Appendix B

Designing an Appropriate EMS System in Rural Areas: Use of a Computer Simulation Model

A computer simulation model (called RURALSIM) has been designed to allow planners to examine how their present emergency medical services (EMS) system functions and to determine the effects introducing changes into their systems.[1] The model also allows planners to set goals for long-term system improvements and to determine if the goals can be met with available resources. RURALSIM was intended to help local decisionmakers allocate scarce EMS funds efficiently and to address specific questions such as:

- Are an appropriate number of emergency response vehicles in the area?
- Are they appropriately located within the region?
- Are the personnel on these vehicles trained at the appropriate level to serve the population in the area'?
- Are helicopters and fixed-wing aircraft required as part of the system and where should they be located?

In this section, the computer simulation model is described as are its attempted implementation in several rural areas.[2]

The Computer Simulation Model

RURALSIM analyzes the effects of changes in the EMS system in terms of a number of performance measures such as response time, level of response, and vehicle utilization. The model uses local EMS demand and response data to generate predicted occurrence and responses at various times of day for a given area. The planner can hold the area's demand for EMS services constant and then alter the configuration of system resources, The effects of introducing changes such as vehicle placement and relocation strategies, vehicle dispatching policies and alternative forms of prehospital care can then be evaluated. EMS planners can use RURALSIM to evaluate the cost of alternative EMS configurations that achieve the desired goals, can modify the system's goals relative to cost constraints, and maximize system effectiveness given a particular cost base.

RURALSIM can take into account several different attributes of the region under study. These can be divided into five categories:

1. technological configurations of an EMS system including access, communications, vehicle and resource deployment, field treatment, transportation, and definitive treatment facilities;
2. different placement strategies for response and transport vehicles including first responders, Basic Life Support and Advanced Life Support providers, and the availability of rescue land and air vehicles;
3. characteristics of the region's environment including populations and the affect of particular population attributes, geography, roads, and weather conditions upon EMS demands, and response capabilities;
4. policies and operating rules for the different EMS system components including dispatch policies; vehicle re-allocation, transport. and first responder policies; and hospital designation policies, which affect patient transport; and
5. changes in demand patterns caused by population fluctuations and/or seasonal population shifts.

The model defines demand as a request for either emergency field treatment or routine transportation services. Within these two categories, demand is further subdivided according to type of case and severity level. Emergent case types may include: cardiac, trauma (non-motor vehicle related), and motor vehicle accident, and non-trauma/non-cardiac. Special categories of incidents (e.g., basic manufacturing, mining, river) can also be included. For each type of emergent incident, three levels of presenting severity are typically defined: life threatening, severe, and minor/moderate. In addition to classifying demand by type and severity. RURALSIM also allows for variation in the demand rates by time of day and day of week.

RURALSIM must not only generate the emergency incident according to type, severity, and time, but must also determine its location. In order to do this, a network model is used to represent the region's transportation system. The area's primary roads, important secondary roads, intersections, and population clusters are modeled.

Once an incident has been generated, the access component models the process which occurs between the time of the incident and the time when initial contact is made with the EMS system. The events which occur in this period include incident detection, possible aid rendered by a citizen, and EMS system access utilizing public telephone, radio, call box, or direct contact. Given the complexity of the access problem and the unavailability of representative data, this process is modeled in terms of the probability that an incident is witnessed, the time for discovery of unwitnessed incidents and the time to

I The development of the computer simulation model occur-red from 1979 to the mid- 1980s by researchers at the University of Pittsburgh, Health Operations Research Group with support from the U.S. Department of Transportation (Shuman and Wolfe, 1989).

2Four rural sites were used to develop RURALSIM: 1) Aroostoock, Penobscot, Piscataquis, Waldo, Hancock, and Washington Counties m Maine; 2) Camden, Miller, and Morgan Counties (Lake of the Ozarks) m Missouri; 3) Craig, Delaware, Mayes, Muskogee, and Okmulgee Counties m Oklahoma; and 4) Indiana County m Pennsylvania.

contact the EMS system. These access probabilities and parameters must typically be estimated by EMS planners since little data are available. They may be varied in different simulation experiments in order to assess their effects.

Three types of communication functions are considered in RURALSIM: the initial request for assistance to activate (access) the EMS system: communications between the EMS dispatch center and the ambulance vehicle base station; and communications between the EMS dispatch center and a responding vehicle away from the base for the purpose of directing or redirecting the vehicle to or from an incident scene and for the purpose of relaying medical information and receiving medical command. The system access is assumed to be via telephone and is modeled as a time delay. Randomly generated time delays are also introduced depending on the type of dispatch facility available (e.g., with or without 911), and the means of communication with the base stations. Communications between the dispatch center (or medical command) and a vehicle away from base are not explicitly modeled (e.g., number of radio channels, etc.) but are assumed to be available for the purpose of redirecting or calling off a vehicle.

The EMS system response function is concerned with ambulance vehicle dispatch, prehospital treatment, and patient transport. As input to the model, each ambulance vehicle must be specified according to its type (BLS, ALS, Rescue, or First Responder), base station, crew availability, level of crew training, and shifts in service.

The heart of RURALSIM is its ' 'dispatcher"' module, A series of decision rules has been programmed into RURALSIM to replicate the manner in which the simulated region's dispatchers would function. The dispatcher must assign the different types of vehicles in accord with the perceived severity of the incoming call. If primary and secondary vehicles are not available, RURALSIM can search for the closest available vehicle, reassign a vehicle, or queue the patient until an appropriate vehicle becomes free.

