FACTORS INFLUENCING THE IMPLEMENTATION OF HELICOPTER AMBULANCE SERVICE IN MEDICAL FACILITIES

by

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ABSTRACT

FACTORS INFLUENCING THE IMPLEMENTATION OF HELICOPTER AMBULANCE SERVICE IN MEDICAL FACILITIES

The need for transporting patients who require emergency care—the critically ill or seriously injured from to motor vehicle crashes—either on-the-scene of the accident or between medical facilities, has resulted to the accelerated growth of Helicopter Emergency Medical Service (HEMS) programs worldwide. Particularly in the United States, the number of medical facilities deploying the HEMS programs has been steadily rising. According to the Association of Air Medical Services (AAMS), the helicopter ambulance programs in the U.S. have doubled during the past ten years.

Several studies have debated the sustainability of air ambulance service deployment for the injured victims of motor vehicle accidents. Although some studies do not prove that helicopter transports are ineffective, "it does however, raise serious questions about the appropriateness of the use of helicopter transport" (Cunningham et al. 1997). Helicopter ambulance assistance is considered a high cost service unit: the average disbursement for each helicopter intervention mission ranges between $8,000 and $12,000, which makes it very costly for all the parties involved.

The intent of this research study was to determine, list and rank in importance the factors influencing the implementation of helicopter emergency assistance programs and to rank them according to their significance in reference to the two survey instruments developed especially for the purpose of interviewing relevant specialists in the field of

civilian helicopter ambulance services. The study was performed in the greater Washington, D.C., and Baltimore area.

The first survey was conducted between May and September of 2008. The interviewees were requested to identify and list the factors which they associated with the decision for helicopter ambulance service intervention. Within three months' period, the second survey was performed. The interviewees were instructed to rank the top twelve factors which they cited in the first round of interviews, using a pair-wise comparisons questionnaire. Their responses were analyzed by means of the Bradley-Terry (BT, 1952) psychometric model to scale preferences and gauge the relative importance of the twelve factors.

The results of our research study have demonstrated that, among the specialists in the field, there is a noteworthy inclination to choose patient-related aspects, which constituted over two thirds of the total number of factors. For instance, the most highly ranked were the following attributes: access to definitive care, improving quality of services, and providing inter-facility service. Non-patient related factors were ranked as least relevant of all to be considered.

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Chapter 1

Introduction

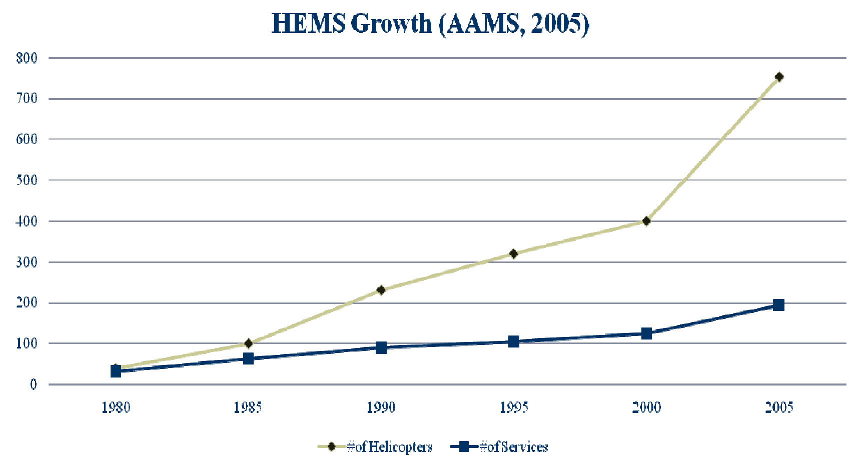
1.1 Overview of Air Ambulance Services

In the early 1970's, Dr. R Adams Cowley began in Maryland what was to become the first helicopter ambulance program that utilized police helicopters which had been specially adapted to civilian needs. He set up a statewide Emergency Medical Service (EMS) ground system that provided the same level of care to all the state's population. At about the same time, the first hospital-based civilian medical helicopter program was started "in 1972 with the "Flight for Life" program at St. Anthony's Central Hospital in Denver, Colorado." (Kelly D., 2007).

Two main factors affected the accelerated development of the EMS system in the early 1960's. The first one was the development of the defibrillator machine, which has been most helpful in cardiac arrest cases with patients who were a high fatality risk. The second factor was the rapid increase in highway motor vehicle accidents resulting in injuries and fatalities. According to the World Health Organization (WHO) "Global Burden of Disease Project" ; during the past decade, traumas subsequent to road traffic accidents have been rated as the second leading cause of mortality (deaths) within the young generation and, in the overall population worldwide, ninth among one hundred fatality cases.

Since mortality among casualties of traffic accidents is now considered a global phenomenon (WHO, Statistical Annex, 2004**),** many countries have been paying a great deal of attention to this issue. According to the Federal Aviation Administration (FAA), “Air medical transport falls into two categories. The first is emergency air rescue and recovery. In such cases, governmental agencies operate air ambulance interventions on-the-scene to extract and recover patients to transport them to definitive medical care facilities. Other forms of air ambulance service are used to transport patients between hospitals for continuation of specialized medical care or, in other cases, for transport over long distances of patients who are too ill or unstable to travel by a commercial airliner. Of the former, most are helicopter services; of the latter, a mixture between helicopter and fixed-wing operations” (Section II.7.2 FAA Transportation of Patients of Air Ambulance Guidelines).

Figure 1-1 Helicopter Emergency Medical Services (HEMS) Growth (AAMS, 2005)



Depending on the type of service, helicopter ambulance programs could be categorized into two major categories. The first category is on the injury on-the-scene service which requires attending to patients involved in trauma situations. These are mainly outcomes of motor vehicle crashes occurring in rural areas, or “penetrating” traumas happening in urban areas. The second category requires providing an inter-facility transport for patients already hospitalized but needing an emergency medical intervention at a highly specialized health care facility at another location.   Helicopter emergency medical transport programs have capabilities to offer both services and exceed those of ground Advanced Life Support (ALS) providers.

Integrating the air medical service program to the health system is considered as an essential constituent of modern-day EMS systems. Rapid transport is the main advantage over ground transportation in this time-sensitive care service. Additionally, a helicopter ambulance crew can often assure higher quality care than the traditional ground ambulance service. This is a crucial factor, especially for the on-scene service interventions.

Although most helicopter ambulance programs employ crews that consist of a pilot, a paramedic and a registered flight nurse, studies have shown that adding a physician to the team could greatly increase patients' chances for survival during the pre-hospital phase, particularly, in case of critical on-scene service (Baxt, 1986). Other studies (Lossius, H.M., et al. 2002**)** have shown that the probability of survival was increased and the "Life Years Gained" factor was improved as a result of adding an anesthesiologist to a rapid transport service crew in cases of patients in pre-hospital interventions.

On-scene helicopter ambulance services are usually initiated by first responders. These initial EMS personnel members respond to the scene of the accident and pursue the national guidelines for initiating such a service. Recently, some HEMS programs have been relying on the new technology called "ON-STAR" that General Motors (GM) has installed in some of its automobile models. The system's sensors can instantly evaluate the magnitude of the crash that the involved automobile has incurred and, therefore, the extent of the injuries that the car occupants have probably sustained may be easily assessed.

An inter-facility helicopter ambulance transport mission is usually initiated by the medical team of the referring hospital. Communications services operated by the air ambulance service providers usually facilitate such operations between referring and admitting hospitals (Larson, J.T., et al, 2004).

Patients from rural community hospitals transferred to urban specialized treatment facilities gain more incentives for their HEMS providers. This provision is consistent by most third-party payers, especially Medicare. Full-service rural hospital patients generate higher compensation rates than patients who are transferred from or within urban locations.

In general, air medical transportation is advantageous as it provides a higher level of medical care directly to the patient during the pre hospital phase and also provides a quicker response time. With interventions requiring this service, speed is of the essence. Response time for most helicopter ambulances for on-scene accidents is about 25 minutes. Most HEMS programs operate in a 130 to 150 mile radius. This capability often covers a wide range of terrain. Helicopter ambulances travel at an average speed of 120 miles per hour, which is of crucial importance, especially in traumas occurring in non-urban settings.

Speedier response is a huge advantage in case of remote HEMS missions. At the same time, the utilization of ground emergency service in a rural area to transport patients to a health facility at a distant urban location deprives that rural area of emergency care availability, leaving it cut off from access to trauma care.

Helicopter ambulance services can be called upon to operate in the most adverse weather conditions. According to the National Transport Safety Board (NTSB), the greatest single threat to the safety of HEMS missions is the weather (NTSB, 1988). For instance, on-scene emergency services can be required at any time for trauma victims during adverse weather conditions, which poses a potential threat to this type of rescue. As stated by the NTSB, the HEMS accident rate is 3.5 times greater than regular non-scheduled helicopter taxi operations' rate (NTSB, 1988). The average number of accidents for HEMS missions is about ten accidents per 100,000 hours of flight time (Bowden, 2003).

Important as civilian air ambulance service is for urban and suburban areas, it is even more beneficial for rural area patients. Due to traumas resulting from traffic accidents, the non-urban population has a higher mortality rate than the urban population. This state of affairs has been attributed to the "Delayed discovery of injury, long transport times, rudimentary training of pre-hospital personnel, fewer available physicians, and reduced exposure to trauma patients" (Fredrick, 1997). These factors are regarded as the major causes of fatalities among victims of motor vehicle accidents and other trauma patients. However, lack of adequate emergency care due to prolonged transportation time to or between medical facilities is ranked as the number one cause of high death rates.

According to the WHO findings, in the past two decades, this experience has become a global phenomenon. It is widespread, especially in developing countries that are limited in their scope of investments for health care projects. For instance, in Saudi Arabia, fatalities per 100,000 population are considered among the highest in the world together with Malaysia, South Korea, Latvia, and Colombia (Jacobs and Aeron-Thomas, 2002).

1.2 Statement of the Problem

As a part of an organized trauma system, HEMS significantly cuts the injury-to-operating-room time. In light of experience, there are other factors that influence rapid development of helicopter ambulance programs, specifically the growing number of traumas resulting from accidents occurring in rural and urban communities. Also, the use of navigation instruments, e.g., Global Positioning (GPS) tools, or night vision equipment that aids in mission maneuvering, have enhanced the HEMS services program. Furthermore, the rise in demand of specialized medical interventions has led to the increased need of helicopter air ambulance emergency service.

Inter-facility transport missions have also increased due to the development of high-tech medical equipment that can be placed in a helicopter ambulance to administer vital emergency care to patients. For instance, the use of a civilian helicopter air ambulance service is especially critical in rural areas containing major highways and in urban areas with dense population. Due to traffic congestion, such conditions create complications in reaching the scene of an accident.

Helicopter ambulance utility is considered a high cost unit of service. The average disbursement for each helicopter ambulance dispatch ranges between $8,000 and $12,000.Therefore the utilization of a civilian helicopter ambulance service to reach highway accident victims must be justified. It is indispensible if the injured in need of emergency care cannot reach a trauma center within the “golden hour,” or if medically isolated populations cannot reach critical care facilities in a timely manner. Thus, helicopter ambulances have proved themselves to be more effective in rural than urban areas (Van Wijngaarden, 1996). Also, air ambulance services have been more effective than ground services in transporting trauma patients.

1.3 Importance of the Problem

The increasing number of helicopter ambulance programs globally has been subjected to a careful examination of this helicopter service, especially in the face a rising helicopter ambulance accident rate. Fatalities due to motor vehicle crashes (MVC's) are considered as of upmost concern. The goal of most pre-hospital services (either ground or air transport) is to provide rapid transport and appropriate medical care. Most rural emergency ground transport has been proven ineffective, particularly for trauma patients for whom the "golden hour" is critical. That is, the chances of survival are much greater if trauma victims are treated within 60 minutes. Highway accidents are considered the number one cause of trauma victims. "Motor vehicle-related injuries kill more children and young adults than any other single cause in the United States."(http://www.cdc.gov/ncipc/duip/mvsafety.htm).

The global rise in number of vehicles, increase in road networks, and growth in the middle-aged population are societal and institutional developmental factors that influence the need for instituting air ambulance programs.

1.4 Purpose of the Study

The purpose of our research study was to investigate the major factors in the decision-making process with respect to utilizing a civilian air ambulance system in health care facilities, with the Washington, D.C.-Baltimore MD. metro area as an example.

Providing air ambulance services to a certain population requires careful examination and analysis. Any aviation service is usually expensive to run and maintain. The construction of modern highways between cities and countries has created a high volume of traffic resulting in higher driving speeds, despite existing speed limit regulations. The drivers' eagerness to travel at high speeds has resulted in a growing number of fatal motor vehicle crashes, especially in rural highways. The ground ambulance system in non-urban settings in many cases is not able to respond effectively and in timely fashion to a number of emergency cases. Additionally, the medical care facilities that exist in rural areas with major highways are community hospitals typically lacking advanced trauma care. Furthermore, major trauma centers are found only in large cities; access to them may be difficult due to traffic congestion or remote distances.

Currently, in many countries pre-hospital care in rural areas is primitive as compared to that found in urban settings. Helicopter ambulance service is considered a fairly new technological tool. There has been limited research done regarding the decision-making process with regard to using air ambulance service and its operations in rural or urban settings. Some aspects of the process are discussed further in the literature research (see Chapter 3).

