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Evaluating Laguna Beach Fire Department's Association Between Cardiopulmonary Arrest Outcomes and Advanced Life Support (ALS) Time Standards

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Abstract

The problem was that the Laguna Beach Fire Department did not know what, if any, impact the adherence to the Advanced Life Support (ALS) time standard as defined in the *2004 National Fire Protection Association (NFPA) 1710 Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* had on patient outcomes for those patients who were determined to be in cardiopulmonary arrest at the time of first ALS contact when examined by (a) the return of spontaneous circulation (ROSC) prior to the patient being transferred to the care of the emergency department staff and (b) survivability to hospital admission. The purpose of this research was to determine Laguna Beach Fire Department's level of adherence to the ALS time standard as identified in the 2004 edition of the National Fire Protection Association (NFPA) 1710, and examine those findings for an association to patient outcomes for those patients who experienced a cardiopulmonary arrest. Evaluative research methodology was used in formulating this project. Three research questions focused on capturing Laguna Beach Fire Department's experience with cardiopulmonary arrest outcomes (a) What was the percentage of incidents where an ALS company arrived within an 8-minute response time? (b) What was the percentage of incidents where there was a return of spontaneous circulation (ROSC)? and (c) What was the percentage of incidents where the patient survived to hospital admission? Cardiopulmonary arrest data was obtained from prehospital care reports (PCR). The results of logit regression models and chi-square testing, demonstrated no statistically significant correlation existed when the ALS 8-minute response time standard was juxtaposed to patient outcomes. It was recommended that the study be duplicated with a larger sample size, and that the analysis should be expanded to events other than cardiopulmonary arrest.

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Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and the appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: _____

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INTRODUCTION

The City of Laguna Beach, California, was incorporated on June 29, 1927 (City of Laguna Beach, 2006, p. 12). Census data indicates that in the year 2000 the City of Laguna Beach had a population of 23,727 (U.S. Census Bureau, 2000, p. 1). Laguna Beach is a seaside residential community that formally acknowledges its commitment to the arts and tourism. As a tourist destination it draws an estimated "three million visitors each year" (City of Laguna Beach, 2009, p. 1). The primary out-of hospital emergency medical service needs of the visitors and residents of Laguna Beach are provided by personnel employed by the City of Laguna Beach and assigned to the Laguna Beach Fire Department.

The Laguna Beach Fire Department provides fire protection and emergency medical services to the community. This service is provided by the daily staffing of 12 firefighters operating from four strategically-located fire stations. The City operates two advanced life support (ALS) units and two basic life support (BLS) units. In 2008, the data recorded in the National Fire Incident Reporting System (NFIRS) indicated the members of the Laguna Beach Fire Department responded to 2,613 incidents. Sixty-two percent or 1,622 calls for service were coded as emergency medical services related.

Laguna Beach Fire Department Policy 1-III-4 *Departmental Goals and Objectives* indicates that a goal of the Department is: "To locate, construct and maintain an appropriate number of fire stations that would ensure a five minute response from the time the alarm is received to 90 percent of the population" (Laguna Beach Fire Department, 2009, p. 2). However, there is no policy to distinguish goals based on the type of service requested. Thus the Laguna Beach Fire Department does not differentiate or identify in a policy statement the specific response criteria for BLS or ALS level of service.

Arguably the most referenced fire service response time standards are identified in a National Fire Protection Association (NFPA) document commonly known as NFPA 1710. Section 5.3.3.4.3 of the *2004 National Fire Protection Association 1710 Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* states: "…ALS shall be deployed to provide for the arrival of an ALS company within an 8-minute response time to 90 percent of the incidents…" (National Fire Protection Association, 2004, p. 1710-18).

No data has been collected to identify the effectiveness and efficiency of the Laguna Beach Fire Department's ALS system when examined through the time standards as outlined in NFPA 1710. Specifically, it was not known if the Laguna Beach Fire Department had met the 8-minute response time standard to 90 percent of the incidents. This research was guided toward examining potential correlations that demonstrated a nexus to the NFPA 1710 ALS response time standard and patient outcomes. With the myriad of variables and interwoven dynamics that are associated with any out-of hospital cardiopulmonary arrest, it is statistically difficult to establish the scientific rigor required to establish an irrefutable cause and effect relationship to response times and patient outcomes. Yet, the time standard remains a benchmark for the fire service. The brand recognition of the time standards in NFPA 1710 are stamped firmly in the minds of both fire service labor and fire service management. Thus it is imperative to explore opportunities to provide some scientific anchor from which to examine only the time standard when there are competing factors synergistically influencing the final outcome of patient survivability.

The problem is that the Laguna Beach Fire Department does not know what, if any, impact the adherence to the Advanced Life Support (ALS) time standard as defined in the *2004*

National Fire Protection Association 1710 Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments has had on patient outcomes for those patients who were determined to be in cardiopulmonary arrest at the time of first ALS contact when examined by (a) the return of spontaneous circulation (ROSC) prior to the patient being transferred to the care of the emergency department staff and (b) survivability to hospital admission.

The purpose of this research is to determine Laguna Beach Fire Department's level of adherence to the ALS time standard as identified in the 2004 *NFPA 1710 Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Department*, and examine those findings for an association to patient outcomes for those patients who experienced a cardiopulmonary arrest.

Evaluative research will be the methodology used in formulating this Applied Research Project (ARP). Evaluative research is defined as "the systematic process of collecting and analyzing data in order to facilitate decision making" (National Fire Academy, 2003, p. II-26). The intent of this project was to explore two paths (a) the collection and analysis of cardiopulmonary arrest data and (b) based on the outcome of the data analysis, determine criterion that have the greatest probability to affect patient outcomes. Of significant interest to the Laguna Beach Fire Department was the examination of the association of patient outcomes with an ALS 8-minute response time standard. The process of overtly focusing only on the time standard has limitations as the time standard is only one ingredient in a cauldron of criteria that contributes to the predictability of patient outcomes. However, the process provides for evaluating potential associations between criterias and outcomes for the grimmest of pre-hospital care presentations, clinical death. Ultimately, the process has the potential to direct future

policies and standards. Thus the evaluative format provided the framework to use time series data analysis to identify outcomes over time, project future outcomes, and serve as fodder to identify opportunities for improving ALS delivery and ultimately enhance patient outcomes. Using data collected from the Laguna Beach Fire Department's records management system, FIREHOUSE Software®, for incidents where the patient was initially determined to be in cardiopulmonary arrest, it is possible to examine correlations between a number of criteria and intermediate survival outcomes (a) return of spontaneous circulation (ROSC) and (b) survivability to hospital admission.

In an attempt to remain focused on the problem, four questions have been identified to narrow the scope while simultaneously providing an opportunity to quantify outcomes. The questions are: (a) Using Laguna Beach Fire Department's cardiopulmonary arrest data, what was the percentage of incidents where an ALS company arrived within an 8-minute response time? (b) Using Laguna Beach Fire Department's cardiopulmonary arrest data, what was the percentage of incidents where there was a return of spontaneous circulation (ROSC) prior to the patient being transferred to the care of the emergency department staff? and (c) Using Laguna Beach Fire Department's cardiopulmonary arrest data, what was the percentage of incidents where the patient survived to hospital admission?

BACKGROUND AND SIGNIFICANCE

In the *Campaign Guide* published by the International Association of Firefighters the author states: "The medical response times established by 1710 are based on well-established, empirically-based measurements of the maximum amount of time that a patient in cardiac arrest can survive without intervention" (International Association of Firefighters, n.d., p. 17). The Executive Leadership course in part focused on developing decision making skills, and Henri-

Frédéric Amiel was cited and credited with the following: "The man who insists upon seeing with perfect clearness before he decides, never decides" (National Fire Academy, 2005, p. 4-1). Although perfect clearness may not be required, the research, hypothesis, and conclusion regarding ALS response time in NFPA 1710 appear murky when examined against other credible and scientific based findings. *The New England Journal of Medicine* reports: "There is no improvement in the rate of survival with the use of advanced life support….The incremental benefit of advanced life support has not been established for out-of-hospital cardiac arrest" (Stiell, Wells, Field, Spaite, Nesbitt, and Maio, 2004, p. 647). In pursuit of the logical soundness of the research, Ameil evokes another axiom: "Truth is not only violated by falsehood; it may be equally outraged by silence" (Amiel, 2009, p. 1). The Laguna Beach Fire Department has not examined its own findings in outcomes for those patients who suffer a cardiopulmonary arrest and are treated in a pre-hospital setting by ALS personnel.

The soundness of the arguments expressed by the International Association of Fire Firefighters (IAFF) et al., appear to provide diametrically opposed conclusions when compared with the arguments put forth by the American Heart Association (AHA) et al., particularly when one only focuses on the ALS time standard as defined in NFPA 1710. The findings and presentation of this research have the ability to provide the decision makers of the Laguna Beach Fire Department with knowledge that can serve as the foundation of Socratic debate to independently and collectively analyze the issues presented with the ultimate goal: to make ALS service decisions that are intellectually sound and result in maximizing the efficacy for emergency medical care to those patients served by the members of the Laguna Beach Fire Department.

The City of Laguna Beach, California, began ALS service in June 1988 when it initiated its paramedic program (City of Laguna Beach, 1988, p. 1). Firefighters were cross-trained as paramedics and have served that dual function role as firefighter and paramedic since the inception of the program. Although there have been changes in staffing and mode of apparatus delivery, the basic tenant of providing ALS level of service to the community has not changed since the genesis of the program. This researcher was not able to identify documents or data related to the effectiveness or efficacy of ALS service provided by Laguna Beach Fire Department paramedics for those patients who experienced a cardiopulmonary arrest. Thus the seriousness of the problem, in part, rests with what is not known. Arguably, clinical death is one of the most time sensitive and life-threatening emergency medical events, and if one can understand the role ALS played in patient outcomes, then perhaps more quantitative exploration of the value ALS plays in the community can be examined.

The significance of this research to the Laguna Beach Fire Department can be viewed from a number of related global and local events. They include, (a) potential closing of the local emergency room, (b) privatization of ALS care, (c) specialty centers (d) enhanced field treatment, (e) change in response patterns, and (f) ambulance contract.

South Coast Medical Center

South Coast Medical Center (SCMC) is the only hospital located in the City of Laguna Beach, California, and SCMC has served the community since 1959. In April 2009, during the writing of this Applied Research Project (ARP), South Coast Medical Center is for sell and its future is unknown (California Attorney General, 2009). Although there is interest in purchasing the hospital there is no assurance of the new owner's interest in maintaining an emergency room. As of April 2009, SCMC has not been updated to meet federal structural seismic requirements,

and if the Federal Emergency Management Association (FEMA) refuses a time extension through the Hazardous United States Multi-Hazard (HAZUS-MH) program, then the emergency department could be closed as early as 2013. The Laguna Beach Fire Department must explore contingency planning in preparation of the potential closing of the emergency department at SCMC. A closure of the emergency department would significantly impact Laguna Beach Fire Department's emergency medical services (EMS) delivery model and result in a need to change response patterns and policies.

