Determining EMS Effectiveness

Executive Leadership

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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 that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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ABSTRACT

This research project examined methods for determining the effectiveness of the Hobart Fire Department's emergency medical services. The purpose of this research project was to solve an existing problem and to improve performance.

The problem was that the Hobart Fire department lacks a means of determining the effectiveness of its emergency medical services. Service delivery has traditionally been reactive rather than proactive. Action research was used to answer the following questions:

1. What are the key elements to measure the effectiveness of emergency medical services?
2. What key indicators can be utilized to improve performance?
3. How can the Hobart Fire Department improve the effectiveness of emergency medical services?

The procedures consisted of a literature review and analysis of available department statistics. The results concluded that cardiac arrest survivability rates are considered the gold standard for determining EMS effectiveness. Recommendations included utilization of statistical data to measure the effectiveness of early CPR, early defibrillation and advanced life support response times.

TABLE OF CONTENTS

INTRODUCTION

This research project will examine methods for determining the effectiveness of the Hobart Fire Department's emergency medical services. The problem is that the Hobart Fire Department lacks a means of determining the effectiveness of its emergency medical services. Service delivery has traditionally been reactive rather than proactive. The purpose of this research project is to solve an existing problem and to improve performance.

The results of this research project are intended to develop strategies to further improve performance. These strategies will then be applied to further enhance the Hobart Fire Department's effectiveness in providing emergency medical services and ultimately improve performance. This is an action research project. The research questions to be answered are:

1. What are the key elements to measure the effectiveness of emergency medical services?
2. What key indicators can be utilized to improve performance?
3. How can the Hobart Fire Department improve the effectiveness of emergency medical services?

BACKGROUND AND SIGNIFICANCE

The City of Hobart is a charter law city with a council/mayor form of government. The city is located in Lake County, Indiana. Lake County is located in the Northwest corner of the State of Indiana. The City of Hobart encompasses approximately 35 square miles (United States Census Bureau [USCB], 2000).

The community has a population of approximately 26,000 people (USCB, 2000). The make-up of the community consists primarily of residential housing, a large retail area, and a limited number of small industrial sites.

The Hobart Fire Department has four stations that are geographically located in four equal parts of the city, creating four separate response districts. Station 1 houses and staffs one front line aerial/pumper with two personnel, one Advanced Life Support (ALS) ambulance with two personnel, one command vehicle staffed by a battalion chief, and one reserve engine. Total staffing at Station 1 per day is 5 people. In addition, Station 1 consists of administrative personnel, including the fire chief, assistant chief, director of fire prevention, fire inspector, a secretary and the director of emergency medical services.

Station 2 is located on the west side of Hobart and houses a first-line engine as well as an ALS ambulance. Station 2 is staffed with a total of 4 personnel.

Station 3 is located in the far northeast corner of the city. Station 3 houses 2 personnel who staff a first-line engine. Also located at Station 3 is a dive-rescue truck and boat.

Station 4 is located near the southern boundary of the City of Hobart. It is staffed each day with four personnel. Station 4 houses one first-line engine, one ALS ambulance, two reserve ALS ambulances, a tanker, as well as a reserve aerial platform. Station 4’s response area includes a large retail shopping corridor. It has been estimated that during the holiday shopping season the day time population of the population within district 4 can swell to in excess of 125,000 people during peak hours.

Beginning in the early 1980's the City of Hobart began providing emergency medical services (EMS). The original emergency medical response was provided by one Basic Life Support (BLS) ambulance staffed with two civilian emergency medical technicians (EMTs). The fire department supplemented the ambulance response by providing two firefighters trained in first-aid on life-threatening calls. Prior to 1980, EMS was provided by local funeral homes.

In 1992, Hobart started providing emergency medical services at the ALS level. This was accomplished by staffing a chase car with a part-time paramedic hired from neighboring communities. Transportation was provided by two BLS ambulances. The BLS ambulances were each staffed with two firefighter/EMTs. Additionally, three civilian EMTs were enrolled in paramedic school.

In 1994, the City of Hobart initiated a program to merge the civilian EMS department into the fire department. Civilian EMTs were given the opportunity to cross train as firefighters and current fire department personnel were encouraged to attend paramedic school. Beginning in 1999, all applicants to the fire department were required to be certified at the paramedic level prior to applying for employment.

The Hobart Fire Department currently staffs three ALS ambulances and four first-line engines equipped with automated external defibrillators (AEDs). Each engine is also equipped with Basic Life Support equipment and is certified by the State of Indiana as a BLS Non-Transport Vehicle. The Hobart Fire Department roster consists of fifty-seven sworn personnel. Eighteen firefighters are certified as paramedics and another twenty-seven are certified emergency medical technicians. The remaining members of the department are certified first responders.

In 2002, the department initiated a computerized EMS reporting system utilizing software provided by the State of Indiana. The software allows the collection of specific data sets for analysis. The fire department is in the initial stages of utilizing this statistical information for the purpose of quality improvement.

