies which could possibly change would be the private emergency ambulance system, the initiation of ambulance service by another municipal agency such as the police department, the initiation of service by a hospital, or a change in the procedures at hospital emergency rooms or clinics.

Finally, it should be noted that the specific coefficients of the Lansing equation cannot be completely generalized to other cities. They do, however, indicate tendencies which would probably be found elsewhere. However, the methodology in combination with the choice of variables creates a model which is generalizeable to all other parts of

the United States.

Analysis of Results

Application of the model on a census tract by census tract basis in the Lansing area shows that the model estimates the number of ambulance runs quite well. The total ambulance runs estimated by the model for the entire city is less than one percent over the actual count for 1975. Complete tabulation of actual and estimated ambulance runs by census tract in Lansing in 1975 is shown in Appendix B.

It would be very difficult to analyze what exactly makes up the difference between the actual and estimated ambulance runs in each tract. The differences may even vary from tract to tract. Because of this, this section will analyze the present emergency ambulance system in Lansing using the results gained from applying the model to the census tracts in Lansing. The actual tract ambulance runs are also considered in this analysis.

There are 7 census tracts in Lansing which have an actual ambulance run rate of 50 runs per 1000 persons per year or more. They are tracts 2, 13, 14, 15, 19, 20, and 34. All are near the center of the city. Figure 7 shows these tracts as well as the locations of fire stations housing ambulances within the city.

Judging from what is shown on the map in Figure 7, ambulances are currently placed quite well in relation to the tracts which have the most runs per 1000 persons per year. If an ambulance was to be added or transferred to another fire station (it is assumed that ambulances can only be placed at fire stations), the best place to put it might be in the station in tract 2 at 2114 North Grand River Avenue. More is

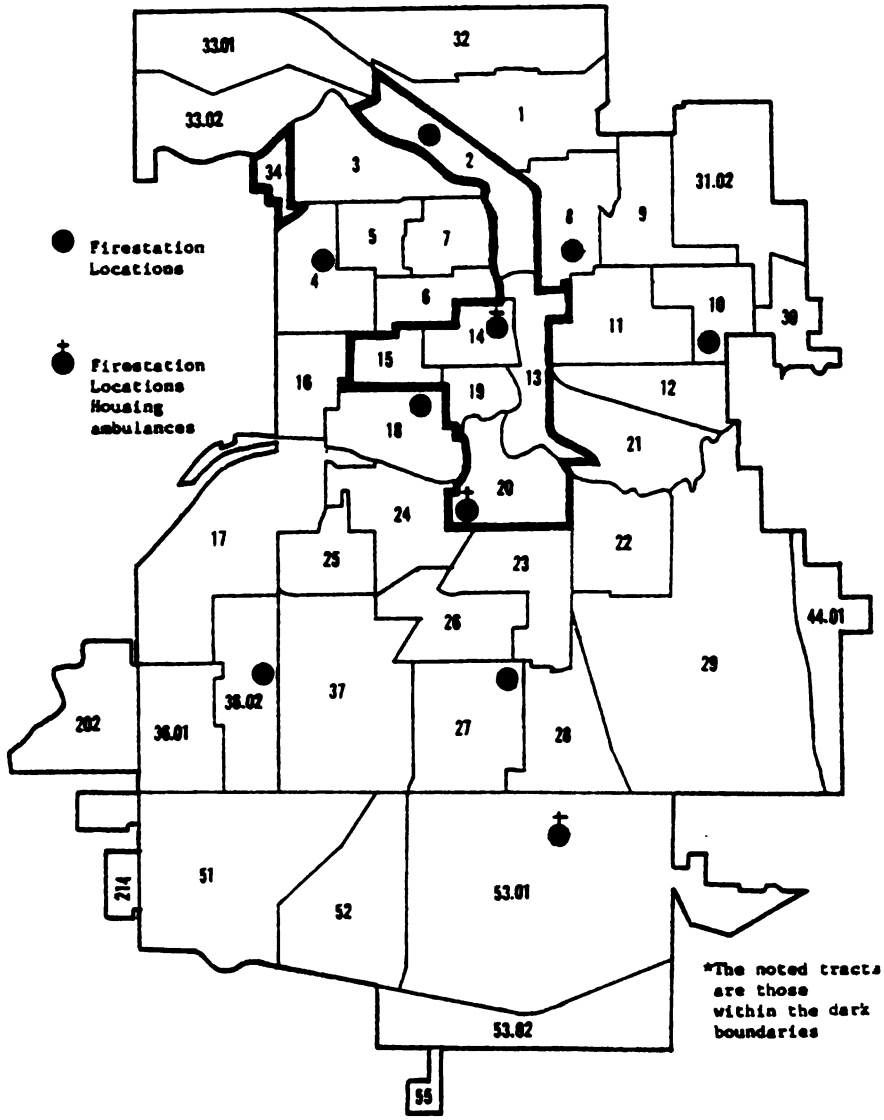

Figure 7

LANSING CENSUS TRACTS WITH 50 OR MORE AMBULANCE CALLS PER 1000 PERSONS, LOCATIONS OF FIRESTATIONS, AND LOCATIONS OF FIRESTATIONS HOUSING AMBULANCES - 1975 *

said concerning this location later in this section.