Privatization of ALS Service

On March 11, 2009, the Orange County Health Care Agency (OCHCA) posted a draft policy on their website titled "Interfacility Advanced Life Support (ALS) Transport Units" (Orange County Health Care Agency, 2009). The scope of the policy provides for private ALS transport units to facilitate interfacility patient transports. The Orange County Fire Chief's Association President (OCFCA), Steve Lewis, filed a letter on behalf of the Association opposing the draft policy. A sampling of the opposition can be surmised from the following excerpt:

> We, the members of the Orange County Fire Chief's Association, are ardently opposed to the proposal being made by Lynch Ambulance Company. Emergency care in our streets has always been and should remain the business of City and County government, not a private enterprise whose primary motivation is revenue generation for its investors. (personal communication, April 16, 2009)

If approved, the draft OCHCA policy could represent a change in past practice for the fire service in Orange County, California, as historically those transports are provided by hospital staff accessing 911 and requesting a fire service based ALS unit. Additionally, a number of

entertainment-oriented businesses in Orange County, California, want the ability to hire private ALS service for special events. Local ambulance companies are also actively pursuing opportunities to provide ALS service at major sporting and entertainment events where historically those services have been provided by local fire departments that in turn invoice the event sponsor for their public safety services. From the perspective of the OCFCA's, the debate before OCHCA is analogous to the maxim--a foot in the door. If private ALS is used for inter-facility transports and major spectator events, then what precludes contracting for service calls that enter the local 911 public safety answering point (PSAP)?

Specialty Centers

The Orange County Emergency Medical Service Agency (OCEMSA) has continually expanded the use of specialty care centers. In 2009, OCEMS Policy 240.30 *Orange County Specialty Services*, outlines when to use (a) burn receiving centers, (b) trauma receiving centers, (c) cardiac receiving centers, (d) stroke-neurology receiving centers, (e) reimplantation receiving centers, and (f) labor and delivery receiving centers (Orange County Health Care Agency, 2009). SCMC is not a specialty care center, thus Laguna Beach Fire Department paramedics must travel to receiving centers that range from the closest facility, Mission Hospital, at 11.73 miles from the center of town to the most reasonable distant facility, UC Irvine Douglas Hospital (UCI) at 22.83 miles from the center of town. The center of town was arbitrarily selected as 285 Agate Street which is the location of Laguna Beach Fire Station Two. With 12 firefighters staffing four fire engines, anytime a fire engine is out of its service area, delivery of public safety services is proportionally reduced. To exacerbate the problem, there is often significant vehicular traffic congestion that can result in delays for units traveling to and from hospitals located outside of the

City of Laguna Beach. During peak periods of vehicular traffic congestion, it is not uncommon to experience travel times of 30 minutes to cover a distance of ten miles.

Enhanced Field Treatment

The Laguna Beach Fire Department routinely implements newly recommended OCEMSA policies and procedures. OCEMSA often provides optional equipment or procedures. The recommendations are imported from the larger field of medical science; however, the options are usually not mandates as the equipment and procedures require funding. OCEMSA has traditionally avoided non-funded mandates that would result in significant implementation costs. Based on its size and fiscal stability, the Laguna Beach Fire Department often opts to incorporate the recommendations in hopes the expanded practice will provide optimal patient care. The Laguna Beach Fire Department was an early entrant in the field 12 lead electrocardiogram (EKG) protocols, and the first fire department in Orange County, California, to adopt the transcutaneous pacing protocols. This leading-edge philosophy comes at a price for equipment, training, and maintenance. Although the Laguna Beach Fire Department has relied on the scientific community to advocate and adopt changing technologies and practices, the Laguna Beach Fire Department has not examined its own findings to analyze the value of its implementation decisions.

Response Patterns

In 2008, the Laguna Beach Fire Department began dispatching the closest fire department units based on automatic vehicle location (AVL) data. The adjoining fire agencies, Orange County Fire Authority and Newport Beach Fire Department, are expected to convert from their existing system of dispatching fire units based on fire station locations and begin dispatching the closest available unit based on AVL data. This change is expected to have an impact on

automatic aid policies and potentially changing Laguna Beach Fire Department's response patterns for both ALS and BLS units.

Ambulance Contracts

Doctor's Ambulance Service provides transport service for the Laguna Beach Fire Department; however, there is no written contract between the two agencies. In January 2009, the OCEMSA published an Ambulance Zone Summary. In that summary it indicated that an exclusive operating area "has been served non-exclusively by Doctor's Ambulance Service, Inc. since 1996" (Orange County Emergency Medical Services Agency, 2009). The exclusivity rights as applicable in Section 1797.224 of Division 2.5 of the California Health and Safety Code and commonly referred to as 224 rights will likely require the City to seek a competitive public bid for ambulance service. OCEMSA's concern is that without a competitive bid process, a monopoly or restraint of trade condition could exist. The 224 rights are designed to address competitive processes for creating exclusive operating areas. "If the local EMS agency decides to create exclusive EMS operating areas, a Request for Proposal (RFP) must be developed" (State of California, 1997). The development of the RFP in anticipation of obtaining an ambulance service contract has the ability to be tailored to meet the unique emergency service demands in the City of Laguna Beach.

Although there are a number of facets to this ARP, it also parallels lessons learned from the National Fire Academy's curriculum for Executive Leadership (EL). The model of executive fire officer leadership focused on the nexus of interpersonal skills and effective leadership, and a triad of analytically-centered traits that include (a) action areas, (b) environment, and (c) leadership base. Subsets of that framework included two areas that are specific and relevant to this research project (a) "ability to perform analysis and exercise judgment" and (b) "recognition

of blind spots and weakness; commitment to corrective action" (National Fire Academy, 2005, p. 1-4). This project is designed to evaluate existing conditions, and through a process of evaluating future probabilities, modify outcomes to maximize emergency medical services, effectively accomplishing the equivalencies of analyzing data, identifying blind spots, and taking corrective actions.

Pre-course reading for Executive Leadership included Heifetz and Linsky's *Leadership on the Line*. The authors focus on distinguishing technical from adaptive challenges. Even an announcement indicating that cardiopulmonary arrest cases would be reviewed by the Laguna Beach Fire Department, has the potential to send guardians forward to question the need for inquiry. Tenured firefighters have likely been a participant or recipient of the management review cycle that begins by identifying a problem and then launching a process to investigate, analyze, conclude, and if appropriate, change. There is danger to the leadership and Heifetz and Linsky offer the following: "The hope of leadership lies in the capacity to deliver disturbing news and raise difficult questions in a way people can absorb, prodding them to take up the message rather than ignore it or kill the messenger" (Heifetz and Linsky, 2002, p. 12).

This research has the ability to touch all five of the United States Fire Administration (USFA) Operational Goals and Objectives as outlined in the 2009-2013 Strategic Plan; however, its greatest impact is the ability to focus on improving emergency services' capability for planning and responding to the emergency medical needs of the visitors and residents of Laguna Beach, California. It is hoped that the end users of the ALS system will ultimately benefit from an examination of the established national response standards and its implications on a municipal fire department. Although all five goals and thirteen objectives could, to some extent, be tied to this research project, its strongest correlations are in response, planning, and impact to the

business model. The research is current and matches the goals and objectives of the USFA. Finally, the data presented in this research is significant in its immediate and direct application to the researcher's own organizational needs in relation to service indicators for ALS service.

In summary, it is hoped that through analysis of existing data, recommendations can be extrapolated providing direction for the Laguna Beach Fire Department to either maintain the existing level of service, make service modifications, or retool to meet existing and future service needs. Additionally, it is hoped that the fire service's seminal staffing document can be accepted or refuted in regard to the 8-minute response time for ALS units. The importance of the study is founded in the desire to explore one City's experience in the most finite of presentations--clinical death.

LITERATURE REVIEW

With the focus of the research centered on the findings in the City of Laguna Beach, it is important to compare the research findings with data from other organizations performing a similar service. This comparative analysis provides the opportunity to examine similarities, differences, and anomalies. Thus one purpose of the literature review is to provide opinions that do not conform to the research findings when the data supports such disclosure. The literature review will be guided toward addressing the research problem, and assisting in providing data for consideration when formulating answers to the research questions.

Uniform terminology is beneficial when examining reports and literature. Research documents use slightly different terminology with similar, yet specific meanings. For the purpose of this research, the terms clinical death, sudden cardiac arrest, and cardiopulmonary arrest will be considered synonymous and defined as follows. "In the clinical setting, cardiac arrest is defined as the cessation of cardiac mechanical activity….It is a clinical diagnosis,

confirmed by unresponsiveness, the absence of a detectable pulse, and apnea or agonal respirations" (American Heart Association, 1996, p.4). Both sudden cardiac arrest and cardiopulmonary arrest are also conditions similarly defined and involve the moment when the heart no longer provides a viable contraction, and is the time point of clinical death. The importance of the three aforementioned events is the fact that at the moment that breathing and cardiac function stop, the clock of irreversible brain damage begins. "Within 4 to 6 minutes" (Werman, 2008, p. 1226) from the time of clinical death, brain cells begin to die, and this irreversible condition is defined as biological death. This subtle link is significant because the majority of cardiopulmonary arrest mitigation efforts are designed to interrupt the brain death cycle, and the literature suggests that there is a small 4 to 6 minute window of time to intervene to maximize the probability that a patient in cardiopulmonary arrest will recover neurologically intact and capable of attaining self sustaining cerebral function.

As applied to this research, return of spontaneous circulation (ROSC) is defined as the recording of a systolic blood pressure of at least 60 millimeters of mercury, or the recording of a palpated distal pulse. The Prehospital Care Reports (PCR) reviewed for this study recorded the rate of a palpated pulse, but the anatomical site from which the pulse was obtained was not noted on the PCRs. Distal pulse sites can be used to estimate systolic blood pressure. An article titled *Managing Shock*, indicates that systolic blood pressures can be estimated based on the anatomical location that a pulse is palpated. The pulse site and corresponding systolic blood pressure include the following (a) radial pulse suggests a systolic blood pressure of 80 millimeters of mercury, (b) femoral pulse suggests a systolic blood pressure of 70 millimeters of mercury, and (c) carotid pulse suggests a systolic blood pressure of 60 millimeters of mercury (CE Solutions, 2009, p. 4). This study's definition of ROSC varies somewhat from the Utstein-

Style Guidelines that recommends ROSC be defined as "maintenance of a systolic aortic blood pressure of at least 60 mm for at least 10 consecutive minutes" (American Heart Association, 1996, p. 7). The 10 minute criterion was difficult to track as the ROSC may have occurred shortly before transfer of patient care from ALS field personnel to hospital emergency department staff.