Time spent at the scene is determined by the type and severity of the incident, and the highest level of capability of the responding vehicles (BLS or ALS). Two variables are involved in the field transportation function-the decision to transport and the choice of destination. Patients may not be transported if their condition does not warrant it, or if transportation is refused. Destination for emergency patients is typically a hospital within the region or an adjoining area. Location, type and severity of the incident typically determine the receiving institution, Patients picked up at a hospital may be transported to another hospital, an extended care facility, or the patient residence.

The internal workings of the definitive care treatment facilities (hospitals) in the region are explicitly excluded from the model since little is to be gained by their inclusion and their introduction would furthcr complicate the model. Hospitals are modeled primarily as destinations for the transportation of patients.

RURALSIM collects relevant information on each simulated patient which describes the incident type and location. response times, and the resolution of the case. Output information on each patient includes: incident type, seventy level, location, time of incicient, time dispatch contacted, time each responding vehicle contacted, time each vehicle left its respective base or location, time each vehicle arrived at the scene, time patient transported (or left scene), time patient arrived at receiving facility, and time each vehicle was back in service. From these profiles, response times, delay times. and total EMS service times can be determined for each incident.

A number of measures of effectiveness are utilized to facilitate the comparison of alternative configurations and policies. These include average BLS and ALS response times, time first vehicle arrives at scene, percent of patients serviced (vehicle at scene) within 4 minutes of contacting the dispatcher, percent of patients serviced in more than 10 minutes, the average time for each component of the incident (access, dispatch, response, field treatment, and transport), and vehicle utilization. Other measures such as the number of times a vehicle is unavailable for emergent requests and average patient waits can be included.

A number of EMS options for improving an area's EMS system can be evaluated by RURALSIM. The model allows planners to develop innovative strategies to use available resources to reduce the response time for critically injured patients and thus improve the care delivered at the scene.

Options to improve EMS access that can be considered in the modeling exercise include using more efficient communications systems, improving response (by enabling care to be delivered to the scene with an acceptable response level), improving transportation, improving skill maintenance of prehospital providers and improving the hospital or clinic response capability. In a rural area the options must be chosen with respect to available services and individuals; the size and distribution of population clusters; and the social, cultural, economic, political, and geographic constraints and incentives characteristic of the specific community.

Three major groups of options are available to a community:

- those that facilitate the development of a new rural EMS system;

- those that provide linkages for small population clusters and;
- those that offer solutions to specific problems in an existing rural EMS system.

The first option group is, in reality, a process for building an EMS system from scratch. The simulator can help develop a set of steps for building an effective EMS system in a rural area. The second option group pertains to those communities that already have some form of EMS, but do not appear to have the resources required to achieve a desired level of service, These options include an evaluation of various configurations of communities cooperating with each other in order to provide a more effective system. Finally, there are options which are directed at specific problems facing a functional EMS system (e. g., communication systems). For any specific EMS area, options from any or all three groups might be important to evaluate through simulation.

During field testing of the model in several rural areas, numerous shortcomings of the simulation model were noted. These shortcomings included:

- it required data that was not available in rural areas;
- it was so complex, it required reconfiguration before it could be used in different rural environments;
- results from simulations were not available in time for local planners to use the information; and
- a rational EMS system as specified by the model was not implemented because there were limited planning resources within the region and because of various social and political constraints.

Example: Aroostoock County, Maine

The population of Aroostoock County, Maine was approximately 100,000 at the time of the field test. The population was scattered among 71 towns (most with a population under 1,000) most of which were spread over a 7,500-square-mile land area. At the time of the study, the county was served, somewhat sporadically. by 12 independent BLS ambulance providers. The development of a countywide system and/or the introduction of ALS capabilities was being considered.

The impact of several EMS system changes were evaluated including:

- using an ALS non-transporting unit which operated out of the region's hospitals and from some of its more rural clinics;
- downgrading several very low volume BLS units to IRP status; other BLS units were redeployed to provide both first response and transportation in conjunction with an ALS (non-transporting) unit;
- a transport vehicle unit was created to provide interfacility transportation from the rural hospitals to the State's tertiary and secondary care facilities (a trip of up to 4 hours or more in some cases).

The results of this seemingly ideal and cost-effective alternative were for the most part very promising: Average response times for a number of areas would be reduced by up to 2 minutes. However. even though the number of BLS vehicles deployed was reduced while an ALS capability was introduced, the rural nature of the area was not conducive to an acceptable ALS response times that remained relatively high (12.5 to 14.0 minutes). Further, the long-haul transfer vehicles were not utilized with the anticipated frequency, and hence, did not lead to significant system improvement.

While RURALSIM provided planners with a considerable amount of information, much of its potential value was not realized, in part because there were delays due to data limitations and because RURALSIM needed to be reconfigured. Primary reasons for selecting Maine as the first test site were its computerized EMS data system, the only such statewide system in existence at that time. and the sophisticated staff. However, in a number of cases, the data requirements of RURALSIM exceeded the capabilities of Maine's system necessitating either manual compilation or the development of alternative methods to estimate demand. Neither the local providers, nor the local communities were willing to accept a more efficient and effective EMS delivery system if it meant giving up a certain amount of local autonomy and independence.

The Future of RURALSIM: Microcomputer Adaptation

RURALSIM can't be used directly by most rural EMS planners because it requires a mainframe computer. The costs associated with modeling also limit its use. The model is so complex that a single simulation could cost several hundred dollars. Since RURALSIM's development, rapid advancements in personal computers have occurred and RURALSIM's could be adapted to the microcomputer. Adapting the computer model to a microcomputer would allow rural areas with microcomputers to conduct their own simulations and work with the system interactively.

A microcomputer version could be simplified and used for the training/education of rural EMS planners and administrators. A number of different rural EMS scenarios could be developed which the ''planner' could use to test-out possible alternative EMS improvements. The microcomputer-based model could also serve as a technical planning tool that could be incorporated into a technical assistance program.