The purpose of this research project is to provide a method for determining the evaluation of past performance, analysis of current practices and to develop strategies to further improve performance. These strategies will then be applied to further enhance the Hobart Fire Department's effectiveness in the provision of emergency medical services. The results of this research are intended to have a significant impact on how the Hobart Fire Department determines the effectiveness of service delivery. Currently, the Hobart Fire Department does not have in place a program to measure the effectiveness of its emergency medical services.

This applied research project will fulfill the requirements associated with the *Executive Leadership* (EL) course, a component of the Executive Fire Officer Program at the National Fire Academy (NFA). This research is in accordance with the course goal as stated in the *Executive Leadership Student Manual*, "The chief fire executive will develop the ability to conceptualize and employ the key processes used by effectve executive-level managers." (National Fire Academy [NFA], 2005, p. v).

This research is linked to the United States Fire Administration's (USFA) fourth operational objective. The fourth operational objective is to "promote within the community a comprehensive, multi-hazard risk reduction plan led by the fire service organization" (NFA, 2002, p. II-2).

LITERATURE REVIEW

Methods of Measuring EMS Effectiveness

An extensive literature review was conducted to examine information regarding what methods were most effective in determining the effectiveness of EMS, The recommendations of the American Heart Association as well as the USA Today articles by Robert Davis were referenced. These resources proved to be extremely valuable and greatly influenced the applied research project.

The AHA (2000) surmises that, “the best way to evaluate the strength of the community Chain of Survival is to assess the survival rates achieved by the emergency cardiac care (ECC) system (p. I-363). Furthermore, the AHA stated (2000), “The Chain of Survival model suggests an important dynamic to consider when performing an evaluation of an EMS system” (p. I-368).

The AHA further reinforced their position in 2003. According to the AHA (2003):

> The effectiveness of an ECC system can not be evaluated by examining an individual link-the whole system must be evaluated. The rate of survival has emerged as the “gold standard” for determining the effectiveness of treatment of sudden cardiac arrest (p. 44).

Writer Robert Davis in his July 3003 article, “*Keys to EMS Success*”, attributed the City of Houston’s high rate of cardiac arrest survival to better measurement. Davis wrote, “Houston raised its success rate for saving cardiac arrest victims from nearly zero to 21% by measuring repose times”(Davis, 2003a).

Davis further discovered that response times and the time interval between collapse and early defibrillation played a significant role when compared to survival rates. When Boston looked closely at each response to cardiac arrest, the city found that crews simply could not reach some victims within six minutes-the dividing line between life and death. In response to these statistics, Boston launched an effort to involve citizens in saving lives, offering CPR training to individuals, churches, clubs and anyone who requested it. As a result, Boston's bystanders CPR rate is thirty-percent, contributing to its forty percent survival rate. Boston's survival rate is now the second highest in the nation (Davis, 2003c).

Cardiovascular disease is the single greatest cause of death in the United States. Every year more than 480,000 Americans die from a heart attack or its complications. About half of those deaths result from sudden cardiac arrest, a complication of a heart attack. A cardiac arrest can occur within seconds of the heart attack, before the victim arrives at the hospital. It will result in death unless immediate emergency treatment is provided (AHA, 1998).

According to a report by the Northwest Indiana Quality of Life Council, heart disease and cancer continue to be the leading causes of death in Lake, LaPorte, and Porter Counties. The percentage of deaths due to heart disease is somewhat higher in Lake and Porter Counties than it is in the state as a whole. In 2001, thirty-nine percent of all deaths that occurred in Lake County were attributed to heart disease (Northwest Indiana Quality of Life Council [NWIQLC], 2003).

Most victims of cardiac arrest are middle-aged or elderly. Though the average victim is about 65 years old, some victims are in their 30s or 40's. Most collapse at home (Newman & Christenson, 1998, p.1). For many, there is no previous history of heart problems. Sudden

cardiac arrest is often the first symptom. Nationally, the average survival rate for SCA nationally is five percent (Davis, 2003b).

An extensive literature review was conducted to examine the existing body of information regarding sudden cardiac arrest. Various publications were analyzed. As a result, this research recognized the concept of the *Chain of Survival*, as prescribed by the American Hear Association, as being vital in maximizing cardiac arrest survival rates. The literature review consisted of an examination of medical, fire service and scientific journals, textbooks, EMS research material, position statements, as well as various published reports and articles. This comprehensive search for literary resources added an enhanced understanding of the key elements crucial to the fire department's effectiveness in responding to cardiac arrests.

In summary, the literature review indicates that cardiac arrest survival rates are the key standard for measuring the effectiveness of EMS. The collection and analysis of data was of the highest value in assessing the strengths and weaknesses of each individual link in the Chain of Survival.

The writings of Newman and Christenson (1998) influenced this research by proving insight to the development of a comprehensive approach to challenging cardiac death. USA Today (Davis, 2003a) published a series of articles in July of 2003. As a result of an eighteen month study, USA Today (Davis, 2003a) documented the effectiveness of EMS departments in the nation's largest cities. These series of articles proved to be extremely valuable and greatly influenced the applied research project.

