Paramedic Response Time: Does It Affect Patient Survival?

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Abstract

Objectives: One marker of quality emergency medical services care is measured by meeting an 8-minute response time guideline. This guideline was based on results of paramedic response times for nontraumatic cardiac arrest patients and has not been studied in unselected patients. The objective of this study was to evaluate the effect of paramedic response time on survival to hospital discharge in unselected patients in a large urban setting while controlling for a number of potentially important confounders, including level of illness severity. **Methods:** This was a retrospective cohort study performed in an urban 911-based ambulance service system. Patients transported by paramedics to a single urban county teaching hospital from January 1, 1998, to December 31, 1998, were included. Data collected included patient demographics; paramedic response, scene, and transport times; the nature of the medical complaint; and whether the patient survived to hospital discharge. Multivariable logistic regression models were developed using response time as the primary independent variable and survival to hospital discharge as the dependent variable. Covariates included scene time, transport time, age, gender, and level of illness severity. **Results:** Of 34,111 calls involving emergency response, 11,078 patients (32%) were transported to the study institution and 10,382 (94%) had response time data available. Of these, 9,559 patients (92%) had data available to categorize them into groups based on their level of illness severity and were thus included in the study. A survival benefit was identified for response times ≤4 minutes (odds ratio [OR], 0.70; 95% confidence interval [CI] = 0.52 to 0.95). No survival benefit was identified when response time was modeled as a continuous variable (OR, 1.01; 95% CI = 0.98 to 1.04) or when dichotomized at 8 minutes (OR, 1.06; 95% CI = 0.80 to 1.42). **Conclusions:** A paramedic response time within 8 minutes was not associated with improved survival to hospital discharge after controlling for several important confounders, including level of illness severity. However, a survival benefit was identified when the response time was within 4 minutes for patients with intermediate or high risk of mortality. Adherence to the 8-minute response time guideline in most patients who access out-of-hospital emergency services is not supported by these results.
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Paramedic response time to the scene of a call for emergency medical assistance has become a benchmark measure of the quality of the service provided by emergency medical services (EMS) agencies.[1,2] A suggested target response time of ≤8 minutes for at least 90% of emergent responses has evolved into a guideline that has been incorporated into operating agreements for many EMS providers.[3]

This response time guideline has its origin in an article published in 1979 that evaluated patient outcomes after out-of-hospital nontraumatic cardiac arrest.[4] The investigators reported that survival decreased significantly if basic life support and advanced life support were initiated in >4 minutes and >8 minutes, respectively. They therefore suggested these times as recommended guidelines for the emergency response of basic and advanced life support providers. Although that study reported exclusively on outcomes from cardiac arrest, the response time guidelines were subsequently generalized to all emergent responses and to any type of illness or injury.

Since the publication of that initial report, much work has been done to evaluate which interventions provided by basic or advanced life support providers positively affect patient outcomes after nontraumatic cardiac arrest. This resulted in the recognition that an important determinant of survival is the time

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elapsed from onset of cardiac arrest to electrical defibrillation[5–8] and has led to the development and implementation of a variety of programs designed to provide rapid defibrillation.[9–17] As a result, the single most important intervention in the management of the cardiac arrest victim may no longer be dependent on the response time of an ambulance with advanced life support providers. In fact, a recent study reported that the addition of advanced life support procedures did not improve patient survival from cardiac arrest beyond that achieved with rapid defibrillation.[18]

Although the response system to cardiac arrest has evolved over the past two decades, little work has been done to evaluate the continued need for a rigid ambulance response time guideline for patients experiencing other types of medical emergencies. In most EMS systems, cardiac arrest accounts for <1% of calls. Only two studies have been published that have evaluated the effect of the 8-minute response time guideline on something other than cardiac arrest.[19,20] Although both studies identified no outcome difference in patients based on the paramedic response time, the first did not control for illness severity and the second only evaluated outcomes in trauma patients.

The objective of this study was to evaluate the effect of paramedic response time on survival to hospital discharge in unselected patients in a large urban setting while controlling for a number of potentially important confounders, including level of illness severity.

METHODS

Study Design. This was a retrospective cohort study performed in an urban 911-based ambulance service system. The study was reviewed by our institutional review board and met criteria for exemption from informed consent requirements.