The United States Fire Administration (USFA) estimated that in 2007 there were approximately 30,185 fire departments in the United States and those fire departments responded to 25,334,500 incidents, and sixty-two percent of the total number of incidents were classified as emergency medical service related (United States Fire Administration, 2009, p. 1). The 2008 National Fire Incident Reporting System (NFIRS) data, as recorded by the California Office of the State Fire Marshal, indicated that state-wide in California, 1,928,488 incidents were recorded and sixty-one percent or 1,182,153 of the total number of incidents were classified as emergency medical service related (California Department of Forestry and Fire Protection, 2009, p. 1). In 2008 the Laguna Beach Fire Department responded to 2,613 incidents. Sixty-two percent or 1,622 calls for service were classified as emergency medical services related.

Table 1 identifies the Laguna Beach Fire Department's calls for service for the calendar year 2008. The subheadings are those identified in the City's report management system. Quarterly the incident summaries are forwarded to the California Office of the State Fire Marshal for mandatory reporting purposes.

Table 1

Laguna Beach Fire Department's 2008 Incident Totals Based by Call Type

Call Type	Total
Fire alarm	280
Fire code	13
Fire	103
Fire mutual aid	29
Hazardous condition	132
Hit and run	2
Lifeguard rescue	11
Emergency medical	1,622
Missing swimmer	15
Public service request	107
Rescue-cliff and mudslide	4
Smoke investigation	59
Suicide	31
Traffic collision	204
Total	2,613

One of the primary objectives of this ARP was to determine if the findings of the Laguna Beach Fire Department met NFPA 1710's ALS response time standard, specifically NFPA 1710, Section 5.3.3.4.3. "When provided, the fire department's EMS for providing ALS shall be deployed to provide for the arrival of an ALS company within an 8-minute response time to 90

percent of the incidents" (National Fire Protection Association, 2004, p. 1710-17). For clarification, NFPA 1710 defines response time as "The travel time that begins when units are en route to the emergency incident and ends when units arrive at the scene" (National Fire Protection Association, 2004, p. 1710-9).

There are many references that suggest the 8-minute ALS time standard is crucial to patient outcomes. *The Washington Times* produced an article about Washington D.C.'s EMS response and stated the following:

> The best monthly performance on record for the city [Washington DC] was in October, when 77.1 percent of calls received responses within eight minutes. The eight-minute benchmark is crucial because cardiac arrest victims have a 33 percent higher survival rate when paramedics arrive within eight minutes, according to the American Heart Association. After eight minutes, the prospects of recovery decrease rapidly. (Cella, 2003, p. 2)

An article in *The Journal of the American Medical Association (JAMA)* supports the need for a rapid emergency medical response. "For cardiac arrest, the highest hospital discharge rate has been achieved in patients in whom CPR was initiated within four minutes of arrest and advanced life support (ACLS) within eight minutes" (International Association of Firefighters, 2009, p. 1).

One of the informational references in NFPA 1710 is *Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiac Care.* In that document the authors' focus on cardiopulmonary-cerebral resuscitation. "If restoration of spontaneous circulation occurs after the 8-to-10 minute limit, the frequency of significant, permanent neurological damage becomes unacceptably high. Responding and shocking as fast as possible, seldom

exceeding 8-to-10 minutes, is a central objective of all EMS systems" (American Heart Association, 2001).

Sudden cardiac arrest outside of the hospital is a significant health care issue in the United States. It is estimated that approximately 500,000 deaths per year are the result of a sudden cardiac arrest and approximately 235,000 of those cases occur outside the hospital. For those incidents that occur outside of the hospital, the survival rates are 1 to 5 percent (International Association of Firefighters, 2009, p. 1). Additionally, there is no evidence that survival rates are increasing even with enhanced pre-hospital treatment.

One of the larger controlled clinical trials included 5,638 patients who had a cardiac arrest outside the hospital. Known as the Ontario Prehospital Advanced Life Support (OPALS) Study, it examined the survival rates of out of hospital cardiac arrest patients after an advanced life support program was added to a rapid defibrillation program. Although the rate of admissions to the hospital increased, the survival to hospital discharge did not.

> The primary hypothesis of improved survival rates from the rapid-defibrillation and advanced life support phases was tested with chi-square analysis….The results of the OPALS study did not show any incremental benefit of introducing a full advanced-life-support program to an emergency-medical-services system of optimized rapid defibrillation….The primary outcome, the rate of survival to hospital discharge, did not improve significantly from the rapid-defibrillation phase to the advanced-life-support phase (5.0 percent to 5.1 percent, P=0.83)….These results are consistent with previous case series that demonstrate poor survival after out of hospital cardiac arrest, despite the benefit of advanced life support interventions. The rate of survival was as low as 1.3 percent in Chicago and 1.4 percent in New York City. Two meta-analyses showed no

benefits to advanced life support for emergency-medical-services systems. (Stiell et al., 2004)

In the end, the OPALS Study demonstrated that adding an advanced life support program to an emergency medical system that already employed rapid defibrillation did not decrease the mortality or morbidity rates for patients who suffered an out of hospital cardiac arrest.

In an article titled, *Epidemiologic Study of In-Hospital Cardiopulmonary Resuscitation in the Elderly* the authors suggest that, at least theoretically, a point can be reached where survival rates for patients of in-hospital CPR cannot be improved. "The study examined data from 1992-2005….and identified 433,985 patients who underwent in-hospital CPR; 18.3% of these patients survived to discharge. The rate of survival has not changed substantially during the period from 1992 through 2005" (Ehlenbach, 2009, p. 1). The concept of a theoretical maximum survival rate can be viewed from a manufacturing practice that evaluates product life cycles. If one accepts the premise of comparing managing product life cycles with managing customer service processes such as the delivery of CPR then the concept of theoretical maximum survival rates would be equivalent to the saturation and decline phase of the product life cycle. Money spent on additional research to provide process adaptation likely will be counter-optimal.

In the 2004 Edition of NFPA 450 *Guide for Emergency Medical Services and Systems* it defines NFPA 1710 as “an industry standard on which fire department-based EMS system design analysis may be based. This voluntary standard contains minimum requirements relating to the organization and deployment of emergency medical operations to the public by ‘substantially all career fire departments’” (National Fire Protection 450, 2004, p. 450-13). The phraseology is unique in that the content of NFPA 450 acknowledges that NFPA 1710 is a voluntary standard. Conversely, NFPA 1710 defines standard as "A document, the main test of which contains only

mandatory provisions using the word 'shall' to indicate requirements…" (National Fire Protection Association 1710, 2008, p. 1710-7). The ALS time standard in NFPA 1710 uses the term "shall" (NFPA) indicating a mandatory requirement.

Both NFPA 1710 and NFPA 450 reference personnel deployment guidelines. Section 5.5.2.3.4 of NFPA 450 states "In systems that have attained survival rates higher than 20 percent for patients with ventricular fibrillation, the response teams have a minimum of two ACLS providers plus a minimum of two BLS personnel at a scene" (National Fire Protection Association 450, 2004, p. 450-13). This was an important aspect, as the purpose of this study did not encompass a staffing evaluation. However, the Laguna Beach Fire Department sends a minimum of two ALS personnel and six BLS personnel to a medical service call. To reach eight personnel the Laguna Beach Fire Department dispatches an ALS unit with three personnel two of whom are trained to the ALS level and one trained to the BLS level. A second BLS unit is dispatched and staffed with three BLS trained personnel. Finally, an ambulance is dispatched staffed with two BLS trained personnel. The exception would be an injury below the elbow or knee where only one BLS unit and one ambulance are dispatched.

The cost for lifesaving measures can be quantified. The proposed 2009/2010 fiscal year budget for the Laguna Beach Fire Department is $9,708,300 (City of Laguna Beach, 2009, p. 72). Although the fire service seldom, if ever, openly compares such critical care services as resuscitation of a cardiopulmonary arrest patient against the cost of human life, there are other agencies that do define the worth of a human life and base decisions on the value of statistical life. In 2008 the Environmental Protection Agency "lowered its official estimate of life's value, from about $8.04 million to about $7.22 million" (Fahrenthold, 2008, p. 1). Cost benefit analysis and decisions on acceptable losses are routinely performed in life and in business.

"When drawing up regulations, government agencies put a value on human life and weigh the costs versus the lifesaving benefits of a proposed rule. The less a life is worth to the government, the less the need for a regulation…" (The Associated Press, 2008, p. 1). The government often makes decisions that altruistically are designed to benefit a segment of the nation's population; however, questions often arise about the true purpose behind the political decisions.

Ultimately, value assessments are personal, and it is likely that our evolutionary development has relied on accurate internal calculations of risk verses gain. Often the analysis is seemingly a subconscious iteration. The decision to wear a seat belt is one such analysis. The logic appears simple. If one chooses not to wear a seat belt, and if one is traveling in a vehicle that is involved in a front end collision, and if Newton's First Law is correct, then one must accept a higher risk that his or her cranium will potentially carom off an unforgiving object. It is a personal choice, and nationally 29 percent of motorists conclude their internal cost benefit analysis with a decision to opt out of the safety feature (Wald, 2001, ¶ 6). Fire station locations and staffing is a public policy decision that has, among other factors, placed a value on statistical life. The public disclosure of such data is likely uncomfortable, and often marred in a matrix of agendas that when solidified are nearly impossible to independently expose. The ALS 8-minute response time standard is a conglomeration of special interest groups, government intervention, and personal choices, in effect, each stakeholder determining the statistical value of life.

Orange County Emergency Medical Service Agency (OCEMSA) treatment guidelines provide opportunities to limit treatment in specific cases. Based on historical and scientific findings, the medical director ordains EMS treatment protocols. One example, OCEMSA Treatment Guideline C-05, allows the base hospital physician to pronounce death in the field if no return of spontaneous pulse and respiration are noted after initial resuscitative efforts (Orange

County Emergency Medical Service Agency, 2009). The field ALS personnel complete one round of treatment that may include advanced airway, cardiac defibrillation, and pharmacological therapy, and if the patient fails to respond to the treatment, the ALS staff with concurrence from the base hospital physician ceases treatment and pronounces death. Although the guiding principal is a physician's Hippocratic Oath, the decision to include field pronouncements likely at some level included debate of the statistical value of life.

