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Florida Adult Trauma Scorecard Methodology and Scene Transportation Choice

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This is to certify that the doctoral dissertation by

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Abstract

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MPA, University of San Francisco, 1996

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

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Abstract

Prehospital management of patients who are traumatically injured within the state of Florida starts with the use of the Florida Adult Trauma Scorecard Methodology. The scorecard methodology may indicate that a patient is a Trauma Alert based on applied physiological and other judgment criteria. However, patients may be transported via Helicopter Emergency Medical Services (HEMS) without justified physiological needs. Rawls' theory of justice posits that a fair and equal distribution of social resources is essential to public wellbeing. To evaluate this premise regarding prehospital trauma transports, archival 2015 data from the Florida Department of Health Trauma Registry was obtained. Using logistic regression, each trauma scorecard assessment criteria was individually and collectively evaluated regarding its predictive likelihood of a scene responder requesting HEMS versus ground ambulance transport. Controlling for trauma center locations, all five of the triage classifications illustrated a significant likelihood (p = 0.000) of HEMS transportation requests. Category 4 (EMS Judgment) predicted the highest likelihood of HEMS transport requests (b = 2.39, Wald $\chi^2(1)$ = 2026.88, OR = 10.9, p = .000, CI [9.83, 12.09]). Categories 4 (14.7%) and 6 (Local Criteria; [25.8%]) illustrated unexpectedly high percentages of emergency department discharge when Trauma Alert patients were HEMS transported. Over triage of patients to HEMS without meeting physiologic criteria provides less than an equal and fair distribution of public and private resources. State-level social change can be realized through HEMS transport criteria modifications applying more stringent application of physiologic patient condition scoring when determining the mode of prehospital scene response transport.

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Dedication

First and foremost, to my husband and soulmate Chip who kept after me to get my Masters degree then move on to my doctorate. Every step of the way, together and forever. “In Periculis Audax.”

To the flight crew member that I met very briefly in Orlando who survived a HEMS crash and is learning to teach Crew Resource Management to other flight crews. Thank you for your dedication and courage.

And finally, to Randy Mains and Michael Abernethy MD who have dedicated themselves to effective and safe patient transportation by helicopter in the United States. They are fighting the good fight to make sure everyone comes home: The flight crew, the patient, and the prehospital professionals. “Every call for service, every time.”

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I cannot say enough about by committee chair Dr. Steven A. Matarelli! His ability to help me keep a vision when every sentence seemed to be a struggle was essential and much appreciated. He kept me on task and helped me learn when I stumbled. I could not have asked for a better mentor and we even shared some laughs along the way. I also offer my sincere thanks to Dr. Joseph Pascarella. Dr. Joe shared his knowledge of my subject and his suggestions for evaluating our dataset were extremely valuable and kept me on the right track. To my University Research Reviewer, Dr. Lydia Forsythe - Thank you for your diligence in reviewing my manuscript. A great editor is essential to success and I certainly appreciate your efforts on my behalf.

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Chapter 1: Introduction to the Study

Introduction

In 2015, the Florida Department of Health (2016b) recorded 102,363 traumatic injuries being transported to a designated trauma center; 1,103 were fatal. Prehospital management of patients who have suffered a traumatic injury starts with the use of the Florida Adult Trauma Scorecard Methodology (see Appendix A) for Emergency Medical Services (EMS) responders. The scorecard methodology is a predefined checklist of physiological criteria that may indicate a patient is a Trauma Alert, which requires transportation to the closest trauma center.

One of the significant drawbacks of the scorecard is the lack of criteria to determine if a patient should be transported via Helicopter Emergency Medical Service (HEMS) or a traditional ground ambulance. Decisions regarding transportation method are left up to the first responder crew, usually a paramedic. The decision processes of paramedic outside the guidance of the trauma scorecard is called paramedic discretion. Paramedic discretion has been determined to be an unreliable method of classification (Mulholland, Gabbe, & Cameron, 2005; Smith et al., 2013). My study explores if the physiological criteria of the trauma scorecard have any relationship with the use of HEMS as a transportation method outside of paramedic discretion.

Background of the Study

Triage is thought to have its origin during the Napoleonic war when the Surgeon in Chief to Napoleon's Imperial Guard Baron Dominique Jean Larrey sorted patients

based on their level of injury (Robertson-Steel, 2006). The origin of the word triage comes from the French trier meaning to sort. Robertson-Steel (2006) stated that the overall goal of triage is to sort patients into categories by severity so that patients with minor injuries do not receive care before more injured patients. Triage is a method to manage patients most efficiently, so the overall good of the public is addressed. The Florida Adult Trauma Scorecard Methodology is a version of triage meant to discover critical trauma patients through the use of screening methods (Florida Administrative Code, 2016). The scorecard also assures the common good of the public is addressed by timely trauma treatment.

