Top Emerg Med
Vol. 26, No. 2, pp. 143–156
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Automatic Crash Notification and the URGENCY Algorithm

Its History, Value, and Use

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Automatic Crash Notification (ACN) Systems provide rapid notification with accurate location of automobile crashes. Advanced ACN systems also provide additional information on the nature and severity of the crash. To take advantage of this crash information to improve triage, transport, and treatment decisions, the National Highway Traffic Safety Administration developed a predictive algorithm called *URGENCY*. The purpose of URGENCY is to identify, instantly and automatically, the approximately 250,000 crashed vehicles with serious injuries occurring each year from the 28,000,000 crashed vehicles with minor or no injuries. **Key words:** *ACN*, *crash injury*, *URGENCY*

NUMEROUS recent studies have documented the enormous human and financial costs associated with traffic-related deaths and injuries.[1,2] The problem is not only in the United States. The World Health Organization, preparing a report on the issue, says vehicle crashes will become the world's third leading cause of death and disability by 2020.[3] In the United States, the economic costs of crash injuries incurred each year amount to an estimated $140 billion. Including compensation values for pain and suffering, the comprehensive costs of crash injuries incurred each year amount to an estimated $345 billion.[2] The human costs, incurred by individuals and families because of the deaths, injuries, and disabilities in crashes, each year, are unmeasured tragic losses that burden all of society—for decades.

Beginning with its first Administrator, Dr William Haddon, the National Highway Traffic Safety Administration (NHTSA) has worked to reduce crash-related morbidity and mortality. To understand the factors underlying injuries from motor vehicle crashes, Haddon proposed that the elements of the epidemiology triad should be considered in unison with the crash sequence. The crash sequence can be examined in terms of 3 items: the circumstances surrounding the event prior to the

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The National Highway Traffic Safety Administration funded this research. The authors acknowledge the contributions of Dr A. C. Malliaris (deceased), who performed the statistical analyses that resulted in the first URGENCY algorithms, and Mr Louis Lombardo (NHTSA), who continues to provide leadership and guidance for efforts to improve safety on our highways.

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crash occurring, the circumstances involved during the crash, and those involved after the crash. The Haddon matrix illustrates how the crash sequence interacts with human, environment, and vehicular factors to define the frequency and severity of injury.

Haddon argued that an appropriate understanding of the factors affecting injuries in each cell of the matrix could lead to more effective interventions. By identifying important factors and their location in the crash sequence, it will be possible to understand where interventions may be most appropriate.

Haddon's matrix helps to put the current interventions in proper perspective[4]. In 1973, he wrote: "The ninth strategy in loss reduction is to move rapidly in detection and evaluation of damage that has occurred. The generation of a signal that response is required; the signal's transfer, receipt, and evaluation; the decision to follow-through, are all elements here—whether the issue is wounds on the battlefield or highway."

Figure 1 illustrates the use of the matrix to summarize selected key current crash injury mitigation interventions. As noted, a number of interrelated infrastructure and vehicle-based technologies and systems apply to the "Post-Crash" category. The remainder of this article discusses 2 of these interventions, namely automatic crash notification (ACN) and URGENCY.

	Human	Vehicle	Environment
Pre-Crash	Reduce DWI Enforce Speeding, Safe Driving Classes	Anti-roll over ABS, Intersection Collision Avoidance	Lighting, Sight Lines,
Crash	Increase Seat Belt Usage	Airbags, Seatbelt Pretensioners, Vehicle Compatibility, Side Curtains, Roof Strength	Breakaway Poles Safer Guard Rails
Post-Crash	Educate EMS, Public Safety and Medical Service Providers	ACN and AACN	End-to-End Emergency Communications, Trauma Systems, Shorter Notification Times, "URGENCY" Improved Transport & Triage Decisions

Figure 1. Haddon matrix for crash injuries.

BACKGROUND

Each year, along the 4 million miles of roads in the United States, about 5 million Americans are injured in 17 million crashes involving 28 million vehicles. Among those 28 million crash-involved vehicles, approximately 250,000 Americans suffer life-threatening injuries. Specifically where and when they will occur is not predictable. Thus, it is important to be able to distinguish, instantly and automatically, the one crashed vehicle that has a seriously injured person from every 100 vehicles in crashes, most of which have no injury or simply minor injuries.[5-10] The challenge is to improve the timeliness and quality of emergency response and care over present practices.[11-14] For example, currently in virtually all 42,000 deaths and 250,000 serious injuries every year, helicopter rescue operations do not begin unless, and until, someone with the expertise and authority to request air medical services travels over land to the crash scene. As a result, frequently, rescue occurs too late to save lives and prevent disabilities.