Another debate about the ALS content in NFPA 1710 is the concept of comparing the subtle differences between emergency service delivery and patient outcomes. In review of the 2001 Report on Proposals for NFPA 1710, it was noted that the Technical Committee accepted a recommendation for the following text revision. "(Log #1825) 1-1.1.1.1 The requirements address emergency service delivery functions and outcomes of [*sic*] performed by fire departments, emergency service delivery, in addition to fire department response capabilities and resources." The substantiating comment was, "It is not feasible to establish a standard for outcomes. The standard addresses functions and capabilities and resources that are needed to perform those functions" (National Fire Protection Association 1710, 2001, p. 5). In context of the substantiating comments, it opens for debate if comparing patient outcomes to time standards in NFPA 1710 was ever the intent of the authors.

In review of the literature, it appears that the value of ALS response times to cardiopulmonary arrest patients is supported in some cases and refuted in other cases. The general conclusion appears that to pluck a single contributing factor such as response time out of an interdependent and complex event such as a cardiopulmonary arrest makes the analysis short on scientific rigor.

PROCEDURES

Prior to attending the Executive Leadership (EL) course at the National Fire Academy this researcher had developed a draft problem statement and set of potential research questions. With the broad concept of the ALS time standard referenced in NFPA 1710, it was important to obtain potential samplings from a variety of emergency medical services related incidents to narrow the scope of the project. All Prehospital Care Reports (PCR) on file with the Laguna Beach Fire Department for the calendar years 2006, 2007, 2008, and the first quarter of 2009 were considered for inclusion in this ARP. A total of 3,267 Prehospital Care Reports were reviewed and categorized. The reports were divided by patient status categories already pre-identified on the PCR. The categories and the approximate percentage of the total each represents is as follows: (a) mild 46%, (b) moderate 38%, (c) acute medical 3%, (d) cardiopulmonary arrest 1%, (e) moderate trauma victim 6%, (f) critical trauma victim <1% (g) neurological <1%, (h) dead on arrival <1%, (i) do not resuscitate<1% , (j) burn <1%, and (k) multiple casualty incident <1%. In approximately 3% of the Prehospital care reports reviewed, no patient status category was identified. The number of cardiopulmonary arrests included in this study and defined by calendar year includes 16 events in 2006, 7 events in 2007, 19 events in 2008, and 2 events in the first quarter of 2009. In all, 44 events were included in the study.

After all the incidents were subdivided, an analysis was made in an attempt to control time variables and identify static triggers to provide statistical anchoring. In review of the subgroups, it became apparent that the incidents classified as cardiopulmonary arrest would likely provide the most consistent data elements with the least amount of variation. The combination appeared to provide the opportunity to provide elements necessary to conduct quantitative and qualitative analysis. The clinical presentation was definitive, the treatment was

standardized, the distribution of incidents was random, and the clinicians were arbitrarily selected. The remaining patient status categories shared some of the variables, yet no other subset provided the number and degree of standardized data elements. The most significant limitation with the cardiopulmonary arrest data was the total number of incidents included in the study.

Based on preliminary analysis of the information, it was determined that cardiopulmonary arrest data would serve as the basis for evaluating the potential association between the 8-minute ALS time standard and patient outcomes. After a cursory literature review and discussion with the Orange County Emergency Medical Services Director, Dr. Samuel J. Stratton, it was determined that nine data elements would be useful in examining time standards to patient outcomes. Those nine elements are (a) ALS response time, (b) patient's age, (c) patient's gender, (d) initial cardiac rhythm, (e) return of spontaneous circulation, (f) CPR prior to arrival of ALS personnel, (g) automatic external defibrillation prior to arrival of ALS personnel, (h) patient's survival to hospital admissions, and (i) BLS care initiated prior to arrival of ALS personnel. These nine data elements were collected and transferred to a spreadsheet to allow for examination and statistical review.

Once at the NFA, and having a broad scope of the project along with preliminary data, this researcher had the opportunity to conduct focused research at the Learning Resource Center (LRC) on campus. Using the LRC online card catalog, a search was conducted covering a broad spectrum of related subjects in an attempt to identify relevant and recent documentation of issues related to the research. Medical journals were the most often referenced with significant scientific data available for varying elements of cardiopulmonary arrests. The data was collected for inclusion into this research.

Working with Dr. Samuel J. Stratton, the cardiopulmonary arrest data elements were examined using the software program SPSS Advanced Statistics (Version 13.0) to conduct chi-square testing. Chi-square is defined as "a statistical method used to test whether the classification of data can be ascribed to chance or to some underlying law" (Your Dictionary, 2009, ¶ 1). Through the use of general linear models, it was the intent of the analysis to describe the relationship between a dependent variable and a set of independent variables. The chi-squared (x^2) test and resulting probability distribution was chosen based on the ability to estimate event significance.

Working with the City of Laguna Beach's Senior Plan Checker, Issam Shahrouri, PhD, PE, CBO, the data elements were further examined using binary logit regression models. Quantitative software was used to perform the regression models to help quantify outcomes. EView 5.1 software was used as the tool to conduct the analysis. The NFPA 1710 ALS time standard of 8-minutes was a candidate for conversion as a binary variable and offered comparison to other dummy variables. In reviewing regression models, the binary regression logit model was selected for its ability to model situations using a set of dummy variables. For example, ALS response time within 8-minutes is a dummy variable because ALS response time within 8-minutes was either demonstrated or not. Therefore, all variables were given a value of 0 or 1. Table 2 demonstrates the value of the variables used in the analysis.

Table 2

Dummy Variables Explained

Gender	ALS Response Time[a]	ROSC[b]	CPR PTA[c]	AED PTA of ALS[d]	Survival to Hospital Admission[e]	BLS PTA of ALS[f]
0-female 1-male	0->8 minutes 1-≤ 8 minutes	0-false 1-true	0-false 1-true	0-false 1-true	0-false 1-true	0-false 1-true

[a]NFPA 1710 ALS response time standard within 8-minutes. [b]Return of spontaneous circulation. [c]Cardiopulmonary resuscitation prior to arrival of ALS personnel. [d]Automated external defibrillation applied and shock delivered prior to arrival of ALS personnel. [e]Survival to hospital admission. [f]Basic life support personnel on scene prior to the arrival of ALS personnel.

Cardiac rhythms were also evaluated, and Table 3 demonstrates the value of the variables used to identify specific cardiac rhythms.

Table 3

Dummy Variables for Specific Cardiac Rhythms

Asystole[a]	Ventricular Fibrillation[b]	Pulseless Electrical Activity[c]
0-false	0-false	0-false
1-true	1-true	1-true

[a]Asystole is "a heart rhythm indicating absence of any electrical activity in the heart" (Werman, 2008, p. 1245). [b]Ventricular fibrillation is "a continuous, uncoordinated, chaotic rhythm which does not produce a pulse" (Werman, 2008, p. 1255). [c]Pulseless electrical activity is "a condition in which the heart generates relatively normal electrical rhythms but fails to perfuse the body because of an absent cardiac output" (Werman, 2008, p. 1252).

In an attempt to further understand the origin of the 8-minute ALS time standard in NFPA 1710, this researcher contacted Steven F. Sawyer, Senior Fire Service Specialist at the National Fire Protection Agency. Mr. Sawyer is the staff liaison to NFPA 1710. Mr. Sawyer directed this researcher to the NFPA web site located at http://www.nfpa.org to examine the following documents (a) *NFPA 1710* Report on Comments (ROC), (b) *NFPA 1710* Report on Proposals (ROP), and (c) draft 2010 edition of *NFPA 1710*.

Additionally, this researcher contacted Jonathan W. Moore, Director IAFF Fire and EMS. Mr. Moore provided source documents that contained historical reference and citations to the origin of the 8-minute ALS time standard found in NFPA 1710. Those documents are (a) Consolidated Key Comments, (b) 2004 Edition NFPA 1710, (c) Annoted Bibliography, and (d) 2004 Edition *NFPA 450 Guide for Emergency Medical Services Systems*.

On May 14, 2009, Kristi Fong, NFIRS Program Coordinator from CAL FIRE was contacted to discuss the California All Incident Reporting System (CAIRS). "The California All Incident Reporting System (CAIRS) is a statewide emergency incident data program that collects, compiles, analyzes and distributes statistical information by the California Fire Service" (Office of the State Fire Marshal, 2009, p. 1). CAIRS staff reviews state-wide information and then forwards it to the United States Fire Administration (USFA) to maintain compliance with the National Fire Incident Reporting System (NFIRS). Ms. Fong provided a customized spreadsheet demonstrating incident type for all incidents reported to the California State Fire Marshal for the date range of January 01, 2008, through December 31, 2008.

Procedurally, it was apparent that consistent data was difficult to obtain. The literature research suggested that conflicting results are often due to differences in experimental methods and laboratory model designs. An article from the American Heart Association likely summed it up the best. "Variations in study design, such as quality of chest compressions and ventilation, definitions of variables, or time intervals between an event and the beginning of therapy, are probably responsible for many of the inconsistencies and contradictions reported" (Idris, 1996, p. 1).

Limitations of the Research

Certain limitations in the conduct of this study are recognized. In particular, the study was limited to the availability of Pre Hospital Care Reports and the researcher's ability to retrieve and transcribe the information accurately. Although the data collection spanned 39 months, the total number of cardiopulmonary arrests was statically limited. The result is likely a stochastic relationship, and by definition a "stochastic relationship is not always right on target in the sense that it predicts the precise value of the variable being explained, just as a dart thrown at a target seldom hits the bull's eye" (Kennedy, 2003, p. 3). Additionally, statistical modeling was guided by subject matter experts; however, the pen to paper interpretations were not rote. Therefore, the written extrapolations and conclusions of the statistical data may be subject to debate based on limited statistical expertise and an open acknowledgement that the researcher is not a subject matter expert in the field of econometrics.

Delimitations of the Research

Certain delimitations were identified. The study only viewed cardiopulmonary arrest incidents that met a finite set of terms and conditions, and the study did not separate statistics based on the medical precursor that resulted in the cardiopulmonary arrest.

Assumptions of the Research

It was assumed the information obtained from the Prehospital Care Reports was accurate, and that the researchers understanding of the data was correctly interpreted. Additionally, the project required the manual transfer of data from the hand printed PCR to a Microsoft Office Excel spreadsheet, where the data was manipulated for the formation of varying tables and figures, and finally imported into a Microsoft Word document. With the transfer of single data elements across programs and iterations of draft reports, concern for accurate data transfer

should be considered. As previously identified, in a small data set, one mistake can skew the results. Also, it was assumed that the data retrieved from the report management system used by the Laguna Beach Fire Department was accurate. Finally, this researcher had extensive personal experience with the original formulation and adoption of NFPA 1710. Thus it was assumed that objective analysis could be obtained without the undue influence of personal experiences with the genesis of NFPA 1710.