Study Setting and Population. The Paramedic Division of the Denver Health and Hospital Authority is responsible for all 911 emergency ambulance responses for the city and county of Denver, which has a geographic area of approximately 150 square miles and an approximate census of 550,000 based on year 2000 census data. The Paramedic Division responds to approximately 55,000 calls for emergency medical assistance annually using a maximum of 15 paramedic-staffed ambulances at peak staffing and six during lower-demand hours. The division employs approximately 130 paramedics.

We included consecutive patients who required emergent ambulance response to the scene and who were subsequently transported to the emergency department (ED) at Denver Health Medical Center in Denver, CO. Patients were excluded if they were transported to another receiving hospital or refused transport.

Study Protocol. Calls for emergency medical assistance are received via 911 at a centralized communications center. All medical calls are referred to Paramedic Division dispatchers, and the dispatchers assign response priorities (emergent vs. nonemergent) based on information obtained from the caller. A paramedic-staffed ambulance is sent to all calls for medical assistance. In addition to advanced life support ambulances, dispatchers also initiate responses by police and fire department first responders as needed based on preexisting protocols.

Denver paramedics initiate care using standardized protocols and standing orders after initial assessment of the patient. Interventions such as intravenous line placement, fluid administration, endotracheal intubation, defibrillation, and pharmacologic interventions can be performed by paramedics before base-station physician contact. Medical oversight is provided by a full-time EMS medical director who is a member of the physician staff of the Department of Emergency Medicine at Denver Health Medical Center. Base-station physician direction is performed by either full-time emergency physician staff or by senior emergency medicine residents.

Using the computerized dispatch log maintained by the Denver Paramedic Division Dispatch Center, all 911 calls to which an ambulance was sent emergently to the scene were identified from January 1, 1998, to December 31, 1998. Data obtained from the dispatch log included the date and time of the 911 call, the EMS call (run) number, the time of arrival to the scene, the time of departure from the scene, the time of arrival to the hospital, the nature of the call as determined by the dispatcher, and whether returning to the hospital was emergent (defined as returning with red lights and sirens) or nonemergent. Response time was defined as the interval (in minutes) from the initiation of the 911 call to the arrival of the ambulance at the scene. Scene time was defined as the interval (in minutes) from arrival of the ambulance at the scene to departure from the scene. Transport time was defined as the interval (in minutes) from departure from the scene to arrival at the hospital.

Data were collected from the paramedic trip report and included patient age, gender, interventions performed in the out-of-hospital setting, and disposition, including transportation to the hospital or pronouncement of death. The paramedic report was then matched with the ED patient log, and each patient's medical record was reviewed to determine disposition from the ED (discharged, admitted to the ward, admitted to the intensive care unit, or died in the ED) as well as survival at the time of discharge from the hospital. All data were obtained by two abstractors using a closed-response data collection instrument.

Each abstractor was trained by the principal investigator and met with him bimonthly to maintain quality abstraction and to answer questions. Each abstractor was blinded to the purpose of the study.

Data Analysis. All data were entered into an electronic database (SPSS release 11.0; SPSS Inc., Chicago, IL) and converted into native SAS format using translational software (dfPower DBMS/Copy; DataFlux Corp., Cary, NC). All statistical analyses were performed using SAS (version 8.2; SAS Institute Inc., Cary, NC).

Descriptive statistics were performed for all variables. Continuous data are reported as medians with interquartile ranges (IQRs), and categorical data are reported as percentages with 95% confidence intervals (CIs). Bivariate statistical testing was performed using the Wilcoxon rank sum test or Fisher's exact test, where appropriate. Missing values were imputed using multiple imputation procedures in SAS (PROC MI and PROC MIANALYZE). Imputation is a statistical technique that replaces each missing value in a data set with a plausible value based on known characteristics of the data set. This allows all observations, including those that would have been excluded due to missing values, to be included in the analysis and to make an unbiased estimate of the effect measures.[21] Multivariable logistic regression analysis was performed to assess the effect of paramedic response time on survival to hospital discharge, while controlling for age, gender, scene time, transport time, and three levels of medical acuity (categorized as low risk for mortality, intermediate risk for mortality, or high risk for mortality based on the dispatch nature code and the ED diagnosis) as potential confounders. The high-risk group included all traumatic and nontraumatic cardiac arrest patients. The intermediate-risk group included all suicide attempts, accidental exposures (defined by exposure to toxins or environmental exposures), unconscious patients, those with penetrating trauma, those with any respiratory complaints, or those who were hypotensive (defined by a systolic blood pressure ≤90 mm Hg) in the out-of-hospital setting.[22] All other patients were grouped into the low-risk category. Categories were defined by two investigators (PTP and JSH) using a consensus process before performing the analysis. Three separate multivariable logistic regression analyses were performed. The primary independent variable, response time, was modeled as a continuous variable and then as two categorical variables (one model with a 4-minute cutoff point and another model with an 8-minute cutoff point). To assess the effect of response time on survival in patients not experiencing trauma or cardiac arrest, subgroup analyses of medical noncardiac arrest patients were performed while controlling for the same confounders. Logistic regression model diagnostics were performed, the need for variable transformation was assessed, and all possible interaction terms were evaluated for inclusion into each model. Odds ratios (ORs) and 95% CIs are reported where appropriate. No adjustments were made for multiple comparisons.