This section will discuss the critical findings in the areas of:

1. Early Access
2. Early Cardiopulmonary Resuscitation(CPR)
3. Early Defibrillation
4. Early Advanced Cardiac Life Support (ACLS)

Early Access

The American Heart Association addressed the issue of early access in its *ACLS: Principles and Practice* textbook (2003). The AHA (2003, p.45) states that:

> Early access encompasses the events initiated after the patient's collapse until the arrival of EMS personnel prepared to provide care. Recognition of early warning signs, such as chest pain and shortness of breath, encourages patients to activate the emergency response system before collapse. This "early recognition" is the key component of the early access link. In fact, it is so important that experts attending the 1999 Evidence Evaluation Conference considered separating early recognition from early access to make a total of 5 links in the Chain of Survival.

The AHA (2003, p. 45) goes on to identify the following events, each of which must occur rapidly, as key elements in the early access link. The key elements according to the AHA (2003) are:

- Early identification of the patient's collapse or signs of emergency by someone who activates the system
- Rapid notification (usually by telephone) of the Emergency Medical Dispatcher (EMD)

- Rapid recognition by the EMD of a potential cardiac arrest or emergency
- Immediate initiation of an EMS Response (both BLS-level and ACLS-level personnel respond simultaneously)
- Rapid directions, as needed, to guide EMS responders to the patient
- Determination by the EMD of the need for dispatcher instruction for CPR or defibrillation
- Rapid arrival of properly equipped EMS responders at the scene plus short "intervals to locate" and arrive at the patient's side
- Immediate assessment and management of the cardiac arrest (p. 45)

Use of a 2 or 3 digit dedicated number has simplified and shortened access to emergency response. Sophisticated telecommunications systems now make it possible for EMDs to identify the location and telephone number of the incoming call (AHA, 2003, p.45). 1998, according to Newman and Christenson (p. 8), Eighty-five percent of the population and fifty percent of the geographical area of the U.S. has 9-1-1 emergency telephone coverage. Recent statistics published in Emergency Medical Services Magazine (EMS, Dec 2003, Vol. 32, Number 12) identified ninety-nine percent of Indiana's population was covered by 9-1-1 and eighty-five percent was covered by enhanced 9-1-1 (EMS, 2003, Vol. 32, Number 12, p. 44).

In the late 1980's EMS leaders developed the highly successful concept of pre-arrival instructions that the EMD gives to the caller during a 911 call.

Newman and Christenson (1998) wrote:

> Less than one-third of dispatch centers in the U.S. provide dispatcher assistance and most of these are large, urban areas. To address this problem, medical authorities urge more widespread implementation of this specialized training. The National Heart Attack Alert Program recommends that all EMS dispatchers receive EMD training and that "dispatch life support be adopted nationwide". The National Association of EMS physician urges that pre-arrival instructions become a "mandatory function of each EMD in a medical dispatch center". The National Association of State EMS Directors also endorses the concept (p. 9).

This researcher found that no statistical information was available from the State of Indiana regarding the number of departments in Indiana that utilize EMD. The City of Hobart has yet to implement EMD.

In summary, the research seems to indicate that rapid recognition of an emergency prior to the victim collapsing is imperative in order to initiate the succeeding links in the Chain of Survival. Additionally, the use of enhanced 9-1-1 in conjunction with Emergency Medical Dispatch instructions plays a significant role in the patient's resulting outcome.

Early CPR

The second link in the AHA's *Chain of Survival* is early CPR. Recently published materials from the American Heart Association provide valuable information regarding the importance of early CPR that greatly influence the research.

The AHA (1999) describes this second link:

> CPR is a set of actions that the rescuer performs in sequence to assess and support airway, breathing, and circulation as needed. CPR is performed in steps so that the rescuer provides only the support the victim needs.
>
> CPR is the critical link that buys time between the first link (early access to the emergency response system) and the third link (early defibrillation). CPR supports delivery of oxygen to the brain and heart until defibrillation or other advanced care can restore normal heart action. *Victims of out-of-hospital cardiac arrest who receive CPR from bystanders are more than twice as likely to survive as victims who do not receive CPR.* The earlier you give CPR to a person in cardiac or respiratory arrest, the greater the victim's chance of survival (p. 9).

Furthermore, the AHA (1999) establishes goals for early defibrillation. According to the AHA, "outside the hospital, first shock provided within 5 minutes from the call to EMS to defibrillation; inside the hospital, first shock provided within 3 minutes from collapse to defibrillation" (AHA, 1999, p.52). The results of research by Brillhart, Rea, Becker, Eisenberg, and Murray (2002) collaborate the efficacy of the AHA's establishes call-to-shock time goal. The study attempted to measure the time from on-scene emergency medical technician (EMT) recognition of cardiac arrest to AED application and shock in ventricular fibrillation arrest. In addition, the authors endeavored to compare the results with subsequent patient outcomes.

Brillhart et al. (2002) wrote:

> The findings of this study suggest that a 1-minute goal and a 90-second minimum standard for time to first shock are appropriate for EMT AED defibrillation in the field. Such efforts may aid in the improving the outcome of cardiac arrest (p. 376).

