Emergency Medical Service Rescue Time in Fatal Road Accidents

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Ambulance rescue times in fatal road accidents in the United States have improved little over the past few years. In rural areas, it still frequently takes a half-hour, or more, for an ambulance to arrive after a crash. On the average, this happens in about one out of every five fatal accidents. Ambulance rescue time consists of two almost equal components: response (or travel) time and communication time. A decrease in response time is unlikely in the future, but more could be done to reduce the time it takes to call for an ambulance. In particular, interagency delays in notification could be eliminated. A matched data set from Missouri shows that in 10 to 20 percent of fatal accidents the police delayed 5 min or more in notifying an ambulance dispatcher. Delays of this nature occur because a caller may fail to report injuries in the road accident. Perhaps an ambulance should be sent out anyway even if it is not certain that injuries are involved.

In 1988, the average ambulance response time in fatal road accidents in the United States was about 6 min in urban areas and about 11 min in rural areas. This level of accessibility is a product of more than two decades of effort on the part of federal, state, and local authorities. The goal of the Federal Emergency Medical Services Act of 1973, to blanket the entire nation with ambulance services, has largely been realized (*1*). The question that needs to be asked now is whether a plateau has been reached or whether there are still opportunities for further progress.

If ambulance speeds average about 1.5 min/mi in urban areas (40 mph) then a response time of 6 min can be equated to an average distance of about 4 mi from ambulance station to accident scene. If mile-a-minute ambulance speeds are usual in rural areas (60 mph) then the average rural ambulance station in the United States was within 11 mi of a rural road accident.

Some areas of the United States are below acceptable standards of emergency medical service (EMS) accessibility, and no doubt with better training some services may be able to reduce their response times. Nevertheless, the prospect for a major improvement in ambulance response time in the years ahead seems unlikely. Indeed, the U.S. Department of Transportation 1988 annual Fatal Accident Reporting System (FARS) indicated that neither urban nor rural ambulance response times had shown a significant change since 1982.

But is response time the only, or even the best, statistic to use to evaluate the accessibility of EMS in road accidents? Response time is defined as the number of minutes between EMS notification of an accident and EMS arrival at the scene of the crash. From the point of view of a public health administrator, response times provide useful statistics for locating or relocating ambulance services. Response times also provide performance standards that may be useful in judging the efficiency of a service station relative to others. But from the point of view of the injured, response time is only one component of total rescue time. What really matters most to the injured is the length of time it takes an ambulance to arrive after a crash.

In 1988, for the entire United States, rescue time in fatal road accidents in urban areas averaged about 12 min and in rural areas about 22 min. Rescue time, which includes communication delays, will always be longer than over-the-road travel time (or response time). Consequently, figures for rescue time will always have a more sobering appearance.

Given that a seriously injured person can go into an irremediable state of shock in 15 to 20 min, then the average rural rescue time of 22 min is still not fast enough. Police and emergency medical technicians do observe cases where the injured die during the rescue process. Time is a factor in survival, or in degree of recovery, otherwise there would be no sense of emergency when responding to a road accident.

The mathematical difference between rescue and response time is communication time. Communication time is the duration from the time of an accident to the time when the EMS dispatcher was first alerted. Communication time is often neglected because it does not fall within the responsibility of any health professional. Medical professionals are trained to deal with the injured after they arrive.

Emergency 911 operators, police communication officers, and EMS dispatchers are concerned about delays in communication, but little has been published about the problems they encounter in communication. State funding has largely been devoted to purchasing state-of-the-art electronic equipment, but the human element involved in sending unambiguous messages and in making difficult decisions under uncertainty has largely been left to the common sense of the bystanders who first call in the accident and to individual operators who must make sense out of what is frequently a garbled accident report.

Every minute saved in dispatching an ambulance is equivalent to a minute saved in response time. But of the two, communication time probably stands a better chance of improvement because it is not only a matter of technology and economics, but also a matter of procedural efficiency. Existing procedures are so varied that it is hard to imagine that much thought has been given to determining what works best. Complexity is taken for granted and therefore communication time is ignored. Consequently, national or state-

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wide guidance for dealing with certain types of troubling but recurring situations are largely nonexistent.

But how important is communication time as a component of rescue time? To answer this question, statistics are helpful, but reliance on overall averages may be misleading because communication varies with location. The key to understanding why communication delays occur is knowing where they occur.

Statistics show that between 1983 and 1988, changes in rescue time have been negligible for the United States as a whole. Any trends within states are difficult to verify because of insufficient data.

An analysis of merged police and EMS data from the state of Missouri shows that communication time actually consists of two separable components: call time and injury verification time. The distinction between call and injury verification times is more than perfunctory. Different strategies will be needed to improve each of these separable aspects of communication time.

