

## DEVELOPING AN AMBULANCE NETWORK MODEL FOR TEXAS RURAL COUNTIES

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### ABSTRACT

The Texas rural health care setting is plagued with limitations stemming from a lack of health care resources. The purpose of this article is to assist emergency medical services (EMS) planners in creating an effective and efficient ambulance network model. The article examines the existing network models already in use by rural Texas counties and presents a model for developing a new ambulance network. This article examines variables that are important to consider when developing an ambulance deployment model decentralized from a hospital. The model is based on the premise of decentralizing ambulance deployment stations away from a central depot or hospital and locating them throughout the county. The ultimate goal is to reduce response times and save lives.

Key words: ambulance, rural model, Texas.  
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### INTRODUCTION

Texas rural health care is a large, loosely connected, and fragile infrastructure comprised of numerous stakeholders. Community residents, medical providers, suppliers, and

financers create the foundation upon which Texas health care is delivered. Texas rural health care is plagued by a lack of monies, providers, and facilities. For this reason it is important that every health care resource is used with discretion. Poor planning can cost Texas rural counties thousands of dollars annually. One example of poor planning is the misappropriation of health care monies and resources for emergency services.

All too often ambulances are deployed from inappropriate locations within a county making their primary purpose less efficient. It is difficult to pinpoint an exact reason for the incorrect positioning of ambulances and ambulance depots throughout a county. One may assume that planners suppose that it is correct to place ambulance depots within the vicinity of a hospital. This assumption is dangerous because emergencies can occur at any location throughout a designated service area. The intent of this article is to help rural Texas counties reevaluate or create an efficient emergency ambulance network to serve their community. We will develop a model and overlay that model on a Texas rural county. We will also explore the ambulance deployment models used by three Texas rural counties.

Before we begin, it is important to understand the context of the information. The majority of Texas' counties are designated as rural. According to the Center for Rural Health Initiatives (2001), which is now the Office of Rural and Community Affairs (ORCA), Texas has 196 rural counties and 58 metropolitan counties. By definition, rural counties have a minimum population of 50,000 people. A second important designation to consider is medical access. Of the 196 rural counties, 176 are classified as Medically Under-served Areas (MUAs) (Center for Rural Health Initiatives, 2001). MUA is a federal designa-

tion that identifies areas with insufficient access to health care. Counties with MUA designation are entitled to increased reimbursement rates and operate under a different set of policies and procedures than counties without MUA designation. MUA designation applies to counties with a ratio of more than 3,500 people per primary care physician (Center for Rural Health Initiatives, 2001). Funding and reimbursement levels for MUAs are designed to attract and retain health care providers to rural areas.

In relation to emergency medical services (EMS), rural counties operate differently than urban ones. The primary difference between rural and urban EMS departments is funding and service area. Counties with large metropolitan areas such as Austin and Houston operate city level EMS departments. Funding for city-based EMS departments is derived through a large and extensive tax base. An urban tax base includes corporations, complex organizations, and residents with a broad spectrum of taxable assets. Rural counties finance EMS services at the county level and have a substantially lower tax base. Funds are primarily derived from county level taxes levied on rural workers and organizations. The main idea is that rural counties have a limited budget to staff and operate an effective EMS department.

Service area is also different between rural and urban areas. Urban areas have a higher ambulance density and serve a more diverse cross section of residents. Urban EMS crews treat a gamut of emergencies ranging from heart attacks to mass casualty incidents. Urban areas also have a great deal of traffic congestion, which is important to consider when developing service area routes. Rural counties have a larger service area to cover and fewer ambulances to handle emergency calls. Travel times are significantly longer for

rural EMS departments. For example, rural counties with centrally located hospitals have longer travel times to county boundaries than counties with several hospitals or ambulance depots located throughout the county.