Just a year later, the AHA (2000, I-23) further reinforced their position by stating:

> Early CPR is the best treatment for cardiac arrest until the arrival of an AED and advanced cardiovascular life support (ACLS) care. Early CPR prevents VF from deteriorating to asystole, may increase the chance of defibrillation, contributes to preservation of heart and brain function, and significantly improves survival.

Additionally, the AHA (2003) stated:

> Many articles have been compiled results of studies that consistently confirm the value of bystander-initiated CPR started after the victim's collapse. The probability of survival to hospital discharge can double when bystanders initiate CPR. The value of bystander CPR appears to be particularly significant for infants and children. The best survival has been observed in infants who receive CPR from their parents, in submersion victims, and in children who receive immediate bystander CPR (p.46).

Newman and Christenson (1998) recommend the following steps in order for communities to strengthen the early CPR link:

- Ensure that the personnel who serve your community or workplace (e.g., firefighters, police officers, security officers, corporate safety personnel) have CPR training and review their skills on a regular basis.

- If CPR is not offered in local schools, get it started. Ensure that all students learn CPR before they graduate from high school. In time, your community will have a broad base of citizens trained in CPR.
- Work with the American Heart Association, the American Red Cross, the National Safety Council, local EMS agencies and fire departments to promote widespread CPR training (p. 10).

Although the resources referred to in the literature review agree upon the importance of bystander CPR, there appears to be no assurances that CPR will be initiated, even among CPR trained witnesses. A research of Casper, Murphy, Weinstein, and Brinsfield (2003) concluded that “victims of cardiac arrest are more likely to receive CPR when the event was witnessed by bystanders unknown to the victim than if the arrest is witnessed by friends or family”. They further suggest that, “there may be psychological barriers to overcome to perform CPR on a known victim” (p. 301).

The American Heart Association addressed this very concern in 2003.

The AHA (2003) states:

> Despite the value of early initiation of CPR by a trained layperson, no research has confirmed a method that increases the probability that a witness actually will start CPR. Randomized community intervention trials, such as sending out a short CPR video, direst mail campaigns, home visits by nurses and CPR trainers, and targeting relatives of high-risk persons, do not seem to increase the likelihood that CPR will be

> performed or EMS called. In contrast, parents of high-risk infants who learn CPR appears to perform it willingly and successfully (p.46).

In summary, the research indicated that the initiation of CPR immediately following collapse is essential in the continued oxygenation of vital organs. Furthermore, the administration of CPR enhances the likelihood of successful subsequent defibrillation and other advanced resuscitation efforts. Regardless of the general acceptance of the benefits of CPR, there appeared to be no assurances that trained individuals would actually perform CPR, especially in instances in where the victim was known to them.

Early Defibrillation

The AHA (2001) presents the following case for public access defibrillation:

> Cardiac arrest usually results from some underlying form of heart disease. Most cardiac arrests are due to abnormal heart rhythms called arrhythmias. Ventricular fibrillation (VF) is the most common arrhythmia that causes cardiac arrest. VF is a condition in which the heart's electrical impulses suddenly become chaotic, often without warning. That causes the heart's pumping action to abruptly stop. When cardiac arrest occurs, the victim loses consciousness, has no pulse and stops breathing normally. Death follows within minutes.
>
> Defibrillation is the only known therapy for VF. This technique of giving an electrical shock can restore the heart's normal rhythm if it's done within minutes of the arrest. For every minute that passes without defibrillation, a victim's chances of

> survival decrease by 7-10 percent. After as little as 10 minutes, very few resuscitation attempts are successful (p. 1).

The American Heart Association (2003) further states:

> Any community that can achieve earlier defibrillation will improve its rate of survival from cardiac arrest because early defibrillation is the only link in the Chain of Survival that is both necessary and sufficient .The 3 links of early access, early CPR, and early advanced life support cannot improve survival without early defibrillation (p. 46).

Traditionally, the ability to defibrillate was held exclusively in the hands of trained medical personnel. Today, with the increased growth in technology, new generations of defibrillators make it possible for trained lay rescuers to delivery life saving defibrillation. The widespread use of automatic external defibrillators by the trained public is commonly referred to as Public Access Defibrillation (PAD).

Several professional organizations have published position statements regarding the use of PAD programs. The American College of Emergency Physicians (1999) stated:

> The efficacy of early defibrillation with the reliable technology of current automatic external defibrillators (AEDs) is proven and widely accepted within the out-of-hospital provider community. However, before early defibrillation programs can be promoted in a widespread manner, they must be integrated into or coordinated with EMS systems that are designed to maximize the potential for survival in the ventricular fibrillation victim.

Bradley and Sahni (2000) stated, “Increased survival has been postulated if other non-traditional first responders and minimally trained or untrained bystanders have access to AEDs.” Despite this endorsement the NAEMSP expressed the concern, “that providing these groups with access to AEDs could result in potential delays in activation of the EMS system that may be detrimental to the patient outcome” (p. 358).