STATUS OF EMS DATA IN FARS

The U.S. Department of Transportation has collected data on EMS notification and arrival times in fatal accidents since 1975 (FARS tapes). At first, only a handful of states were in a position to supply such data, but by 1988 the majority of states were able to submit fairly complete records. Seventeen states had reasonably complete records going back to 1982. However, certain states apparently do not have legal requirements for ambulance districts to supply trip information.

California, New Jersey, Virginia, Massachusetts, and Washington are among the states that have a large proportion of missing data, at least as of 1988. Ambulance services have traditionally been funded locally and a fierce independence often exists between local and state offices. Even where a state can gain the voluntary cooperation of a local ambulance service, a match has to be made between the records of two entirely different agencies: police and ambulance service. A correct matching of records can be difficult and expensive. In some FARS data police notification and arrival time have been found to be erroneously substituted for EMS notification and arrival time. For certain analyses, these FARS records are more than useless, they are absolutely misleading.

Why then is there a reluctance to publish figures on rescue times along with other EMS road accident statistics? Data are available from the FARS tapes for the time of the accident and for the time of arrival, only a matter of subtracting the time of arrival from the time of the accident to obtain the rescue time is involved. However, the time of accident is estimated by the police, usually by asking witnesses when the crash occurred, or by estimating the time of the crash on the basis of the first incoming call. Figures are often rounded, a sure sign that they are estimates (*2*).

Because the time of the accident is estimated it may seem less reliable than notification or arrival times, which are based on actual observation. On the other hand, police have no reason to bias their estimates of accident time because their performance, like that of EMS, is based on response time, not on communication time. Therefore, accident time averages are likely to be meaningful. But even notification and arrival times are subject to random errors because of misreading clocks, fast or slow clocks, mismatches of ambulance and police records, and clerical errors.

In 1988, there were 41,601 fatal accidents in the United States with about 58 percent in rural areas and 42 percent in urban areas. Of the 24,025 fatal accidents in rural areas, 27.9 percent were lacking data that would enable a rescue time to be calculated. In urban areas the situation was worse. Of the 17,576 urban fatal accidents, rescue time could not be calculated in 44.8 percent of the cases because these urban figures are strongly influenced by California, which alone accounts for almost 40 percent of the missing urban data. Does this missing data introduce biases in the national averages? It all depends on how the data are used. If ambulance service is no better, or worse, in California than in the rest of the United States, then this missing data may have little effect on overall national averages.

A small proportion of the remaining data were not used in this analysis because EMS notification time was given as earlier than accident time. Police may simply have underestimated accident time. On the other hand, such data may also be caused by clerical errors. Also, in a relatively small number of cases rescue time took more than 2 hr after the accident. Without a doubt, cases of this nature are real because a car can crash into a ditch late at night and not be discovered until the morning. But these data represent unusual circumstances and perhaps should be analyzed separately. In any event, including such data might strongly skew summary statistics. Accordingly, all negative rescue times and times greater than 2 hr were left out of this analysis.

COMMUNICATION TIME AS A PROPORTION OF RESCUE TIME

In urban areas, an ambulance can be expected to arrive quickly (in 5 min or less) at the scene of a crash in about one-third of the fatal accidents. In rural areas, this arrival time occurs in only about 10 percent of the cases. From another point of view, in about 1 out of 20 fatal accidents (5 percent) in urban areas an ambulance may take an unconscionable half-hour, or more, to arrive at the crash site. In rural areas, even this dismal record will be exceeded in one out of five fatal accidents (Figure 1).

However, for rapid rescues of 5 min or less, communication may be almost instantaneous. In only 25 percent of the fatal accidents where rescue was within 5 min did the communications take more than 1 min. But communication delays become a progressively greater problem as rescue time increases. In rescue times of greater than a half-hour, in half of the cases at least 21 min was required to communicate a need for an ambulance (Figure 2). Delays in communicating the need for an ambulance and delays in the length of time it takes to get out to the rural scene of an accident generally work together to exacerbate a problem that is virtually certain to result in a large number of fatalities among injured people.

Behind these dry statistics is a sense of frustration. An ambulance crew called to the scene of a distant rural accident may rush to try to save a life. What the statistics above indicate, however, is that much of the delay in the arrival of the ambulance may be due to initial difficulties in communication.