RESULTS

During the study period, Denver paramedics responded to 49,851 calls for medical assistance. Of these, 34,111 (68%) involved emergent response to the scene. Of the 34,111 calls involving emergency response, 11,078 (32%) were transported to Denver Health Medical Center and 10,382 (94%) had response time data available. Of these, 9,559 patients (92%) had data available to categorize them as low risk ($n = 6{,}696$), intermediate risk ($n = 2{,}619$), or high risk ($n = 244$) for mortality and were thus included in the study. Of the 9,559 patients, transport time was missing in 561 cases (6%), age was missing in 83 cases (0.9%), and gender was missing in 12 cases (0.1%). All other variables had complete data.

The median age for the entire cohort was 38 years (IQR, 26–50 years; range, 1–99 years); of 9,547 patients for whom data were available, 5,936 (62%) were male. The median response time was 5.8 minutes (IQR, 4.3–7.7 minutes), the median scene time was 10.8 minutes (IQR, 7.5–14.8 minutes), and the median transport time was 7.7 minutes (IQR, 4.8–11.4 minutes). Of the 9,559 patients, 8,827 (92%) survived to hospital discharge. Of the 6,696 patients categorized into the low-risk group, 6,650 (99%) survived to hospital discharge; of the 2,619 patients categorized into the intermediate-risk group, 2,169 (83%) survived to hospital discharge; and of the 244 patients categorized into the high-risk group, eight (3%) survived to hospital discharge ($p = 0.0001$). Figure 1 shows patient survival percentages by response time when stratified by the three risk groups.

All emergent responses to the scene were evaluated to determine if a response time >8 minutes resulted in more patients being pronounced dead at the scene and therefore not transported to the hospital. Of the 24,932 patients in which the response time was ≤8 minutes, 421 (1.7%; 95% CI = 1.5% to 2.0%) were pronounced dead and not transported to the hospital. Of the 9,179 patients in which the response time was >8 minutes, 159 (1.7%; 95% CI = 1.5% to 1.9%) were pronounced dead and not transported to the hospital.

When response time was modeled as a continuous variable while controlling for scene time, transport time, patient age and gender, and level of illness severity, there was no effect on patient survival to hospital discharge (OR, 1.01; 95% CI = 0.98 to 1.04) (Table 1). Descriptive statistics for variables included in the model in which response time was categorized as ≤4 minutes or >4 minutes are shown in Table 2. In this case, a survival benefit was identified when response time was ≤4 minutes (OR, 0.70; 95%