In an effort to address this challenge, NHTSA sponsored the ACN Field Operational Test Program. As part of this program, the first ACN systems were designed, constructed, and deployed in a fleet of vehicles in western New York state in 1997.[15,16] This work was performed by a team led by the Buffalo Operations of General Dynamics Advanced Engineering Information Systems, Buffalo, NY (formerly Calspan).

The ACN Field Operational Test played an important role in the development of ACN systems. The test demonstrated the ability to (1) develop vehicle crash sensors and associated algorithms to detect crashes and discriminate minor crashes from potentially serious crashes in which there was a probability of occupant injury; (2) utilize global positioning systems (GPS) technology to accurately determine the crash location, and (3) automatically initiate a call for help using an onboard

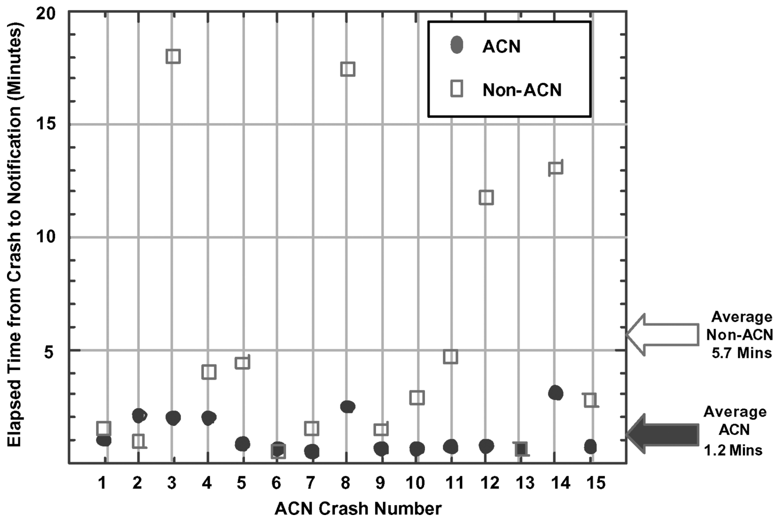

Figure 2. Summary of ACN field test crash notification times.

cellular telephone to transmit voice and data. The call electronically communicated information on the location of the crash and the severity of the crash (for all major crash modes: frontal, side, rear impacts, and rollover). It also transmitted data on vehicle precrash speed, direction of travel, and vehicle identification information, including many attributes such as vehicle type. The equipment also opened a communication link to the vehicle occupants.

Of particular note, during this field operational test most crashes occurred in urban or suburban locations in western New York. Nevertheless, the ACN system was shown to reduce the average crash notification time by 4.5 minutes to approximately 1 minute in 90% of the crashes.[15] Figure 2 summarizes the crash notification times for personal injury crashes occurring during the test that involved an ACN equipped vehicle. As noted, the average ACN notification time was 1.2 minutes. The average non-ACN notification time (ie, 9-1-1 call by a witness or bystander) for the same crashes was determined to be 5.7 minutes.

Concurrently with the NHTSA ACN Field Operational Test, General Motors (GM) launched OnStar in their 1996 Cadillac models. This commercially available system generated an automatic wireless call in the event of an airbag deployment event. The call provided vehicle location as determined from an onboard GPS receiver. After the data were transmitted a voice link was established with the vehicle occupants. Since 1996, OnStar has increased the types of vehicles on which their equipment is available. Currently OnStar is available on more than 50 GM models, as well as a range of models built by Acura, Audi, Isuzu, Subaru, and Volkswagen. Other vehicle manufacturers now offer similar systems, including Mercedes-Benz and BMW.

In 2002, several milestones marked advances toward widespread deployment of ACN technology. The American College of Emergency Physicians (ACEP) adopted a resolution supporting "the development and implementation of programs, policies, legislation, and regulations that promote the use of ACN."[17] Subsequently, both GM and Ford announced deployments of advanced automatic crash notification (AACN) technology in fleets of their vehicles. General Motors OnStar announced that it would equip several hundred thousand vehicles beginning in 2003, and that it would use the Vehicular Emergency Data Set developed with 9-1-1, emergency medical services (EMS), and other agencies in a year-long process led by the ComCARE Alliance to deliver telematics emergency data.[18,19] Ford announced a test fleet of 500 ACN-equipped police vehicles that began operating in Houston, Tex in 2002.[20] The current NHTSA Administrator, Jeffrey W. Runge, MD, recently expressed his support for ACN technologies:

> Serious crashes happen every day, more than half of them in rural areas where the ability to rapidly contact 9-1-1 and the capability of responders to quickly reach the scene can mean the difference between life and death. New technologies such as wireless E9-1-1, automatic collision notification and emergency vehicle route navigation are available that will make emergency access more reliable and help deliver faster and better emergency care.[21]