1.5 Contribution

The contribution of this research study is twofold. First, we have built a list of factors which relate to a comprehensive air ambulance service for health care facilities located in rural and urban areas of the Washington, D.C.-Baltimore, MD. metro area. Second, we have ranked these factors according to their significance in the HEMS service as a tool in on-scene and inter-facility patient transportation. Also, this dissertation will add to the body of knowledge of how major metropolitan regions such as the one studied, and its rural neighbors, can institute utilization for helicopter service within their medical facilities systems.

In the healthcare industry worldwide, the introduction of helicopter ambulance programs in the civilian field is considered relatively new, particularly in developing countries. The utility of these programs should be looked into them not as an extravagance but as a means of saving lives of injured people involved in major accidents, or patients needing a more specialized medical intervention.

Chapter 2

Research Questions and Risk Areas

2.1 Research Questions

Two questions are set forth to be answered:

1. What are the main factors which influence the decision making processes of health care facilities to incorporate an air ambulance service in their current medical programs?

2. What is the ranking of factors in their importance that was identified in question #1 regarding the implementation of air ambulance services in existing health care facilities?

2.2 Risk Areas

This research is focused on identifying the factors that affect the decision for utilization of helicopter ambulance services in rural and urban health care facilities. Although pre-hospital care is a vital part of an ambulatory care system, this study does not intend to find ways to decrease fatality rates by changing in-house trauma care, nor does it find ways of decreasing fatalities through road construction development and design. It is proper to consider transporting patients as a pre-hospital service and explore the reasoning for its use. This study examines helicopter transport service programs in a rural and urban setting.

2.3 Scope and Limitations

The aim of this study is to develop and examine the list of factors that influence health care facilities' decision makers on air ambulance services programs for on-scene motor vehicle crash response and inter-facility transport as a means of saving lives in rural and urban health care facilities by focusing on ranking these factors on their importance. This study is not intended to be a guide to establishing an air ambulance system for urban and rural areas; however, it could help determine the appropriateness of using air ambulance services in rural and urban parts of those regions.

Chapter 3

Preliminary Review of the Literature

3.1 Introduction

Air ambulance systems employ a relatively new technology in helicopter utilization programs. For instance, the first fully operational civilian system in the United Kingdom was established in Cornwall only in 1987. In Germany, the National Automobile Club (ADAC), in conjunction with the German Ministry of Traffic, established the first helicopter ambulance system in 1972. Other European countries, such as Sweden, are now considering the introduction of a nationwide air-medical system program. Less is known concerning the utilization of this technology in the developing countries. Within the research literature, studies have debated the appropriateness of the use of air ambulance services for trauma victims. It has not been considered justified unless ground ambulance could not reach the scene of the accident in a reasonable amount of time (which is mainly the golden hour), or could not completely reach to the scene due to natural or manmade obstacles, such as traffic jams. Severity of the injury was considered a factor; trauma victims with a low "Injury Severity Score" would not qualify for an air ambulance service intervention. Baxt and moodys' study (1986) showed that air ambulance service had a significant impact on the patients' survival rate. There is a keen debate regarding air ambulance service between its proponents and opponents. But the majority of the parties involved focus on its positive impact, especially in rural settings where significant distances are involved.

3.2 History

The idea of using air transport for evacuating of trauma victims can be traced to Napoleon III during the siege of Paris in 1870, when 160 injured soldiers were removed from the battlefield. “The armies of Napoleon were the first to use structured ambulance corps assigned to each division. Those specialized units were staffed with approximately 170 medical personnel, including a surgeon, and horse-drawn carriages for evacuation,” (Meier, et al. 1989). Though the belief that Napoleon used air balloons to transfer injured soldiers from the battlefield to a medical facility was a myth, the ambulance corps inspired the idea of utilizing aerial vehicles for patient transfer.

During the First World War (WWI), aero-medical evacuation teams transported the wounded to more specialized hospitals for emergency care. The French army used airplanes for evacuation. “In 1916, Dr. Eugene Chassing converted the Brequet airplanes into air ambulances to evacuate wounded soldiers,” (Meier, et al. 1989). Though the Germans were the first to introduce a functional model of a helicopter during WWI, it was Igor Sikorsky, an American of Polish ancestry, who envisioned helicopters as rescue vehicles (Hodges, 1989). In the 1940s, the Sikorsky Aircraft Corporation was the first in the industry to mass produce and sell these machines. The United States Army acquired 400 helicopters from Sikorsky’s company during World War II (WWII) and put them to limited use.

There was a far greater use of helicopters during the Korean War. They were employed to evacuate wounded soldiers to the famous Mobile Army Surgical Hospitals, (MASH). Approximately 20,000 casualties were airlifted during that war from the battlefield to stationary medical bases. These helicopters were poorly equipped with medical equipment and supplies, and, due to their primitive design, they could only transfer a limited number of patients over short distances.

The Korean experience led military officials to deploy the MEDEVAC system during the Vietnam War. “The first major use of rotorcraft as an adjunct to medical care took place during the Korea conflict.” (Baxt and Moody, 1983). And though the mortality rate was 2.5 deaths per 100 injured soldiers, this was a marked improvement over the WWII record, where 4.5 percent of the injured soldiers died. The use of helicopters saved many lives and it brought advancement in military tactics. These technological and tactical advances caused the Vietnam War to be known as the “Helicopter War.” Helicopters transported approximately 200,000 casualties to advanced medical care during the Vietnam War (Meier and Samper, 1989). In another case, advancements in air evacuation was that the casualties were treated en route to the medical facility (Baxt and Moody, 1983). “The response time from injury to arrival at an advanced medical care facility fell to one hour.”(Meier and Samper, 1989). Over a 10-year period in Vietnam the Medical Evacuation (MEDEVAC) system transported about 372,000 casualties. The success of the military MEDEVAC in recent wars led experts to see a great need for helicopter ambulances in the civilian field, given the increase in fatalities from motor vehicle accidents.

The use of helicopters in the civilian field is relatively new. Congressional passage of the U. S. National Highway Safety Act was an effort to save the lives of victims of motor vehicle accidents. The first hospital to implement this act was in Maryland. Maryland hospitals started using police helicopters to evacuate injured drivers and passengers to specialized trauma care centers. But the first hospital to set up a fully integrated hospital-based system was the St. Anthony's Hospital in Denver, Colorado, in October 1972.

Deaths due to motor vehicle accidents are categorized into two categories: those who expire at the scene of the accident, or soon thereafter, and those who die at least 24 hours after admission to a hospital.

The use of helicopter ambulances reduces the need to build new emergency trauma centers in rural areas. Medical helicopters are used in four situations: 1) on-the-scene of accident, 2) newborn premature babies who need advanced health care, 3) transfer of patients from hospital to hospital (inter-facility transport), and 4) the transfer of blood or organs. On the other hand, an air ambulance service (HEMS) can be most functional in two of the following situations: on-the-scene of the accidents, and the hospital-to-hospital transfer of patients who require medical care not available at their current location.

There is a spectrum of trauma accident victims as far as their medical condition is concerned. On the one hand, there are MVC victims who have very little hope of survival; on the other hand, there are patients who need little pre-hospital care. The victims in the middle of the spectrum are basically those who mostly need pre-hospital care (Gold, 1987). Much of the time, first responders have little or no knowledge of how to perform critical life support techniques (Gold, 1987). This statement, though, may not be applicable these days with increases in advanced training and more thorough regulated guidelines.

The argument for utilizing a helicopter rather than a ground ambulance system in a rural area is the speed in transporting the injured patients to trauma centers as well as having trained personnel and experienced paramedics during transportation. Rough terrain and long distances can hinder a ground ambulance rescue process.

Some have recommended that helicopters carry a medical crew comprising a physician and a flight nurse to the scene of an accident rather than just a paramedic and a nurse. Baxt and Moody (1986) discovered that the survival rate for critically injured MVC victims transported by helicopter ambulance teamed by a physician and a nurse in an urban setting was higher than the survival rate using a ground ambulance system. Another study (Schiller et al. 1998), however, found that both air and ground ambulance systems had the same outcome (survival rate). However, both studies were looking at metropolitan settings that have advanced EMS systems and trauma centers designed to get patients into treatment in a short time. An air ambulance system can be very effective when a ground ambulance is not able reach the on-scene of the MVC accident location either in a reasonable amount of time or at all due to natural obstacles.

Field paramedics are considered as first responders, i.e., the first to appear on-the-scene of an accident, and they are also the part of the system that usually initiates a helicopter ambulance mission. With effective training, they can recognize when patients are critically injured and who can benefit from rapid delivery to a trauma center. In some air ambulance systems, mission requests are initiated by the first responders, who are usually highway patrol officers, fire department members, EMS technicians, or off duty physicians. Baxt and Moody(1986) determined that in some cases almost half of the helicopter missions reviewed were initiated by a non-medical official. When the distance from the scene of the accident to the trauma center exceeds 20 miles dispatching a helicopter ambulance is often favorable. Ground ambulances have a high risk of being involved in traffic accidents and can be severely damaged, especially at intersections.

The government of Sweden is considering the possibility of creating a national helicopter ambulance system (Vesterbacka and Eriksson, 2001). This study showed that it costs about half as much to transfer a patient via a ground ambulance as a helicopter ambulance. Although this service has been applied, it has not been implemented on a country wide basis.

Other studies have shown that the model type and construction design of the helicopter affects loading and unloading time. Not all helicopters can be utilized for HEMS applications. As far as safety is concerned, a twin-engine helicopter is preferable to a single engine helicopter. "Hot loading," i.e., loading the patient into the helicopter while the engines are running, showed a slight savings rate in rescue time over the "cold loading," i.e., loading while the engines are off. Though studies have shown that hot loading saves time, they did not rule out the dangers associated with it.

When a helicopter ambulance system was added to an existing ground ambulance service, there found to be an overall increase in missions (Thompson, et al. 1998). Adding this option to the existing ground ambulance system showed that there is an additional burden on annual costs. However, in Thompson's study, patient transfer was mainly from one hospital in a rural setting to another that provided more specialized trauma services.

According to various studies, helicopter ambulance services in an urban setting, such as New York City, account for only 0.004 percent of all EMS calls. This can be explained by the presence of a sophisticated ground ambulance system and medical facilities dispersed throughout the city, which combine to create short travel times.

Another study questioned the efficacy of helicopter ambulances in Germany (Lechleuthner, et al. 1998). Germany is a relatively small country geographically with a high population- to-area ratio. Hospitals are within a 50-kilometer reach. Today, 46 helicopters cover almost the entire country. The annual expenditure for a single helicopter program was about 1.575 million DM ($1.24 Million). The staff consists of a pilot, a physician, and a paramedic. The German air ambulance system can thus perform the scoop-and-play method rather than the usual scoop-and-scoot system. This study also showed that assuming a 15-minute response time, if the ground ambulance speed averages 50 km/hr and the helicopter ambulance averages 150 km/hr, the area coverage of a helicopter could be nine times greater than the ground ambulance system. To cover a 4,000-km area, a typical health system would need two air ambulance units or 18 ground ambulance units.

3.3 Rural Health Care

In considering an effective air ambulance service in rural areas, it is essential to mention a few facts that are distinctive rural areas:

- The total number of emergency calls is low as compared to urban areas.
- The population is dispersed across a large area.

- Highway crashes are considered more destructive in lives lost and have a higher fatality rate than urban MVC's.
- Highway Motor Vehicle Crashes (MVC) do tend to increase in certain seasons, such as summer breaks, when more people are on the road.
- The type of injuries sustained on highways are highly traumatic and life threatening, requiring a quick response.
- Hospitals in rural areas are usually less well equipped and their staffs usually are less experienced with trauma victims than hospitals in urban areas.

Health care in rural areas is threatened by privatization of the health care system. Many rural populations have a high poverty percentage. Health insurance coverage is low compared to that of urban areas. "In general, residents of rural areas are not as healthy as residents of urban areas" (Sammer, 1991). Most rural EMS's are not attached to hospital facilities or clinics. Funding is usually less than major urban areas. "Another characteristic shared by rural areas is that the injury problem resulting in the request for EMS is more severe than urban areas" (Straub and Walzer, 1992).

3.4 Classification of Health Care Facilities

In the Department of Health and Human Services' nomenclature, health care facilities are classified into two major categories according to their size and economic environment, i.e., urban versus rural area medical service providers.

Chapter 4

Research Methodology

4.1 Introduction

The purpose of this research study was to provide a comprehensive examination of the factors that are involved in the reasoning and analysis behind the application of air ambulance services in health care facilities. This research involved interviews of a stratified set of health care facility experts to assess the reckoning of air ambulance service.

Helicopter transport was chosen due to its speed and proven response time in reaching distant accident scenes. Trauma centers in rural areas are scarce; also if trauma centers were established in these areas there would be a high possibility that these centers would not be utilized at full capacity. Therefore a mechanism was needed to investigate the factors that influence the decision of application of these systems for the main reason of saving the lives of injured highway accident victims.

The use of helicopters in emergency health care is considered a costly program. The debate over whether to take steps to improve health care despite limited resources continues among health care providers. Therefore the reasoning behind the decision making pointed out above should serve as a starting point for assessing the research methodology. The research literature points to major questions about utilizing the air ambulance system and its justification and efficacy.

However, research that examined its utilization has usually focused on an urban setting. The majority of researchers' findings support the use of helicopters in a rural setting where there is no integrated ground ambulance system and where significant distances are involved. In addition to these findings, the absence of local trauma centers at many hospitals in these areas poses a challenge for ground ambulances to deliver trauma patients to an appropriate facility in a reasonable time. The analysis conducted for this study is based on interviews of officials working in health care facilities located in urban and rural areas.