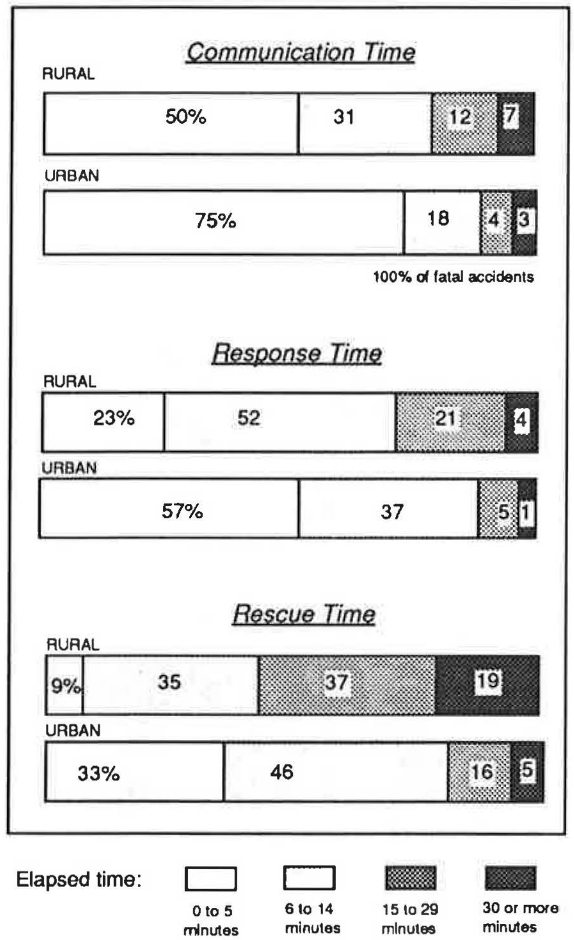

FIGURE 1 EMS communication, response, and rescue time for fatal accidents, 1988. (Source: FARS tape, 1988, based on 16,561 rural and 9,661 urban fatal accidents.)

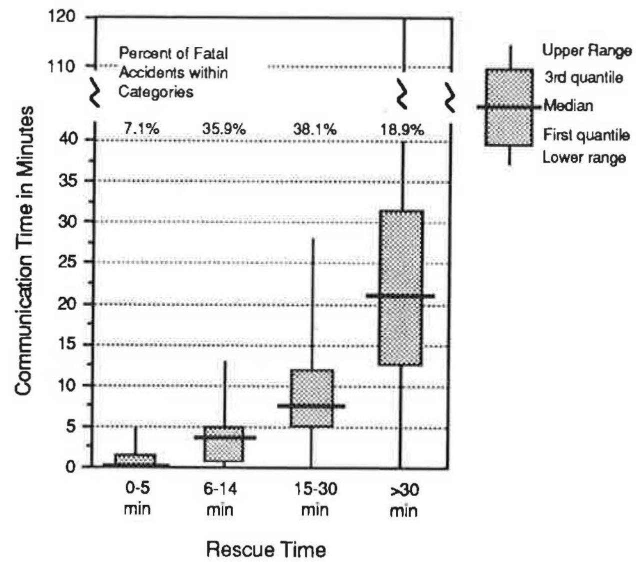

FIGURE 2 Communication as component of rescue time for rural fatal accidents, 1988. (Source: FARS tape, 1988, based on 15,334 rural fatal accidents.)

COMMUNICATION TIME AND ENVIRONMENT

Communication delays vary with the environment. Low travel densities and low land use densities next to the road will result in fewer passersby when an accident occurs. For those observing the accident, a low density may make it difficult to find a telephone to notify the authorities. The density effect can be studied by selecting relevant variables: first, the United States can be divided roughly into two discrete density regions: (a) lower density for the mountain and plains states, and (b) higher density for the remaining states. Second, a communication delay can be expected to be more likely during the late hours of the day (between 11 p.m. and 6 a.m.), than during other hours. Finally, the type of road might be examined because the more housing adjacent to a road the more likely communication will be quicker. This situation suggests that limited access highways (Interstates) would be more likely to have longer communication delays than other roads.

When data from the 1988 FARS tape are examined with each of these factors (region, hour, type of road) in mind, it appears that rapid communication (of 5 min or less) is less likely in mountain and plains states than in the rest of the United States, during late hours than during normal hours, and on Interstates than on other roads. Overall, rapid communication is also less likely in rural than in urban areas (Figure 3).

No surprises are apparent in these statistics. Indeed, if these relationships did not hold one would be inclined to suspect the accuracy of the data. Density relates to accessibility to a telephone and being close to a telephone seems to be the major factor in EMS communication delay.

EMS RESCUE TIME AND MULTIFATALITIES

In accident analysis one would like to know how many lives might be saved if certain actions were undertaken. But unless one has a perfectly matched sample it will be difficult to obtain completely convincing results. In any nonexperimental analysis a possibility will always exist that one factor or another may have been left out of consideration.