The initial work leading up to URGENCY began at about the same time that early development work began on ACN systems. The stimulus for URGENCY originated from findings at the William Lehman Injury Research Center (WLIRC) in the early 1990s on occult injuries among occupants protected by air bags and/or belts.[22,23] Prior to the widespread use of airbags and seat belts, external injuries were an obvious indicator of crash severity and of the potential presence of internal injuries. However, the growing absence of external injuries among people protected by air bags and/or belts was found to mislead emergency medical care providers into missing internal injuries—sometimes with fatal consequences. This resulted in NHTSA publishing a Research Note in 1993, and a Poster in 1994 titled *Look Beyond the Obvious* to educate the EMS community to the changing pattern of injuries.[24]

The emerging ACN technology provided the opportunity to obtain crash sensor measurements of accelerations, direction of forces, final resting position, etc, immediately after the crash. The NHTSA Office of Crashworthiness Research recognized that to enhance the utility of ACN data in the medical community, a method was needed to translate the available crash severity data into an easily understandable rating of potential occupant injury severity. With this in mind, NHTSA convened a multidisciplinary team of trauma surgeons, emergency physicians, crashworthiness engineers, and statisticians under a cooperative research agreement with the University of Maryland National Study Center for Trauma and EMS. The purpose of the project was to improve triage, transport, and treatment of people injured in crashes.

The team conducted retrospective analyses of NHTSA data on crashes, deaths, and injuries. The focus of this research was "how to identify, rapidly and automatically, those vehicles in which people are seriously injured and need time-critical emergency care?" A key objective of this research was to develop a reliable measure of the probability of serious (AIS 3+) injuries being present in a crash. The scientific literature was reviewed and statistical analyses of the NHTSA Fatality Analysis Reporting System (FARS) and National Automotive Sampling System (NASS) electronic files were conducted. Logistic regression analyses were used to relate injury probabilities to parameters of crash severity, including crash delta velocity and principal direction of force in the crash as estimated in NASS data. Then a mathematical algorithm was developed to convert the crash severity data from vehicle sensors into an easily understandable, objective, and actionable "urgency" rating that could provide EMS dispatchers with a probability rating of the presence of serious injuries. The algorithm was named *URGENCY* 1.0.[11–13, 25, 26] The team and other researchers recognized that use of ACN technology with URGENCY could produce significant improvement in postcrash care with substantial benefits in reductions of deaths and disabilities from crash injuries.[27–31]

APPLICATION AND UTILITY OF URGENCY

For a crash involving a vehicle equipped with ACN, Figure 3 illustrates a timeline showing the critical links in the chain of events from the time that the crash occurs until the injured occupant arrives at a hospital. The

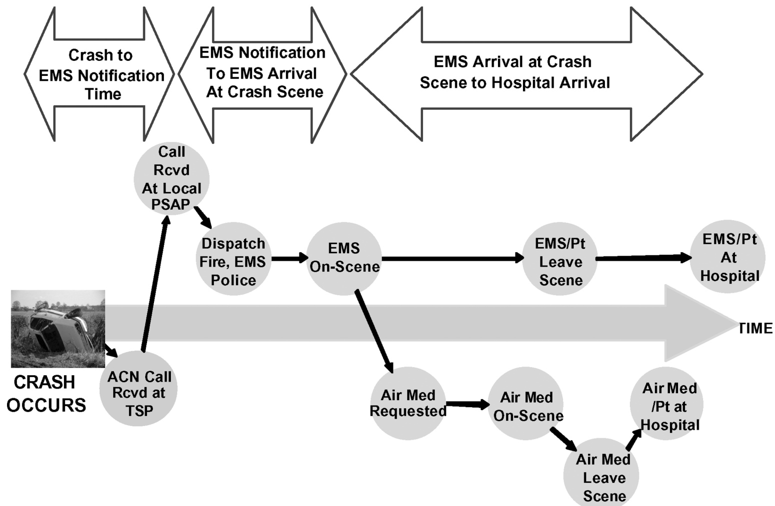

Figure 3. Timeline of key post crash events.

figure identifies several features of importance, namely, the key metrics used to characterize the time between the crash and when the patient receives definitive care. These metrics are events associated with both ground and air transport modes as follows:

1. Elapsed time between crash occurrence and EMS notification.
2. Elapsed time between EMS notification time and EMS scene arrival.
3. Elapsed time between EMS scene arrival and hospital arrival.
4. Total elapsed time from crash to hospital arrival (sum of the above).

Of note, as is the practice in most instances, the decision to request/alert air transport is made by someone who is at the crash scene.