RESULTS

Through evaluative research, data was collected and analyzed in an effort to evaluate the need to explore the City's adherence to the ALS time standard identified in NFPA 1710, and based on the findings, explore opportunities to enhance the City of Laguna Beach ALS delivery system. The first question that guided this research was: Using Laguna Beach Fire Department's cardiopulmonary arrest data, what was the percentage of incidents where an ALS company arrived within an 8-minute response time?

Based on Laguna Beach Fire Department's cardiopulmonary arrest data, an ALS company arrived within an 8-minute response time in 39 of the 44 recorded incidents representing 88.64%. Since the 39th incident represents 88.64% and the 40th incident represents 90.91%, or a difference of 2.27%, it is possible to calculate the estimated percentage at 8-minutes. The 39th incident response time was 7:48, and the 40th incident response time was 8:17, a difference of 29 seconds. Thus each one second represents a percentage of 0.0783. Therefore the results of this study would suggest that theoretically an ALS company would arrive within an 8-minute response time to 89.58% of the incidents. Table 4 is a progression of Laguna Beach Fire Department’s ALS response times to cardiopulmonary arrest over the study period, and the corresponding percentage of compliance is listed for the 39th and 40th incident.

Table 4

Progression of ALS Response Times to Cardiopulmonary Arrest

Number	ALS Response Time	90 Percentile Compliance
1	0:00:00	
2	0:00:12	
3	0:00:35	
4	0:00:59	
5	0:01:04	
6	0:01:07	
7	0:02:15	
8	0:02:27	
9	0:02:28	
10	0:02:33	
11	0:02:37	
12	0:02:41	
13	0:02:44	
14	0:03:00	
15	0:03:00	
16	0:03:02	
17	0:03:16	
18	0:03:23	
19	0:03:25	
20	0:03:27	
21	0:03:28	
22	0:03:33	
23	0:03:36	
24	0:03:49	
25	0:03:50	
26	0:04:00	
27	0:04:24	
28	0:04:30	
29	0:04:58	
30	0:05:19	
31	0:05:33	
32	0:05:52	
33	0:06:17	
34	0:07:09	
35	0:07:10	
36	0:07:11	
37	0:07:24	
38	0:07:25	
39	0:07:48	88.64%
40	0:08:17	90.91%
41	0:08:33	
42	0:09:42	
43	0:12:01	
44	0:13:00	

The problem statement initially identified in this Applied Research Project (ARP) demonstrated an interest in the impact that the adherence to the ALS time standard in NFPA 1710 had on patient outcomes. NFPA 1710 specifically identifies the arrival of an ALS company within an 8-minute response time to 90 percent of the incidents. The data compiled for the Laguna Beach Fire Department demonstrates non-compliance with the ALS standard identified in NFPA 1710. Albeit a proportionally small fallout of only 1.36 percent. Each of the 44 calls in the study represents an approximate percentage of 2.27, thus indicating non-compliance by technically less than one incident. Incident 07-2593 occurred on a hiking trail that travels over property lines separating the City of Laguna Beach from the County of Orange. The exact location of the incident was not identified, so the data was not excluded from this report. The implications of not including the data are significant. That is, reversing a non-compliant finding to a compliant finding.

Figure 1 plots the 44 incidents in the recorded response time progression from the shortest recorded response time of 0:00 to the longest recorded response time of 13:00. The five response times that exceeded the 8-minute standard are specifically identified.

Figure 1

Progressive ALS Response Times

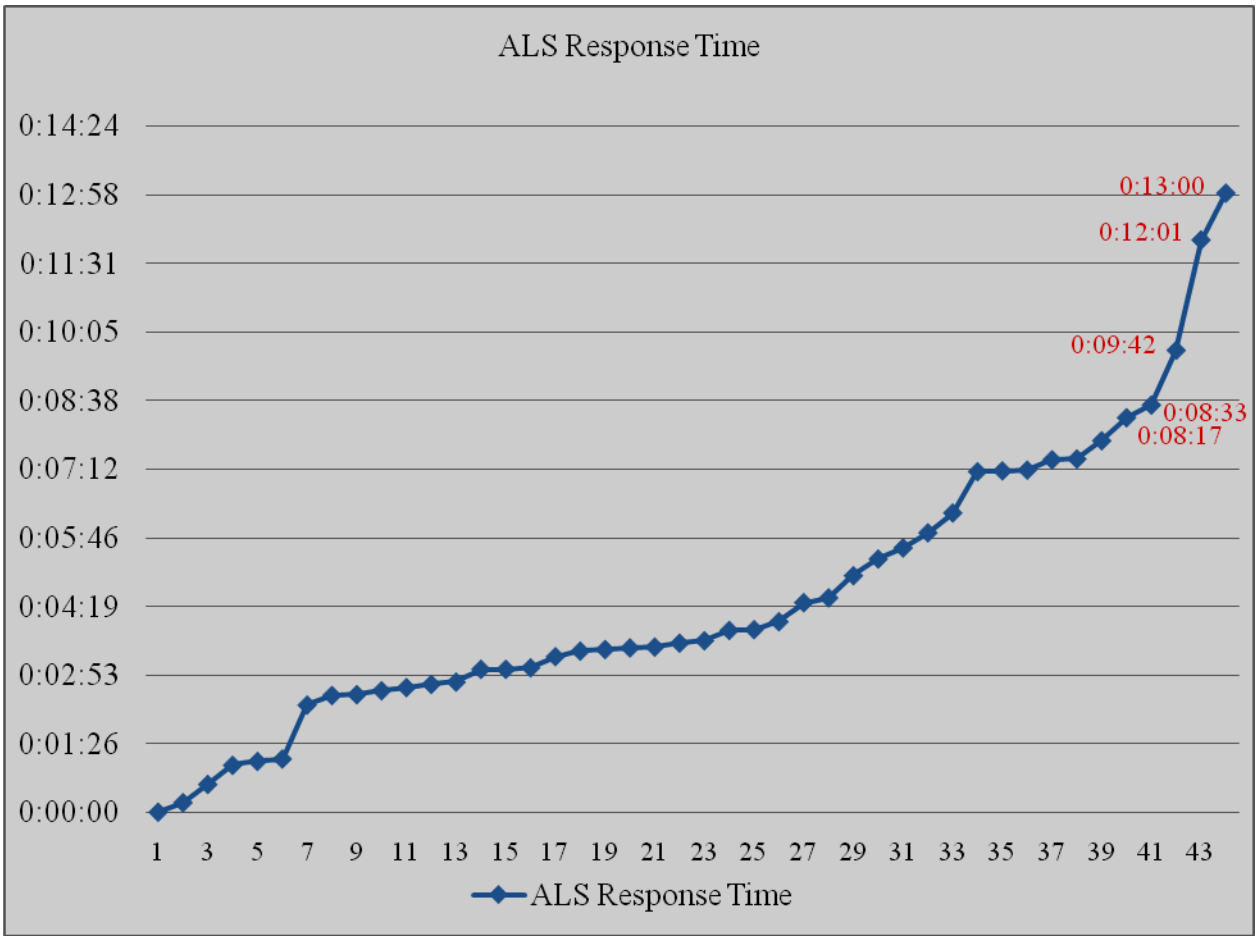


Figure 2 plots the 44 incidents in a response time progression over the course of the study beginning with the study's first recorded incident of January 20, 2006, and until the last recorded incident of February 14, 2009. The five response times that exceeded the 8-minute standard are specifically identified.