All persons in a vehicle involved in a crash are at risk of becoming a fatality. But in some accidents only one fatality will occur, whereas in others there will be multifatalities. In part, the age and health of the individuals involved in a crash will affect the probability of a multifatality accident occurring. In part, the probability will also depend on the nature of the accident. Certainly, the probability of more than one person dying in a crash will also depend on the number of persons involved in the crash. If there are four people in a vehicle when it crashes, the probability of more than one person dying, all other things being equal, will be greater than if only two persons were involved. However, the probability of a multifatality will also depend on how fast EMS arrives at the scene to render aid.

In order to verify these assumptions, 1988 FARS data for the United States were used consisting of an initial sample size of 9,381 fatal accidents in which there were exactly two persons involved in the accident. Overall, in only 5.5 percent of these two-person accidents did multifatalities (two fatalities

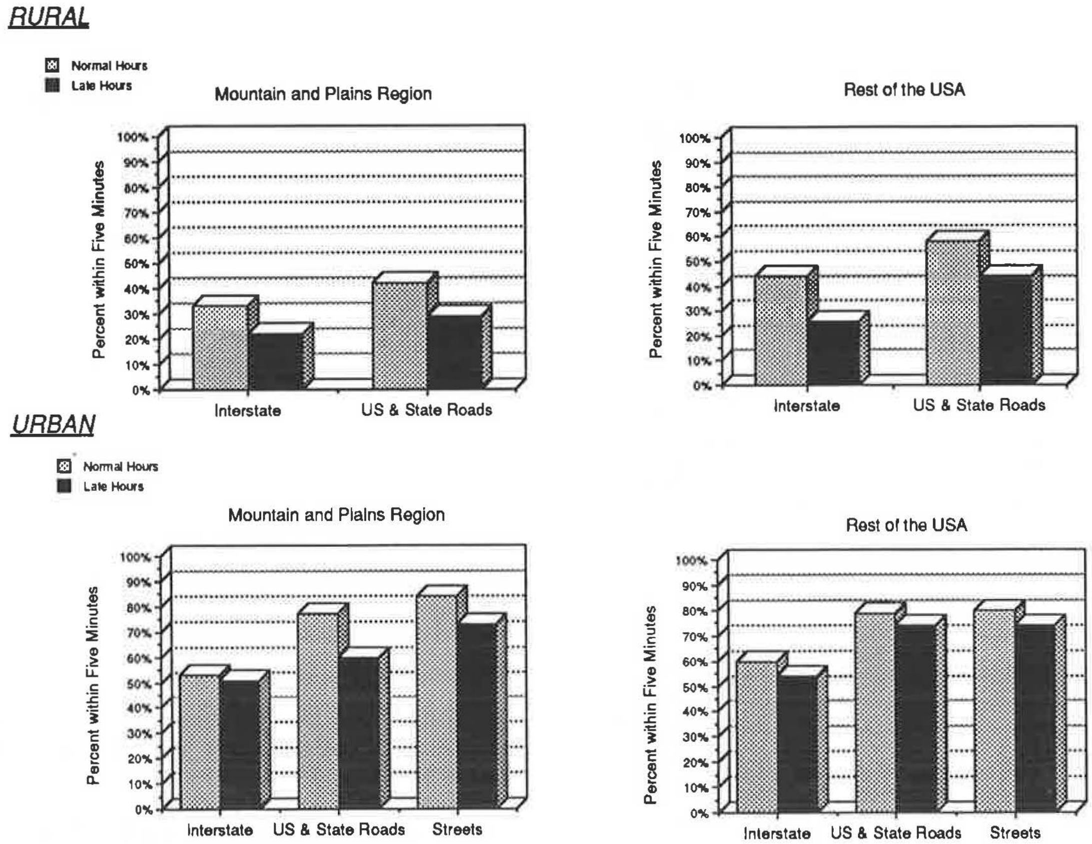

FIGURE 3 Percentage of rural and urban fatal accidents with a communication time within 5 min, by region, hour, and type of road, 1988.

in this case) occur. When broken down into groups of rescue time categories, the percent of multifatalities varied. Multifatalities occurred in 3.9 percent of cases where EMS arrived within 5 min. But the rate increased to 8.3 percent in cases where rescue time for EMS was 30 min or more. The same EMS rescue time relationship was also examined for involvement categories consisting of three-, four-, and five-person accidents with similar results. In all cases, as one would expect, multifatalities increased with involvement category. But more important, multifatalities also increased with the length of time it took EMS to make the rescue.