Figure 4 illustrates some of the key postcrash decisions that must be made by Telematics Service Provider (TSP), public

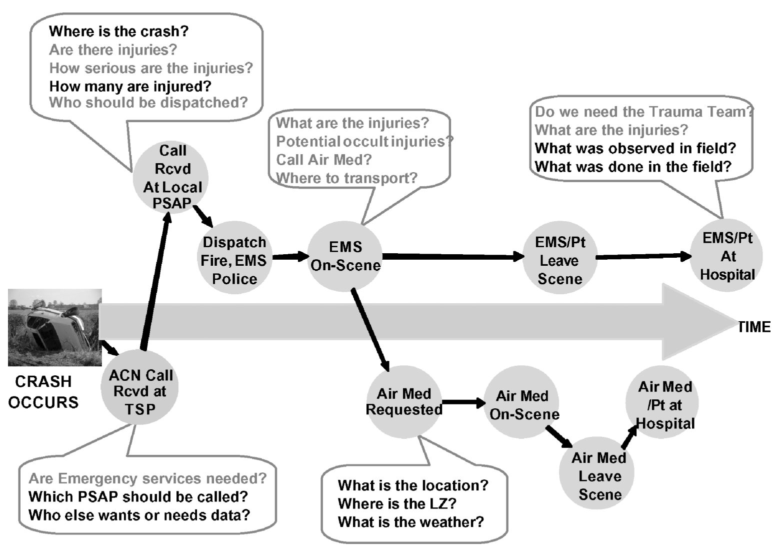

Figure 4. Application of crash severity/injury severity information to key post crash decisions.

safety agency, prehospital care, and hospital-based care personnel. Given that little or no crash information is currently available to these personnel, the "instant and automatic" availability of accurate and reliable crash severity and probable injury severity information, such as that provided by URGENCY, would lead to better, more informed decisions. These decisions affect the timeliness of care, and triage and treatment options that significantly affect patient outcomes. For example, the most disabling injury which is compatible with life, but which produces the greatest degree of long-term morbidity and cost is the posttraumatic brain injury. Recent studies have shown that there is a significant interaction between the initial severity of the brain injury and the degree and extent of duration of a period of hemorrhagic shock induced by blood loss. Even a mild to moderately brain injured patient is likely to have the severity of his or her cerebral damage accelerated by any period of uncontrolled blood loss which increases the body's degree of oxygen debt. Thus, reducing the time to (1) recognize the occurrence of a severe crash-induced multiple trauma, and (2) provide the appropriate EMS advanced life support team is likely to make the difference between a permanently disabling, or fatal brain injury, and a recoverable normal life.[32,33]

The literature of emergency medical care has long documented that for many serious injuries, time is critical. As described by R. D. Stewart:

> Trauma is a time-dependent disease. 'The Golden Hour' of trauma care is a concept that emphasizes this time dependency. That is, in polytrauma patients *(typically, serious crash victims suffer multiple injuries)*, the first hour of care is crucial, and the patient must come under restorative care during that first hour.... Pre-hospital immediate care seeks to apply supportive measures, and it must do so quickly, within what has been called the 'Golden Ten Minutes.'[34]

The remainder of the article provides data, for the most part from FARS, that illustrates the importance of reducing the postcrash timeline and providing high value crash and

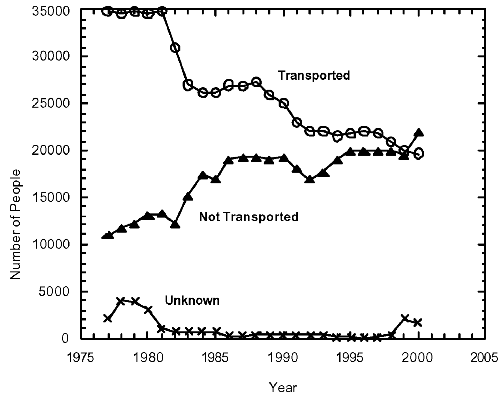

Figure 5. Deaths of people not transported, transported, and unknown transported to an injury treatment facility.

injury severity data to support postcrash triage and treatment decisions.

CRASH DEATHS AT THE SCENE

Figure 5 shows NHTSA FARS data on motor vehicle related fatalities and whether or not the crash victims were transported to a medical treatment facility for the years 1977 through 2000. About 42,000 Americans die from crash injuries each year. Nearly 20,000 people die each year before being taken to a hospital for medical care. Before reaching a hospital, about 13,500 people die from injuries in crashes along rural roadways and about 6500 in crashes along urban roadways. The remaining 22,000 people die either enroute or after reaching a hospital.

The data indicate that in the year 2000, 20,828 people died in crashes without being taken to a medical treatment facility, nearly 50% of crash deaths. The number of crash fatalities each year that are "Not Taken" to a medical treatment facility has not declined during the past 15 years. The number of crash fatalities "Taken" for medical treatment declined during the 1980s but that decline did not continue in the 1990s.