4.2. Research Design

Recapitulation of the research questions and sub-questions will be useful in this chapter.

Two questions were set forth to be answered:

1. What are the main factors which influence the decision making processes of health care facilities to incorporate an air ambulance service in their current medical programs?

2. What is the ranking of factors in their importance that was identified in question #1 regarding the implementation of air ambulance services in existing health care facilities?

Our research was conducted in the Washington, D.C. – Baltimore MD. Metropolitan areas. The significant increase in automobile accidents during the past decade especially in third world countries has been noted in other literature. However, the factors that affect the decision for this kind of air medical services in the health sector have been rarely discussed. As a result of the articulated need for listing and identifying these factors, and investigating why some health care facilities are utilizing the HEMS program and why others are using it just to adjust their overall needs, further research should be conducted.

To structure the research, we developed a two-step procedure for the purpose of identifying and then ranking in importance those factors, according to health care professionals which pertained to the type of operation. The first step was to identify the most important factors that influence the decision of a health care facilitator with regards to utilizing a helicopter ambulance service. The second step was ranking in importance the factors cited in step one.

In all cases, data for this research were gathered from health care industry executives who were in one way or another utilizing helicopter ambulance services in the medical facilities included in this study. These experts were chosen because:

1-The decision regarding air ambulance service is an operational decision.

2-The experts related to the operations are officials who had the knowledge to respond to our research questions set forth.

4.3 Research Plan

From the selected institutions referred to above, we sought to contact and get agreement from health care officials by using a referral approach (i.e., contacting an official and requesting him/her to help us contact other experts).The reason behind this approach was that we had more success in recruiting subjects by using this method other than by any technique including mailing questionnaires.

Once we had collected the set of factors from each subject, we combined them into categories of similar or like factors. We then made a judgment call by eliminating those factors that had relatively low mentionings by those subjects. Our goal in reducing the number of conceptual factors was to make manageable the process of the Bradley-Terry method for pair-wise comparisons to rank the factors, which was the second step to be performed. Restricting the factors to a manageable size was crucial, since the pair-wise comparison questions would rapidly increase with the number of factors.

The number N of pair-wise comparisons for the Bradley-Terry method for n factors is calculated using the following equation:

$$N = \frac{n(n-1)}{2}$$

For example, in case of 12 factors in the following equation:

$$N = \frac{12(12-1)}{2} = 66$$

i.e., there are 66 comparisons that must be made by each subject. The truncated list of factors thus obtained was the basis of a questionnaire for each of the same subjects to make pair-wise decisions on the relative importance of the factors. Thus, this model is a simple case of a linear model. It deals with the factors being compared between each other in paired contests. "It is one of several psychological scaling models that can be implemented in pair-wise comparisons"(Cooke, 1991). The Bradley-Terry method enabled us to prepare a list of the factors ordered by their relative importance.

In summary, the research protocol will be developing a decision model through a three-step process:

1- Identifying the attributes

2- Using experts' opinions to rank these factors by creating a pair-wise comparison survey questionnaire

3- Apply the Bradley-Terry model for paired comparison to weigh the factors in the utility model

4.4 Research Setting

This study was conducted through interviews performed on site and in person through arranging appointments either through connections or referral approaches. Data was collected from a variety of medical facilities in the Washington D.C.-Baltimore metropolitan area. Rural and urban medical facilities were included. Hospitals which do not have HEMS are also included in this study. Both public and private health care facilities were included in this study.

Once the perspective panelists were identified, agreement on the first visit was conducted with them asking for their participation in the study. As a result, appointments were acknowledged for the face-to-face interview. The head advisor for this research was present in many of the interviews. This showed a positive response in gaining the data required showing the seriousness of this study.

To keep costs low for the researcher, the experts were sought out in the greater Washington D.C. area, Baltimore, northern Virginia and the Richmond metropolitan areas. Health care facilities located in rural, urban, and suburban areas were chosen to reduce any possible bias pertaining to any decision-making process in this study. Because of his past experience in the area, one expert was chosen outside this region. This subject was located in the State of Maine. His interview was performed via teleconference.

4.5 Factors Influencing Helicopter Ambulance Service Use

In order to accomplish the goal of this research study, the decision variables were categorized into specific groups. From the literature related to air ambulance services, factors were combined, collected, and tabulated into five major categories. These factors had either a direct or indirect relation to the helicopter ambulance service program. They are presented here to document the state of consideration of the issue that is reflected in the professional literature on the subject. It is important to note that these factors are not believed to address the decision to have or not have helicopter ambulance service. In fact, they represent literature studies in the discipline of helicopter ambulance service.

1-Flight Vehicle:

Materials and Hardware:

- High technology involved
- Ownership of aircraft (cost and financial structure)
- Type of aircraft (number of patient capacity)
- Type of medical equipment involved
- Type of medicine involved
- Back-up vehicle
- Number of cots in vehicle (patient capacity)
- Number of defibrillator in vehicle
- Number of loading doors (logistics)
- Cost of flight
- Response time

Type of operation (medical intervention) On-scene or On-board
Type of rescue operation (scoop and scoot or stay and play)
Aviation regulations
Urgency and reliability
Insurance coverage
Vehicle location
Helipad location
Helipad availability
Type of loading
Hospital affiliated or not
ETA (Estimated Time of Arrival) to definitive care

Human Related

Medical and Aviation expertise
Pilot fatigue
Level of training of caregiver
Medical team involved (physician, nurse, and paramedic)
Pre-hospital caregiver level of care
Pilot's distraction
Pilot's medical training
Level of patient care provided

Support

Maintenance team
Back-up vehicle

2-Ground Vehicle:

Materials and Hardware

High technology involved
Type of medical equipment involved
Road surface condition
Warning devices: e.g. sirens and horns

Human Related

Medical expertise involved
Level of training of caregivers
Medical tram involved (physician, nurse, and paramedic)
Pre-hospital caregivers' level of care
Personnel training
Driver fatigue
Driver distraction

<u>Operations (Logistics)</u>

Response time
Type of rescue operation (scoop and scoot or stay and play)
Ambulance crashes
Level of patient care provided
Hospital affiliated or not
ETA (Estimated Time of Arrival) to definitive care

<u>Support</u>

Maintenance (auto)

<u>3-Site of the Accident</u>:

<u>Materials and Hardware</u>

Size and weight of vehicles involved
Vehicles' center of gravity
Hazardous materials spilled
Secondary traffic

<u>Operations (Logistics)</u>

Dispatch authority
Extended extrication (rescue from danger)
Injury severity score (ISS)
Probability of survival

Alcohol level, etc.
Limited lighting
No shoulders on road
Crash characteristics
Age of victim
Daylight vs. Nighttime
911 dispatch availability

<u>Human Related</u>

Bystanders
Number of victims involved
Type of patients (victims) involved
Variables (for victims) sex, age, injury time, type of injury, blood

<u>4-Trauma Center:</u>

<u>Materials and Hardware</u>

High technology involved
Type of medical equipment involved
Type of medicine involved
Type of operation (medical procedure)
Type (grade) of trauma center
Receiving hospital landing facilities (helipad availability)

<u>Operations (Logistics)</u>

Hospital charges
Hospital days
Intensive care days
Insurance coverage
Ability to pay

<u>Human Related</u>

Level of training of caregivers
Length of stay (ICU)
Magnitude of survival

Level of patient care provided
Caregiver experience and accreditation

Support

Biomedical department
Laboratory
Medical supplies department

Directly Related Factors

Medical team
Medical equipment
Hospital procedures and by-laws

Indirectly Related Factors

Management
Hospital resources
Training and continuing education

5-Ambient Environment:

Materials and Hardware

Type of road (bi-way or highway)
Type of roadway (international, farm)
Traffic intensity
Number of stoplights
Traffic congestion
Technological safety items on road
Oncoming traffic observers
Secondary accidents involved

Operations (Logistics)

Distance from trauma center
Estimated time of arrival (ETA)

Inaccessibility to the scene by ground personnel or equipment
Response region
Significant distances involved

Human Related

Bystanders

Topographical

Climate
Topographical road conditions
Season
Inclement weather conditions

4.6 The Survey Instruments

Two survey instruments were utilized for the of this research study. Also, multiple individual interviews were conducted to elicit preferences from the experts.

The first step in the first survey was to perform interviews to identify the initial factors. It consisted of a single questioned interview survey requesting from the respondents to identify in no particular fashion the factors that they believe that has the most influence on the implementation of air ambulance services in medical facilities.

The panel contributed twenty factors which were needed to be reduced. A larger number of factors could have been produced if the interviewer was given longer time, although what we had was sufficient, and therefore the top twelve factors would not likely have been different. The list of factors mentioned by the experts in the interviews showed a correlation between them, but when given more time they would mention factors which were distinctive from each other. This showed that experts had the same area of attention and concerns. As a result the first survey interview would be satisfactory viable.

During the interviews, the experts listed five areas of concern to them, which is considered an essential step in the approach to implementing the HEMS. The following list of factors shows the areas of focus that were referenced by the experts.

1) Focus on Air Service
    a) Operator of Rotorcraft
    b) Base for Rotorcraft
        i) Hospital
        ii) Airfield
        iii) Disperse
    c) Aircrew & Maintenance Operations
        i) Rotorcraft Owner
        ii) Hospital
    d) Air medical team
        i) Owner
        ii) Hospital
        iii) Other
2) Focus on Patients
    a) Emergency
    b) Trauma
        i) Blunt
        ii) penetrating
        iii) Inter-facility transport
3) Focus on hospital operations
    a) Expensive specialized services
    b) Patients' needs

c) Meeting accreditation requirements

d) Gaining expertise for personnel

4) Focus on Economics

a) Societal cost of disability due to lack of adequate and timely transport

b) Lifetime value of survival (Productive life years saved)

5) Focus on Finances

a) Reimbursements for services: how? by whom?

b) Covering losses

c) Taxes (if service is considered a public entity)

d) Liability

The second survey instrument contained a list of 66 pair-wise factor comparisons. Respondents were requested to put a check in the box next to the factor they thought would have more influence on implementing a helicopter ambulance program in existing medical facilities. This survey was performed by contacting the officials at their respective workplaces via e-mail or telephone to request their response to the e-mail attachment accompanied by a letter request to fill out the pair-wise comparison review. A comprehensive list of pair-wise preferences of the twelve mentioned factors from the first survey was produced.

The second survey instrument (Appendix A) was administered in the month of October 2008, and subsequent responses were collected between the months of October and December. Most of the responses from the second survey were also collected through e-mail contacts, and some were collected personally. In the case of the second survey, there was no need to administer it in person, since the questions were straightforward and the instructions were attached in the cover page of the request letter. Also, the clarification and definitions of the 12 factors were accompanied with the survey. The experts were expected to complete the survey individually and entirely on their own.

4.7 The Bradley-Terry Model for Paired Comparisons

"The Bradley-Terry model was first introduced by Bradley and Terry (1952) and further developed by Bradley (1953)" (Cooke, 1991). This method is used for analyzing paired comparisons to determine the weighing of factors and therefore determining preferences. It is a tool of measuring qualitative research methods where decisions of the experts are subjective (Berkum, 1987). According to (Cooke, 1991), The Bradley-Terry models' acceptable range of experts needed would be 10 to 20 responses from experts having at least 20 years of experience in the related field of study of helicopter emergency management. The assumptions of the Bradley-Terry model assumes that when comparing two factors i and j, we gain N_{ij} which represents the number of times j was preferred over *i* in a given subjective judgmental pair-wise comparison of N_i and N_j . Since S_{ij} , the probability that the object *N* will be favored over N_j, is given by:

$$S_{ij} = \frac{\pi_i}{\pi_i + \pi_j}$$

we may therefore assume:

$$\sum_{i=1}^{n} \pi_i = 1$$

or

$$\sum_{i=1}^{n} \log \pi_i$$

Since the Bradley-Terry method is one of the “three psychological scaling models that can be used for pair-wise comparisons (Cooke, 1991), other paradigms that were utilized included the Thurstone and NEL models.

The Thurstone mathematical model was “used with one judge who expressed his preference for each pair several times,” (Cooke, 1991). Therefore, it is not appropriate to use this model, since we have other judges who expressed their preference for each pair only once. The other psychological model which is “computationally identical to the Bradley-Terry model, but different in interpretation,” (Cooke, 1991) is the NEL model. This model uses mechanical components where the expert is to “answer the question by performing a mental experiment observing which fails first” (Cooke, 1991). Therefore, it is not appropriate to use this model since our subjects were not mechanical.

4.8 Survey Validation

A pilot study test was conducted to provide a cohesive understanding of the derived factors.

4.9 Research Scope and Limitations

The scope of our research study was to identify and list the related factors and issues relevant in the decision-making process and application guidelines with respect to implementation of the HEMS program. Our intent was not to promote this service, nor provide recommendations for the health care facilitators to implement this service.

This study has focused on identifying, ranking, and evaluating the factors associated with utilization of the HEMS programs in existing medical facilities. Although Helicopter Ambulance Service impacts most of the health care facilities' departments' work, our research study has focused here only on the opinions of official decision-makers directly engaging in the development and implementation of the helicopter air medical services. Geographical context of the research population area was considered a limitation.

The interviewed officials (experts) discussed their assessment and knowledge of their respective health care facilities' problems and pondered the necessity of incorporating the HEMS utilization into their existing programs. In order to get the most out of the outcomes of the first survey, it was administered whenever possible, in person and during individually pre-arranged meetings with interviewed experts at their convenience on the premises of their respective medical facilities.