Looking only at the information in Figure 7, the decision to place an additional ambulance in tract 2 may be a logical one. On the other hand, the information given in Figure 8 may indicate that another choice may be wiser, especially when the direction of growth for the city is considered. Figure 8 shows the tracts which have 25 or more ambulance runs per 1000 persons per year. Most of the tracts in the city fall into this category. By observing the distribution of ambulances in Figure 8, one can see that there could be three potential areas which might benefit from improved ambulance service, assuming that ambulances can only be placed at fire stations. The first area which might benefit from improved service is the north side, mentioned previously. The second area which could benefit would be the east side. Service could be improved by adding an ambulance to tract 10 at the station at 2300 East Michigan Avenue. The southwest side could also benefit from improved service. An additional ambulance could be placed at the station in tract 36.02 at 3708 Pleasant Grove Road. An ambulance here could help to serve tracts 37, 51, and 202 better. The location in tract 36.02 must be considered for future expansion, since the southwest section of the city seems to be experiencing the greatest amount of growth at the present time.

Nonetheless, the possibility of placing an additional ambulance in tract 2 must be seriously considered if the city decides to expand its ambulance service. People of lower socio-economic class or those who live in areas of social disorganization probably do so because housing is lower in cost in these areas. These areas are concentrated around

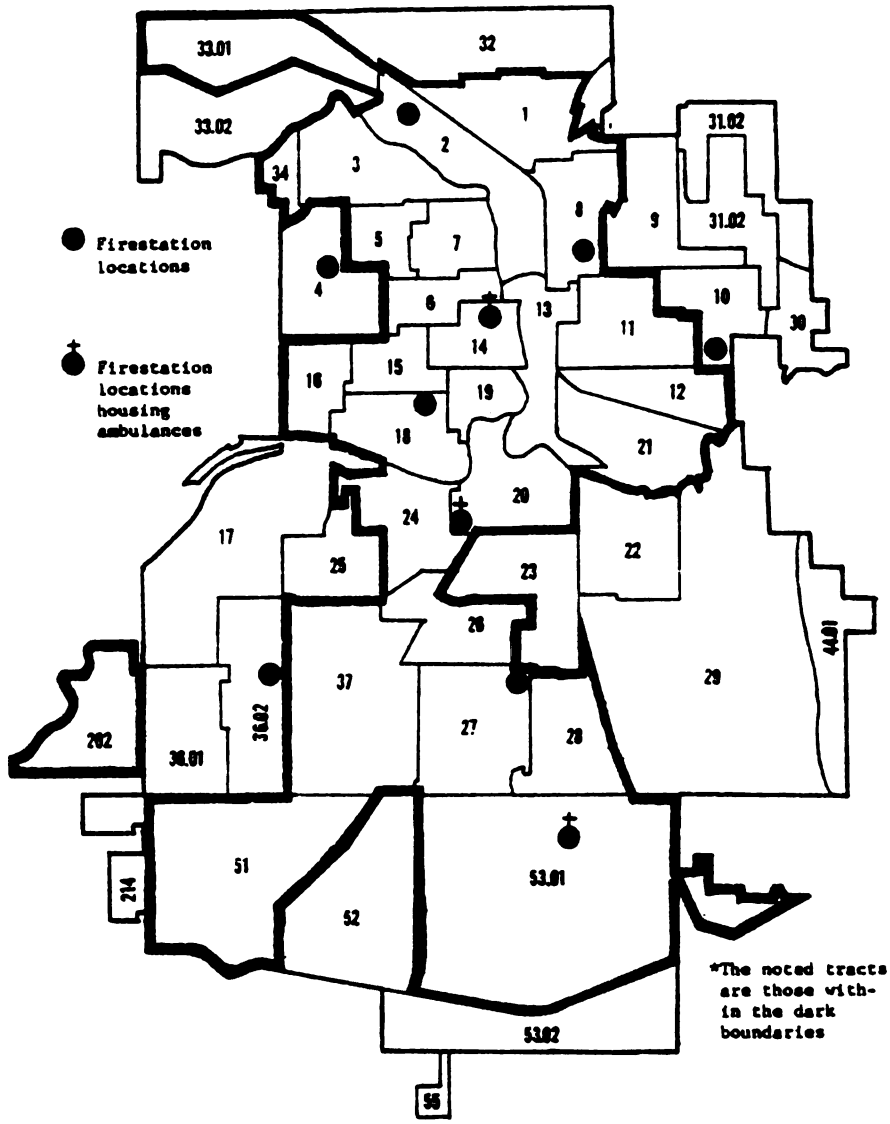

Figure 8

LANSING CENSUS TRACTS WITH 25 OR MORE AMBULANCE CALLS PER 1000 PERSONS, LOCATIONS OF FIRESTATIONS, AND LOCATIONS OF FIRESTATIONS HOUSING AMBULANCES - 1975*

the center city and in the north section of the city.