Problem Statement

The Florida Adult Trauma Scorecard Methodology (Florida Administrative Code, 2016) does not provide specific guidance to paramedics in determining patient transportation via HEMS to a trauma center. The Adult Trauma Scorecard Methodology contains specific anatomical and physiological criteria divided into color-coded categories. The red category is structured to represent the most severe injuries where one selection would indicate a Trauma Alert. The blue category involves less severe criteria that may be combined to declare a Trauma Alert. The Glasgow Coma Score (GCS) is also listed on the scorecard where an assessment of Best Motor Response ≤ 12 is classified as a Trauma Alert. None of the listed criteria indicate when a HEMS unit may be appropriate. Currently in Florida and many other states, because there is no specific guidance within the trauma scorecard, decisions regarding mode of patient transportation

rest with the paramedic and the specific trauma scorecard criteria. However, paramedic discretion has been determined to be an unreliable method of classification (Fitzharris, Stevenson, Middleton, & Sinclair, 2012; Mulholland et al., 2005; Smith et al., 2013).

In comparison, Hirshon et al. (2016) provided data from the implementation of a specific HEMS triage protocol within their single dispatch center showing a resulting decrease in flights by 55.9% in the state of Maryland. Brown et al. (2017) provided a retrospective analysis applying the Air Medical Prehospital Triage score (AMPT) to past EMS responses in Pennsylvania. The AMPT is not currently in use within any EMS system in the United States but showed promise in reducing the inappropriate use of HEMS (Brown et al., 2017).

Improper use of HEMS when it is not medically indicated can impact patients negatively. The overall cost of transportation differs by upwards of $30,000 to $90,000 for patients transported by HEMS when compared with transportation by an ambulance (Cates-Carney, 2016; Delgado et al., 2013; Plevin & Evans, 2011; Taylor, Curtis, Jan, & Newcombe, 2013; Taylor et al., 2010). Additionally, inappropriate use of a limited number of HEMS aircraft may result in patients who would benefit from HEMS transport not receiving the service because the aircraft is carrying a nonemergent patient (Giannakopoulos et al., 2012). Serious concerns have been raised concerning flight safety. Mains (2017) reported that 322 crew members had died out of more than 700 crew members who were involved in HEMS accidents from 1979 to 2014

Many possible factors contribute to the problem of determining the appropriate use of HEMS in trauma triage situations. Some of these factors include the design of the trauma scorecard, the visual impact of the scene upon the paramedic, and paramedic experience (Mulholland et al., 2005; Smith et al., 2013). There is scant published literature showing a possible correlation between the lack of specific trauma triage transportation criteria and the misuse of HEMS apart from paramedic discretion. This study contributes to the literature by providing data about the specific Trauma Alert criteria for Florida public officials and decision-makers to the extent that the lack of specific trauma transportation criteria may result in the misuse of HEMS resources.

Purpose of the Study

The purpose of my quantitative study was to investigate the extent that a lack of specific transport criteria within the Florida Adult Trauma Scorecard Methodology may result in the use of HEMS resources. This study evaluated trauma triage criteria as listed on the trauma scorecard (IV) about how individual patients were transported to a trauma center (DV). This investigation used a retrospective quantitative methodology to analyze 2015 data from the Florida Department of Health Trauma Registry (Florida Department of Health, 2016b).

Research Question and Hypotheses

My study investigates the relationship between the listed anatomical and physiological criteria listed on the trauma scorecard and the mode of patient transportation. The research question and hypotheses follow:

RQ: Is there a likelihood of field scoring for red (single criterion), blue (two criteria), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard to predict scene responder request for the use of HEMS versus ground ambulance transport when controlling for trauma center location?

H_0*:* There is no significant likelihood that field scoring for red (single criterion), blue (two criteria), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard predicts scene responder request for the use of HEMS versus ground ambulance transport when controlling for trauma center location.

H_a*:* There is a significant likelihood that field scoring for red (single criterion), blue (two criteria), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard predicts scene responder request for the use of HEMS versus ground ambulance transport when controlling for trauma center location.

Logistic regression was used to assess these research questions. Field (2012) said logistic regression analysis describes relationships between the IVs and DVs. Rejection of the null hypothesis indicates that the DVs were affected by the IVs. Conversely, if the null hypothesis is retained, the IVs likely have no predictive effect on the DVs. The control variable, trauma center location was selected based on the May 2017 trauma center listing shown in Appendix B.

Theoretical Framework

Florida Administrative Code 64J-2.004 established the development and mandatory use of the adult trauma triage criteria and methodology through the

rulemaking process ascribed in Chapter 120, The Administrative Procedures Act of the State of Florida (Florida Administrative Register, 2017). The administrative code process provides public notice and requires public comment before filing rules for adoption. The Florida Administrative Register publishes a daily edition which is accessible for all public notices, hearings, and other actions as required (Florida Administrative Register, 2017).

The Florida rulemaking process is aligned with the social contract theory originated by 17th-century political philosopher Thomas Hobbes. The social contract theory involves how the legitimacy of social policies requires the consent of the public (Duncan, 2009). The Florida Adult Trauma Scorecard Methodology traveled through the administrative code process with the opportunity for public participation most recently in 2002 without a determinant for HEMS transportation (Florida Department of Health, 2004). Blacksher, Diebel, Forest, Goold, and Abelson (2012) described the minimum requirements for public deliberation: there must be (a) a factual display of information presented without bias to increase knowledge of the issue at hand, (b) diverse representation to offer alternative viewpoints, and (c) open discussion regarding issues surrounding the topic to test competing ideas.