4.10 Contribution

The value of saving a life cannot be firmly established, and different ways of saving lives are subject to debate. Our research study has approached this problem in a quantitative way through gathering expert opinions in the process of extensive interviews and conducting our specially devised surveys.

Next, we have analyzed and ranked the derived factors according to their significance in affecting the decision-making processes with respect to incorporating the HEMS program into existing medical establishments' agendas. It is our hope that this research study will contribute to the understanding of the various health care facilitators' attitudes as regards the integration of HEMS utilization in their overall health care system programs.

Chapter 5

Discussion of Findings

5.1 Population and Sample Description

As earlier indicated, experts for this research study were selected due to the fact that they are specialists in the field of emergency air medical services. They were asked to list the critical factors that impact the decision-making processes with regard to the implementation of Helicopter Emergency Medical Services programs in their respective medical facilities.

The experts were initially invited to be interviewed to help list these pivotal factors. Next, for the purpose of the second survey, they were requested to subjectively rank in importance the derived attributes, based on their expertise in the field. This was done by performing a pair-wise comparison of the derived factors.

The total number of the derived (truncated) factors is critical to our research study. Our goal was to limit the number of factors to 12, which was determined after considering the time that every interviewee would require for answering our pair-wise comparisons. The experts were asked to perform the two tasks with a time interval between them.

Since this research study was not aimed at promoting the implementation of Helicopter Emergency Medical Service in health care facilities, it rather concentrated on depicting the important factors that influence the decision-making process regarding the implementation of the HEMS program in existing health care facilities. The participants of this study were recognized senior level executives and officials in the field of Emergency Medical Services. Several types of program sponsorship included private and publicly owned health care facilities. Also, hospital and community based, as well as state owned, HEMS programs were included in this study.

The investigator has done a thorough research of health care institutions that operate or do not operate the HEMS program in the region. The referral approach through professional contacts yielded a high outcome in responses from experts, especially when the request was sent by a high profile expert in the field of Emergency Medical services.

The referral requests were sent via email contacts; responses were received from more than half of the approached experts. The second follow-up emails were sent individually to those experts who did not respond to the initial invitation. We renewed our request for their participation in the survey. As a follow-up, telephone calls were made to those program directors (experts) who failed to reply to the first and second email requests. We wish to acknowledge here another doctoral candidate in the George Washington University Department of Engineering Management and Systems Engineering (Dr. Beverly Magda), who was very helpful in making these contacts.

5.2 Research Plan

Recapitulating the steps of our research study would be useful in this chapter. The development of the decision model was performed through a three-step process:

1 - Identify the attributes.

2 - Use expert opinion to rank these factors by creating a pair-wise comparison survey questionnaire.

3 - Apply the Bradley-Terry model for paired comparisons to weigh the factors in the utility model.

5.3 Scoring the Factors

The initial list of factors collected from the first survey and personal interviews was reduced to a set of 12 factors. This involved the scoring process to determine how many times the participants mentioned the factors that were extracted. By doing so, the process omitted the least cited factors. Subsequently, indentifying and grouping of the factors were performed. The Bradley-Terry method revealed the comparative importance of the factors, but not the subsets of these derived factors.

The result of the process produced 12 factors that were applied in the pair-wise comparison survey in ranking in importance the produced set of 12 factors. The survey was sent to the participants using two methods. The first method was administering the survey by means of a Microsoft Word attachment within the request, accompanied by a cover letter (Appendix D). The second method was using a Google Document, where the administrator could pick who could access the survey and share changes in real time.

The result of the pair-wise comparison testing was then analyzed using the Excalibur's wcompare software program utilizing the Bradley-Terry method for estimating the ranking of each factor. This software program was developed by the University of Delft, Netherlands (Mazzuchi et al.2008).

Since most HEMS programs are linked with the Emergency Department in their respective health care facilities, those Emergency Departments are fully involved in the

HEMS programs and linked to the decision-making process of that particular health care facility. They create the vision and image of the HEMS programs.

The number of the subjects for this study was restricted to a manageable size, since the relationship between the number of factors and number of paired comparisons significantly increases.

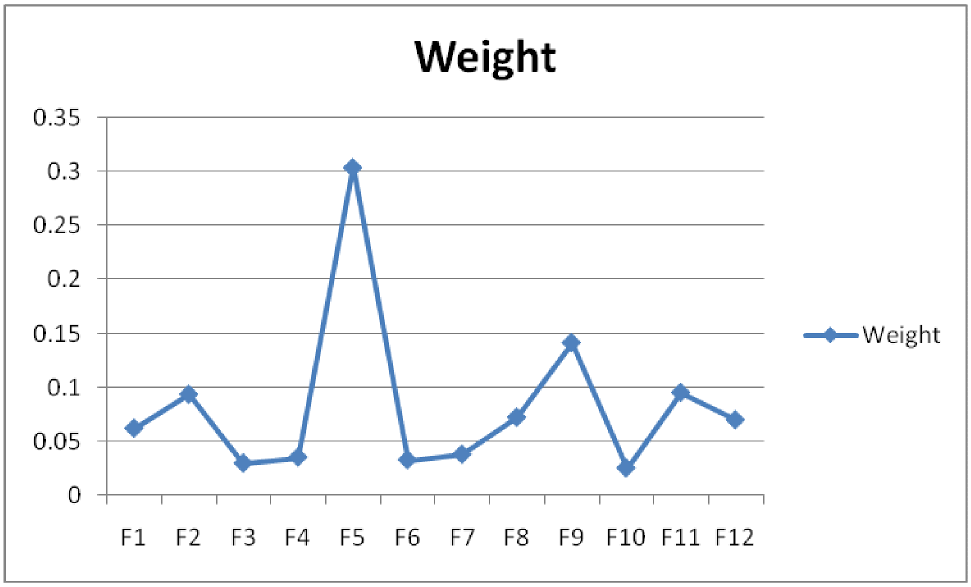
5.4 Ranking the Factors

The weighing attributes of the factors were ranked by the order of importance. The 12 factors were put in a graph shown in figure 5-1, along with their ranking in Table 5-1. The bars indicated the factor value and all the factors are a cumulative sum of 1.

Table 5-1: Initial Weighing of the 12 Factors

Factor	Weight
F1	0.0621
F2	0.0936
F3	0.0297
F4	0.0353
F5	0.3041
F6	0.0329
F7	0.0379
F8	0.0723
F9	0.1416
F10	0.0253
F11	0.0953
F12	0.0699

Figure 5-1: The 12 Factors and the Cumulative Weight



5.5 Data Collection and Analysis

5.5.1 Overview

A two-step survey data collection process was used in our research study by a panel of experts. The survey was prepared to identify, rank in importance, and evaluate the factors that were associated with implementing Helicopter Emergency Medical Service programs in health care facilities.

The relevant literature was utilized to help in identifying the preliminary factors. Accordingly, a pilot study was performed to identify and define the specified factors in the first survey interview process. This step was performed to acquire a unified understanding of the specified factors to be introduced in the second survey questionnaire.

Expert opinion was used in the second survey to evaluate and identify the factors associated with the HEMS programs implementation. The identified factors were reviewed and a reduction to a reasonable number of factors was performed. This was achieved through a score evaluation method. This method weighed the genuine factors given, thereby eliminating redundant factors and then reducing them to a manageable amount.

The third step was to use the expert opinions acquired from professionals working with HEMS programs in health care facilities to rank in importance the evaluated factors. This was administered through performing a pair-wise comparison of the final twelve factors.

This step employed a survey instrument. This instrument included a cover letter in Appendix A-1. Also a unified clarification and definition of the compared factors was included in the e-mail request. These were executed by the same experts who were interviewed in the first interview survey.

The subjective assessment test consisted of 66 pair-wise comparisons which took no more than fifteen minutes of the participants' time. Each question contained a comparison between the two factors. Experts were asked to arrange the factors according to their relative importance. They were instructed to choose the factor they consider the most important in each pair. The pair-wise comparison was presented in a two pair factor checkbox (Appendix A).

To ensure that all factors were clearly understood, a definition of the listed factors was attached to the survey request.

5.5.2 Data analysis

The weighing of factors in the second survey was performed by implementing the pair-wise comparison technique. The 66 attributes received from the 12 respondents were analyzed using the Bradley-Terry model for paired comparisons. Prior to performing this analysis, the initial ranking of the derived factors was prepared by determining how many times each factor was selected by the experts. A selection percentage was tabulated using this method and an initial ranking was observed. This was conducted by dividing the number of times that each factor was selected by the total number of times it was cited in the paired comparison. The number of times each factor was selected is shown in Appendix D.

Table 5-2: Selection Percentages of the 12 Factors

Factor	Rank	Number of Times Selected	Selection Percentage
Transport of trauma victims	7	60	0.500
Limiting time to 6o min. (Golden Hour)	4	72	0.599
Revenue generation	11	39	0.322
Facility Utilization	9	44	0.363
Access to Definitive Care	1	101	0.835
Marketing of Medical Facility	10	42	0.347
Continued Certificate of Need	8	46	0.38
Long Distance Involved	5	65	0.537
Bringing Higher Level of Care to Patient	2	84	0.694
Lowering Hospital Cost	12	35	0.289
Providing Inter-Facility Service	3	73	0.603
Providing On-the-scene Service	6	64	0.529

5.6 Identifying the Attributes

A single question survey was conducted in the interview process to instruct the experts how to list the factors they believed had most impact on decision-making with respect to implementing the HEMS program in existing health care facilities. The experts were kindly asked to explain (in their own words) the reasons for implementing the

HEMS in their respective medical facilities. The participants independently listed the factors they viewed as most important. The respondents were not instructed to limit the number of factors; in fact, they were directed to feel free in recognizing them.

The survey was unambiguous and straightforward. First, the interviews generated a list of factors influencing the implementation of the HEMS programs. There were 20 factors collected in the process of the interviews conducted. The following is the listing of the 20 factors:

1- Inter-facility transport
2- Improving quality of service
3- Transporting Organ transplant cases
4- Lowering hospital cost
5- Access to definitive care
6- Limiting time to 6o min. (Golden hour)
7- Transporting Trauma victims
8- Transporting Cardiac care patients
9- Transporting Severe burns patients
10- Neurosurgical care required
11- Long distance involved
12- Revenue generation (downstream)
13- Facility utilization
14- Marketing of the health care facility (Advertising)
15- Mass casualties transport
16- Integration of the health system

17- Rural population transport

18- Continued certificate of need

19- Transporting Neonatal patients

20- On-scene service

This comprehensive list of factors was then truncated to establish a reasonable number of 12 factors for the implementation in the second survey. The process included categorizing and eliminating redundant factors.

5.7 Reducing the Number of Factors

In order to reach a reasonable and manageable number of final factors to be evaluated, there has to be an acceptable number ranges. This is crucial because participants in the second survey were asked to answer an assortment of questions. If the number of paired comparisons was n where n =20, then the number of combinations would result in the following equation:

$$r = \frac{n(n-1)}{2}$$

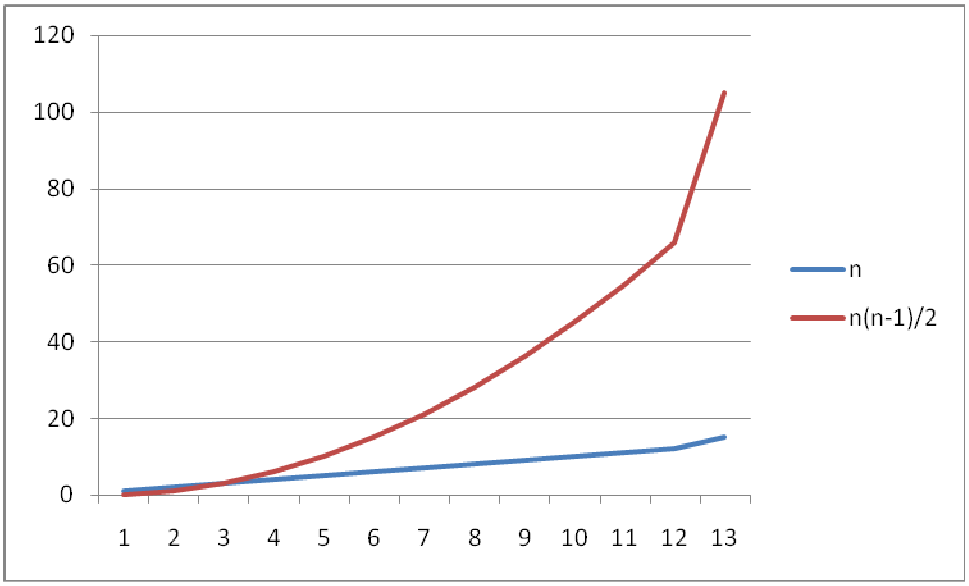
This would result in using 190 questions in the pair-wise comparison, which was clearly unacceptable. The decision to reduce this number to 12 was due to the time it would take for participants to answer such questions in a practicable amount of time. Our goal was to let the participants perform the survey entirely on their own and not miss or jump any of the comparisons given. In conclusion, the 12 factors were found to be sufficient to result in sixty-six pair-wise comparisons.

The table and diagram below show the direct relationship between the number of truncated factors and the number of pair-wise comparisons that would be generated.