There are several basic commonalities between urban and rural EMS departments. The principle commonality between urban and rural EMS departments is that they are both intended to provide emergency health services to the public. When properly staffed and funded, EMS departments help prevent death, disability, and suffering (Willemain, 1974). Other commonalities between urban and county EMS departments include maintaining an appropriate level of personnel, training, funding procurement, equipment maintenance, and route mapping and planning. Planning is an essential tool for properly locating ambulance deployment stations throughout a county.

Debates often arise among individuals when determining the ideal location for an ambulance deployment station. Contributing factors to the debate include county and community support, demand, and type of ambulance network that is chosen. According to Saydam (1985), four issues determine the efficiency and effectiveness of an EMS department:

1. Accurate forecasts of demand for emergency services;
2. The number and locations of ambulance units within a regional area;
3. Equipping EMS units and training of EMS personnel to staff those units; and
4. Educating the public to decrease delays in calling for an ambulance caused by not knowing what to do.

The success of an EMS department depends on the integration of all four primary

issues. Operations research and GIS (geographical information systems) models can help planners designate prime locations for ambulance deployment depots. The main concern planners take into consideration is response time. Time variables differ between rural and urban planners. Rural planners have road mileage and routes as primary time considerations, whereas urban planners have traffic congestion, call frequency, and high utilization areas as primary time considerations. To determine the current effectiveness of ambulance networks, planners within a county should use defined time performance measures.

Variables such as response time, number of deployable vehicles, and dispatching strategies can be used to create performance measures (Saydam, 1985). These measures are often developed and set by using various models formulated by the field of operations research. Specific measures for rural EMS departments were not found in the research. A county's specific EMS needs should be measured individually. One could use the above-mentioned measures as a foundation for creating specific measures for analyzing the performance of a rural EMS department.

Rural counties generally have a single-channel waiting line, which means that there is usually one ambulance dispatcher that handles fluctuating call volumes. Emergency calls arrive to dispatch following a Poisson probability distribution. In essence, this means that calls are random, and there is not a specific set amount of calls a dispatcher might receive during a given timeframe (Anderson, Sweeny, & Williams, 2001).

For example, a dispatcher for a county would be responsible for determining which ambulance would be dispatched to a specific location based on variables. These variables include travel distances to county boundaries

or service areas, number of available ambulances, and the severity of an emergency. These are the reasons why proper planning is needed to ensure an appropriate level of staff and equipment exists to handle daily emergency needs for a community.

Assuming a rural county is operating three ambulances, response times would be shortened if ambulances were located in zones dividing the entire county, as opposed to being deployed from a central hospital location. The network model described in this article utilizes the dispatcher as the primary gatekeeper when an emergency situation develops. For example, once the dispatcher receives a call, he or she must determine which zone needs emergency assistance and then dispatch the closest ambulance. If an ambulance is in route to another location then the second closest ambulance can be activated.

Revelle's (1997) multiple ambulance station model suggests locating one ambulance onsite with the primary hospital in rural settings so that trained personnel can assist with hospital overflow during idle times. The remaining ambulance deployment stations should be located in zones throughout the county. The zones are designed to help an ambulance reach the periphery of a region faster than if they were centrally located at a hospital. Industry standards do not require that ambulance zones be a specific size. Planners can identify zone location and service area by researching areas within a county that utilize greater levels of emergency services. Service areas should be located around elderly neighborhoods, high-risk intersections, or more densely populated areas.

Planners must also consider the terrain to be traversed and plan for the expected level of traffic congestion. Rural areas have signifi-

cantly less congestion than urban areas, but are plagued with poorly marked county roads and intersections. In emergencies, ambulance drivers have state law in their favor. According to Perez (2002), Texas law states that an ambulance driver may drive as fast as they deem necessary, given they have due regard for people and passing cars. In reality, this often does not hold true, as insurance companies only allow ambulances to drive ten miles an hour over the posted speed limit (Perez, 2002). The use of ambulance deployment stations throughout the county can significantly reduce drive times and road mileage between the emergency site and the hospital.