There are many individual factors contributing to the changes in "Taken" and "Not Taken" over the decade. For example, one factor concerns the changes in EMS over this period that have resulted in greater authority of EMS to declare people dead at the scene. In the past, many victims were transported to a medical facility to be declared dead, thereby increasing the number of people "Taken for Treatment."

However, the data suggest that many of the fatalities, "Taken" and "Not Taken" resulted from serious injuries that did not receive timely definitive medical care. Hopefully, in the future, improvements in triage, transport, and treatment, with ACN plus URGENCY, will reduce the number of deaths of people—both those "Taken for Treatment" and those "Not Taken for Treatment."

URBAN/RURAL FATALITY RATES

NHTSA FARS statistics on urban and rural fatalities generally are based on roadway function class. The statistics in this article are also based on roadway function class.

A word of caution: use of the "Roadway Function Class" categorization of urban and rural results in classification of "rural" fatalities as fatalities that occur on rural roads in both rural counties and urban counties. An analysis that defined rural counties as having a population of less than 50,000 found that in 1998, there were 12,215 fatalities (29%) in rural counties and 29,256 fatalities (71%) on all roads in urban counties defined as having a population greater than 50,000.

The need and the opportunities are especially important on rural roads (in both rural and urban counties) where nearly 25,000 crash fatalities occur each year. Data collected by NHTSA show that only 24% of crashes occur on rural roads, but nearly 59% of the crash deaths occur on rural roads. "Delay in delivering emergency medical services is one of the factors contributing to the disproportionately high fatality rate for rural crash victims."[35]

Currently, each year, about 20,000 people die at the crash scene. The problem is greater on rural roads than on urban roads. Although for crashes on both rural and urban roads the number of deaths of people taken to a hospital for treatment is about equal at 10,000 per year, the number not taken on rural roads (13,500) is more than twice the number on urban roads (6000).

On both urban and rural roads, about 16,000 (43%) fatal crashes occur each year between the hours of 9:00 PM and 9:00 AM, times when crash discovery, notification, and emergency response are more likely to be slower.

Reducing the time to definitive care

Table 1 lists the average time intervals experienced in fatal crashes in the U.S. in 1998.[36] Entry number 5 for the emergency department (ED) resuscitation time interval is not based on FARS data, but rather is a medically recommended value of 15 minutes assumed for the purpose of relating prehospital times to the "Golden Hour" for the delivery of definitive care to save seriously injured patients.[37]

Table 2 lists the number of crash fatalities in 1998 with reported times that meet or exceed the benchmark time intervals, as well as the number reported as Unknown times, or Questionable times. The data in Table 2 indicate the magnitude of the need for improvement in the rescue of crash victims.

ELAPSED TIME FROM CRASH TO EMS NOTIFICATION

Among crashes with reported times, nearly 4000 fatalities occurred in 1998 in which more than 10 minutes elapsed before EMS was notified, much less able to deliver prehospital emergency care within the "Golden Ten Minutes." In addition, there were 14,708 crash fatalities (35%) where both times were not reported. With many of these fatalities, this time interval also may have exceeded 10 minutes.[6]

FARS data show that since 1992, there has been a steady reduction in the national average of both rural and urban fatal crash notification times – down nearly 30% to 3.6 minutes on urban roadways and to 6.8 minutes on rural roadways in 1998.

This improvement in Crash to EMS Notification Times has been coincident with, and

Table 1. Average elapsed time in fatal crashes in 1998*

Time intervals	Urban		Rural	
	Average minutes	% unknown	Average minutes	% unknown
1. Crash to EMS notification	**3.6**	46	**6.8**	37
2. EMS notification to scene arrival†	6.3	47	**11.4**	35
3. Scene arrival to hospital arrival†	26.6	72	36.3	67
4. Crash to hospital arrival	35.5	71	51.8	68
5. Recommended time for ED resuscitation (No data in FARS)	15		15	
Average totals	51		**67**	

Times given in bold indicate average elapsed times that exceed benchmarks of 1 min for EMS Notification, 10 min for EMS scene arrival, and 45 min for hospital arrival in fatal crashes.
*These are US average elapsed times. The times associated with individual crashes are both longer and shorter and vary greatly by state.
†Time intervals 2 and 3 do not include the elapsed time from crash to EMS notification.

apparently significantly caused by, the increasing number and use of wireless telephones by crash-involved victims and "Good Samaritans." The number of wireless subscribers in the United States has grown from 5 million in 1990 to 165 million in 2004. The estimated number of wireless 9-1-1 distress calls over the same period has grown from 6 million to more than 57 million calls per year.