Figure 2

ALS Response Times in Sequence of Occurrence

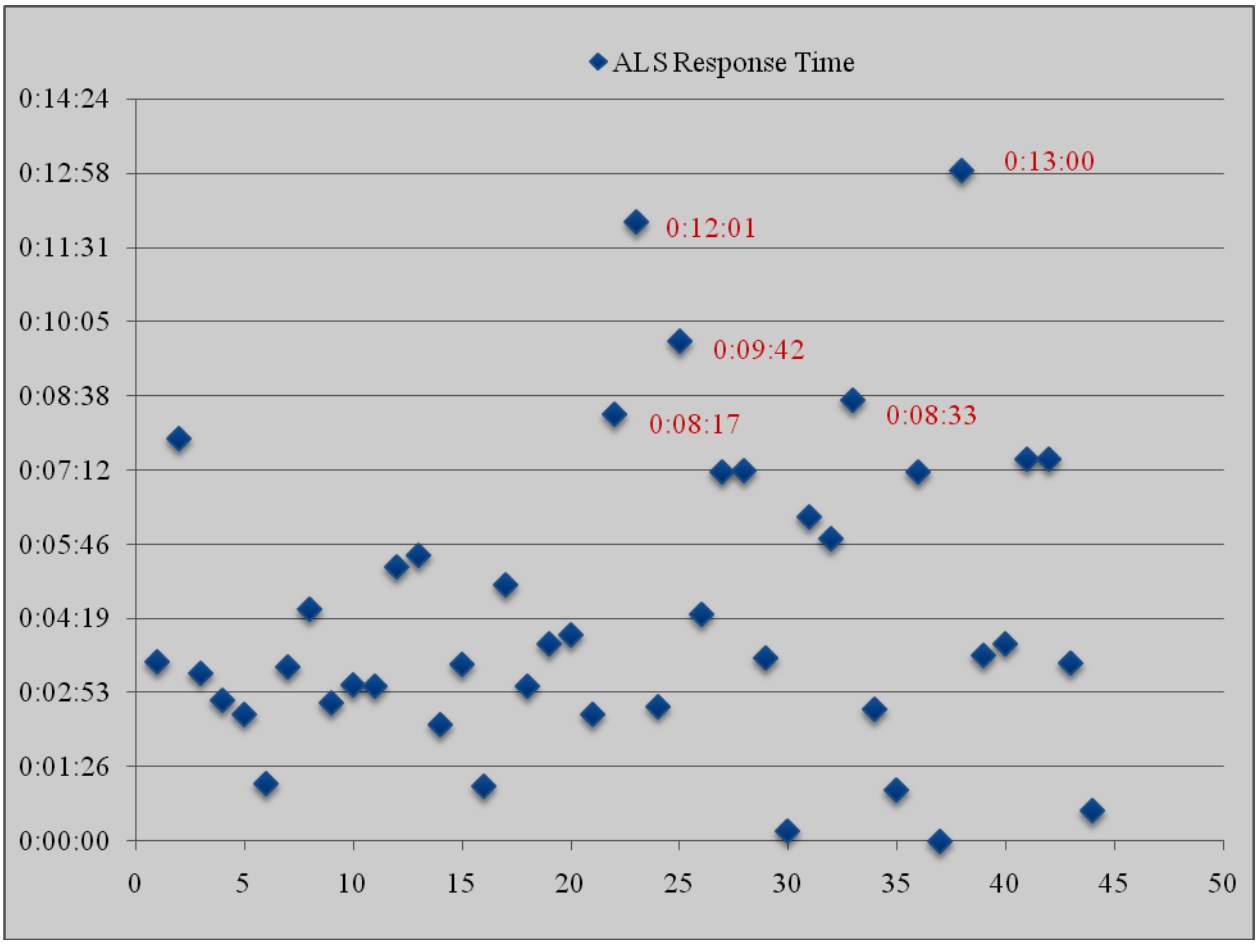
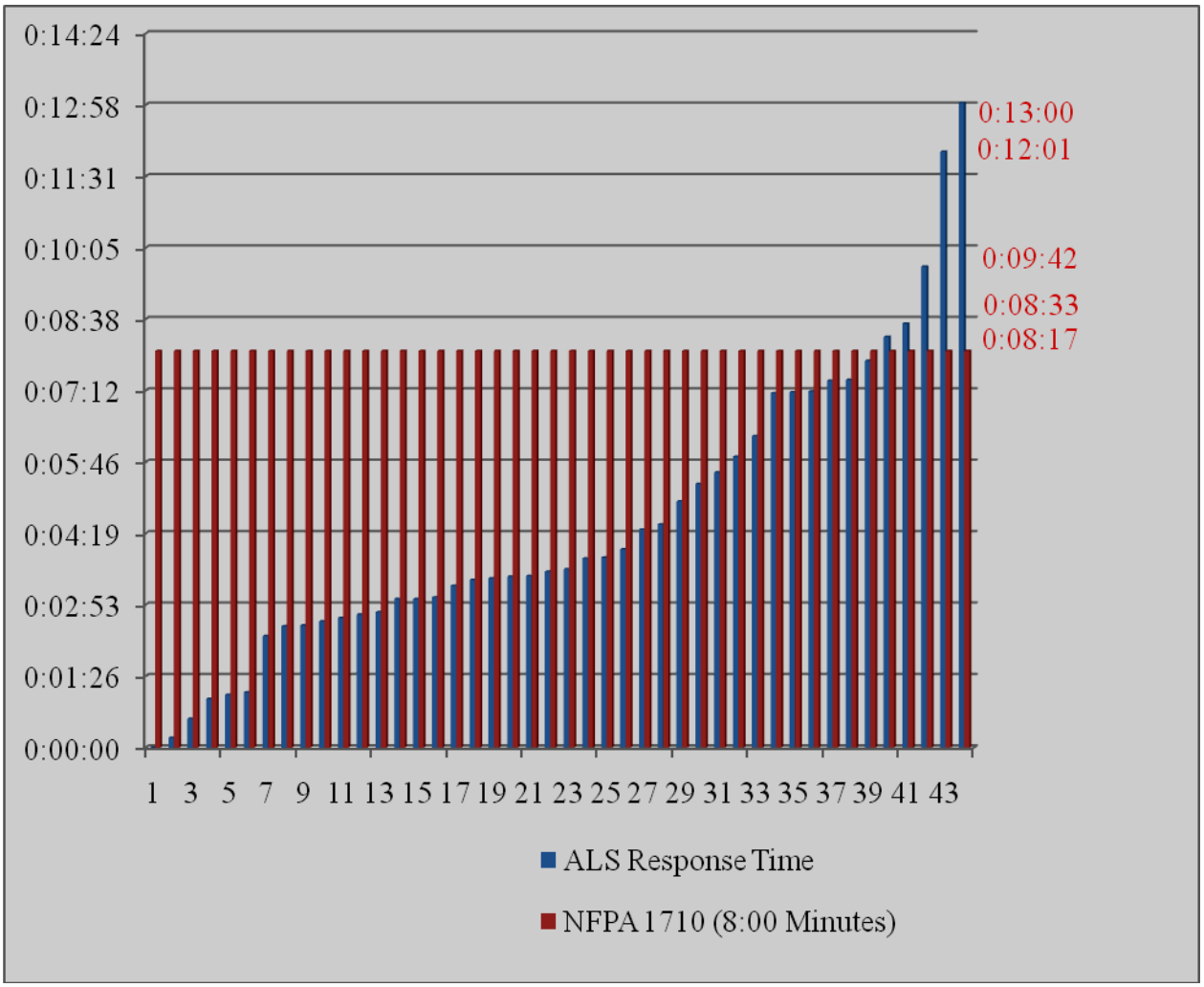


Figure 3 plots the 44 incidents in a response time progression and contrast it with the 8-minute time standard. The five response times that exceeded the 8-minute standard are specifically identified. Figure 3 provides an opportunity to examine the 90 percent linear concept. It delineates the 40th incident as the 90 percentile for the study, and the corresponding response time is 8:17.

Figure 3

Response Time Contrasted with 8-Minute Time Standard



Return of spontaneous circulation (ROSC) is another triggering event to monitor ALS effectiveness. The second question that guided this research was: Using Laguna Beach Fire Department's cardiopulmonary arrest data, what was the percentage of incidents where there was a return of spontaneous circulation (ROSC)? The data collected indicated that 10 of 44 or approximately 22.73 percent of the cardiopulmonary arrest patients in the study had a return of spontaneous circulation. Table 5 lists the incidents where a ROSC was recorded using the incident number and method used to confirm return of spontaneous circulation.

Table 5

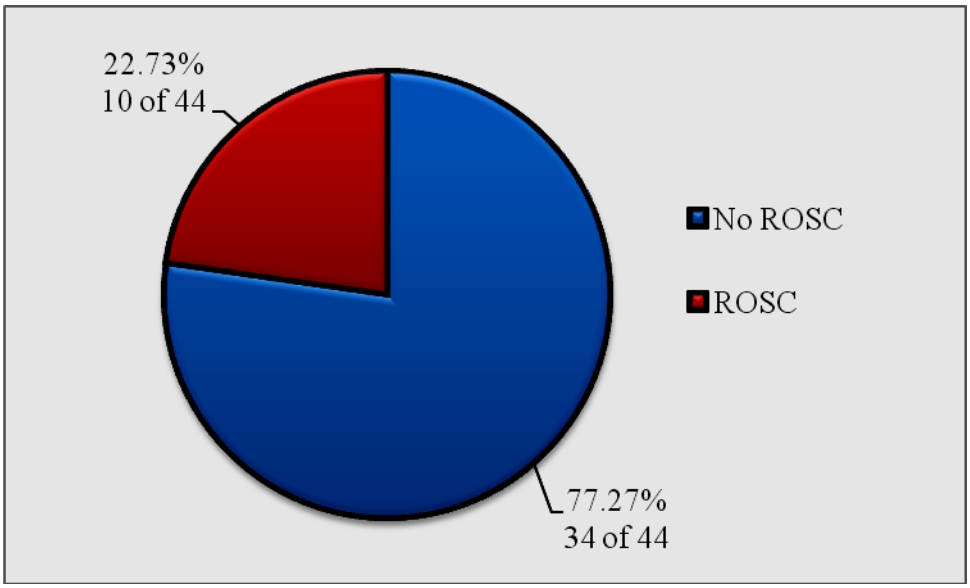
Return of Spontaneous Circulation

Incident Number	Method Used to Confirm Return of Spontaneous Circulation (ROSC)
06-128	blood pressure systolic >60 mm
06-423	distal pulses
06-519	blood pressure systolic >60 mm
06-566	distal pulses
06-1075	blood pressure systolic >60 mm
07-2249	blood pressure systolic >60 mm
08-309	distal pulses
08-365	blood pressure systolic >60 mm
08-769	blood pressure systolic >60 mm
09-292	blood pressure systolic >60 mm

Figure 4 graphically demonstrates the findings by indicating 22.73 percent of the patients in the study had a return of spontaneous circulation and 77.27 percent of the patients in the study did not demonstrate signs that indicated a return of spontaneous circulation.

Figure 4

Return of Spontaneous Circulation



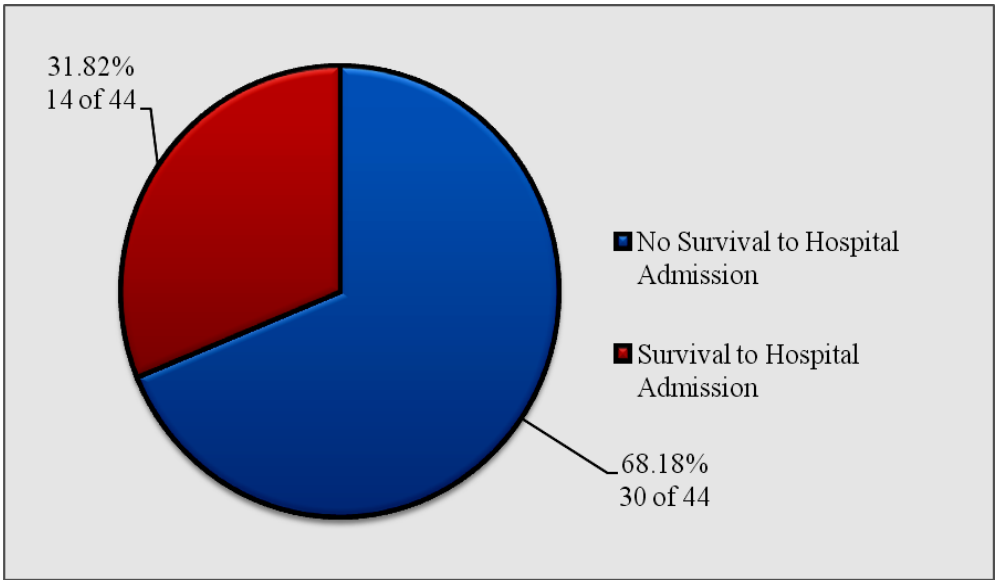
A chi-squared test was used to analyze data when return of spontaneous circulation was compared to ALS response times of less than or equal to 8-minutes and ALS response time of greater than 8-minutes. Statistically significant for this data set is defined as a two-tailed chi-squared probability value or p-value of less than or equal to 0.5, $p \leq 0.05$. The analytical results provided a chi-squared value equal to 0.445 and a probability value of 0.50. Thus the data demonstrates there is no statistical significance in return of spontaneous circulation when comparing ALS response in less than or equal to 8-minutes to ALS response time of greater than 8-minutes.

A patient's survival to hospital admission was another triggering event that was studied. The third question that guided this research was: What was the percentage of incidents where the patient survived to hospital admission? The American Heart Association recommends that survival studies should identify the period of time the patient survived. This researcher was not able to obtain the time period that a patient survived; however, data was available that

demonstrated the patient survived long enough to be admitted to the hospital. The data collected indicated that 14 of 44 or 31.8 percent of cardiopulmonary arrest patients survived to hospital admission. The findings in a pharmacotherapy study found that "Only one in every three patients who experience an out-of-hospital cardiac arrest survives to hospital arrival, and only 3-13% survive to discharge" (Dager, 2007, p.1). Figure 5 graphically demonstrates the findings by indicating 31.8 percent of the patients in the study survived to hospital admissions and 68.2 percent of the patients in the study did not survive to hospital admissions.