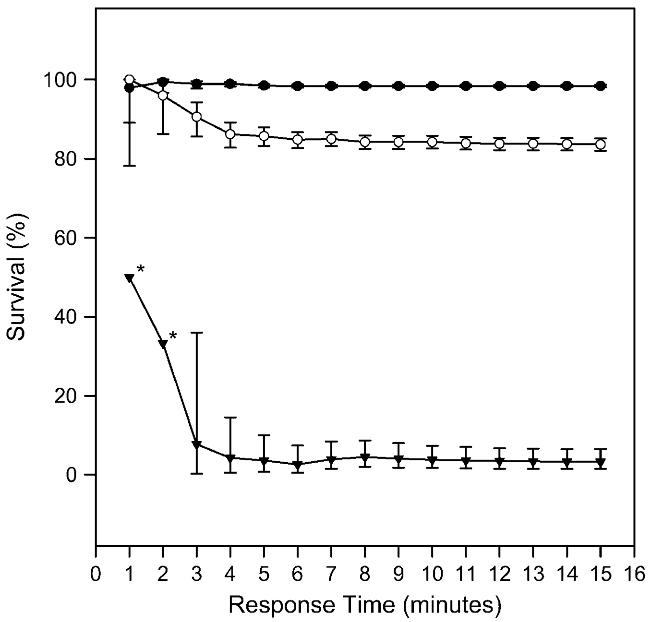

Figure 1. Percentages of survival to hospital discharge by paramedic response time and stratified by risk groups (bars represent 95% CIs). All patients were categorized into low-risk (●), intermediate-risk (○), or high-risk (▼) groups. The high-risk group included all traumatic and nontraumatic cardiac arrest patients. The intermediate-risk group included all suicide attempts, accidental exposures, unconscious patients, those with penetrating trauma, those with respiratory complaints, and those who were hypotensive in the out-of-hospital setting. All other patients were grouped into the low-risk category. *CIs were not calculated for these response times due to sparse data.

CI = 0.52 to 0.95) (Table 1). This effect is seen graphically in Figure 1. Descriptive statistics for variables included in the model in which response time was categorized as ≤8 minutes or >8 minutes are shown in Table 3. There was no effect on patient survival to hospital discharge based on the 8-minute cutoff point (OR, 1.06; 95% CI = 0.80 to 1.42) (Table 1).

After including only medical noncardiac arrest patients ($n = 5{,}062$) in separate subgroup analyses, the effect of response time did not significantly change when modeled as a continuous variable (OR, 1.01; 95% CI = 0.98 to 1.05), categorized by the 4-minute cutoff point (OR, 0.56; 95% CI = 0.38 to 0.83), or categorized by the 8-minute cutoff point (OR, 1.08; 95% CI = 0.77 to 1.52).

DISCUSSION

The 8-minute response time recommendation was developed with the goal of optimizing survival from nontraumatic cardiac arrest. Little work has been done to determine if this response time goal is appropriate for the other 99% of emergencies for which EMS providers respond. The results of this study suggest that response times >4 minutes do not influence mortality in unselected patients while controlling for scene time, transport time, patient age and gender, and varying levels of illness severity, including cardiac arrest. There does appear to be a survival advantage for patients in instances where paramedics respond within 4 minutes. It is unclear, however, which patients besides those experiencing cardiac arrest benefit from such a brief response time, and this was not specifically evaluated in this study.

The results of this study indirectly support those studies that have evaluated the time difference between emergent and nonemergent ambulance response or transport times.[23–28] These studies have demonstrated a relatively modest time savings of 1–4 minutes when comparing emergent responses with nonemergent responses. If, as the results of this study suggest, there is no effect of paramedic response time on patient outcomes, then more ambulances may be sent to calls for medical assistance nonemergently, thus minimizing the intrinsic risk of emergent response without increasing risk for morbidity or mortality for the patient.

The majority of research evaluating paramedic response times has been conducted in two general groups of patients, namely those experiencing cardiac arrest or those with traumatic injuries. Although field times are commonly reported in articles describing studies involving victims of traumatic injury, few studies have attempted to analyze the effect of response time on patient outcomes. Several studies, however, have evaluated the effect of total out-of-hospital time on survival following blunt or penetrating trauma. In each case, no survival advantage was identified for those patients who had shorter out-of-hospital times.[29–31] We previously evaluated a heterogeneous group of consecutive trauma patients for whom an ambulance responded emergently and found no difference in patient outcome based on the ambulance response time.[20]

To our knowledge, only one published study has previously evaluated paramedic response time on survival in a group of patients with unselected medical problems. Blackwell and Kaufman evaluated more than 5,000 patients using the response time criterion in place for their EMS system and found the mortality curve flattened for response times >5 minutes.[19] This study did not, however, account for potential confounders, including illness severity.