Note, however, that despite the increasing use of wireless phones, comparable percentage improvements have not been observed in the subsequent critical EMS time intervals discussed below.[6]

Table 2. Crash fatalities by reported EMS times for 1998

Time interval	Elapsed time (min)	Number of fatalities	% fatalities within time interval
Crash to EMS notification	< 1	9195	22
	>**1**	**15852**	38
	Unknown and questionable times	16424	40
Crash to EMS arrival at scene	<10	12161	29
	>**10**	**14362**	35
	Unknown and questionable times	14948	36
Crash to hospital arrival	<45	5211	13
	>**45**	**3166**	8
	Unknown and questionable times	33094	79

Bolded times indicate fatalities in which reported elapsed times exceeded benchmarks of 1 min for EMS Notification, 10 min for EMS scene arrival, and 45 min for hospital arrival in fatal crashes.
Fatalities in each time interval equal 41,471 (100%) and fatalities may not be summed across time intervals.

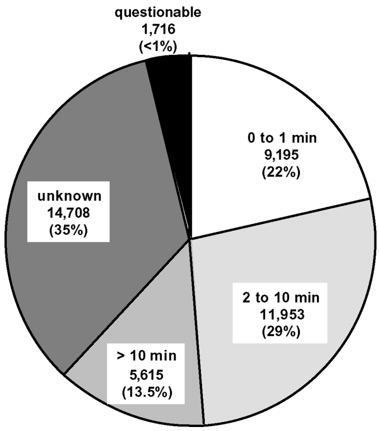

Figure 6. Fatalities in 1998 by elapsed time: crash to EMS notification (41,471 deaths).

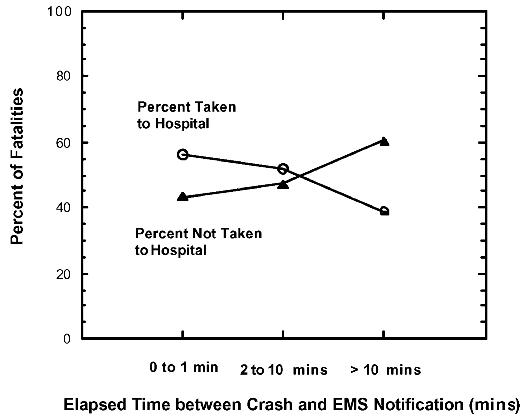

Figure 7. Percent fatalities: taken vs not taken by elapsed time between crash and EMS notification (all roads).

In the future, with ACN, one can expect reductions in many of the longer times. With fully deployed ACN, all crash notification times, not just average notification time, will be reduced to about one minute. ACN has now demonstrated the technological and economical feasibility of a national EMS crash notification benchmark of 1 minute.[15]

Reductions in average crash notification times from 9 minutes to 1 minute after the crash have been estimated to potentially save 3000 lives per year among crashes along rural roads.[27] When *all* crash notification times are reduced to 1 minute, the number of lives saved can be expected to be greater.

As shown in Figure 6, the FARS data indicate that improvement in the system is still needed to get all EMS Notification Times down to 1 minute. In 1998, only 22% of all fatalities were reported to have EMS Notification within 1 minute of the crash. (In FARS files there are some questionable times, eg, where crash time appears to be later than EMS times. Such cases have not been included in the elapsed time segments).

Figure 7 shows that increased times between crash and EMS Notification are associated with higher percentages of crash victims dying at the scene rather than being taken to a medical treatment facility. This effect of time between crash and EMS notification also is evident when multiple years of data are analyzed.

As shown in Figure 8, FARS data indicate how much further improvement in the system is still needed to get all fatal EMS scene arrival times to within 10 minutes. Among crashes with both reported times in 1998, there were 12,161 crash fatalities (29% of 41,471 deaths) in which the time from crash to EMS arrival was reported to be less than 10 minutes (14,240 unknown). There were 14,362 crash fatalities (35%), however, in which the reported time from crash to EMS arrival exceeded the "Golden 10 Minutes" (11,626 rural, 2660 urban, and 76 unknown roadway classification). The actual number is higher,

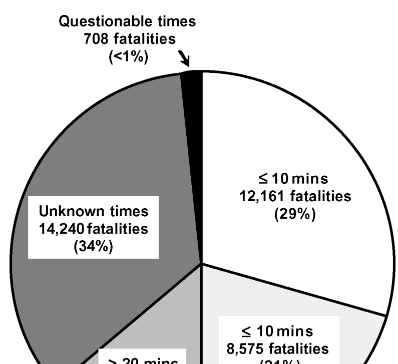

Figure 8. Fatalities by elapsed time: crash to EMS arrival at scene (41,471 deaths).