Figure 5

Survival to Hospital Admission



Quantitative software was used to perform binary logit regression models to help quantify survival to hospital admissions. EView 5.1 software was used as the tool to conduct the analysis. EView defines the capability of their software as a program that “can quickly and efficiently manage data, perform econometric and statistical analysis, and generate forecasts or model simulations” (Quantitative Micro Software, 2009, p. 2). Using EViews 5.1 software, a regression model was created and examined for statistical findings related to patients in the study

who survived to hospital admissions. The criteria for the model included: (a) binary logit regression model, (b) 44 observations, (c) survival to hospital admission was the dependent variable, (d) convergence achieved after 17 iterations, (e) covariance matrix computed using first derivatives, (f) 30 observations with deposition of 0, and (g) 14 observations with deposition of 1. Statistical significance would be defined as a probability >1.96 with a 95% confidence interval. Table 6 demonstrates the outcome of the logit regression model. Its findings suggest that no statistical significance exists between the dependent and independent variables.

Table 6

Binary Logit Regression Model for Survival to Hospital Admission (Version 1)

Variable	Coefficient	Standard Error	z-Statistic	Probability
C[a]	-0.434471	1.544646	-0.281275	0.7785
NFPA 1710[b]	-0.002376	0.002769	-0.858083	0.3908
Age	-0.008606	0.014313	-0.601268	0.5477
Gender	0.455702	1.029568	0.442615	0.6580
Asystole[c]	0.170770	.704210	0.242499	0.8084
BLS[d]	0.562792	0.922759	0.609902	0.5419
CPR[e]	0.107455	0.791423	0.135775	0.8920

Mean dependent variable	0.318182
S.E. of regression	0.497001
Sum squared resid	9.139385
Log likelihood	-26.45409
Restr. Log likelihood	-27.52162
LR statistic (6 degrees of freedom)	2.135059
Probability (LR stat)	0.906867
S.D. dependent variable	0.471155
Akaike information criterion	1.520640
Schwarz criterion	1.804489
Hannan-Quinn criterion	1.625905
Average log likelihood	-0.601229
McFadden R-squared	0.038789

[a]C represents a constant. [b]The ALS 8-minute response time standard identified in *NFPA 1710*. [c]"A heart rhythm indicating absence of any electrical activity in the heart" (Werman, 2008, p. 1245). [d]Basic Life Support. [e]Cardiopulmonary resuscitation.

Table 7 demonstrates the outcome of the regression model using alternative independent variables. Its findings suggest that no statistical significance between the dependent and independent variables. The criteria for the model included: (a) binary logit regression model, (b) 43 observations, (c) survival to hospital admission was the dependent variable, (d) convergence achieved after 28 iterations, (e) covariance matrix computed using first derivatives, (f) 30 observations with deposition of 0, and (g) 13 observations with deposition of 1. Statistical significance would be defined as a probability >1.96 with a 95% confidence interval.

Table 7

Binary Logit Regression Model for Survival to Hospital Admission (Version 2)

Variable	Coefficient	Standard Error	z-Statistic	Probability
C[a]	2.237932	7.687107	0.291128	0.7710
Response[b]	-0.173063	1.349414	-0.128251	0.8980
Age	-0.049666	0.042344	-1.172936	0.2408
Gender	0.197833	2.599888	0.076093	0.9393
Asystole[c]	0.850236	1.525637	0.557299	0.5773
BLS[d]	-0.411953	2.650672	-0.155415	0.8765
CPR[e]	-0.620570	1.381127	-0.449322	0.6532
ROSC[f]	4.185171	2.243916	1.865119	0.0622
2006	-1.636363	1.634698	-1.001018	0.3168
2007	-2.395726	3.528051	-0.678051	0.4971
AED[g]	0.949800	2.219071	0.428017	0.6686

Mean dependent variable	0.302326
S.E. of regression	0.416659
Sum squared resid	5.555364
Log likelihood	-16.56477
Restr. Log likelihood	-26.35134
LR statistic (10 degrees of freedom)	19.57315
Probability (LR stat)	0.033558
S.D. dependent variable	0.464701
Akaike information criterion	1.282082
Schwarz criterion	1.73622
Hannan-Quinn criterion	1.448227
Average log likelihood	-0.385227
McFadden R-squared	0.371388

[a]C represents a constant. [b]The ALS 8-minute response time standard identified in *NFPA 1710*. [c]"A heart rhythm indicating absence of any electrical activity in the heart" (Werman). [d]Basic Life Support. [e]Cardiopulmonary resuscitation. [f]Return of spontaneous circulation. [g]Automated external defibrillator.

Data was also evaluated using the chi-square test. The population included 39 cases, 87.2% male and 12.8% female with an average age of 59.4 years. The ages ranged from 2 to 89 years. Statistically significant for this data set is defined as a chi-squared probability value or p-value of less than or equal to 0.5, $p \leq 0.05$.

The chi-squared test analyzed data when survival to hospital admission was compared to ALS response times of less than or equal to eight minutes and ALS response times of greater than eight minutes. The analytical results provided a chi-squared value equal to 3.48 and a probability value of 0.066. Thus the data demonstrates there is no statistical significance in survival to hospital admission for the population studied when comparing ALS response time in less than or equal to 8-minutes to ALS response time greater than 8-minutes.

The same sequence was run using a response time of 5 minutes. Survival to hospital admission compared to ALS response time of within 5 minutes or 5 minutes or greater resulted in a chi-square value equal to 0.223 and a probability value of >0.50. Thus the data demonstrated there is no statistical significance in survival to hospital admission when comparing ALS response time within 5 minutes or 5 minutes or greater. Comparing the 5-minute standard with return to spontaneous circulation resulted in chi-square equal to 0.227 and a probability value of >0.50. Thus the data demonstrated there is no statistical significance in return to spontaneous circulation when comparing ALS response time within 5 minutes or 5-minutes or greater.

DISCUSSION

Study Results and Specific Findings

The study was in part designed to examine Laguna Beach Fire Department's compliance with the NFPA 1710 time standard that states "ALS shall be deployed to provide for the arrival of an ALS company within 8-minute response time to 90 percent of the incidents" (National Fire Protection Association, 2004, p. 18). Over the 39 month study period a compliance ratio of 88.64 percent was obtained. Perhaps technically a non-compliant finding; however, the fallout represented 1.36 percent. This difference represents a fraction, 59.91 percent, of one call, or simply stated, one call would have pushed the compliance rate to 90.91 percent.

The American Heart Association has indicated that "The eight-minute benchmark is crucial because cardiac arrest victims have a 33 percent higher survival rate when paramedics arrive within eight minutes" (Cella, 2003, p. 2). Based on the American Heart Association's premise, the incidents where paramedics arrived in under 8-minutes should have a 33 percent higher survival rate. That was not noted in this study. Other studies suggest that "For those incidents that occur outside of the hospital, the survival rates are 1 to 5 percent" (International Association of Firefighters [IAFF], 2009, p. 1). The findings in this study demonstrate a survival to hospital admission of 31.8 percent. Although the causation for this finding is unknown, the study did demonstrate in its findings that there was no statistical correlation between survival to hospital admission and response time. A key component in comparing data outcomes is the study's rigor to examine identical outcomes. The term used by the American Heart Association, "survival rates" (IAFF), points out a distraction in the study's findings. Survival rates are vague as one does not know if that refers to survival to hospital admission, survival to hospital

discharge, survival after one year, or survival of event which is equivalent to a return of spontaneous circulation for greater than 20 minutes.

The return of spontaneous circulation (ROSC) presented similar findings to the hospital survival rates. The data collected indicated that 10 of 44 or approximately 22.73 percent of the cardiopulmonary arrest patients in the study had a return of spontaneous circulation. Again, the causation for this finding is unknown, but the study did demonstrate in its findings that there was no statistical correlation between ROSC and response time.

In conclusion, the study's data did not provide a correlation between response times and patient outcomes, and the findings from this small study appear congruent with larger studies such as the OPALS Study. In the OPALS Study, it included 5,638 patients who had a cardiac arrest outside of the hospital.

> The primary outcome, the rate of survival to hospital discharge, did not improve significantly from the rapid-defibrillation phase to the advanced-life-support phase (5.0 percent to 5.1 percent, P=0.83)….These results are consistent with previous case series that demonstrate poor survival after out of hospital cardiac arrest, despite the benefit of advanced life support interventions. (Stiell et al., 2004, p. 1)

These findings require a reflection on text found in the 2004 Edition of NFPA 450 *Guide for Emergency Medical Services and Systems*. It defines NFPA 1710 as "an industry standard on which fire department-based EMS system design analysis may be based. This voluntary standard contains minimum requirements relating to the organization and deployment of emergency medical operations the public by 'substantially all career fire departments'" (National Fire Protection Association 450, 2004, p. 450-10). In the end, compliance to the industry standard is voluntary.

Authors Interpretation and Organizational Implications

When viewed holistically, the outcome of the research is unimpressive. No operational decisions will be anchored to the findings. However, when the proverbial onion is peeled and the core is exposed there is value in dissecting components of an organization's service. In 2008, EMS incidents accounted for 62% of Laguna Beach Fire Department's total incidents. Therefore, examining quantitative outcomes related to Laguna Beach Fire Department's EMS delivery system against national standards is a seemingly prudent exploration. In fact NFPA 1710 requires it. NFPA 1710 Section 5.3.4.1 states: "The fire department shall institute a quality management program to ensure that the service has response times as required in 4.1.2.1 for all medical responses" (National Fire Protection Association, 2004, p. 1710-18). The logic at this point is reasonably soluble, yet the difficulties arise with a closer examination of the ALs time standard. "When provided, the fire department's EMS for providing ALS shall be deployed to provide for the arrival of an ALS company within an 8-minute response time to 90 percent of the incidents as established in Chapter 4" (National Fire Protection Association, 2004, p. 1710-18). The complexity of the 38 aforementioned words is virtually inexplicable. Why 8-minutes? Why response time? Why 90 percent of the time? Why cannot these answers be explained and verified with scientific rigor? NFPA 1710 is held in such regality with members of the fire service that to even write questioning the content of the document is unpleasant and the writer skates on the thin ice of heresy. Perhaps therein lies the value of this research. Groupthink may be an intoxicant blurring objectivity. The fire service is marching down the road of adherence to NFPA 1710, and perhaps that is the nation’s ultimate fire service strategic plan. Perhaps that is good, and questioning origins and efficacy of time standards is bad. The train of conformity to the ALS 8-minute response time dogma is going full steam ahead as apparent in the 2009 NFPA

1710 Report on Proposals. The proposed language is as follows: "When provided, the fire department's EMS for providing ALS shall be deployed to provide for the arrival of an ALS company within an 8-minute travel time to 90 percent of the incidents provided a first responder with AED or BLS unit arrived in four minutes or less travel time as established in Chapter 4" (National Fire Protection Association 1710, 2008, p. 1710-18). The informational references noted in the 2004 NFPA 1710 and the proposed 2009 NFPA 1710 appear identical, yet change was proposed and accepted. Why? The substantiation simply stated.