However, these results were based on accidents at all speeds. Speed also affects the probability of multifatalities. Further, slower speeds may be associated with locations where rescue time is faster. Therefore, it seemed reasonable to sample only those accidents where posted speed was ≥ 55 mph. When this procedure was followed, the sample size for the two-person involvement category dropped to 4,676 accidents. The overall percent of multifatalities increased from 5.5 to 6.5 percent (not a large increase, but certainly in the expected direction for increased speeds). In fact, all involvement categories (three-, four-, and five-person) showed an increase in multifatalities. Clearly, probability of a multifatality in a fatal accident increased with posted speed. However, controlling for speed did not affect the general relationship of an increase in multifatalities with an increase in EMS rescue time. Posted speed was not a confounding variable, although it could have been.

Next, pedestrian accidents were removed from the sample. For two-person involvements the sample size dropped to 3,893. Here, the underlying assumption was that although two people may be involved in a pedestrian accident, only the pedestrian will actually be at risk. Removing pedestrian accidents from the sample actually improved the relationship between speed of EMS rescue and percent multifatalities. (Removing pedestrian accidents would have had an opposite effect if they occurred more frequently in remote locations.) The variation now became 6.1 percent for rescue times of 5 min or less, and 9.9 percent for rescue times of 30 min or more. But the presence of pedestrian accidents in the original sample did not alter the general relationship between rescue time and multifatalities.

The type of accident might possibly affect the association because the risk of having more than one person die may vary depending on whether the crash was single or multiple vehicle. Consequently, the sample was reduced to multiple-vehicle crashes. Sample size now dropped to 1,913 accidents for two-person involvements. Nevertheless, the relationship between speed of rescue, number of persons involved, and multifatalities still remained (Figure 4). The validity of this association was checked for statistical significance with logit analysis. Both of the independent variables, involvement and EMS rescue time, were found to be significant at the 1 percent level.

Additional control variables such as age of persons involved and precise nature of the accident could be used to further refine the process. However, each refinement reduces the sample size and introduces the possibility that a valid relationship may be obscured by random variation.

The results as they now stand are consistent with the general understanding that speedy rescues save lives. The results may actually underestimate this effect quantitatively because some of the individuals who died in single-fatality accidents may also have been affected by delays in EMS arrival.

As in many studies of risk, no one demonstration will be sufficient. A combination of studies using different methods of standardization of risk will certainly make a stronger case for a causal relationship. In a study done in Texas, for example, the effect of EMS accessibility on fatalities was measured using a severity ratio, rather than multifatalities, as a means of standardization (*3*).

But a logical relationship between EMS rescue time and survival is not the issue because there can be little doubt about the emergency of injury road accidents. The major purpose of a statistical analysis is to provide a better quantitative assessment of the numbers of fatalities affected by variations in EMS rescue time. As the quality of the data improves, one can expect to see progressively more accurate assessments.

TRENDS IN RESCUE TIME, 1983 to 1988

The quantity and completeness of EMS data on fatal accidents in FARS has improved since 1983. For example, in 1983 only 53.3 percent of rural rescue times in fatal accidents could be calculated. By 1988, 72.1 percent of rural fatal accidents had EMS data associated with it; only 27.9 percent were missing. But precisely because the proportion of missing data has changed, especially within certain states, it is not always possible to assume a trend. Improvement, or lack of it, may simply be caused by the effect of having more complete data.

Mapping state-by-state changes between 1983 and 1988 indicates that 20 states improved their rescue time, at least in rural areas, with respect to the percent of fatal accidents with a rescue time of 30 min or more. But 11 states showed an increase in percent of EMS rescues in rural areas that were 30 min or more (Figure 5).

No pattern is apparent in the state-by-state comparisons, and overall national statistics do not indicate significant improvements. Delays in communication time actually increased from 5.7 to 6.3 percent in fatal accidents with 30 min or more needed for communication. Response time declined slightly from 3.6 to 3.2 percent in cases of 30 min or more needed for response. Rescue time remained about the same, or slightly declined, from 7.4 to 7.2 percent when 30 min or more are needed for rescue. The static nature of communication time over the past 5 years, like the static nature of response time, might indicate that little can be done to improve rescue time, or it might indicate that the communication aspect of EMS has simply been neglected.

CLARIFYING COMMUNICATION TIME WITH MATCHED MISSOURI DATA

What is not clear from statistics based on FARS data alone is the relationship between police and EMS notification of a