Table 5-3: Number of Factors versus Number of Comparisons

Number of factors (n)	Number of Pair-wise Comparisons n(n-1)/2
1	0
2	1
3	3
4	6
5	10
6	15
7	21
8	28
9	36
10	45
11	55
12	66
15	105
25	300

Figure 5-2: Number of Factors *n* Resulting in Number of Comparisons



Since the first series of interviews created a list of 20 factors, they were reduced to the required 12 factors. This was done through the identification and regrouping of the given respondents from the interviews. A simple ranking process was conducted, based on the total 20 factors produced initially by the participants. The factors that showed duplication were eliminated. The remaining ranked factors were then reduced to 12 by eliminating the least scored factors.

5.8 Discussions of Findings

The primary purpose of this research study was to explore the factors influencing the decision-making processes with reagard to implementation of the HEMS programs in existing health care facilities.

Devising the first and second survey contents was a fundamental step in our research study analysis. As noted, the research was performed in a four step process by identifying and ranking the 12 factors. The initial identification of the experts to be interviewed was extracted from the targeted specialty literature review. The Association of Air Medical Services provided comprehensive directory listings of air medical programs operating in the United States and, also, worldwide. Other HEMS programs were identified via a referral approach.

We initially contacted 16 prospective experts to invite them to participate in our study, and appointments for the interviews were set up. Only senior level officials involved in the HEMS programs were the population for this research study. The majority of our experts were located in the states of Virginia and Maryland; one official came from the state of Maine. The experts represented various sectors: public, private, and a consortium owned by the HEMS program.

The subjects for the first survey were selected and interviewed between May and September of 2008. The results and records of the interviews were kept anonymous. As the research plan stated, every interview was performed in person except for the two interviews which were conducted through teleconferences. One of the interviewees was at a location in Maine, and it was impractical for the researcher to reach that destination in person.

In agreement with the research protocol, the number of factors derived from the interviews in the first survey was limited to twelve. These 12 factors were used in our pair-wise comparison survey instrument. According to the scoring process performed on the cited factors, the 12 most mentioned factors were referred to by at least 6 of the 12 experts. The table below shows the top 12 cited factors and their descriptions.

Table 5-4: Top 12 Factors Identified by the Experts

Factor	**Description**	**Frequency**
Transport of trauma victims	A bodily injury produced by violence or shock (Blunt & Penetrating)	92%
Gaining revenue (downstream)	Income from In-house medical procedures	83%
Limiting time to 60 min. (golden hour)	Patients' chance of survival is greatest when receiving medical care after an injury within one hour	83%
Access to Definitive Care	Complete medical intervention treatment for the patient	83%
Facility Utilization	Hospital use of beds, operating rooms, etc.	83%
Marketing of Health Care Facility	Promoting community awareness of capabilities and services in the medical facility	83%
Long Distance Involved	When deemed too long to travel by means of a ground ambulance service	58%
Improving quality of service	Bringing higher level of care to on-scene or en route	58%
Lowering Hospital Cost	Through increased number of interventions and by utilizing resources as much as possible	58%
Continued Certificate of Need	Certificate of approval granted by authorized agency to a medical facility practicing a certain medical procedure	50%
Providing Inter-Facility Service	Medical care provided en route between two medical facilities	41%
Providing On-Scene Service	Medical care provided to the scene of the accident	41%

The Bradley-Terry model requires that the paired comparison results are statistically valid. They are validated through a series of tests. “In order to verify that statistically valid results are achieved from analyzing the twelve responses using the Bradley-Terry model, certain tests or analyses are required,” (Beach, 2001).

One of the tests checks the experts’ consistency in answering the questions. By testing the consistency of our experts, we can see if they answered the paired-comparisons properly, rather than guessed their responses, which would constitute the grounds for removal from the data analysis portion of the test. This method is called the “Coefficient of Consistence” ξ . It measures the availability of circular triads. Coefficient of Consistence can have the value of one and down to zero; one meaning no inconsistencies, and zero meaning the existence of high number of circular triads.

This test eliminated the experts who did not act in accordance with their answers in the second survey, therefore identifying the respondents who were eligible for the Bradley-Terry analysis. Since every respondent was to answer (in our case) sixty-six pair-wise comparisons, it was not surprising that a few circular triads resulted (Mazzuchi et al, 2008).

For instance, when an expert prefers factor F (1)>F (2), F (2)>F (3), and F (3)>F (1); this process of selection would result in a circular triad.

To define the number of circular triads (*C*) of every expert, we used the following equation (David, 1963):

$$C = V - \frac{1}{2}T$$

If “C=0 this implies complete consistency” (David, 1963), where V is constant depending on t only; where t is the number of objects to be compared (which is twelve in our case), and with:

$$V = \frac{1}{24}\, t\,(t^2 - 1) - \frac{1}{2}T$$

where,

$$T = \sum (c_i - \bar{c})^2$$

And,

$$\frac{\sum c_i}{t} = \frac{1}{2}(t - 1)$$

c_i is considered the number of times factor i is selected by the expert.

When the probabilities “that certain values of c are exceeded under the null hypotheses that experts answered in a random fashion is approximately Chi squared distribution having degrees of freedom”(Mazzuchi et al, 2008).

Cooke (1991) defined the degrees of freedom (v) as:

$$v = \frac{t\ (t-1)\ (t-2)}{(t-4)^{\ 2}}$$

" If the random preference hypotheses cannot be rejected at the 5% level on the basis of the data preference, then the analyst should consider dropping this expert from the set of experts"(Cooke, 1991).

The Coefficient of Consistence ξ is defined using Kendall and Babington Smith by (David, 1963):

$$\xi = 1 - \frac{24c}{t(t^2-4)}, \qquad t \text{ even}$$

The outcomes of the pair-wise comparisons were analyzed using this methodology as shown in Appendix B**.** In our case, all of the experts' choices showed an acceptable statistical response (except the one expert who was eliminated) and, therefore, they were utilized in the group response calculations.

Coefficient of agreement u :

In addition to the Coefficient of Consistence, the Coefficient of Agreement uses the group responses showing agreement (as a whole) on their preferences. Kendall (1962) defined the Coefficient of Agreement as follows:

$$u = \frac{2\sum^{\sim}}{\binom{n}{2}\binom{t}{2}} - 1$$

Complete agreement exists when $u = 1$. "Under the hypotheses that all agreements of the experts are due to chance, the distribution of u can be determined"(Cooke, 1991).

Coefficient of Concordance:

"A measure referred to as the "Coefficient of Concordance" can be used to test the agreement of the experts"(Mazzuchi, et al. 2008). Cooke, 1991 calculated the sum of the ranks $R(i)$ by using:

$$R(i) = \sum_e R(i,e)$$

Also (Siegel, 1956) defined W as:

$$W = \frac{S}{\frac{1}{12}d^2(v^3 - v)}$$

Where "S is the sum square of the observed deviations from the mean of $R(i)$"(Cooke, 1991). In conclusion, when W moves towards 1, complete agreement arises.

The Bradley-Terry Model

After excluding the experts who exceeded the number of triads limit, we then proceeded to use the Bradley-Terry model to describe the experts' preferences. Also, we used the model to determine the relative weights or preferences of the postulated twelve factors.

(Berkum, 1987) described the Bradley-Terry model by postulating the existence of the parameters π_i for T_i, $\pi_i > 0$, such that the probability $\pi_{i,ij}$ of selecting T_i when compared with T_j is :

$$\pi_{i,j} = \frac{\pi_i}{\pi_i + \pi_j} \quad , \quad (i \neq j)$$

when using multiple experts, it is assumed that $\pi_{i,ij}$ is the same for all experts, and the judgment is independent (Cooke, 1991). Also "π_i are determined only up to a constant scale factor, hence we may assume $\sum_{\pi_i} = 1$ "(Cooke, 1991). As Cooke's recommendation of finding the solution iteratively where he puts it as:

$$\pi_i = \frac{b(i)}{\sum_{j,j\neq i}^{\sim} n\left[\pi(i) + \pi(j)\right]^{-1}}$$

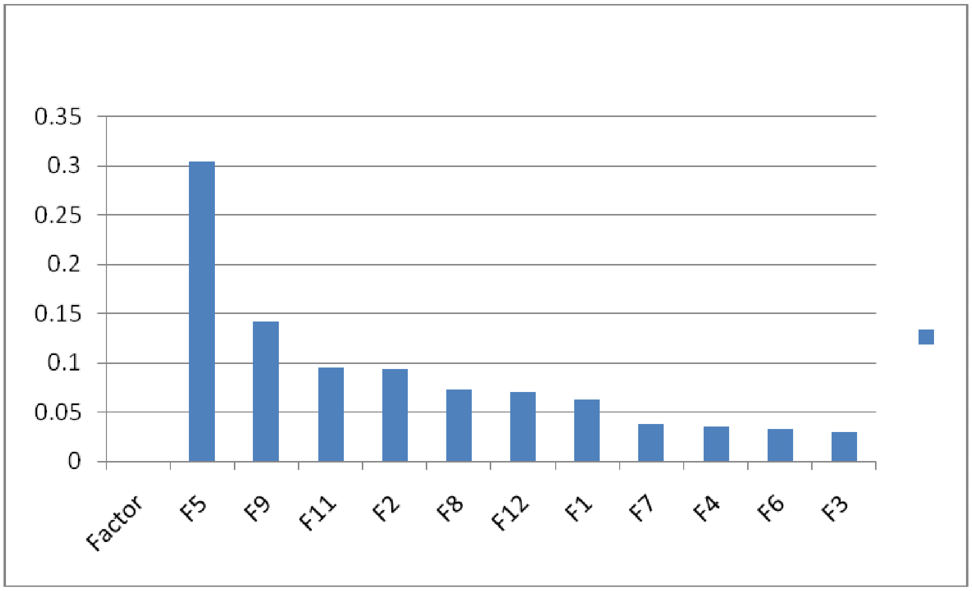
where *i*, *j*=1, 2, 3,………12; *n*=11 and *b*(*i*) is the number of factors *F*(*i*) that is preferred by all experts.

The values of these factors were ranked in order of importance. The twelve factors were put in a bar graph shown below along with their rankings in Table 5-5 **.**The bars indicate the factor value, and all factors are considered a cumulative sum of 1. In addition to that, the figure below shows the first two or four factors which account for about 50% of the total value.

Table 5-5: Weighing Factors for Each of the 12 Attributes

Factor	**Weight**
F5	0.3041
F9	0.1416
F11	0.0953
F2	0.0936
F8	0.0723
F12	0.0699
F1	0.0621
F7	0.0379
F4	0.0353
F6	0.0329
F3	0.0297
F10	0.0253

Figure 5-3: The 12 Ranked Factors Ordered in Importance According to the Bradley – Terry Model



5.9 Initial Identification of Factors Cited by the Experts

During the interviewing process, an extensive amount of information was collected. Appendix F shows the list of selected factors which were obtained during the conducted interviews.

The factors were individually listed and then processed together. A brief description of these factors was included. Upon reviewing the listed ones (Appendix F), which were captured and recognized in the interviews, we notice that the initial derived factor list from the literature review was correlated to each other, except for a smaller sub-factors listing mentioned extensively in the derived factor from the literature review. Since our intent was to list the twelve genuine factors to be implemented in the pair-wise comparison survey, we had to score the most cited factors mentioned by the experts during the first interview.

Table 5-4 shows the listing of the twelve factors along with their definitions and scoring rate percentile. The scoring process showed the "Trauma" was the most referred to factor in the interviews.

All experts except one mentioned this factor. Also, the pertinent literature listings mention this factor. Next most frequently cited were: "Reaching in proper time (the Golden Hour)" "Facility utilization," and "Marketing of health care facility." They all tied in ranking as second repeatedly mentioned factors with ten, or 83%, of the experts citing them. Closely following were the "Revenue (downstream)" and "Access to definitive care." Clearly these two factors were not far from the previous three, having a 75% score percentile or being cited 10 times. The seventh, eighth, and ninth factors were also at a tie, having a big gap score from the last two.

The next three factors scored 58% with 7 experts mentioning them. These factors were: "Long distance involved," "Bringing higher level of care to patients," and "Lowering hospital costs." The "Continued certificate of need" closely followed the previous three with a 50% score ranking in the tenth place. "Providing on-the-scene service" and "Providing inter-facility service" were tied in the eleventh and twelfth places.

It is worth noting here the remaining eight factors cited by some of the experts during the interview process. The following additional factors were mentioned by a number of experts:

1. Transporting Organ transplant cases

2. Transporting Cardiac care patients
3. Transporting Neurosurgical patients
4. Mass casualties transport
5. Integration of the health system
6. Rural population transport
7. Transporting neonatal patients
8. Transporting severe burns patients

5.10 The Bradley-Terry Analysis Results

Prior to conducting the pair-wise comparison survey, initial scoring of the twelve factors mentioned in the interviews was performed. This was done by ranking them in order of their selection percentile seen in Table 5-4**.** This percentile calculation was accomplished through dividing the number of times the experts cited it by the total number of factors--in our case there were 12.

Calculating solutions for this analysis was done by comparing a PC software-based program named “wcompare” developed by Cooke and available from the Delft University of Technology in Delft, the Netherlands. It was used to preliminarily rank and to define the circular triads. Also, it was used to apply the Bradley-Terry model for this research study.

Of the twelve experts participating in the survey, one was excluded due to failing the “Coefficient of Consistence” test.

That expert had a number of circular triads, exceeding the acceptable range. This outcome meant that the expert might have answered the pair-wise comparison survey by guessing or that his competence is doubted.

Most of the experts were highly consistent in making their choices. However, there was one expert who produced 74 circular triads. Because the number produced was larger than the p=0.05 critical value of 44; the null hypotheses was preserved for this expert. The other experts passed the initial phase test "for group agreement of responses at the 5% level"(Mazzuchi, et al, 2008).