Recently published studies support the efficacy of PAD programs. A large multi-center study funded by the National Heart, Lung and Blood Institute in collaboration with the American Heart Association concluded that AEDs in public places, combined with training, can double cardiac arrest survival rates. The study resulted in twenty-nine cardiac arrest survivors to hospital discharge in the group assigned to CPR plus AED compared to fifteen survivors in the group with CPR only. (Journal of Emergency Medical Services [JEMS], 2003)

The research conducted by MacDonald, Mottley and Weinstein (2002) demonstrated, “A rapidly deployable first-responder service permits early defibrillation minutes before arrival of EMS personnel. This rapid response positively impacts the return of spontaneous circulation and survival to hospital discharge after cardiac arrest” (2002, p. 4).

Recommendations from the research by Smith (2000, p.26) state that, “early bystander CPR and rapid defibrillation are the two major contributors to survival of adult victims of cardiac arrest.” Smith further suggests that PAD should include the use of defibrillation by lay persons at home as well as firefighters and police.

The importance of early shock for victims of VF is emphasized in the article by Robert Davis, “The Price of Just a Few Seconds Lost: People Die”. Davis interviewed Roger White, an

EMS physician and anesthesiologist at the Mayo Clinic. Dr White stated, “A one-minute decrease in the call-to-shock time increases the odds of survival by 57%. In other words, a three-minute reduction in call-to-shock time improves a victim’s odds of survival almost four-fold.” Davis went on to compare the call-to-shock time with survival rates in various U.S. cities. Davis (2003b) wrote:

> Seattle had a 45% survival rate, highest among the nation’s 50 biggest cities. On average, Seattle’s emergency crews took 8 minutes 46 seconds to shock victims of sudden cardiac. Oklahoma City had a 27 % rate; average call-to-shock: 7 minutes, 36 seconds. Tulsa, a 26% rate; average call-to-shock: 8 minutes, 46 seconds (Davis, 2003b).

The research appears to indicate very promising support for the widespread use of publicly accessible defibrillators. In contrast, other studies analyzed during this literature review reveal surprising and somewhat disturbing outcomes.

The research conducted by Lerner, Billittier, Newman, and Groh (2002) was conducted in order to determine the rate at which fire and police responders applied AEDs. Data was collected from twenty-one communities and encompassed 2,439 out-of-hospital cardiac arrests. The results demonstrated that first-responders did not apply AEDs to forty-two percent of the appropriate patients. (2002, p.379)

In response to the previously mentioned study, Lerner, Hinchey and Billittier (2003a) attempted to identify what barriers existed to the use of AEDs by firefighters and police officers. Although ninety-nine percent of the first responders surveyed believed that the AED program

should be continued, eighty–three percent of the respondents stated that they had been on the scene of a cardiac arrest yet failed to apply an AED (2003a, pp. 123-124).

A consequent research study endeavored to determine whether there were associations between the characteristics of first-responder AED training and AED application.

Lerner, Billittier, Shah, Newman, and Groh (2003b) concluded:

> The use of a national AED training curriculum, training to the level of Certified First Responder or higher, and the ability for each first responder to apply the AED during continuing training were associated with higher AED application rates. Continuing training within the first year did not appear to be as important as actually using the AED during the training (2003b, p. 456).

In summary, the literature review influenced the research by establishing the magnitude of the benefits of early access to defibrillation and its utilization. The research sustained the universal conjecture that electrical therapy is the definitive treatment for ventricular fibrillation and that the recommended goal for early defibrillation for patients suffering cardiac arrest outside of the hospital is within five minutes from the time of collapse (AHA, 1999).

However, as stated by the AHA (2003):

> Recent reports of unsuccessful early defibrillation initiatives, by police in Indiana and firefighters in Tennessee, teach a valuable lesson. To actually save lives, defibrillators must be in the hands of rescuers committed to the concept of early

> AED use. If personnel hesitate or fail to use their AED, survival will not increase (p. 47).

Early ACLS

The fourth and final link in the chain of survival, as defined by the AHA, is the early delivery of advanced cardiac life support to the cardiac arrest victim by highly trained EMS personnel.

The AHA (2003) states:

> EMS systems should have sufficient staff to provide a minimum of 2 responders trained in ACLS. Because of the difficulties in treating cardiac arrest in the field, additional responders should be present. In systems with survival rates of more than 20% for patients with VF, response teams have a minimum of 2 ACLS providers plus 2 BLS personnel on scene. Most experts agree that 4 responders (2 trained in ACLS and 2 trained in BLS) provide the most effective team in resuscitation of cardiac arrest victims. Although not all EMS system can attain this level of response, every system should actively pursue this goal (p. 47).

In 2001, the National Fire Protection Association (NFPA) published the *Standard for the Organization and Deployment of Fire Suppression Operation, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* (NFPA 1710). In regards to staffing, NFPA 1710 establishes that personnel deployed to ALS responses shall include a minimum of two members trained at the ALS level and two members trained at the BLS level arriving on scene within the established response time (Sec.5.3.3.4.4, 2001)

NFPA 1710 establishes the following response time objectives for EMS response:

1. Turnout time of one minute.
2. Four minutes or less for the arrival of an AED equipped unit with first responder of higher level capability.
3. Eight minutes or less for the arrival of an advanced life support unit.
4. Performance objective of not less than 90 percent for each response time (Sec.5.3.3.4, 2001).