A reevaluation of the current 8-minute ambulance response time guideline is particularly important, because today's EMS systems are significantly different when compared with EMS systems from 10 or 20 years ago. This guideline resulted directly from the desire to improve outcomes from nontraumatic cardiac arrest by decreasing times to defibrillation. In the past, first responders provided basic life support, which consisted of performing closed chest cardiac massage and bag-valve-mask ventilation but involved few, if any, advanced interventions such as cardiac rhythm

TABLE 1. Logistic Regression Analyses to Model Paramedic Response Time as a Predictor for Survival to Hospital Discharge

Variables	Response Time as a Continuous Variable*		4-Minute Cut Point†		8-Minute Cut Point‡	
	OR	95% CI	OR	95% CI	OR	95% CI
Response time	1.01	0.98, 1.04	0.70	0.52, 0.95	1.06	0.80, 1.42
Scene time	1.22	1.20, 1.25	1.22	1.20, 1.24	1.22	1.20, 1.24
Transport time	1.06	1.03, 1.10	1.07	1.04, 1.10	1.05	1.02, 1.09
Age	0.95	0.94, 0.96	0.95	0.94, 0.96	0.95	0.94, 0.96
Gender	0.65	0.51, 0.84	0.64	0.50, 0.83	0.65	0.50, 0.83
Intermediate risk§	0.05	0.04, 0.06	0.05	0.03, 0.06	0.05	0.03, 0.06
High risk§	0.001	0.0004, 0.003	0.001	0.0004, 0.003	0.001	0.0004, 0.003

*Response time as a continuous variable. The Hosmer–Lemeshow goodness-of-fit statistic was 0.97, which indicates an adequate fit.
†Response time categorized as ≤4 (referent) or >4 minutes. The Hosmer–Lemeshow goodness-of-fit statistic was 0.97, which indicates an adequate fit.
‡Response time categorized as ≤8 (referent) or >8 minutes. The Hosmer–Lemeshow goodness-of-fit statistic was 0.89, which indicates an adequate fit.
§All patients were categorized into low-, intermediate-, or high-risk groups. The high-risk group included all traumatic and nontraumatic cardiac arrest patients. The intermediate-risk group included all suicide attempts, accidental exposures, unconscious patients, those with penetrating trauma, those with respiratory complaints, and those who were hypotensive in the out-of-hospital setting. All other patients were grouped into the low-risk (referent) category.

determination, manual defibrillation, endotracheal intubation, or pharmacologic therapy. These procedures were generally reserved for and provided by paramedics responding on advanced life support ambulances.

Technological advances have changed the paradigm for emergency response to victims of cardiac arrest. The development of automated external defibrillators has permitted the development and implementation of programs that allow first responders and laypersons with minimal or no training to defibrillate cardiac arrest victims.[5,9,10,12–14] This has allowed the procedure of defibrillation to be moved to a health care delivery point that precedes the direct involvement of the EMS system.[16] This profound change in some ways diminishes the importance of rapid response by advanced life support ambulances. Despite this change, no work has been done to reevaluate the need for the response time guideline currently in use.

TABLE 2. Characteristics for Paramedic Response Time Groups Based on the 4-Minute Response Time Criterion

Variables	Response Time (min) ≤4 (*n* = 2,036)	>4 (*n* = 7,523)	p-value
Age (yr)	38 (26–49)	37 (25–50)	0.32
Response time (min)	3.2 (2.6–3.6)	6.5 (5.3–8.3)	<0.0001
Scene time (min)	11.0 (7.8–14.9)	10.6 (7.3–14.6)	0.003
Transport time (min)	6.0 (3.8–8.6)	8.3 (5.3–12.1)	<0.0001
Gender (male)	65% (1,327/2,033)	61% (4,609/7,514)	0.001
Survival to hospital discharge	94% (1,909)	92% (6,918)	0.006
Risk group*			
Low	72% (1,465)	70% (5,231)	0.1
Intermediate	26% (524)	28% (2,095)	
High	2% (47)	3% (197)	

All continuous data are reported as medians with interquartile ranges.
*All patients were categorized into low-, intermediate-, or high-risk groups. The high-risk group included all traumatic and nontraumatic cardiac arrest patients. The intermediate-risk group included all suicide attempts, accidental exposures, unconscious patients, those with penetrating trauma, those with respiratory complaints, and those who were hypotensive in the out-of-hospital setting. All other patients were grouped into the low-risk category.