When developing ambulance zones, planners often use the Golden Hour as a time period measurement. Dr. R. Adams, the founder of trauma care, developed the term Golden Hour (Emergency Preparedness International, 2000). The Golden Hour refers to the window of time that paramedics have to render emergency aid and transport an individual back to a hospital. If complete response time exceeds the Golden Hour, chances of survival decrease dramatically. Emergency Preparedness International (2000) states that within the Golden Hour, the chance of death increases 1% for every minute lost before basic emergency care begins. The Golden Hour is broken down as follows:

- First 20 minutes – Discovery of incident and deployment of emergency services.
- Platinum ten minutes – EMS assessment and intervention.
- Following ten minutes – EMS packaging and transport.
- Last 20 minutes – Initial hospital stabilization.

Legislation under the Emergency Medical

Services Act of 1974 requires that 95% of calls be reached in 30 minutes for rural areas and ten minutes in urban areas (Willemain, 1974).

Research findings unveiled an important caveat; significant amounts of rural paramedics are volunteer individuals who often serve three functions: paramedics, firefighters, and regular employees. In many instances, volunteer EMS crews are not stationed with the ambulance on a 24-hour basis. Many volunteers hold separate jobs in the community and are networked to dispatch via mobile telephones or pagers. Once an individual is activated, they must then travel to the location of the ambulance depot. This fact proves again why ambulances should be located throughout the community and not centrally located with the hospital. Our network model is designed on the premise that ambulance depots should be located throughout the county just as paramedics are dispersed throughout the county.

The notion of locating ambulance depots throughout the county raises an important cost question. With limited funds, how can we (a county) afford to house ambulances throughout the county? A possible solution is to station ambulances with paramedics at their residency. By locating ambulances with paramedics, deployment times can be greatly reduced, especially if paramedics work closer to their homes than to a centrally located ambulance depot or hospital.

According to the literature, response time is defined by four separate criteria. The first criterion is set-up time. The question to ask is how long does it take for an ambulance and crew to be ready for dispatch? The second criterion is dispatch delay. Dispatch delay occurs between the time a call is placed and the time the call is transferred or dispatched to a specific ambulance depot. Delays can occur within the phone system and dispatch

department. It is important to remember that the dispatcher is responsible for selecting the appropriate ambulance to be dispatched. The third criterion is travel time. Ambulance drivers must be trained to pick the correct route during any given time of day (Jarvis, Stevenson, & Willemain, 1975). A fourth component involves the actual amount of time between an accident or incident and the time emergency services are telephoned. Time constraints are a solid measure for planners to keep in mind while developing an ambulance network. We were not able to discover dispatch times for specific rural counties. However, an urban setting in Oklahoma City, Oklahoma, with a population of 494,000, keeps accurate records of its dispatch calls and times. For 2001, Oklahoma City had 53,206 calls with an average dispatch time of 6 minutes and 20 seconds (EMSA Online, 2002). To further examine ambulance dispatch networks we will examine the models utilized by three Texas rural counties.

For the purpose of this discussion, each county is coded as county A, B, and C. Demographic data was obtained for each county through the United States Census Bureau (2002). The population of county A is 22,229, county B is 4,520, and county C is 7,729. The land area of county A is 909 square miles, B is 1,215 square miles, and C is 770 square miles. Population and land mass ratios show that Counties A, B, and C roughly have the same population density and can be compared to one another. Each county is a designated MUA with one critical access hospital. Each county owns and operates three ambulances (United States Census Bureau, 2002).

A comparison of all three counties revealed that counties A and C operate the same type of ambulance network. All three ambulances are based out of the hospital.

Average travel times for these two hospitals could not be obtained. In relation to salaried paramedics, both counties A and C utilize their paramedics to assist with hospital duties until they are dispatched to an emergency location.

County B operates a completely volunteer ambulance department and fire department. All three ambulances are located in a centrally located stand-alone ambulance depot. Paramedics for county B work throughout the county and are dispatched via a pager system when a call is received by dispatch. During a phone interview, the dispatcher for county B stated that the average response time for a volunteer paramedic to reach the central ambulance depot after the initial notification and dispatch was seven to ten minutes.