After eliminating one of the experts, the test had to be recalculated using the "wcompare" software program. Both, the initial and second actual outputs of the "wcompare" software are provided in Appendix B**.** The total circular triads of the twelve experts were 138 circular triads; which was an average of 12.5. The analysis gave a coefficient of agreement value of $u = 0.157$, the Chi-Square value was 216.3, and the Degrees of Freedom value was 20.625.

When the data from Appendix A is used, we have the following result for Coefficient of Agreement: Coefficient of Agreement is $u = 0.157$, and the Coefficient of Concordance is $W = 0.255$.

Table 5-6: Simulation of 90% confidence intervals

Factor	Series 1	Series 2
1	2.60E-02	9.70E-02
2	4.60E-02	1.70E-01
3	8.60E-03	4.90E-02
4	1.40E-02	5.60E-02
5	2.00E-01	4.60E-01
6	9.30E-03	7.20E-02
7	1.40E-02	7.50E-02
8	4.30E-02	1.40E-01

9	8.60E-02	2.20E-01
10	8.70E-03	4.70E-02
11	3.60E-02	1.70E-01
12	2.50E-02	1.10E-01

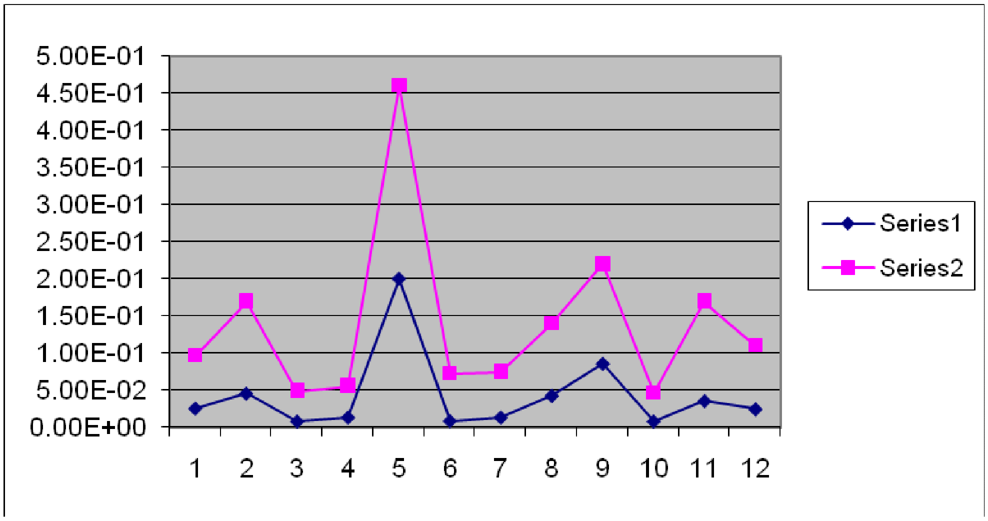


Figure 5-4: Simulation of 90% confidence intervals

Table 5-7: Response Data for Circular Triads

Expert	# of Circular Triads (c)	DOF	P-Value	Coefficient of Consistence (ζ)
E1	22	55	<0.0001	0.6857
E2	17	55	<0.0001	0.7572
E3	11	55	<0.0001	0.843
E4	39	55	<0.0001	0.4429
E5	12	55	<0.0001	0.8286
E6	8	55	<0.0001	0.8857
E8	0	55	<0.0001	1.0000
E9	4	55	<0.0001	0.9429
E10	12	55	<0.0001	0.8286
E11	2	55	<0.0001	0.9714
E12	11	55	<0.0001	0.843

Table 5-8: Factor Weight Values and Rank

Factor	**Coefficient of Agreement C(e)**	**Factor Weight**	**Rank**
1. Transport of trauma victims	60.5	0.0621	7
2. Limiting time to 60 min. (the Golden Hour)	72.5	0.0936	4
3. Gaining Revenue (downstream)	39.0	0.0297	11
4. Facility utilization	44.0	0.0353	9

5. Access to definitive care	101.0	0.3041	1
6. Marketing of health care facility	42.0	0.0329	10
7. Continued certificate of need	46.0	0.0379	8
8. Long distance involved	65.0	0.0723	5
9. Improving quality of service	83.0	0.1416	2
10. Lowering hospital cost	35.0	0.0253	12
11. Providing Inter-facility service	73.0	0.0953	3
12. Providing on-the-scene service	64.0	0.0699	6

5.11 Response to Research Questions

As stated in Chapter 4, this research study sought to answer the following two questions:

1. What are the main factors which influence the decision making processes of health care facilities to incorporate an air ambulance service in their current medical programs?
2. What is the ranking of factors in their importance that was identified in question #1 regarding the implementation of air ambulance services in existing health care facilities?

This research study has succeeded in answering both questions. The first research question was solved through performing two steps. First, we listed and identified the initial factors. They were analyzed in the literature review which resulted in extensive listing and sub-listings. The second step was performed by way of analyzing the outcomes of the first survey questionnaire. The results were provided in Table 5-8. Answering the second question required tabulating the second survey questionnaire that included a pair-wise comparison discussed in Chapter 4.

The results of the twelve factors were tabulated and ranked accordingly to their individual importance with respect to the experts' point of view. The "Chi-Squared" test was utilized to determine the statistical significance between the ranked factors.

Chapter 6

Conclusions and Recommendations

6.1 Research Methodology Summary

The main purposes of this research effort were to list and rank in importance the key factors that influence the implementation of HEMS in existing health care facilities. The development of this ranked list is the result of a four-step process:

1. Identify the initial factors (by implementing the first survey)
2. Reduce the number of factors (to a manageable number)
3. Determining the weighing methods for the selected factors

A panel of health care professionals experienced in emergency helicopter service representing various public, private, and state organizations throughout the states of Virginia and Maryland was selected for this research study.

Two survey instruments were developed, tested and then presented to the experts. The first survey was performed in person, as much as possible, and individually executed. The experts who were interviewed were requested to identify the factors that they thought to have the most influence on the implementation of the HEMS programs in their respective health care facilities.

The second survey followed the first three months later. Experts, who were contacted again, individually performed the second survey tasks by executing a pair-wise comparison test of the factors cited in the first survey. This was done in order to obtain a ranking gradation of these top 12 identified factors.

The identified factors were fully sufficient to describe the relevant characteristics related to helicopter emergency services. The second survey responses were analyzed by applying the Bradley-Terry model through the implementation of a PC software program called “wcompare”. With the application of this quantitative method, we produced the prioritized ranking of 12 factors, which represented the overall preferences of the experts. Ranking in importance of these 12 factors, through his method, was the second research question sought to be answered, which succeeded in achieving this goal.

This step produced a list of genuine factors recognized by the experts as the main factors that influence the implementation of the HEMS programs in existing health care facilities. The factors derived from this study are listed and ranked based on their importance:

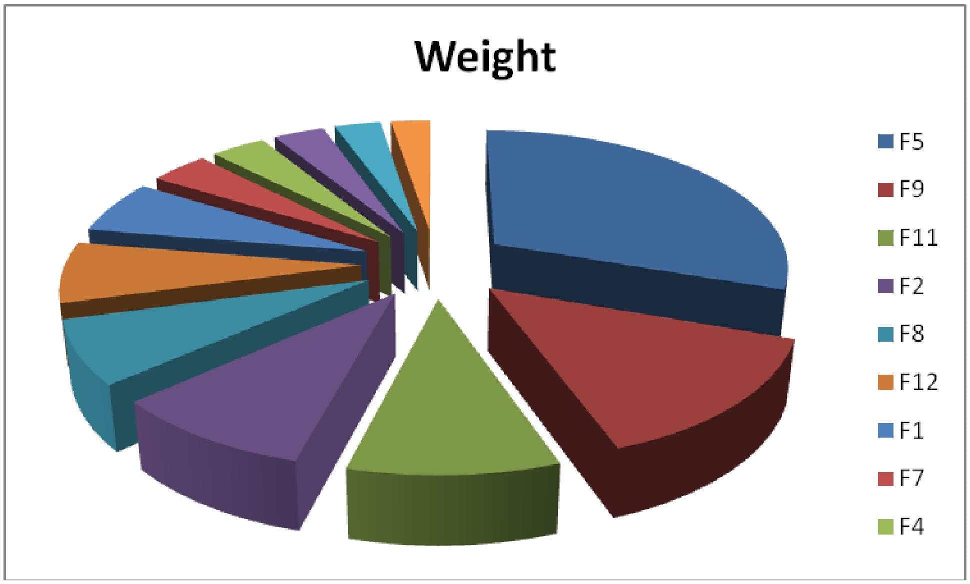
1- Access to definitive care (F5)
2- Improving quality of service (F9)
3- Providing inter-facility service (F11)
4- Limiting time to 60 min. (the Golden Hour) (F2)
5- Long distances involved (F8)
6- Providing on-the-scene service (F12)
7- Transport of trauma victims (F1)
8- Continued certificate of need (F7)
9- Facility utilization (F4)

10- Marketing of a health care facility (F6)

11- Gaining revenue (downstream) (F3)

12- Lowering hospital cost (F10)

Figure 6-1: Final Truncated Original Factors



6.2 Conclusions

The Helicopter Emergency Medical Program is considered an extension to the health care facility utilizing its service. An HEMS program is considered a high cost unit of service. Funding for air medical service is considered a problematic issue, also worldwide, even in Europe where most HEMS services programs are mainly government funded.

Helicopter Ambulance primarily transports the critically ill and injured, or patients requiring definitive care, to health care facilities, either from on-the-scene of the accident, or from another health care facility. The objective of an HEMS program is to deliver patients to a higher level of care. This factor proved to be the primary selection by the experts, with a large margin of difference between this and the next in ranking factors.

It seemed that the goal of either on-the-scene or inter-facility missions was to deliver the injured person to a better service than he or she was receiving. A delay in access to definitive care could result in more patient complications.

It is interesting to note here that the first ranked factor weighed significantly more than any other factor which followed. The decision involved is whether to have more hospitals and highly specialized staff in dispersed areas with low population concentration, or to have helicopter ambulance transport the needy patients to more definitive care health facilities and, thereby, decreasing the cost.

This is exemplified in rural areas where the objective is to provide an equal level of care for all the population. In one instance, 90% of patients arriving by helicopters to a specialized hospital came from community hospitals not having an advanced level of care for the patients who were admitted.

Secondary to "Access to definitive care" was "Improving quality of service" factor. Having more specialized hospitals is not only more cost-effective (no need to build more specialized wards), but additionally, it is more clinically effective because the level of expertise in the specialized hospitals rises with the introduction of highly specialized equipment. Also, more complex experience is gained through more frequent interactions with the HEMS transported patients.

The above explication illustrated how “Access to definitive care” and “Improving the quality of care” emerged as top priority factors. The need for implementing a HEMS program involves more than simply leasing or owning a service. Helicopter ambulance missions are driven by clinical needs.

1. Although all the experts except one cited “Transport of trauma victims” as the most scored factor in the first survey, the second survey results showed that it was ranked in the seventh place. Hence it was clear that the concern in HEMS transportation was not only “Transport of trauma victims.” Other life-threatening causes are as important, which is why HEMS are dedicated to on-the-scene and inter-facility transportation. Additionally, access to definitive care can include trauma and other interventions, such as: neurosurgery, cardiac or pediatric patients, as well as others. Finally, the national U.S. estimates show that 85% of all EMS transported patients with injuries can be treated in non-trauma centers.
2. The experts mentioned “Limiting time to 60 min. (Golden Hour)” scoring second place in the first survey, showing that it has less impact in the decision making than originally expected. The literature indicated that the “Golden Hour” period was critical to trauma patients’ survival rate upon reaching definitive care. This could constitute the reason to influence the decision of utilizing the air medical service, due to trauma related injuries of the patient. Since on-the-scene HEMS missions accounted for only about half of the total HEMS missions performed, this factor went down to the fourth place in the second survey. This supported the first survey premise, where time was more important during on-the-scene missions.

3. "Gaining revenue (downstream)" was mentioned as last but one factor in the second evaluation. Yet, this factor was scored as one of the top factors cited in the first survey. Although it was not entirely clear why this factor was ranked at this level, it is quite possible that the experts thought that concern for the patient's welfare should come first.
4. It is clear that patient-related factors were ranked first in the second survey. For instance, the following factors were most frequently cited: "Access to definitive care," "Improving quality of service," and "Providing inter-facility service." Accordingly, non-patient related factors such as: "Lowering hospital costs," "Gaining revenue (downstream)," and "Marketing of health care facility" were considered as the lowest weighing factors in the pair-wise comparison assessment. This could probably be indicative of the fact that experts in the air medical field are concerned to provide quality patient care rather than generate revenue. It should be noted here that most of the HEMS services are exclusively not-for-profit programs. In addition to that, the health care industry is one of the most scrutinized human endeavors.
5. "Access to definitive care" is the factor that was cited by many experts as the most important of all factors. This meant that the rural population should have access and utilization to the same level of care as the urban population. Providing equal levels of care is essential to many HEMS program policies. Since "Limiting time to 60 min. (Golden Hour)" is considered a pivotal factor in patients' survival outside the hospital, health care industry officials agreed that helicopter ambulance service would provide that critical time needed to save the patients'

lives by minimizing the transfer time to definitive care. Conditions unique to non-urban areas are connected to population dispersion. Rural population is dispersed into many local communities. Therefore, many of the rural areas' inhabitants are mainly the elderly. New retirement communities are established in these areas, which plays a crucial role in the future phase planning, expansion and providing the need for implementing the HEMS program. . Almost 95% of the highway networks in the United States are located in rural areas. Also, more than 66% of highly fatal motor vehicle accidents occur in rural areas. Thus, the need for implementation of the HEMS programs service should be further studied. The objective of "Access to definitive care" is to transport patients, with distances involved, to a higher level of medical care facility, or to bring the higher level of care to the patients who cannot be reached by means of the traditional ground ambulance service.