TABLE 3. Characteristics for Paramedic Response Time Groups Based on the 8-Minute Response Time Criterion

Variables	Response Time (min) ≤8 (*n* = 7,475)	>8 (*n* = 2,084)	p-value
Age (yr)	38 (26–49)	37 (25–50)	0.23
Response time (min)	5.1 (3.9–6.4)	9.8 (8.8–11.7)	<0.0001
Scene time (min)	10.9 (7.7–14.9)	9.8 (6.2–13.9)	<0.0001
Transport time (min)	7.1 (4.5–10.4)	10.5 (7–14.9)	<0.0001
Gender (male)	63% (4,696/7,467)	60% (1,240/2,080)	0.007
Survival to hospital discharge	93% (6,928)	91% (1,899)	0.02
Risk groups*			
Low	70% (5,241)	70% (1,455)	0.09
Intermediate	28% (2,057)	27% (562)	
High	2% (177)	3% (67)	

All continuous data are reported as medians with interquartile ranges.
*All patients were categorized into low-, intermediate-, or high-risk groups. The high-risk group included all traumatic and nontraumatic cardiac arrest patients. The intermediate-risk group included all suicide attempts, accidental exposures, unconscious patients, those with penetrating trauma, those with respiratory complaints, and those who were hypotensive in the out-of-hospital setting. All other patients were grouped into the low-risk category.

The survival curve presented in this study raises the question of what should be recommended as the paramedic response time guideline. A number of factors must be assessed and known before this question can be answered. First, we need to know what, if anything, besides defibrillation contributes to patient survival in the out-of-hospital setting. Currently, no evidence exists that documents the benefit of any other out-of-hospital intervention currently provided by emergency medical technicians of all levels. Second, it is necessary to determine where in the sequence of response and care the intervention is best provided. Is it best performed by the first responder, the providers on the transporting ambulance, or, as has become the case with defibrillation, the layperson rescuer? Finally, difficult as it may be, a complete cost–benefit analysis must be accomplished to fully analyze the financial impact of further decreasing the response time interval. Although ambulance response times may be optimized through critical analyses of demand, time of day, traffic flow patterns, and ambulance posting locations,[23,32–36] significant changes usually require additional ambulances and often in significant numbers. At an approximate cost per staffed ambulance of $500,000 annually, the financial impact may be enormous.

It has been suggested that a better measure of EMS system performance is measurement from onset of the medical incident to the intervention.[37] Unfortunately, this concept has not gained widespread acceptance. Paramedic response time is one component of this longer time interval, which generally begins when the ambulance unit has been assigned and dispatched and ends when paramedics arrive at the patient's side. In reality, the interval for medical response includes the time to discovery of the patient after the onset of the medical incident, the time to recognition that emergency medical assistance is needed, the time to access and communicate with the emergency response system, the ambulance response time itself, and the time from arrival of the ambulance at the scene to direct patient contact.[38–41] Clearly, minimizing the delay involved with each of these steps is essential to maximizing survival from out-of-hospital cardiac arrest; however, the only step measured and commonly reported is ambulance response time.

LIMITATIONS

This study has a number of limitations. Data collection was performed retrospectively and was dependent on the computerized dispatch program to identify those cases for which an ambulance responded emergently. The accuracy of dispatch coding was not evaluated, and it is possible that cases in which the response mode was changed en route were not identified. In addition, our cohort was composed of patients transported to a single Level 1 trauma center. The overall study population, therefore, most likely represented a larger proportion of trauma patients. In addition, the cases were stratified into risk categories based on the nature of the emergency as determined by the dispatch call taker and the ED diagnosis. It is possible that the actual nature of the medical emergency was different from that assigned by the call taker or the ED diagnosis. Linkage of the ambulance trip report with patient medical records was dependent on a manual search and matching of demographic information. This resulted in incomplete or missing data in some cases. This study included patients for whom the EMS system responded emergently and who were transported to our hospital. As a result, patients who refused transport were excluded from this study. This exclusion most likely resulted in an overall higher acuity for the patients included in our study, thus potentially biasing our results toward identifying a significant effect on patient survival.

Finally, we used survival to hospital discharge as the primary outcome measure for this study because it is a commonly used outcome measure that allows relatively easy comparisons to be made between studies. Other measures such as functional status, costs of medical care, and intensive care unit or hospital length of stay are also appropriate measures of the benefit of EMS response. These, however, were not evaluated in this study.

CONCLUSIONS

A paramedic response time ≤8 minutes was not associated with survival to hospital discharge after controlling for several important confounders, including level of illness severity. However, a survival benefit was identified when the response time was ≤4 minutes. Adherence to the 8-minute response time guideline in most patients who access out-of-hospital emergency services is not supported by these results. Identification of patients, besides those who experience cardiac arrest, who may benefit from a short response time is required to provide effective and safe out-of-hospital care.

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