The north part of the city is not considered as economically poor as parts of the city near the downtown, but because it is older, the pattern of the poor and socially disorganized moving into the oldest parts of the city may appear more in the north part of the city than is currently visible. This process may be speeded up by the state's purchasing of property near the downtown for the expansion of the Capitol Complex. However, there has been some expansion of government subsidized housing for moderate and low income people in the southwest section of the city. The need for more comprehensive service might present itself, then, unless north Lansing becomes stabilized as far as movement of people and deterioration of neighborhoods is concerned.

The station in tract 14 already houses two ambulances and these take care of the increased demand around the center city. If demand increases more, especially from the north side, consideration must be given to placing an additional ambulance at the station in tract 2.

The area around tract 10 seems to be fairly stable and, therefore, may not need more ambulance service than the downtown station already provides. In addition, Lansing Mercy Ambulance Service, a private, commercial service, is located in this section of the city.

There are many factors which must be considered by those planning the ambulance service in Lansing. One must consider where the high injury related areas, such as highways, are located, whether or nor population fluctuates at different times of the day, such as it does in the downtown area, or whether a part of the city is not being covered quickly enough by the current distribution of vehicles. This paper maintains

that the overriding rule, when it comes to planning for emergency ambulance service, is that those who need it most should be served the quickest. This assumes that those who use the ambulance most are also the ones who need it the most. It may be easier to apply this criteria in Lansing, since the ambulance service provided by the city is "free", i.e., the taxpayers pay for it and no charge is made directly to the user. The ability of ambulance users to pay for the service could have a great effect on a system which charges its users directly.

When a system is tax-supported, there is always the danger of favoring the highest taxpayers over the lowest taxpayers. While this does not appear to be a problem in Lansing, it could be if and when the time comes to expand the ambulance system. If the system were to be expanded by only one vehicle, there may be a tug-of-war between the north side and the southwest side for that vehicle. The north side may be able to use the vehicle more, but the southwest side is growing more and has a higher tax base. Thus, the additional vehicle could end up being placed on the southwest side. This is not to say that it would not be needed there. It may be needed more somewhere else, however. Because of situations similar to this one, need must be studied closely before the system is expanded.

Application of the Model

Enough information was available about the city of Grand Rapids, Michigan to allow for an application of the Lansing model to that city to test the general accuracy of the model.

Lansing and Grand Rapids do not have identical emergency medical service systems, but they are generally similar. Grand Rapids delivers

emergency medical services through a roving police emergency unit (E-Unit) system. These E-Units are equipped with emergency medical supplies and equipment and staffed by qualified police officers twenty-four hours a day. The E-Units do not transport patients, like the Lansing system does. E-Units only treat patients at the scene until a commercial ambulance arrives.

Emergency ambulances in Lansing are staffed by firemen and do transport patients. Both cities have municipal vehicles which respond to medical emergencies, however.

By applying the Lansing model to Grand Rapids, it is assumed that the variables and their coefficients used in the Lansing model will apply to Grand Rapids in the same order that they apply to Lansing. It is also assumed that the variables themselves will be the same ones for both cities.

Grand Rapids Police Department does not keep accurate records on the number of emergency medical runs which the E-Units make, but it does estimate that they make 400 calls per month or 4800 calls per year. The police department also does not estimate runs by census tract, so the model could not be used and compared on a census tract by census tract basis. However, since there was an estimate for total calls in the city of Grand Rapids, the model was applied to the tracts in Grand Rapids and the total estimated calls for the city was compared to what the police department estimated calls to be.

The Lansing model estimated that Grand Rapids should experience 5,324 calls per year in all census tracts, 524 or 10.9% more than the police department estimated calls to be. (For a complete list of

estimates of emergency medical calls by census tract in Grand Rapids, see Appendix D). This estimate may have proven more accurate if more accurate records to compare model estimates with were kept by the Grand Rapids Police Department.

The above estimate was arrived at by applying three of the variables and their coefficients that were used in the Lansing study to Grand Rapids. The variable "Crash" was not applied because the data was not available to make the calculations. The three variables chosen were "Divmen," "Skool," and "Income." The "Crash" variable accounts for just 2.5% of the variation in the Lansing model, so using the model without it does not damage the model's accuracy too much.

Applying the three variable model to Grand Rapids, the equation becomes:

Y = 1.48(Divmen) + (-.01)(Skool) + .000003(Income) + .09463, the constant.

Substituting the values for census tract 1, Grand Rapids, Michigan, the equation becomes:

Y = 1.48(.0105) + (-.01)(12.5) + .000003(11579) + .01463

= .0199 emergency medical runs per person in census tract 1

This figures to 41.69 emergency medical runs for tract 1 in a year, since tract 1 has a population of 2095.

This process was followed for all Grand Rapids tracts and an estimate was arrived at for each one. These estimates were then totalled to get the estimate of 5324 emergency medical calls for a year.