> The committee is changing the term 'response time' to 'travel time.' In 5.3.3.4.3, the additional wording is to clarify that ALS arrival within 8 minutes is contingent upon first responders with AED or a BLS unit arriving within 4 minute travel time. (National Fire Protection Association 1710, 2008, p. 1710-18)

The Executive Leadership class examined the poem *Beowulf* and concluded that Grendel was only a symptom of the disease.

RECOMMENDATIONS

The data, raw and unemotional, suggest there is no correlation between the ALS 8-minute response time as identified in NFPA 1710 and patient outcomes for those patients who experienced a cardiopulmonary arrest; however, the content of the ARP tripped over the concept of life's statistical value. To make recommendations could suggest that an omnipotent evaluation, conclusion, and adjustment to life's value can be postulated. This researcher is not suggesting that conclusion, but concedes that additional research is needed to help the fire service scientifically define the benefit of its service. In an idealistic sense, it is possible to weigh the value of scientific data against the statistical value of life; however, in the context of

decisions that could change seminal beliefs, the impact is likely far from idealistic. The research provided opportunities to suggest recommendations.

1. The findings were limited by the size of the sample. Therefore, additional studies should be conducted using larger sample sizes.
2. Further analysis is required to evaluate the impact ALS response time has on events other than cardiopulmonary arrest.
3. In the course of this research it was identified that in some cases the prehospital care reports (PCR) lacked completeness. Therefore, the Laguna Beach Fire Department should enhance its continual quality improvement program with an emphasis on PCR documentation.
4. With the automatic vehicle locator (AVL) data available to the Laguna Beach Fire Department it is recommended that an analysis be conducted to determine the accuracy of the times documented on prehospital care reports with the times recorded from the AVL data.
5. It is recommended that this information be shared with members of the Laguna Beach Fire Department for their own analysis and subsequent recommendations.

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APPENDIX A: 2006 CARDIOPULMONARY ARREST DATA

Incident Number	Time of Day	ALS Response Time	Age	Gender	Asystole[a]	V-Fib[b]	PEA[c]	ROSC[d]	CPR PTA[e]	AED PTA of ALS[f]	Survival to Hospital Admission[g]	BLS PTA of ALS[h]
06-128	08:08AM	0:03:28	86	1	1	0	0	1	1	0	1	0
06-166	06:46PM	0:07:48	73	1	1	0	0	0	0	0	0	0
06-423	07:40AM	0:03:16	62	1	0	1	0	1	1	1	0	1
06-519	09:52AM	0:02:44	45	1	0	1	0	1	1	0	1	0
06-566	01:20PM	0:02:28	87	1	0	1	0	1	0	0	0	0
06-743	11:20AM	0:01:07	75	1	0	0	1	0	0	0	0	0
06-767	12:25PM	0:03:23	30	1	0	1	0	0	1	0	0	0
06-821	09:13AM	0:04:30	57	1	1	0	0	0	0	0	0	0
06-1075	05:42AM	0:02:41	70	1	0	1	0	1	1	0	1	0
06-1431	06:30PM	0:03:02	54	0	1	0	0	0	0	0	0	0
06-1690	11:39AM	0:03:00	41	1	0	1	0	0	1	0	0	1
06-1695	05:20PM	0:05:19	59	1	1	0	0	0	1	0	0	1
06-2046	05:15AM	0:05:33	88	1	0	1	0	0	0	0	0	1
06-2275	09:10PM	0:02:15	19	1	1	0	0	0	1	1	1	1
06-2390	00:07AM	0:03:25	59	1	1	0	0	0	0	0	0	0
06-2593	11:55PM	0:01:04	61	1	0	1	0	0	0	0	0	0

[a]Asystole is "a heart rhythm indicating absence of any electrical activity in the heart" (Werman, 2008, p. 1245). [b]Ventricular fibrillation is "a continuous, uncoordinated, chaotic rhythm which does not produce a pulse" (Werman, 2008, p. 1255). [c]Pulseless electrical activity is "a condition in which the heart generates relatively normal electrical rhythms but fails to perfuse the body because of an absent cardiac output" (Werman, 2008, p. 1252). [d]Return of spontaneous circulation. [e]CPR prior to arrival of ALS personnel. [f]Automated external defibrillation was employed and an electrical shock was administered prior to the arrival of ALS personnel. [g]Patient survived to hospital admission. [h]Basic life support personnel arrived prior to the arrival of ALS personnel.

APPENDIX B: 2007 CARDIOPULMONARY ARREST DATA

Incident Number	Time of Day	ALS Response Time	Age	Gender	Asystole[a]	V-Fib[b]	PEA[c]	ROSC[d]	CPR PTA[e]	AED PTA of ALS[f]	Survival to Hospital Admission[g]	BLS PTA of ALS[h]
07-1442	05:48AM	0:04:58	3	1	1	0	0	0	1	0	0	0
07-2046	12:38PM	0:03:00	73	0	0	1	0	0	1	0	0	0
07-2073	02:06PM	0:03:49	85	0	1	0	0	0	1	0	0	0
07-2160	09:03PM	0:04:00	82	1	0	0	1	0	0	0	0	0
07-2189	02:45PM	0:02:27	67	1	0	0	1	0	1	1	0	0
07-2249	05:37PM	0:08:17	64	0	1	0	0	1	1	1	1	1
07-2593	03:16PM	0:12:01	51	1	1	0	0	0	1	0	0	0

[a]Asystole is "a heart rhythm indicating absence of any electrical activity in the heart" (Werman, 2008, p. 1245). [b]Ventricular fibrillation is "a continuous, uncoordinated, chaotic rhythm which does not produce a pulse" (Werman, 2008, p. 1255). [c]Pulseless electrical activity is "a condition in which the heart generates relatively normal electrical rhythms but fails to perfuse the body because of an absent cardiac output" (Werman. 2008, p. 1252). [d]Return of spontaneous circulation. [e]CPR prior to arrival of ALS personnel. [f]Automated external defibrillation was employed and an electrical shock was administered prior to the arrival of ALS personnel. [g]Patient survived to hospital admission. [h]Basic life support personnel arrived prior to the arrival of ALS personnel.

APPENDIX C: 2008 CARDIOPULMONARY ARREST DATA

Incident Number	Time of Day	ALS Response Time	Age	Gender	Asystole[a]	V-Fib[b]	PEA[c]	ROSC[d]	CPR PTA[e]	AED PTA of ALS[f]	Survival to Hospital Admission[g]	BLS PTA of ALS[h]
08-198	12:33PM	0:02:37	69	1	1	0	0	0	1	0	1	0
08-309	07:49PM	0:09:42	78	1	1	0	0	1	1	1	1	1
08-365	01:37PM	0:04:24	83	1	0	1	0	1	0	0	1	1
08-390	11:23AM	0:07:09	48	0	1	0	0	0	1	0	0	0
08-400	03:39AM	0:07:11	76	1	1	0	0	0	1	0	0	0
08-515	09:34AM	0:03:33	83	0	1	0	0	0	0	0	0	1
08-614	03:14AM	0:00:12	2	0	1	0	0	0	1	0	1	0
08-769	12:17PM	0:06:17	86	1	0	1	0	1	1	1	0	1
08-776	06:15PM	0:05:52	58	1	0	0	1	0	1	1	0	1
08-782	07:05AM	0:08:33	9	1	0	1	0	0	1	0	1	1
08-785	09:31AM	0:02:33	53	1	1	0	0	0	1	0	0	1
08-795	08:34AM	0:00:59	41	1	1	0	0	0	1	0	0	0
08-1013	07:36AM	0:07:10	75	1	0	1	0	0	0	1	1	1
08-1627	09:49AM	0:00:00	88	1	1	0	0	0	0	0	1	0
08-1647	03:27PM	0:13:00	58	1	1	0	0	0	1	0	0	1
08-2108	09:51AM	0:03:36	20	1	1	0	0	0	0	0	0	1
08-2210	05:20PM	0:03:50	89	0	0	1	0	0	1	0	0	1
08-2448	09:52PM	0:07:24	74	1	1	0	0	0	1	1	0	1
08-2484	01:29PM	0:07:25	69	1	1	0	0	0	1	0	0	1

[a]Asystole is "a heart rhythm indicating absence of any electrical activity in the heart" (Werman, 2008, p. 1245). [b]Ventricular fibrillation is "a continuous, uncoordinated, chaotic rhythm which does not produce a pulse" (Werman, 2008, p. 1255). [c]Pulseless electrical activity is "a condition in which the heart generates relatively normal electrical rhythms but fails to perfuse the body because of an absent cardiac output" (Werman, 2008, p. 1252). [d]Return of spontaneous circulation. [e]CPR prior to arrival of ALS personnel. [f]Automated external defibrillation was employed and an electrical shock was administered prior to the arrival of ALS personnel. [g]Patient survived to hospital admission. [h]Basic life support personnel arrived prior to the arrival of ALS personnel.

APPENDIX D: 2009 CARDIOPULMONARY ARREST DATA

Incident Number	Time of Day	ALS Response Time	Age	Gender	Asystole[a]	V-Fib[b]	PEA[c]	ROSC[d]	CPR PTA[e]	AED PTA of ALS[f]	Survival to Hospital Admission[g]	BLS PTA of ALS[h]
09-190	06:55AM	0:03:27	45	1	1	0	0	0	0	0	1	1
09-292	12:23PM	0:00:35	48	1	0	1	0	1	0	0	1	0

[a]Asystole is "a heart rhythm indicating absence of any electrical activity in the heart" (Werman, 2008, p. 1245). [b]Ventricular fibrillation is "a continuous, uncoordinated, chaotic rhythm which does not produce a pulse" (Werman, 2008, p. 1255). [c]Pulseless electrical activity is "a condition in which the heart generates relatively normal electrical rhythms but fails to perfuse the body because of an absent cardiac output" (Werman, 2008, p. 1252). [d]Return of spontaneous circulation. [e]CPR prior to arrival of ALS personnel. [f]Automated external defibrillation was employed and an electrical shock was administered prior to the arrival of ALS personnel. [g]Patient survived to hospital admission. [h]Basic life support personnel arrived prior to the arrival of ALS personnel.