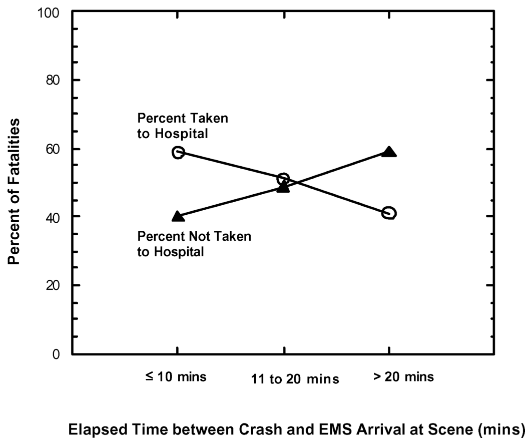

Figure 9. Percent fatalities: taken vs not taken by elapsed time between crash and EMS arrival at scene (all roads).

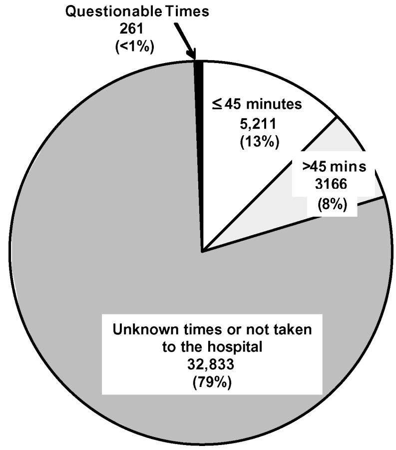

Figure 10. Fatalities in 1998 by elapsed time: crash to hospital arrival (41,471 deaths).

but unknown due to the large number of fatalities (14,240 or 34%) with unknown data on times, plus the 708 fatalities where the times were questionable.

Figure 9 shows that increased times between crash and EMS arrival at the scene also are associated with higher percentages of crash victims dying at the scene rather than being taken to a medical treatment facility.

These data support the need for EMS arrival at the scene of serious injury crashes within the "Golden 10 Minutes."

In the future, with ACN, URGENCY, crash location information, automatic vehicle location, and navigation equipment on board rescue vehicles, we can expect reductions in this time interval between crash and EMS Scene Arrival.

ELAPSED PREHOSPITAL TIMES – TIME OF CRASH TO HOSPITAL ARRIVAL

Figure 10 indicates how much improvement is needed to get crash victims to definitive care within the "Golden Hour." Nationwide, FARS data (where both times are reported) show that in 1998, there were 5211 crash fatalities (13%) that were taken to a medical treatment facility within 45 minutes. In 1998, there were 3166 fatalities (8%) in which the reported time from crash to hospital (not necessarily Trauma Center) arrival, exceeded 45 minutes. The actual number is probably much greater considering that for 33,094 crash fatalities (79% of all crash deaths), times were reported as unknown, questionable, or the victim was not taken to hospital for treatment.

SUPPORT FOR CORRECT TRIAGE DECISION MAKING

The most important decisions to be made once the notification of a crash has been received are:

1. What type of EMS unit is to be sent?
2. And once the crash has been located and the patient extricated, should the closest local hospital facility be bypassed in favor of a Level I or Level II trauma center?

National experience has demonstrated that for suspected AIS 3 or greater injuries, the patient outcome in terms of death or disability improves if the patient is taken directly to a definitive Trauma center, bypassing a closer nontrauma center hospital. Studies of trauma patients have suggested that the rapidity of definitive therapy for patients with severe brain or spinal cord injuries is critical to the reduction of mortality and severe posttrauma disability. In addition, recent analysis of data obtained from the Crash Injury Research Engineering Network (CIREN) studies have strongly suggested that patients injured in crashes where there is a deceleration velocity greater than 48 kph (30 mph) in frontal crashes, or 36 kph (23 mph) in lateral crashes, and where there is an evidence of a high impact energy marked by large crash induced intrusions who also show evidence of injuries to the upper thorax, have a higher incidence of injuries to the aorta than patients injured in other types of crashes (J.H. Siegel, J.A. Smith, S.Q. Siddiqi, et al, unpublished data, 2004). Since this type of injury, if not immediately fatal requires urgent diagnosis and definitive surgical therapy, correct triage with a high priority for BLS transport to a Level I or II Trauma center is essential. Moreover, previous studies of impact velocity and subsequent vehicle damage have shown the relationship between these factors and severe injuries.[13,14,26,33,37] The capability of ACN to report the impact deceleration velocity and the primary direction of force of the crash will provide important information to physicians and others supporting prehospital decisions.

EMS ARRIVAL AT HOSPITAL

ACN with URGENCY information will help dispatchers, instantly and automatically, decide to send appropriate resources such as extrication equipment in severe crashes, thereby, saving additional precious minutes in this time interval. In 1998, extrication was reported in crashes that resulted in 6159 fatalities. Extrication is an increasingly important factor in fatal crashes. In 1990, 4426 fatalities requiring extrication occurred (in 12% of fatal crashes). This has grown to 7051 fatalities requiring extrication (in 19% of the fatal crashes) in 2001. With ACN and the kind of data delivery system discussed elsewhere in this edition of Topics, it is now technically possible for rescue teams to have extrication information on the number of air bags, their location, and vehicle cut points specifically for the crashed vehicle—before arriving at the scene. Such information could be included in the vehicle's ACN URGENCY data transmission and would also aid in the extrication process.