Judging from the distribution by census tract of emergency medical calls which the model projected for Grand Rapids (see Figures 9 and 10),

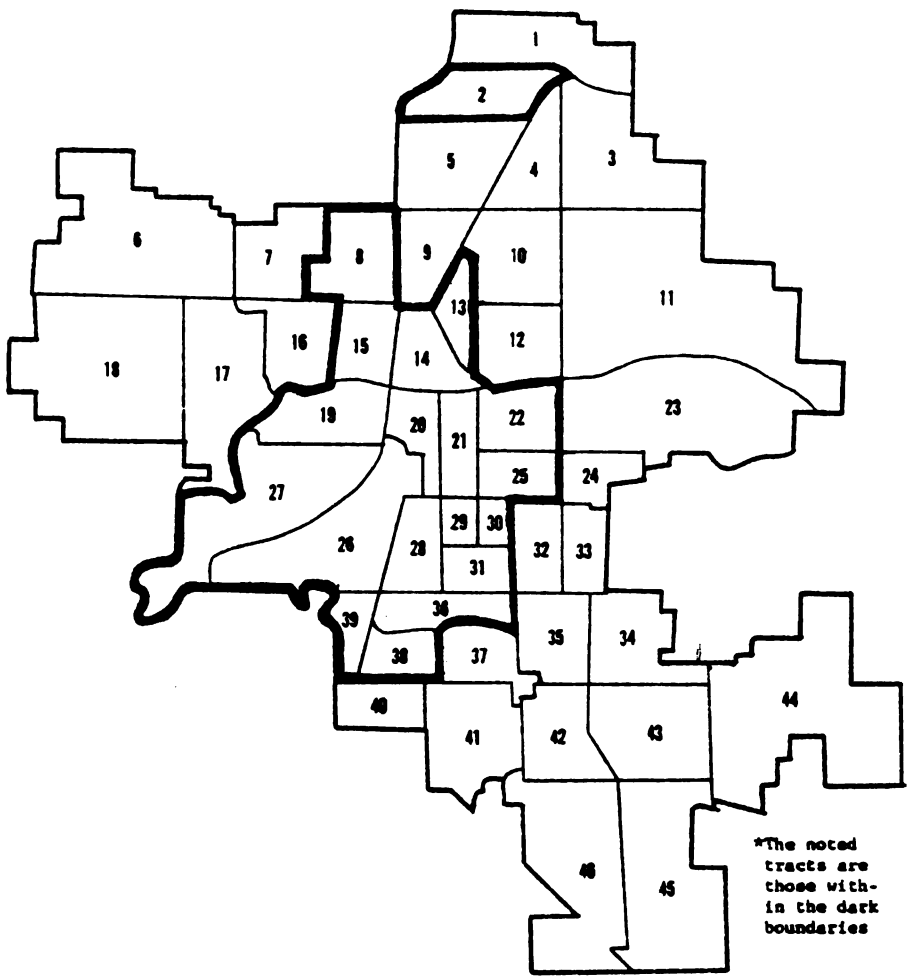

Figure 9

GRAND RAPIDS CENSUS TRACTS WITH 25 OR MORE PROJECTED EMERGENCY MEDICAL CALLS PER 1000 PERSONS PER YEAR*

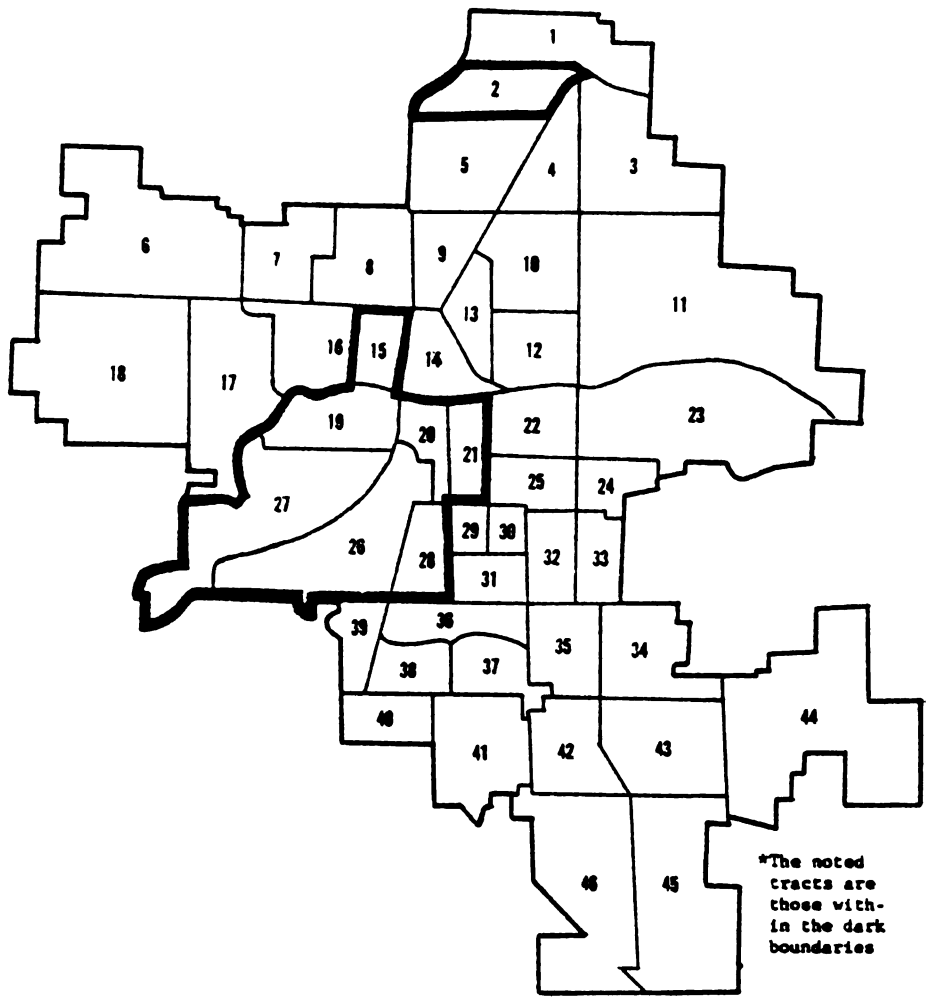

Figure 10

GRAND RAPIDS CENSUS TRACTS WITH 50 OR MORE PROJECTED EMERGENCY MEDICAL CALLS PER 1000 PERSONS PER YEAR*

the areas of the city which experience the most calls are near the center and toward the north parts of the city. This information can be constructively used to help the police department determine patrol beats for E-Units, just as similar information enumerated in the previous section about Lansing, can be effective for determining ambulance location in that city.

The model estimates emergency medical calls in Grand Rapids to be within 11% of what the police department estimates calls to be. This estimate seems fairly accurate and could prove more so if more complete information could be gathered from the police. Since that is not possible at the present time, using a model which estimates calls by census tract as accurately as the Lansing model does is not without merit.

Summary

The computer method used and the methodology for developing pertinent data is unique to this study and can be used in any other study which concerns emergency ambulance utilization.

Some of the results acquired from this study can be generalized to other areas, although they cannot be said to occur with certainty everywhere.

The one result which should be emphasized here is that the destination of most ambulance runs is tracts with a high level of social disorganization. While this result is a function of the data and variables used, it probably would exhibit itself in other similar studies. The application of the results to Lansing also depends on the data used, but, the general rule of ambulances most often going to socially disorganized areas influences what decisions, for application to Lansing,

and perhaps to other areas, are necessary for adequate planning.

Application of the model to Grand Rapids also exhibits the model's effectiveness. Although data was not available on emergency medical calls by census tract in Grand Rapids, one can get an idea of the configuration of high call census tracts in Grand Rapids if the results of the Lansing study are generalized to Grand Rapids.

For both Lansing and Grand Rapids, the comparison of actual calls to model-estimated calls illustrates the effectiveness and accuracy of the Lansing model.

CONCLUSION

In this study, a model has been developed that will project ambulance runs by census tract. By using this model, one can analyze current locations of vehicles or determine potential locations for placing new or additional vehicles.

The methodology for doing this study is important because it allows for maximum input from as many knowledgeable sources as possible. By following the methodology presented here, potential social and economic variables which may explain ambulance use can be identified. Once these variables have been identified, the computer can be used to determine which ones have the greatest correlation with ambulance runs.