Bailey and Sweeney (2003) stated in the National Association of EMS Physicians position paper, “Emergency medical services are time-driven. Response intervals can affect patient care and are thus a medical issue” (p. 397). Bailey and Sweeney further point out, “Shorter response intervals are not without costs. Shorter response intervals, especially when augmented by the appropriate use of lights and sirens, carry established, significant safety risks for EMS providers and the public alike” (2003, p. 399).

In summary, the available research material suggests that the optimal staffing for advanced life support units consists of two personnel trained at the ALS level arriving on scene within 8 minutes. It is further recommended that two personnel equipped with an AED and trained at the BLS level arrive on scene in four minutes or less and deliver the first shock within five-minutes from collapse and with 60 seconds upon arrival at the scene.

PROCEDURES

Action research was the method used to determine the results of this applied research project. This method was used in an attempt to solve an existing problem and to improve

performance. This research methodology was selected in hopes of applying new information, theories and methodologies to an actual organizational problem within the Hobart Fire Department. The research project was conducted in accordance with the June 1, 2002 Edition of the *Executive Fire Officer Program Applied Research Guidelines*.

Literature searches were conducted at the National Emergency Training Center's Learning Resource Center (LRC) in July of 2006 during the author's attendance at the NFA's *Executive Leadership* course. The LRC provided access to literary sources relative to the efficacy of early defibrillation.

Additional research of recent medical journals was conducted at the physician's library at St Mary Medical Center in Hobart, Indiana during September of 2006. Journals such as *Prehospital Emergency Care* provided recent studies germane to the research questions.

Extensive searches were also conducted on-line through Internet search engines to identify materials with content relative to cardiac arrest survival. As a result of examining resources available via the internet, the author discovered a series of articles published in July of 2003. After an eighteen month study, USA Today documented the effectiveness of EMS departments in the nation's largest cities. This series of articles proved to be extremely valuable and greatly influenced the applied research project.

Both the author's private collection of EMS literature and the Hobart Fire Department's library were examined throughout the research project to identify sources of information pertinent to the specific research questions. This consisted primarily of recently published journals such as *Emergency Medical Services Magazine* as well as the *Journal of Emergency Medical Services*.

Textbooks published by the American Heart Association were extensively reviewed. The AHA is internationally recognized as the leading source of educational material for the emergency treatment of cardiovascular disease. The American Heart Association's *Fundamentals of BLS for Healthcare Providers* (2001) and *Heartsaver CPR for the Lay Rescuer and First Responder* (1998) texts were referenced for specific facts and data relative to cardiopulmonary resuscitation.

Information regarding advanced life support benchmarks and standards were gleaned from the American Heart Association's *ACLS: Principles and Practice* (2003) text as well as the *Guidelines 2000 Cardiopulmonary Resuscitation and Emergency Cardiovascular Care* (2000) text. This information was compared to the National Fire Protection Association's (2001) *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments (NFPA 1710).*

It was the researcher's intent to utilize a comprehensive literary review to obtain the most up to date collection of information regarding factors that contribute to determining EMS effectiveness. Information from the literature review was consolidated, examined, analyzed and utilized to answer the research questions and to formulate the recommendations. The identified benchmarks and standards were also summarized within an appendix.

Assumptions and Limitations

It was assumed that all literary resources reviewed for this project were produced with objectivity and unbiased research. Limitations on this research project included the requirement to complete the project within the six months time period allowed by the NFA Applied Research Project Guidelines.

A voluminous amount of research material was identified, retrieved and examined in researching this project. Due to time constraints, much of the research material had to be consolidated for conciseness and narrowing of focus.

Another limitation acknowledged by the author was the lack of statistical information available regarding response data specific for the Hobart Fire Department. Therefore, the information obtained from the literary review was compared to the author's past experience and knowledge of the Hobart Fire Department's current operations and response procedures.

Definitions of Terms

Automatic external defibrillator (AED) is an external computerized defibrillator designed for use in unresponsive victims with no breathing and no signs of circulation. The AED captures the victim's heart rhythm through adhesive electrodes placed on the victim's chest. Once a shockable rhythm is identified, the AED automatically will deliver a shock through the adhesive electrodes.

Advanced cardiac life support (ACLS) refers to the attempts to restore spontaneous circulation with advanced airway management, tracheal incubation, defibrillation, and intravenous medications.

Basic life support (BLS) includes recognition of cardiac arrest, access to the EMS system and basic CPR.

Bystander CPR is an attempt by a bystander, layperson, or citizen to provide basic CPR.

Cardiac arrest is the cessation of cardiac mechanical activity. It is a clinical diagnosis confirmed by unresponsiveness, absence of detectable pulse and absence of breathing.