EMERGENCY DEPARTMENT RESUSCITATION TIMES

Current medical references allocate 15 minutes to ED resuscitation times for tests, diagnoses, decision making on treatment strategies, and required preoperating room procedures before surgical care.[37,38] In Table 1 the needed 15 minutes for ED resuscitation are added to the average reported times. The result is that on rural roads with the 52 minutes that it currently takes to get a seriously injured patient to a hospital (often not a trauma center) in the average fatal crash, the "Golden Hour" is lost. Currently, in thousands of fatal crashes each year, victims do not obtain definitive care within the "Golden Hour."

In the future, URGENCY information on injury probabilities that are transmitted ahead to the hospital at the time of crash can provide an early alert for the need to assemble a trauma team and call for specialists that might be needed. In addition, additional data that may accompany the crash-related information may include patient specific information on preexisting medical conditions, blood types, drug reactions, and medications.

Future versions of URGENCY software will employ additional sensor data to create a more robust and sophisticated triage, transport, and treatment decision-making tool. These versions of the algorithm may calculate the probabilities of the presence of minor as well as major injuries. Information could be included such as the number, size and seating positions of occupants, seat track location (closeness to air bag), crash pulse, air bag time of deployment, level of air bag deployment, deployment of seat belt emergency tensioning retractors (provided today in Mercedes cars), seat belt forces, door openings, presence or absence of fire, precrash speed, and braking deceleration.

SUMMARY AND CONCLUSIONS

The outcome of serious crash injuries is dependent, in part, on the timeliness, appropriateness, and efficacy of the medical care received by the crash victim. In too many cases, especially in rural areas, people die without having obtained definitive care at a trauma center within the "Golden Hour." Definitive care for seriously injured crash victims includes thorough, timely, and accurate diagnoses, intensive critical care facilities and staff, and readily available trauma teams with surgeons specializing in brain and spinal cord injuries, internal organ injuries, and orthopedic injuries, as required.

The technology is now available for an integrated, intelligent public safety/transportation system that delivers help wherever and whenever Americans are in danger, whether from crashes, crime, heart attacks, or other time-critical emergencies—in time to save lives. With this technology it is possible to have EMS crash notification within 1 minute, EMS scene arrival within 10 minutes, and trauma center arrival within 45 minutes of the crash in many of the 250,000 serious injury crashes occurring each year. In particular, notification times and response times will be improved with ACN and URGENCY software. In addition, URGENCY software will enable the nation to advance beyond current rescue practices—especially regarding helicopter dispatch.[39-41] In general, under current practices, when a crash occurs—however serious it may be—someone in authority (police, fire, or EMS) must travel over land to the scene, make a determination that the seriousness requires a helicopter response, and finally, send a radio request for air medical assistance. Only then does the process of helicopter deployment begin. In the future, URGENCY, together with AACN data and newly developed tools such as the Atlas and Database of Air Medical Services[42] will enable the development of uniform computer assisted dispatch protocols that can be expected to expedite this process—with lifesaving results.

Several projections of benefits by other researchers estimate that thousands of lives could be saved each year. In an independent evaluation of the Department of Transportation (DOT) Field Operational Test of ACN equipped vehicles, published by DOT, researchers at the Johns Hopkins Applied Physics Laboratory estimated that "the ACN system could offer an approximate 20% reduction in fatalities."[16] There also is a study, cited by the US DOT, projecting that benefits of an ACN system (without URGENCY) could result in a 12% reduction in rural crash deaths and save an estimated 3000 lives each year when average rural crash notification times are reduced to 1 minute.[24] Another study estimated benefits to range between 1.5% and 6% reduction in fatalities saving as many as 1674 lives each year.[29] In addition to lives saved, it is reasonable to expect significant reductions in disabilities and human misery through the faster and more intelligent delivery of emergency medical care for nonfatal, but serious, injury crashes.[43] Researchers in Germany, which has one of the world's most advanced air medical systems, recently reported that "in at least 18% of all MAIS 3+ (serious injury) accidents, a benefit of use of the ACN could be expected and rescue time diminished. We recommend that the automobile industry, the European Community, and EMS organizations promote the use of new technologies like ACN to save lives in traffic accidents."[44]

The real-world data, collected with ACN and URGENCY, together with injury, treatment, and outcome information, will be a valuable resource. This data will form the scientific basis for continuous improvements in vehicles, roadways, driver behavior, and emergency care. Programs in crash injury prevention and treatment will have a new scientific resource for advancing safety.

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