Those variables with the greatest correlation with ambulance runs can be used to develop a model which can project ambulance runs by census tract.

The variables which have proven most pertinent to the model are the number of divorced men per census tract, median income per census tract, average number of school years completed per person over twenty-five years of age in each census tract, and the number of auto accidents which occur in each census tract. These four variables, when used in the model, will allow ambulance runs to be projected quite accurately. Once the computer calculations on the variables for the model in study were completed, the model took on the following form:

Y(ambulance runs) = 1.48 (The ratio per person of divorced men in

each census tract) + (-.01)(median school years completed by persons 25 years and older in each tract) + .000003 (the actual median income in each tract) + .00009 (the number of actual auto accidents in each tract) + .09463, the constant.

If the variables are coded as they are in Table 1, page 28, the model becomes:

$$Y = 1.48\ (Divmen) + (-.01)(Skool) + .000003\ (Income) + .00009(Crash) + .09463.$$

Using the model, noting which tracts most ambulance runs go to and studying the census information on those tracts, it becomes evident that most ambulance runs go to tracts which exhibit a greater than average tendency toward social disorganization, i.e., tracts with high numbers of divorced people, low average of school years completed, and problem crime areas.

By applying the model to two Michigan cities, Lansing and Grand Rapids, and by comparing actual with model-estimated results, it can be seen that the model developed in this paper can be effective in projecting emergency ambulance calls by census tract.

Analyzing emergency ambulance use by census tract is a relatively new and unused technique. However, given the availability of census tract information and the increasing numbers of agencies which are keeping data on a census tract basis, more studies similar to this one could be beneficial for the field of emergency medical services.

APPENDIX A

APPENDIX A

Search For Information

A copy of the letter on the next page was sent to the individuals mentioned in the text (see page 21). Its purpose was to gain further knowledge of the subject matter of this paper. This letter was sent also because it was hoped that people who were more knowledgeable in the field of emergency ambulances might be more aware of research on ambulance use by census tract.

The census information used in this paper is mostly socio-economic information. A colleague of Mr. Richard Larson, M.I.T., Mr. Keith Stevenson, did send some references on studies done on emergency room use and how this relates to socio-economic data. These studies were consulted and are noted in the bibliography.