Cardiopulmonary resuscitation (CPR) is an attempt to restore spontaneous circulation through any of the broad range of maneuvers and techniques.

Defibrillation is a shock delivered to the heart in an attempt to restore normal heat rhythm.

Emergency cardiovascular care (ECC) system is the term which describes the full range of emergency cardiovascular care. The ECC system includes the care rendered by EMS professionals; activation of the EMS system; basic CPR rendered by witnesses; the Emergency Department that receives out-of-hospital patients; the hospital intensive care unit; inpatient and outpatient cardiac care rehabilitation; prevention programs and public access defibrillation.

Emergency medical dispatchers (EMD) are the personnel responsible for initial triage of telephone calls reporting an emergency, assessing the nature of the emergency, and dispatching the appropriate level of EMS responders to the scene of a medical emergency. In most EMS systems, EMDs also provide prearrival instructions to the caller including instructions for CPR and the use of an AED.

National Fire Protection Association (NFPA) develops and publishes the majority of the national consensus standards that are used by fire departments.

Ventricular fibrillation (VF) is a chaotic and disorganized heart rhythm that results in cardiac arrest.

RESULTS

The answers to the research questions are as follows:

Research Question 1

What are the key elements to measuring the effectiveness of emergency medical services?

The key indicator for determining EMS effectiveness is cardiac arrest survival rates. The American Heart Association states, “The best way to evaluate the strength of the community Chain of Survival is to assess the survival rates achieved by the emergency cardiac care (ECC) system (p. I-363). Furthermore, the AHA stated (2000), “The Chain of Survival model suggests an important dynamic to consider when performing an evaluation of an EMS system,

Research Question 2

What key indicators can be utilized to improve performance?

For victims of cardiac arrest suffering from VF, the optimal treatment is rapid defibrillation within 5 minutes of onset. EMS personnel should administer the initial shock with 60 seconds of arrival and a maximum of 90 seconds.

Basic life support units equipped with an AED and staffed by a minimum of two personnel, both trained at the BLS level, should arrive on scene within 4 minutes of dispatch in 90 percent of all incidences.

Units equipped at the advanced cardiac life support level should arrive within eight minutes or less for 90 percent of all incidences. These units should be staffed with a minimum of two personnel trained at the ACLS level. A turnout time of less than 1 minute should be expected of all units responding to any medical emergency.

Research Question 3

How can the Hobart Fire Department improve the effectiveness of emergency medical services?

The Hobart Fire Department can improve the chances of survival for victims of SCA by insuring response times and staffing capabilities are within the recommended standards.

Geographical locations which prohibited EMS arrival in less than 4 minutes should be considered as possible locations for public access defibrillation capabilities. Survivability for patients in these locations can be further enhanced via emergency medical dispatcher instructions and proper bystander intervention.

The reporting, collection and analysis of responses data and statistics when used in conjunction with patient outcome data proves an invaluable tool for quality assurance and improvement efforts.

DISCUSSION

The research reported here provides strong support for the American Heart Association's *Chain of Survival* model. The model describes the key elements for sudden cardiac arrest survival (AHA, 2000). The *Chain of Survival* model appeared to be the most effective means to save more people from out-of-hospital cardiac arrest. All future efforts by the Hobart Fire Department to challenge cardiac arrest should correlate with the *Chain of Survival* model.

Given that a chain is only as strong as its weakest link; it is this researcher's opinion that an inadequate link can ultimately lead to poor survival rates. Although no link should be weak, the question arises; which should be the strongest link?

Newman and Christenson (1998) espoused that public education and awareness is also a key to cardiac arrest survivability. The general public must be educated as to the signs and symptoms of a possible heart attack. Definitive treatment can be significantly delayed if the victim or family member fails to recognize that an actual emergency is occurring and subsequently delay response time.

Equally important is the number of laypersons trained in CPR. Seattle firefighters work as instructors and teach about 18,000 people a year. Since 1971, the city has trained 650,000

people. As a result, Seattle now has one of the highest bystander CPR rates in the nation, an estimated forty-four percent. This undoubtedly contributes to Seattle having the highest survival rate in the nation. Seattle's survival rate is forty-five percent compared to the national average of five percent (Davis, 2003b). This leads the researcher to believe that active promotion and delivery of CPR training to the general public can have a substantial impact on prehospital cardiac arrest survival.

Even if an individual is trained in CPR, research has shown that there is no assurance that a bystander will perform CPR. Casper et al. (2003) contended that significant psychological barriers exist which may lead an individual to hesitate initiating CPR to a friend, family member or stranger. Casper et al. found that "a low percentage of family members witnessing an arrest perform CPR even when a family member has known cardiac disease" (p. 301).

This hesitation can be mitigated by increasing public awareness and the implementation of EMD by Hobart dispatchers. Clear instructions from a dispatcher detached from the stresses of witnessing a patient collapse can calm and reassure the bystander. The highly trained and professional dispatcher can guide the caller through the emergency techniques which might otherwise be neglected.