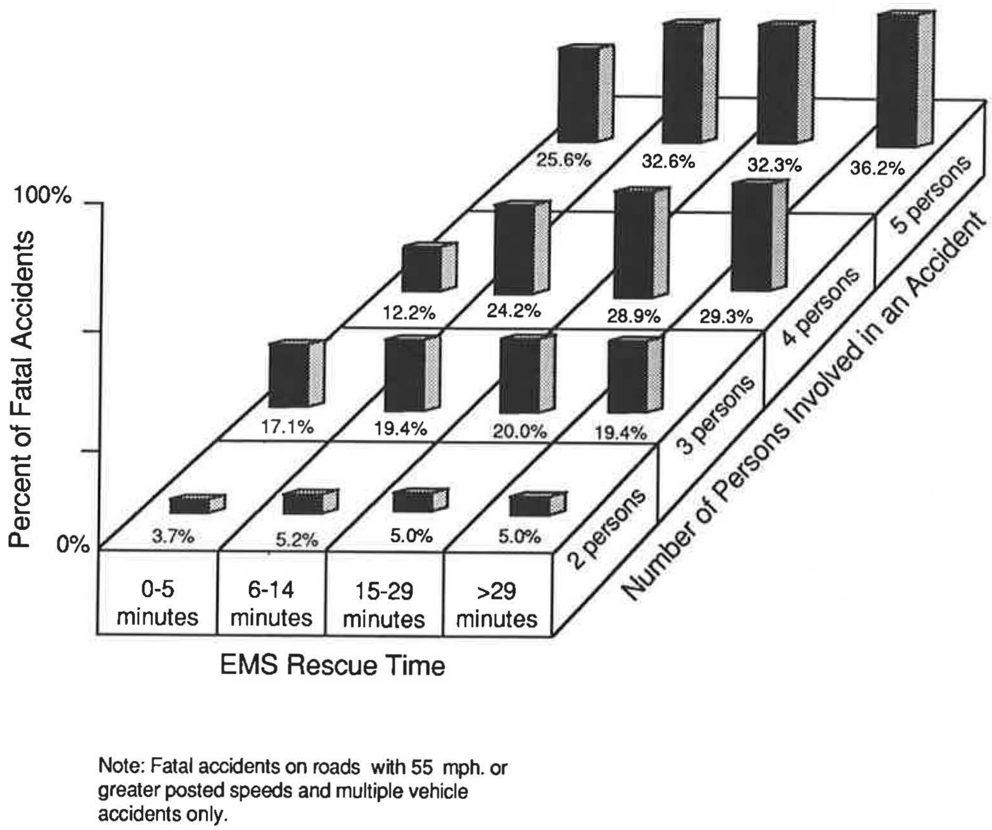

FIGURE 4 Multiple fatality accidents as percentage of total fatal accidents by involvement and EMS rescue time. (Source: FARS tape, 1988.)

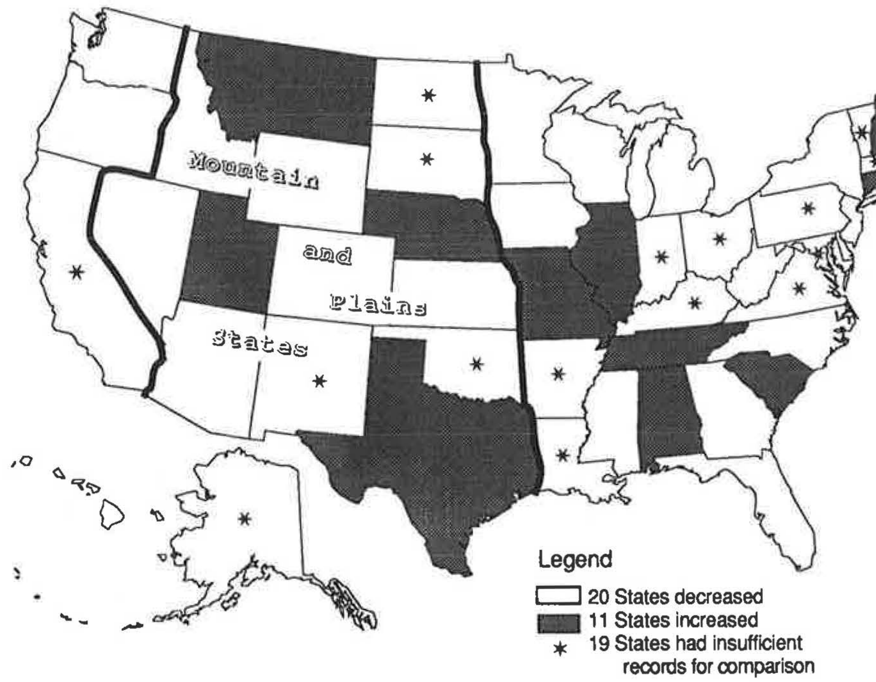

FIGURE 5 Change in percentage of rescues of 30 min or more in fatal accidents, 1983–1988. (Source: FARS tapes, 1983 and 1988.)

road accident. Who gets notified first, the police or EMS? Or do they both get notified at the same time? Are there any delays in notification between agencies? How much of communication time is from delay by a passerby in getting to a telephone, and how much is from interagency delays in transmission?