APPENDIX A

Lansing, Michigan
July 23, 1976

Dear Sir,

I am an Urban Planning graduate student at Michigan State University, currently completing the requirements for the Master's degree.

My thesis is concerned with emergency ambulance utilization in the city of Lansing, Michigan using socio-economic data, mostly from the 1970 census, as independent variables.

This letter is a request for information from you on any studies which may be similar to mine so that I may compare them and study them. I have found very little information on similar studies and am seeking the help of someone who is more knowledgeable in the field of emergency medical service.

Thank you very much for your consideration.

Sincerely,

James A. Breuker
612 W. Barnes, #1
Lansing, MI 48910

APPENDIX B

APPENDIX B

Calculation of Ambulance Runs Estimates

The following table was calculated using the computer's Y estimate when the equation uses the four variables included in the model (see Figure 2 for the list of Y estimates). The Y estimate is the runs per person per year figure and, therefore, must be multiplied by the actual population figures for each tract to find how many runs a tract should generate in a year. The population for each tract came from the 1970 census.

APPENDIX B

Table B-1

ACTUAL-ESTIMATED AMBULANCE RUNS, 1975

Tract	Actual Runs 1975	Projected Runs 1975	Difference	Percent Change
1	96	101	+5	+5.2
2	201	191	-10	-5.0
3	88	92	+4	$4.5
4	89	114	+25	+28.1
5	88	75	-13	-14.8
6	110	117	+7	+6.4
7	127	144	+17	+13.4
8	206	207	+1	+0.5
9	42	50	+8	+19.0
10	69	77	+8	+11.6
11	163	180	+17	+10.4
12	102	121	+19	+18.6
13	185	177	-8	-4.3
14	269	Case deleted due to missing data		
15	276	238	-38	-13.8
16	78	43	-35	-44.9
17	93	131	+38	+40.9
18	61	87	+26	+42.6
99	81	73	-8	-9.9
20	275	298	+23	+8.4
21	77	108	+31	+40.3
22	34	44	+10	+29.4
23	91	120	+29	+31.9
24	136	;45	+9	+616
25	71	74	+3	+4.2
26	95	83	-12	-12.6
27	158	121	-37	-23.4
28	100	96	-4	-4.0
29	55	68	+13	+23.6
31.02	18	39	+21	+23.6
32	70	96	+26	+37.1
33.01	117	73	-44	-37.6
33.02	41	56	+15	+36.6
34	9	Case deleted due to missing data		
36.01	82	95	+13	+15.9
37	213	217	+4	+1.9
38.01	7	7	0	0.0

APPENDIX B

Table B-1--Continued

Tract	Actual Runs 1975	Projected Runs 1975	Difference	Percent Change
44.01	2	Case deleted due to missing data		
51	79	77	-2	-2.5
52	83	76	-7	-8.4
53.01	239	189	-50	-20.9
53.02	43	26	-17	-39.5
202	39	27	-12	-30.8
Subtotal	4705			
Total*	4386	4417	31	0.71

* With tracts 14, 34, 44.01 deleted.

APPENDIX B

Table B-2

ACTUAL-ESTIMATED RUNS PER PERSON, 1975

Tract	Runs/Person 1975	Estimated 1975	Tract	Runs/Person 1975	Estimated 1975
1	.0347	.0366	23	.0202	.0266
2	.0887	.0906	24	.0313	.0334
3	.0286	.0299	25	.0209	.0218
4	.0215	.0276	26	.0329	.0287
5	.0372	.0317	27	.0371	.0284
6	.0361	.0404	28	.0267	.0256
7	.0355	.0403	29	.0212	.0276
8	.0452	.0455	31.02	.0076	.0165
9	.0208	.0248	32	.0241	.0330
10	.0217	.0251	33.01	.0386	.0241
11	.0322	.0356	33.02	.0147	.0201
12	.0339	.0403	34	.1084	-----
13	.0982	.0960	36.01	.0161	.0186
14	1.9635	-----	36.02	.0239	.0141
15	.0665	.0573	37	.0313	.0319
16	.0388	.0237	38.01	.0134	.0134
17	.0212	.0298	44.01	.0233	-----
18	.0380	.0541	51	.0350	.0341
19	.0832	.0772	52	.0189	.0178
20	.0512	.0555	53.01	.0482	.0388
21	.0250	.0351	53.02	.0445	.0269
22	.0145	.0198	202	.0300	.0227