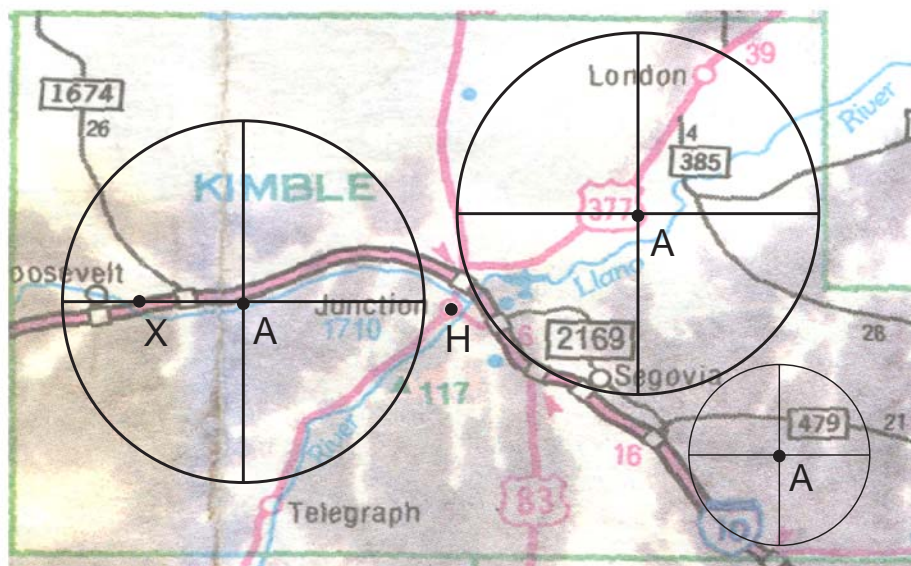
The ambulance network model can be illustrated by using a map of Kimble County, Texas. Circles can be placed onto the map to

help determine ambulance depot locations using variables such as travel distances and primary arteries (roads) from county peripheries and populated areas to the hospital in Junction.

The first step is to determine the location or locations for the number of ambulances operating within the county. The primary goal is to decrease the current response time, meet the federal standard of reaching an emergency site within 30 minutes, and beat the Golden Hour response time frame.

Locating appropriate ambulance deployment sites is achieved by using a set of circles. Each circle has a different diameter that represents a set amount of miles. For example, a one-inch circle = 9.3 miles and a two-inch circle = 18.6 miles. These values vary by map and scale, but the same circles can be used as long as they are calibrated to the scale provided by the map being used.

**Figure 1. County Ambulance Deployment Map**



Scale: 1 inch= 9.3 miles, H= Hospital, X= Emergency Site, A= Ambulance Depot

The hospital within the county where emergency patients are transferred should be located. In the Kimble County example, patients are transferred to Kimble Hospital in Junction. Once the hospital is located, circles can be used to draw service areas. These areas should be drawn on the map representing a move away from the hospital. The hospital should not be located centrally within a circle. The circles are designed to give you an idea of the actual service area and the possible ambulance location sites. We placed a two-inch circle from Junction out towards Roosevelt. Assuming that Roosevelt is where an emergency occurred, the travel distance from Kimble Hospital to Roosevelt would roughly equal 14 miles one way with a round-trip of 28 miles. Now assume an ambulance was located near the radius of the circle; the ambulance is seven miles closer to the emergency and could possibly arrive to render aid within the Platinum Ten Minutes timeframe.

#### CONCLUSION

In conclusion, the intent of this article is to encourage planners to reevaluate or modify their current ambulance networks to create a more effective and efficient model. Through research, we discovered that Texas counties often station their total number of ambulances in a central location or depot; often the primary county hospital doubles as the main ambulance deployment site. We developed a network model that decentralizes the ambulance depot away from the hospital and relocates it in several areas throughout the county. By doing this, ambulance crews can significantly reduce response times and ultimately increase survival rates for emergency victims.

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