6. Most specialized health care facilities incorporate such programs. Their services are crucial for the survival of medical enterprises which want to accommodate as many patients as possible to perform the required medical intervention. For instance, one of the foremost inter-facility transfer types is cardiac care intervention. The revenue from this type of medical procedures by far exceeds the cost of transporting the patients using a ground ambulance service.

7. On-the-scene HEMS missions showed not to be as important as access to definitive care. This is practical when, e.g., on-the-scene rural accident victims are transported via ground ambulance service to a rural community hospital to stabilize their status, and then transferred to a trauma facility that has a more

definitive care capability. In this case, the use of the HEMS for inter-facility transport is better than on-the-scene transport service.

6.3 Implications of the Findings

This research study identified and ranked in importance the factors associated with the implementation of HEMS programs in health care facilities, rather that justifying their utilization. The arguments regarding costs, justifications, and the utility need appealed to the common sense of experts who were involved in pre-hospital care.

This research study alone cannot be the justification for implementing the HEMS programs, but it has gathered a cumulative body of knowledge on similar research studies outcomes. That said, it is possible to make initial speculations and draw conclusions regarding the factors which should be considered in implementing HEMS programs. Our recommendations reflect the analysis of the present HEMS program practices.

6.4 Suggestions for Further Research

Based on the results of this research, it would be appropriate and interesting to explore the new technological trends in the HEMS ownership and service type. Health care facilities are leaning towards outsourcing this type of program to private contractors. It might mean that they want to concentrate on the treatment aspect of the patients' care and not have to attend to reimbursement and helicopter operations issues.

Additionally, most medical insurers, including Medicare, provide reimbursements for this type of service. The privately owned HEMS programs are becoming increasingly more popular and are competing with hospital and state owned programs. The types of service include on-the-scene and inter-facility transport.

More research is needed for the justification of utilization of this service and to whom it should be represented to. For example, who should the on-scene HEMS service be designated to? Is this service selected for the state helicopter use only, or would there be formal criteria for determining who executes that type of mission?

It would be interesting to see a consortium between two health care facilities in implementing a single HEMS program for both facilities, for instance, when there is a university hospital with specialized care and another hospital in the same area with a trauma center. If joined together, they could create a unified HEMS program and, therefore, promote growth for both of the two involved enterprises. In addition to that, conducting a cost-benefit analysis between air and ground ambulance services could be an interesting research exercise to explore.

GLOSSARY

Except where noted, the definitions of these terms were taken from the website (www.dictionary.com).

Aero-medical adj., "Of or relating to aviation medicine. This can include fixed wing aviation or rotary wing (helicopter) aircrafts."(www.dictionary.com)

Air ambulance "A plane or helicopter equipped for flying ill or injured people to a hospital."(www.dictionary.com)

Demography "The study of the characteristics of human populations, such as size, growth, density, distribution, and vital statistics."(www.dictionary.com)

First responder's "Emergency personnel called to the scene of a crisis or responding to emergency calls for assistance. First responders could include emergency medical technicians, police, hotline/crisis line personnel, fire and rescue, child protective services and others."(www.nccev.org/resources/terms.html)

The Department of Homeland Security has defined first responders in a broader sense:

" …those individuals who in the early stages of an incident are responsible for the protection and preservation of life, property, evidence, and the environment, including emergency response providers as defined in section 2 of the Homeland Security Act of

2002 (6 U.S.C. 101)".(Department of Homeland Security, Homeland Security Presidential Directive/HSPD-8)

MEDEVAC n.,

1. "Air transport of persons to a place where they can receive medical or surgical care; medical evacuation."(www.dictionary.com)
2. "A helicopter or other aircraft used for such transport."(www.dictionary.com)

Paramedic: "A medical caregiver with advanced life support training."(www.dictionary.com)

Rotary Wing: Helicopter

Rural area "An area outside of cities and towns." (www.dictionary.com)

Suburban area " A residential district located on the outskirts of a city."www.dictionary.com)

Tertiary care: "A facility that can provide a Level III or Level IV trauma care. "

Trauma

1. **Penetrating Trauma** "Any physical damage to the body caused by violence or accident or fracture."(www.dictionary.com)

2. **Blunt Trauma** "An emotional wound or shock often having long-lasting effects."(www.dictionary.com)

Trauma center "A hospital unit specializing in the treatment of patients with acute and especially life-threatening injuries."(www.dictionary.com)

Urban area "A geographical area constituting a city or town." (www.dictionary.com)

ABBREVIATIONS

AAMS	Association of Air Medical Services
ALS	Advanced Life Support
BT	Bradley-Terry
EMS	Emergency Medical Service
EMT	Emergency Medical Technician
HEMS	Helicopter Emergency Medical Service.
MVA	Motor Vehicle Accidents
MVC	Motor Vehicle Crashes
WHO	World Health Organization

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APPENDIX A

RESEARCH INSTRUMENT (QUESTIONNAIRE) AND DATA

The research instrument applied in the second round used to analyze the experts' preferences is attached in B-1. It utilizes the twelve factors sought out from the first interview to be arranged in a pair-wise comparison survey. The second Questionnaire is divided into three main parts. This first part is a cover letter describing the reason and an invitation to take the survey and how to answer the pair-wise page. The second part is a unified definition of the twelve factors being implemented to gain unity in understandings when answering the questions.

The last part of the questionnaire is the one sought to be filled by the respondents; it contains sixty six pair-wise comparisons with two boxes to check an X on only one box as a preference between the two factors. Twelve experts responded to the survey by returning them as a word document attachment (except one which was returned as a PDF attachment). The first check box was referred to the left factor and the second checkbox was referred to the second factor being compared.

Attachment A-1

Cover Letter for Expert Members

The George Washington University
Department of Engineering Management and Systems Engineering
1776 G Street NW, Suite 110
Washington, DC 20052

Dear Sir/Madam,

During the summer of 2008, we began research interviews to gather information regarding what are the **Factors that influence health care facilities in their decision in implementing a helicopter emergency medical service**. Our interview with you was valuable in helping us understand the structure and organization of the helicopter ambulance service system. We combined the results of our interview with you with those of other interviewees and have identified the twelve decision factors that were most often cited.

We now seek to arrange the factors according to a consensus of their relative importance. Because of your expertise in helicopter ambulance service, we are requesting your participation in this survey, which will be part of a doctoral dissertation.

In the Word document attached to this message, please consider the relative importance of the paired factors as you view the list. Please put an X in the box next to the factor you consider the more important of the pair. Then simply save the changes and send the saved Word document back to us by replying to the message.

You will not be identified in the results of the compilation of the ranking results or any documents. Your records will be confidential.

If you have any questions about the procedures, please contact Dr. E. Lile Murphree at (703) 969-0355 or Abdulrahman Bin Salem at (703) 820-7747 or e-mail deerity@hotmail.com.

We appreciate very much your help in our research both by allowing us to interview you and by completing this survey. Your returning this survey is vital for our research as we are only asking twelve people to respond.

Sincerely,

E.Lile Murphree, Ph.D.
Professor of Engineering Management and Systems Engineering

Attachment A-2

Second Survey Factor Description Sheet

1) **Transport of trauma victims**: "**1 a :** an injury (as a wound) to living tissue caused by an extrinsic agent <surgical *trauma*> <the intra-abdominal organs at greatest risk to athletic *trauma* are the spleen, pancreas, and kidney **b :** a disordered psychic or behavioral state resulting from mental or emotional stress or physical injury
   2 : an agent, force, or mechanism that causes trauma."(Merriam-Webster dictionary)

2) **Limiting Time to the Golden Hour:** "The time from injury to definitive care, during which treatment of shock or traumatic injuries should occur because survival potential is the best."(http://www.ambulancetechnicianstudy.co.uk/popup/index.htm#g)

3) **Gaining downstream Revenue:** Income from In-house medical procedures. For example cardiac by-pass surgery

4) **Facility utilization**: Hospital use of beds, operating rooms, etc. from patients admitted.
5) **Access to definitive care**: is the range of in-house medical interventions that can be administered in a hospital. Access is through ground or air medical transport modes
6) **Marketing of health care facility**: promoting and increasing community awareness of the capabilities and services available in a particular medical facility.

7) **Continued certificate of need**: Certificate of approval granted by the authorized agency to a health care facility to establish a need for a renewal in continual accreditation for certain specialized medical procedures.
8) **Long distance involved**: when the distance needed to travel to an appropriate medical facility is deemed too long to travel by ground. This depends on patient stability and travel time to medical facility. Time is of the essence.
9) **To bring higher level of care to patient**: bringing a highly trained critical care medical team to the patient, whether in the home or on an accident scene. Not waiting for the patient to arrive at the medical facility before beginning lifesaving measures.

10) **Lowering hospital cost**: Through increase number of wards occupied.
11) **Providing Inter-facility service**: transporting patients from one hospital to another by ground or air transport modalities.
12) **Providing on-the-scene service**: bringing the medical crew and interventions to the patient.

Attachment A-3

Paired Comparison Questionnaire
(Second Survey)

	Factor	X	OR	X	Factor
1.	Trauma		OR		Time (Golden Hour)
2.	Trauma		OR		Revenue (downstream)
3.	Trauma		OR		Facility Utilization
4.	Trauma		OR		Access to definitive care
5.	Trauma		OR		Marketing of health care facility
6.	Trauma		OR		Continued certificate of need
7.	Trauma		OR		Long distance involved
8.	Trauma		OR		Bringing higher level of care to the patient
9.	Trauma		OR		Lowering hospital cost
10.	Trauma		OR		Providing inter-facility service
11.	Trauma		OR		Providing on-the-scene service
12.	Time (Golden Hour)		OR		Revenue (downstream)
13.	Time (Golden Hour)		OR		Facility Utilization
14.	Time (Golden Hour)		OR		Access to definitive care
15.	Time (Golden Hour)		OR		Marketing of health care facility
16.	Time (Golden Hour)		OR		Continued certificate of need
17.	Time (Golden Hour)		OR		Long distance involved
18.	Time (Golden Hour)		OR		Bringing higher level of care to the patient
19.	Time (Golden Hour)		OR		Lowering hospital cost
20.	Time (Golden Hour)		OR		Providing inter-facility service
21.	Time (Golden Hour)		OR		Providing on-the-scene service
22.	Facility Utilization		OR		Access to definitive care
23.	Revenue (downstream)		OR		Facility Utilization
24.	Revenue (downstream)		OR		Access to definitive care
25.	Revenue (downstream)		OR		Marketing of health care facility
26.	Revenue (downstream)		OR		Continued certificate of need
27.	Revenue (downstream)		OR		Long distance involved
28.	Revenue (downstream)		OR		Bringing higher level of care to the patient
29.	Revenue (downstream)		OR		Lowering hospital cost
30.	Revenue (downstream)		OR		Providing inter-facility service
31.	Revenue (downstream)		OR		Providing on-the-scene service
32.	Facility Utilization		OR		Marketing of health care facility
33.	Facility Utilization		OR		Continued certificate of need
34.	Facility Utilization		OR		Long distance involved

35.	Facility Utilization		OR		Bringing higher level of care to the patient
36.	Facility Utilization		OR		Lowering hospital cost
37.	Facility Utilization		OR		Providing inter-facility service
38.	Facility Utilization		OR		Providing on-the-scene service
39.	Access to definitive care		OR		Marketing of health care facility
40.	Access to definitive care		OR		Continued certificate of need
41.	Access to definitive care		OR		Long distance involved
42.	Access to definitive care		OR		Bringing higher level of care to the patient
43.	Access to definitive care		OR		Lowering hospital cost
44.	Access to definitive care		OR		Providing inter-facility service
45.	Access to definitive care		OR		Providing on-the-scene service
46.	Marketing of health care facility		OR		Continued certificate of need
47.	Marketing of health care facility		OR		Long distance involved
48.	Marketing of health care facility		OR		Bringing higher level of care to the patient
49.	Marketing of health care facility		OR		Lowering hospital cost
50.	Marketing of health care facility		OR		Providing inter-facility service
51.	Marketing of health care facility		OR		Providing on-the-scene service
52.	Continued certificate of need		OR		Long distance involved
53.	Continued certificate of need		OR		Bringing higher level of care to the patient
54.	Continued certificate of need		OR		Lowering hospital cost
55.	Continued certificate of need		OR		Providing inter-facility service
56.	Continued certificate of need		OR		Providing on-the-scene service
57.	Long distance involved		OR		Bringing higher level of care to the patient
58.	Long distance involved		OR		Lowering hospital cost
59.	Long distance involved		OR		Providing inter-facility service
60.	Long distance involved		OR		Providing on-the-scene service
61.	Bringing higher level of care to the patient		OR		Lowering hospital cost
62.	Bringing higher level of care to the patient		OR		Providing inter-facility service
63.	Bringing higher level of		OR		Providing on-the-scene service

	care to the patient				
64.	Lowering hospital cost		OR		Providing inter-facility service
65.	Lowering hospital cost		OR		Providing on-the-scene service
66.	Providing inter-facility service		OR		Providing on-the-scene service

APPENDIX B

Results of the Initial Paired Comparison Questionnaire Survey using WCOMPARE Software

Case name: Air Ambulance Service4 3/17/2009

RESULTS OF RUNNING MODELS FOR PAIRWISE COMPARISONS

Number of experts: 12 **Number of items**: 12

Transformation: no. Number of experts preferring "left" item to the "top", relative to the total number of replying experts.