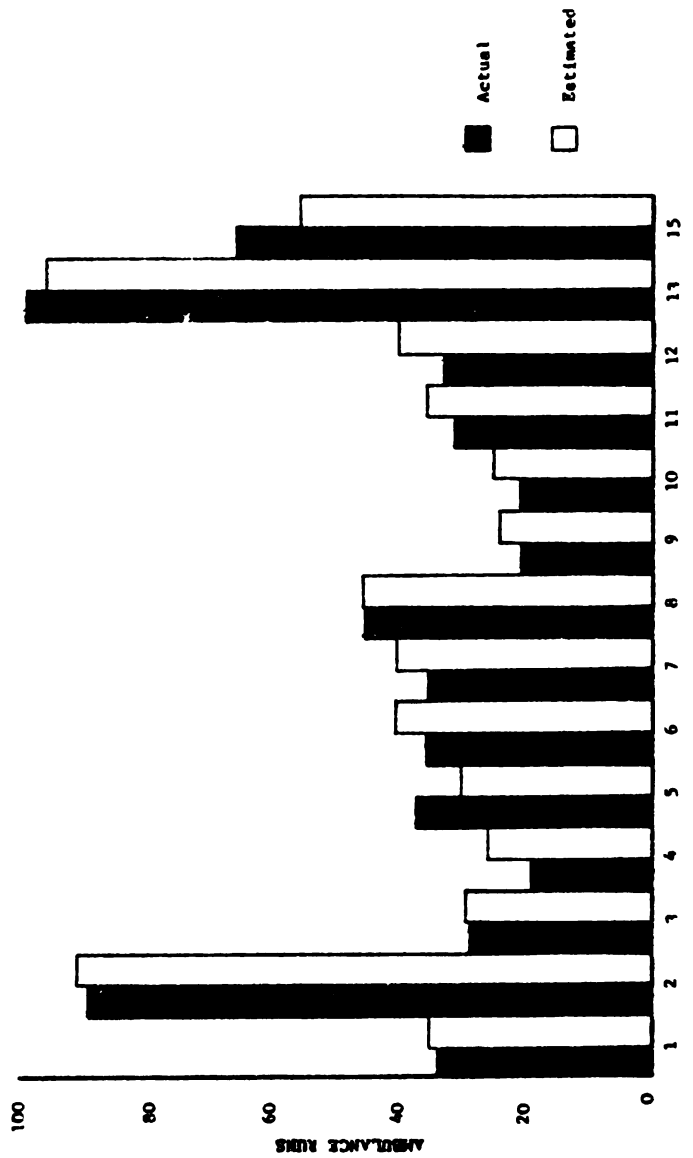

Figure B-1

ACTUAL VERSUS ESTIMATED AMBULANCE CALLS PER 1000 PERSONS BY CENSUS TRACT, LANSING, MICHIGAN, 1975

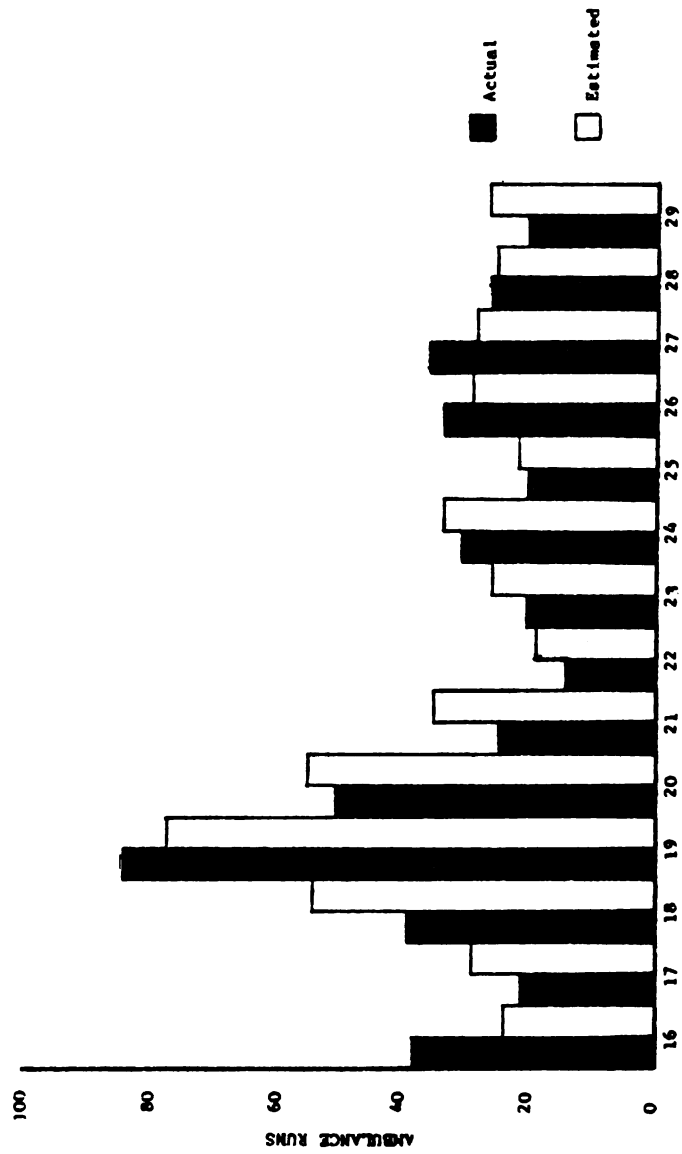

Figure B-1 (continued)