Newman and Christenson (1998) proposed that if a community can achieve the goals of bystander CPR in at least half of all cases and ensure a call-to-shock time of less then seven minutes in ninety percent of cases, an estimated forty-five percent of victims will survive. Based on the number of cardiac arrests occurring in Hobart during 2003, nineteen lives could have been potentially saved. This standard, when applied, will have a significant impact on future cardiac arrest survival rates within the City of Hobart.

Bradley and Sahni (2000) have contended that early defibrillation, when used by trained emergency responders, is the most valuable. However, Bradley and Sahni warned that “by making AEDs available to minimally or untrained bystanders could result in potential delays in activation of the EMS system that may be detrimental to patient outcomes” (p. 358).

Based on the analyses of the research, this researcher espouses that just two variables account for why some patients suffering from cardiac arrest survive and others do not. Those two variables are how much time passes before someone starts CPR and how long it takes for the first shock to be delivered.

The AHA (2003) and the NFPA (2001) are both in agreement in regards to recommended response times and staffing requirements. These standards of care should be recognized as minimal benchmarks for any service that provides response to medical emergencies.

The recent research by Bailey and Sweeney (2003) fail to completely support the efficacy of rapid response times. Bailey and Sweeney had stated, “except for cardiac arrest, there is little or no scientific evidence suggesting a casual relationship between response interval and improved patient outcomes” (p. 397). Bailey and Sweeney also point out that shorter response times go beyond monetary costs and pose safety costs as well. The researchers state that, “shorter response intervals carry established, significant safety risks for EMS and the public alike. For this reason, simply going faster is not the solution” (p. 399).

Ultimately, the chance of surviving a cardiac arrest equates to a matter of geography. People needlessly die because some cities fail to make basic, often inexpensive changes in the way they deploy ambulances, paramedics and fire trucks. The Hobart Fire Department should identify such areas that are inaccessible within the recommended response capabilities and

supplement these locations with public assess defibrillation capabilities until resource location and allocation can be reevaluated and modified as needed.

The best way to improve the Chain of Survival is to develop high levels of evidence needed to refine efforts at responding to cardiac arrests. This is accomplished by meticulous and comprehensive collection, analysis and interpretation of data and statistics. Houston, TX raised its cardiac arrest survival rate from nearly zero to twenty-one percent by measuring response times (Davis, 2003c). The result was the same as in other cities that measured time: more lives were saved almost immediately.

The best test of an emergency system is how many victims of cardiac arrest it actually saves (AHA, 2003). Each EMS system needs to examine its performance by both performance variables and outcome variables and then devise a strategy to optimize patient outcomes. The Hobart Fire Department currently fails to utilize and appreciate the importance of meticulous data collection and analysis. This lack of data significantly limited the researcher's ability to assess current performance. Further study will be necessary to evaluate the effect of implementation of the recommendations of this applied research project.

RECOMMENDATIONS

Based on the research, the following recommendations are made:

1. The Hobart Fire Department should work closely with city officials to implement emergency medical dispatch. EMD should include; rapid recognition of a potential cardiac emergency, immediate initiation of EMS response, rapid directions to the responders, and determination by the dispatcher of the need for verbal instruction for CPR and use of an available AED.

2. The Hobart Fire Department should increase its public education efforts in an effort to enhance public awareness of the importance of bystander CPR and AED. HFD public educators should incorporate early recognition of heart attacks and preventative measures in its efforts at reducing community risks.
3. The Hobart Fire Department should evaluate its training program to make certain that all firefighters and EMTs can consistently utilize an AED to deliver an initial shock to a cardiac arrest victim within 60 seconds of arrival.
4. The Hobart Fire Department should immediately begin collecting, analyzing and interpreting response data. Empirical statistics should be shared amongst all participants in the ECC system in order maximize the chances of favorable patient outcomes.
5. The Hobart Fire Department should assess current response times and resource allocation to ensure compliance with the established response time standards.
6. The Hobart Fire Department should continue with its current hiring practices in order to increase the number of ACLS trained personnel.
7. The Hobart Fire Department should increase the number of vehicles equipped with AEDs to improve response capabilities.
8. The Hobart Fire Department should develop partnerships with outside organizations to help promote and fund public access defibrillation programs.

For other departments looking to evaluate the effectiveness of their emergency medical services, the Chain of Survival model has proven to be an effective tool. The effectiveness of an EMS system can not be evaluated by examining an individual link; the entire system must

be evaluated. The challenge to all departments is the development of a proactive strategy to respond in an inherently reactive environment.

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APPENDIX A

Recommended Response Time Standards

Table A1

Time to Delivery of First Shock from Collapse

Source	Time
Brillhart, Rea, Becker, Eisenberg & Murray (2002, p. 376)	Between sixty and ninety seconds
American Heart Association (1999, p. 52)	Less than five Minutes

Table A2

NFPA 1710 Response Time Standards

Action	Response Time
Turnout Time	Less than one minute
First Arrival of AED Equipped First Responder	Less than 4 minutes
First Arrival of Advanced Life Support Unit	Less than eight minutes

Note. Performance objective of not less than 90 percent for each response time