Inconsistencies (circular triads) in experts answers.
Triads can be of the type C1 : A>B, B>C and C>A
C2 : A=B, A>C and B<C
C3 : A=B, A=C and B<C

Items scores, Circular triads C(e) and Coefficients of agreement
Items:

Expert name	1	2	3	4	5	6	7	8	9
0. E1	7.0	10.0	1.0	3.0	9.0	4.0	4.0	6.0	8.0
0. E2	7.0	9.0	6.0	6.0	10.0	2.0	10.0	1.0	4.0
0. E3	7.0	10.0	1.0	5.0	9.0	3.0	6.0	11.0	3.0
0. E4	6.0	8.0	5.0	3.0	4.0	7.0	2.0	3.0	6.0
0. E5	3.0	3.0	0.0	5.0	10.0	4.0	2.0	7.0	11.0
0. E6	5.0	11.0	0.0	10.0	9.0	2.0	7.0	3.0	6.0
0. E7	1.5	3.0	5.0	3.5	5.0	6.5	4.5	6.0	9.0
0. E8	6.0	5.0	4.0	2.0	11.0	3.0	0.0	7.0	10.0
0. E9	4.0	0.0	5.0	4.0	11.0	1.0	9.0	7.0	10.0
0. E10	1.0	3.0	11.0	2.0	6.0	9.0	2.0	4.0	7.0
0. E11	9.0	7.0	3.0	3.0	11.0	3.0	0.0	9.0	9.0
0. E12	5.5	6.5	3.0	1.0	11.0	4.0	4.0	7.0	10.0
Total	**62.0**	**75.5**	**44.0**	**47.5**	**106.0**	**48.5**	**50.5**	**71.0**	**93.0**

Expert name	10	11	12	Triads
0. E1	1.0	5.0	8.0	22
0. E2	2.0	6.0	3.0	17

0. E3	1.0	6.0	4.0	11	
0. E4	10.0	8.0	4.0	39	
0. E5	6.0	8.0	7.0	12	
0. E6	2.0	5.0	6.0	8	
0. E7	5.5	10.5	6.0	74	
0. E8	1.0	8.0	9.0	0	
0. E9	2.0	7.0	6.0	4	
0. E10	9.0	8.0	4.0	12	
0. E11	1.0	6.0	5.0	2	
0. E12	0.0	6.0	8.0	11	
Total	**40.5**	**83.5**	**70.0**		

Coefficient of agreement u = 0.136 (approxim., because of "=" answers)
Coefficient of concordance W = 0.233
Non-transformed items values

Item name	NEL(Bradley-Terry)	Thurstone C	Thurstone B
1. F1	0.0578	-0.0859	-0.1439
2. F2	0.0876	0.1758	0.3297
3. F3	0.0328	-0.4384	-0.7979
4. F4	0.0368	-0.3659	-0.6609
5. F5	0.2587	0.8141	1.5078
6. F6	0.0380	-0.3288	-0.6068
7. F7	0.0405	-0.3034	-0.5567
8. F8	0.0762	0.0758	0.1375
9. F9	0.1558	0.5228	0.9492
10. F10	0.0292	-0.4816	-0.8972
11. F11	0.1129	0.3532	0.6313
12. F12	0.0739	0.0621	0.1080

Goodness of fit: 33.9566 40.7328(Chi-square distributed with 55 degrees of freedom)
Simulation of 90% confidence intervals:

Item	NEL (Bradley-Terry)	Thurstone C (linear)
1	[2.6E-0002, 9.7E-0002]	[0.0E+0000, 2.8E-0001]
2	[5.5E-0002, 1.5E-0001]	[0.0E+0000, 5.7E-0001]
3	[1.0E-0002, 5.7E-0002]	[0.0E+0000,-1.3E-0001]
4	[2.0E-0002, 8.0E-0002]	[0.0E+0000,-1.0E-0001]
5	[1.5E-0001, 4.0E-0001]	[4.2E-0001, 1.3E+0000]
6	[1.8E-0002, 5.6E-0002]	[0.0E+0000, 1.7E-0001]
7	[2.0E-0002, 6.5E-0002]	[0.0E+0000, 9.6E-0002]

8	[3.7E-0002, 1.1E-0001]	[0.0E+0000, 5.4E-0001]
9	[8.3E-0002, 2.7E-0001]	[2.4E-0001, 9.5E-0001]
10	[1.0E-0002, 5.4E-0002]	[0.0E+0000,-1.5E-0001]
11	[6.2E-0002, 2.0E-0001]	[0.0E+0000, 8.6E-0001]
12	[3.2E-0002, 1.4E-0001]	[0.0E+0000, 4.8E-0001]

APPENDIX C

Results of the Second Paired Comparison Questionnaire survey using WCOMPARE Software (Eliminating expert#7)

Case name: Air Ambulance Service5 2/23/2009

<u>RESULTS OF RUNNING MODELS FOR PAIRWISE COMPARISONS</u>

Number of experts: 11 **Number of items**: 12

Transformation: no. Number of experts preferring "left" item to the "top," relative to the total number of replying experts

Item	2	3	4	5	6	7	8	9
1	5.5/11	9.0/11	7.0/11	2.0/11	9.0/11	8.0/11	3.0/11	2.0/11
2		8.0/11	7.0/11	4.0/11	8.0/11	9.0/11	4.0/11	5.0/11
3			6.0/11	1.0/11	5.0/11	4.0/11	4.0/11	2.0/10
4				2.0/11	6.0/11	4.0/11	3.0/11	4.0/11
5					9.0/11	10.0/11	10.0/11	9.0/11
6						6.0/11	4.0/11	3.0/11
7							3.0/11	3.0/11
8								2.0/11

Item	10	11	12
1	8.0/11	3.0/11	4.0/11
2	7.0/11	7.0/11	8.0/11
3	7.0/11	3.0/11	2.0/11
4	8.0/11	1.0/11	3.0/11
5	9.0/11	9.0/11	10.0/11
6	6.0/11	3.0/11	2.0/11
7	6.0/11	4.0/11	5.0/11
8	9.0/11	4.0/11	4.0/11
9	9.0/11	8.0/11	9.0/11
10		2.0/11	3.0/11
11			7.0/11

Items scores, Circular Triads C(e) and Coefficients of Agreement:

Expert name :	1	2	3	4	5	6	7	8	9
0. E1	7.0	10.0	1.0	3.0	9.0	4.0	4.0	6.0	8.0
0. E2	7.0	9.0	6.0	6.0	10.0	2.0	10.0	1.0	4.0
0. E3	7.0	10.0	1.0	5.0	9.0	3.0	6.0	11.0	3.0
0. E4	6.0	8.0	5.0	3.0	4.0	7.0	2.0	3.0	6.0
0. E5	3.0	3.0	0.0	5.0	10.0	4.0	2.0	7.0	h11.0
0. E6	5.0	11.0	0.0	10.0	9.0	2.0	7.0	3.0	6.0
0. E8	6.0	5.0	4.0	2.0	11.0	3.0	0.0	7.0	10.0
0. E9	4.0	0.0	5.0	4.0	11.0	1.0	9.0	7.0	10.0
0. E10	1.0	3.0	11.0	2.0	6.0	9.0	2.0	4.0	7.0
0. E11	9.0	7.0	3.0	3.0	11.0	3.0	0.0	9.0	9.0
0. E12	5.5	6.5	3.0	1.0	11.0	4.0	4.0	7.0	9.0
Total	**60.5**	**72.5**	**39.0**	**44.0**	**101.0**	**42.0**	**46.0**	**65.0**	**83.0**

Expert name	10	11	12	Triads
0. E1	1.0	5.0	8.0	22
0. E2	2.0	6.0	3.0	17
0. E3	1.0	6.0	4.0	11
0. E4	10.0	8.0	4.0	39
0. E5	6.0	8.0	7.0	12
0. E6	2.0	5.0	6.0	8
0. E8	1.0	8.0	9.0	0
0. E9	2.0	7.0	6.0	4
0. E10	9.0	8.0	4.0	12
0. E11	1.0	6.0	5.0	2
0. E12	0.0	6.0	8.0	11
Total	**35.0**	**73.0**	**64.0**	

Coefficient of agreement u = 0.157 (approxim., because of "=" answers)
Coefficient of concordance W = 0.255
Non-transformed items values

Item name	NEL(Bradley-Terry)	Thurstone C	Thurstone B
1. F1	0.0621	-0.0000	0.0143
2. F2	0.0936	0.2464	0.4490
3. F3	0.0297	-0.4627	-0.8162
4. F4	0.0353	-0.3536	-0.6174
5. F5	0.3041	0.9285	1.6741
6. F6	0.0329	-0.3884	-0.6931
7. F7	0.0379	-0.3186	-0.5654
8. F8	0.0723	0.0689	0.1225

9. F9	0.1416	0.4870	0.8474
10. F10	0.0253	-0.5312	-0.9660
11. F11	0.0953	0.2702	0.4622
12. F12	0.0699	0.0534	0.0885

Goodness of fit : 36.8622 and 43.6723(Chi-square distributed with 55 degrees of freedom)

Simulation of 90% confidence intervals.

Item	NEL (Bradley-Terry)	Thurstone C (linear)
1	[2.6E-0002, 9.7E-0002]	[0.0E+0000, 2.8E-0001]
2	[5.5E-0002, 1.5E-0001]	[0.0E+0000, 5.7E-0001]
3	[1.0E-0002, 5.7E-0002]	[0.0E+0000,-1.3E-0001]
4	[2.0E-0002, 8.0E-0002]	[0.0E+0000,-1.0E-0001]
5	[1.5E-0001, 4.0E-0001]	[4.2E-0001, 1.3E+0000]
6	[1.8E-0002, 5.6E-0002]	[0.0E+0000, 1.7E-0001]
8	[3.7E-0002, 1.1E-0001]	[0.0E+0000, 5.4E-0001]
9	[8.3E-0002, 2.7E-0001]	[2.4E-0001, 9.5E-0001]
10	[1.0E-0002, 5.4E-0002]	[0.0E+0000,-1.5E-0001]
11	[6.2E-0002, 2.0E-0001]	[0.0E+0000, 8.6E-0001]
12	[3.2E-0002, 1.4E-0001]	[0.0E+0000, 4.8E-0001]

Appendix D

Number of times each factor was selected

	1	2	3	4	5	6	7	8	9	10	11	12	
1		5.5	9	7	2	9	8	3	2	8	3	4	60.5
2	5.5		8	7	4	8	9	4	5	7	7	8	72.5
3	2	3		6	1	5	4	4	2	7	3	2	39
4	4	4	5		2	6	4	3	4	8	1	3	44
5	9	7	10	9		9	10	10	9	9	9	10	101
6	2	3	6	5	2		6	4	3	6	3	2	42
7	3	2	7	7	1	5		3	3	6	4	5	46
8	8	7	7	8	1	7	8		2	9	4	4	65
9	9	6	9	7	2	8	8	9		9	8	9	84
10	3	4	4	3	2	5	5	2	2		2	3	35
11	8	4	8	10	2	8	7	7	3	9		7	73
12	7	3	9	8	1	9	6	7	2	8	4		64
													Total: 726

APPENDIX E

Types of HEMS Models

After gaining nine interviews with health care facility officials regarding the factors that influenced them in implementing helicopter ambulance service in their facilities we should seek now the models that are available from the past interviews. We should look at how these services operate in each health care facility and what type of model they implemented. We should articulate the different models that we came up with. From the interviews we sought, we found to 4 different types of model that these health care facilities implemented. They are as follows:

1. Hospital owned model
2. State owned model
3. Private operator owned model
4. Consortium owned of health care facilities model

All the factors gained from the interviews could be put in one general model. Specific models can have certain independent factors. These factors could be given a specific weight, and concerning other common factors could be given the same vale. First we have to describe several ways of interpreting these models in one common language. There has to be a detailed description of each model, what types of factors do they contain, and how they operate.Also in each model we have to sort out who runs the helicopter, who is responsible for the flight crew, maintenance crew, and the medical crew and what does each one of them contain.

Here we have to describe the driving factors that make these health care facilities choose a particular model. Also we need to know what trend the majority of these health care facilities prefer. For instance, such hospitals chose a certain system to provide a high-priced surgeon more patients which should fill in the number of patients that could generate for the hospital the amount of coverage for that physician.

Appendix F

List of Factors Collected from Participants

1-Access to care for rural population

2- Higher quality of care

3-Higher quality of clinical care

4-Cost efficiency of care

5-Distance to definitive care

6- Limiting time to 6o min. (Golden hour)

7- Transport of trauma victims

8- Transporting Cardiac patients

9- Transporting Sever burns patients

10-transporting neurosurgical patients

11-Long distance involved

12- Revenue generation (for hospitals)

13- Facility population (utilization)

14-Marketing of the health care facility (Advertising)

15-Increasing level of care (quality)

16-Integration of the health system

17- Increased number of beds being occupied

18-Reimbursement of this service from health care providers (Insurers)

19- Faster access for patients to definitive care

20-Providing on-the-scene service