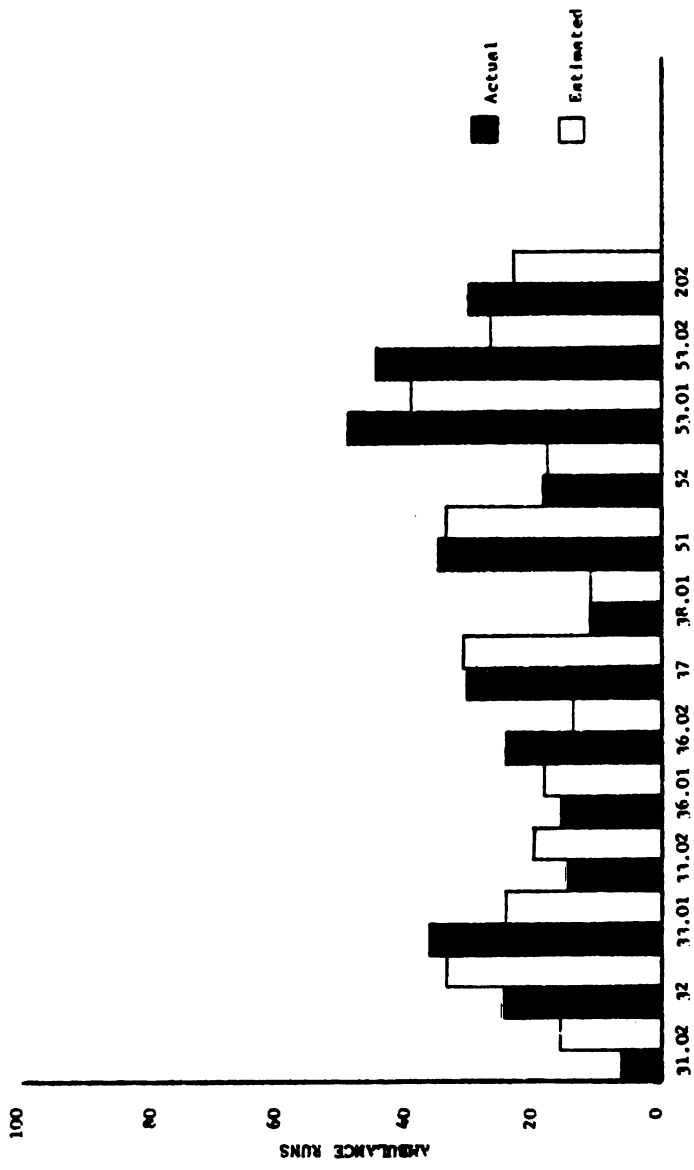

Figure B-1 (continued)

APPENDIX C

APPENDIX C

Definitions

Appendix C is a list of some short definitions for some of the terminology used in the tables.

Y Value Actual ambulance runs per person per year.

B Value The B values are the multiple regression coefficients of the independent variables and have been calculated to help estimate the actual number of ambulance runs per person per year.

X Values Represent the actual variable values, e.g., the number of divorced men per person in a given census tract, which the B values must be multiplied with to obtain the Y estimate (see below).

Y Estimate This figure is found by multiplying the B values with x values in each case, adding each product to the next and adding this sum to a constant, a.

Standard Error Standard error is a measurement of dispersion which, in this case, applies to the B value. It indicates that the B value may fluctuate a certain amount, but on the average, it will be the value which is stated in the table as the B value.

Simple R or Simple Correlation Coefficient This indicates the correlation between two variables and only those two variables. No consideration for the others is taken into account as it is in

APPENDIX C

Definitions--Continued

the partial correlation coefficient, explained later.

Significance This figure indicates the chance that calculations using a variable would be faulty.

R Square This number is the amount of variation which the variable accounts for, i.e., the percent of ambulance runs per person per year accounted for if all the variables up to a certain one were used in the equation.

Partial Correlation Coefficient The correlation coefficient between two variables after the influence of other variables has been taken into account.

F Value The F value is used to calculate the significance of the standard error of B.

APPENDIX D

APPENDIX D

Table D-1

ESTIMATED EMERGENCY MEDICAL CALLS FOR GRAND RAPIDS, MICHIGAN

Tract	Runs/Person	Total Estimated Calls
1	.0199	41.63
2	.1029	289.15
3	.0088	20.60
4	.0127	53.67
5	.0134	68.73
6	.0161	63.17
7	.0208	84.46
8	.0410	149.36
9	.0222	87.56
10	.0120	57.85
11	.0191	103.00
12	.0175	70.43
13	.0263	119.11
14	.0351	88.91
15	.0507	165.54
16	.0237	52.32
17	.0183	95.26
18	.0130	68.23
19	.0520	345.96
20	.1219	167.94
21	.0650	289.44
22	.0281	169.65
23	.0145	73.17
24	.0112	42.91
25	.0262	151.59
26	.0588	232.67
27	.0521	259.36
28	.0710	210.62
29	.0365	91.76
30	.0466	112.60
31	.0420	209.08
32	.0178	117.11
33	.0038	19.53
34	.0097	53.66
35	.0111	66.24

APPENDIX D

Table D-1 --Continued

Tract	Runs/Person	Total Estimated Calls
36	.0432	126.06
37	.0098	46.95
38	.0407	155.53
39	.0305	89.92
40	.0243	72.49
41	.0145	76.58
42	.0142	61.33
43	.0191	79.95
44	.0153	71.71
45	.0134	49.40
46	.0152	60.78
118	.0117	7.60
126	.0441	33.16

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