In order to answer these questions it is necessary to examine both EMS and police notification times. FARS data, unfortunately, omit police notification time, although it could have been obtained easily from the state police accident record.

The need for matching different data sources to produce a richer file of data is becoming more apparent in accident research. Daniel Fife (*4*) describes matching of FARS data with a file from the National Center for Health Statistics (NCHS). Using such criteria as age, sex, and date of death, he was able to uniquely match 85 percent of the FARS data with NCHS data to produce a data set that can examine the nature of the injury with aspects of the motor vehicle crash. Similar research in matching data files currently underway by Sandra W. Johnson in Maine is sponsored by the National Highway Traffic Safety Administration. In the Maine study, ambulance run reports are being linked with police, hospital, and other data files to produce a sensitivity index for statewide systems that will evaluate the sequence of events from time of crash to hospital release of the injured.

In this study, EMS data were taken from the FARS tapes for 1985 to 1988 and matched with data from Missouri police injury accidents. The FARS data include the time at which EMS was called as well as location date and time of accident. Location and time of accident make it possible to match the FARS file with the police file relatively easily. For example, in the 1987 fatal accident data it was possible to match 918 out of 927 fatal accidents. The unmatched nine either had missing or incorrectly coded records. Among the 918 successful matches, some required a small change in the coding. For example, a set of six observations was incorrectly coded in FARS by the county, which was obvious because no counties in Missouri have that digit. Usually, computer consistency checks made with the FARS data are comprehensive, but this particular data set was not checked for valid county codes.

All times were converted to minutes from the beginning of the day to enable simple subtractions to be made. Because there is only one date on the records, a day was added to the subtraction when the rescue times went past midnight. Adjustments were also made when it was clear that military time was not used.

Data from the fatal accidents demonstrate that most frequently both police and EMS are notified at about the same time. In urban areas, police and EMS are notified within 1 min of each other in 41.7 percent of the fatal accidents. In rural areas, the figure is less, only 27.0 percent of fatal accidents. Most rural areas in Missouri do not have 911 emergency numbers, so the caller has to call either the police or EMS. However, what is most disturbing is that in urban areas in 14.7 percent of the fatal accidents EMS was notified 5 min or more after the police had been notified. In rural areas, the percentage increased to 19.9 percent of the fatal accidents (Figure 6).

Police are apparently not always notified first. In urban areas in 15.1 percent of the fatal accidents, EMS was apparently notified more than 5 min before the police. In rural areas, the figure was apparently 19.3 percent. Apparent is used, but the figures for EMS notification before the police are ambiguous. Police notification indicates the time that the officer who filled out the accident report was notified, not necessarily the time that police were first informed of the accident. If a police officer is too occupied with the accident to be able to fill out an accident report another officer may be called on to do this job. The officer who arrives later will record the time he or she was notified of the accident on the accident report. Consequently, some, many, or possibly all instances where the police were apparently notified after EMS become clouded. In some cases, EMS could really have been notified before the police but there is no way of knowing this for sure without access to the original police logbooks.

But why the delay in police notifying EMS? When the police receive a call they always ask about injuries. If the caller indicates that there are injuries, then the police immediately radio the EMS dispatcher for an ambulance. However, if the caller is vague then the police may hesitate until confirmation that an injury is involved before they notify EMS. Consequently, in 15 percent or more of the fatal accidents there may be a delay of at least 5 min because the police are unsure about injuries.

This component of communication delay is well known to both police and EMS communications operators and there are considerable differences in opinion as to what, if anything, can be done about it. Because the vast majority of reported accidents do not require an ambulance and because fatal accidents are comparatively rare occurrences even among accidents that do require an ambulance, there is a tendency to perceive this problem as minor. Only when a statistical analysis is done for an entire state over a period of 1 year or more do the serious dimensions of this problem begin to emerge.

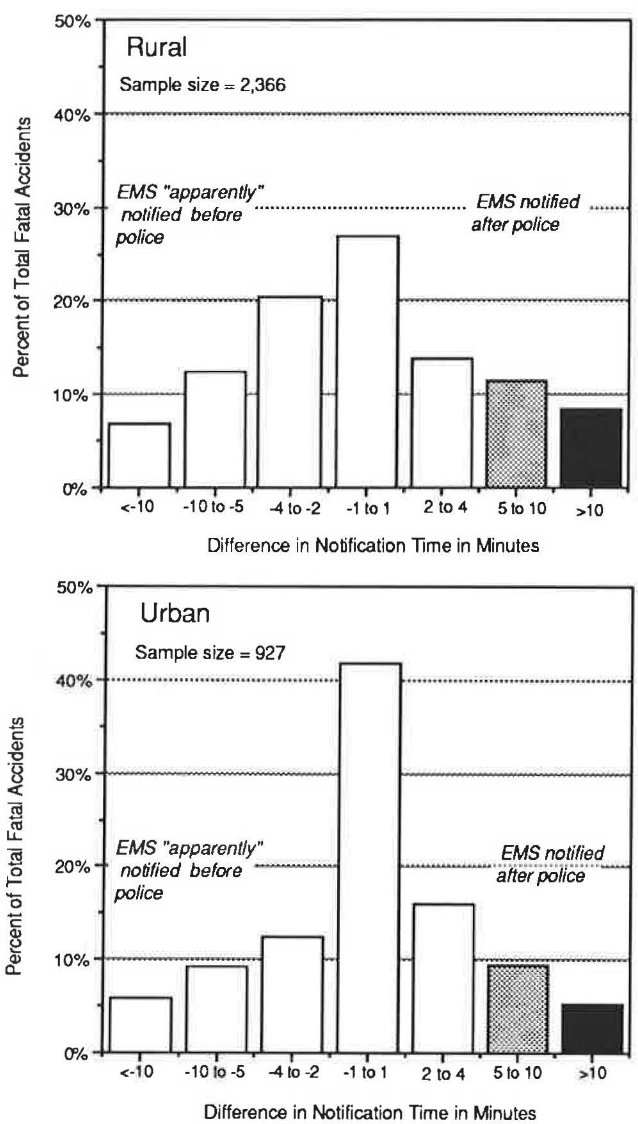

FIGURE 6 Police minus EMS notification time versus percent of fatal accidents, Missouri, 1985–1988.

Some EMS people are of the opinion that the EMS dispatcher should be notified of a road accident, regardless of whether the police think that an injury is involved or not. This practice would place more of the responsibility on EMS for deciding whether or how to respond. EMS dispatchers would then have to decide whether the description of the crash warranted an ambulance rescue. Perhaps EMS should be sent out more frequently to road accidents even when it is uncertain that an injury is involved. The extra burden that this might place on an ambulance service could best be understood by people within the service and might be a factor in decision making.

If a change in policy is initiated, it should be monitored over time to weigh increases in successful rescues against probable increases in dry runs (no transportation of injured persons). At present, no state has a program for evaluating the causes and consequences of delays in emergency communication in road accidents.

CONCLUSION

Although ambulance response time is the most widely used statistic in evaluating EMS, it is meaningful only when making performance comparisons between otherwise similar services. A much more important statistic is rescue time.

From the time of the crash until the time EMS arrives, the injured may suffer irreversible physiological changes affecting survival or complete recovery. Therefore, the faster the ambulance arrives the more likely the individual will recover. The results presented are consistent with an understanding that delays in EMS arrival do affect the number of fatalities.

Rescue time in road accidents has changed little over the past several years. Response time will likely remain frozen at its present level unless additions are made in the number of ambulance stations, which could be costly. Communication time may be more promising to pursue for improvements in the accessibility of EMS in road accidents.

Communication time is a major component of rescue time, about equal in importance to response time. Communication delay occurs in situations where it is difficult to find a telephone. The effect of travel and population densities on communication time is quite clear. However, new technologies involving use of satellites and cellular phones may in the future reduce this problem (*5*). Encouragement should be given to the development of this kind of technology for its potential value in medical emergencies.

But another aspect of communication delay is quite independent of telephone availability. Apparently, not all incoming calls to the police clearly specify the need for an ambulance, and most car crashes do not result in injuries. Consequently, the police generally do not notify EMS about an accident unless they are sure that injuries are involved.

Police communications officers assume the primary responsibility for sorting out road accidents likely to need EMS from those that probably do not. But, in about 15 percent or more of fatal accidents, the communications officer makes the wrong decision by failing to notify EMS immediately. Should this responsibility of sorting things out be shifted to the EMS dispatcher? And if EMS is allowed to make these decisions, what policy should EMS use? Should EMS automatically respond to all reported accidents, or should EMS wait for confirmation of actual need as the police usually do? Or is there a middle ground that has yet to be explored?

Police and EMS are separate agencies that are often reluctant to examine controversial boundary issues unless drawn to it by external pressures. The general public is probably unaware that this problem even exists. But communications officers know that their judgment could be questioned in court. Negligence has been brought up in other situations, but never in connection with EMS delays in road accidents. However, for good reasons both the police and EMS operators record all incoming calls.

Statistical results from the Missouri data on differences in agency notification are dealt with in greater detail by Brodsky (*6*), but the kind of analysis presented here could be repeated in most states. Missouri has a communication system similar to many others in the United States. Therefore, it is likely that delays in EMS rescue in road accidents because of communication problems will be found to be widespread in this country and perhaps in other nations as well.

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