Bruera and Stone (2008) discussed the social contract theory as well as the theory of justice attributed to John Rawls concerning limited medical resources. Rawls' theory of justice adds to the social contract theory that the public is not subject to political and moral authority unless a substantial reason exists which has been agreed upon (Bruera &

Stone, 2008; D'Agostino, Gaus, & Thrasher, 1996; Quong, 2013). The issue of public deliberation as a conversation of morals and value-based reasoning is central to Rawls' ideals (Abelson, Blacksher, Li, Boesveld, & Goold, 2013) Additionally, Rawls (1999) supported the theory that justice should be equitably distributed but how is fair determined through the public hearing process? Derlet and Ledesma (1999) said that public discussion of complex medical issues might result in personal application of a participant's own needs rather than that of the public at large. Applying public reason and the theory of justice to limited medical resources such as HEMS would require that choices regarding who does and does not receive resources should not be left to chance or opinion.

Nature of the Study

My research used secondary data obtained from the Florida Trauma Registry to determine if a significant likelihood exists between the IVs trauma triage criteria and the field transport decision between the dichotomized (DV) of HEMS versus ground ambulance. Evaluation of secondary data fits with the quantitative research methodology which examines relationships between variables. The obtained data will include all trauma patients during the calendar year 2015 as entered through the Florida Trauma Registry.

Definitions

The following definitions are added to clarify their use throughout my study.

Balance billing: Occurs when providers bill a patient for the difference between the amount they charge and the amount that the patient's insurance pays (Perritt, 2016).

Certificate of public convenience and necessity (COPCN): Approved and issued by the county commission in the county where an ambulance or aircraft has operations. The requirements for approval include a medical director (licensed Florida physician) with a Department of Justice-Drug Enforcement Administration (DEA) registration (DEA registration is required for ALS only), vehicle liability insurance, trauma transport protocols, and an approved radio communication system (Florida Department of Health, 2017).

Emergency medical services: The arrangement of personnel, facilities, and equipment for the effective and coordinated delivery of prehospital emergency medical services required for the prevention and management of incidents (Florida Department of Health, 2016c).

EMS judgment: The EMT or paramedic on the scene of a traumatic emergency can call a Trauma Alert if, in his or her judgment, the patient's condition warrants such action in the absence of pertinent criteria on the trauma scorecard (Florida Administrative Code, 2018).

Florida Trauma Scorecard Methodology: Administrative Code 64J-2.004 defines the Florida Trauma Scorecard Methodology and mandates use by all EMT or Paramedic personnel for each trauma patient encountered (Florida Administrative Code, 2016).

Golden hour: The concept that an injured patient has 60 minutes from time of injury to receive definitive care, after which morbidity and mortality significantly increase (Rogers, Rittenhouse, & Gross, 2015).

Helicopter Emergency Medical Services (HEMS): A rotary-wing aircraft configured to transport critical patients to a hospital (Federal Aviation Administration, 2015).

Glasgow Coma Score: The neurological assessment method developed by G. Teasdale and B. Jennette in *"Assessment of Coma and Impaired Con*sciousness: *A Practical Scale*" (Florida Administrative Code, 2018; Teasdale & Jennett, 1974).

MEDEVAC: Aerial Military Medical Evacuation as commonly used in military terminology (Keneally, Robbins, & Lunday, 2016).

Over triage: The initial transportation of a non severely injured patient to a trauma center (Fullerton et al., 2014)

Trauma: Blunt, penetrating, or burn injuries caused by external force or violence (Florida Administrative Code, 2018).

Trauma alert: The notification made by an EMS provider informing a hospital or trauma center that they are enroute with a patient meeting approved triage criteria listed in the trauma scorecard (Florida Department of Health, 2016c).

Trauma center: A specialty trauma-receiving hospital meeting specific staffing and treatment standards as dictated within Florida Administrative Code section 64J-2.011 (Florida Department of Health, 2016c).

Trauma registry: A statewide database which integrates medical and system information related to trauma patient diagnosis and the provision of trauma care (Florida Administrative Code, 2018).

Triage: Criteria designed to match a patient's injury type and severity to prioritized transportation to a location offering definitive patient care (MacKersie, 2006).

Under triage: The initial transportation of severely injured patients to a non trauma center (Haas et al., 2010).

Assumptions

An essential aspect of selecting quantitative analysis for scientific inquiry is assumptions. A clear statement of assumptions, including selected protocols and paradigms and how those assumptions are met, is required for a quantitative study (Field, 2013). The specific requirements of the selected logistic regression analysis method will be discussed in Chapter 3.

Aside from the specific assumptions of quantitative analysis, there are three essential assumptions regarding the content of this study:

It is assumed that all EMS responders are trained and proficient in the use of the Florida Adult Trauma Scorecard Methodology as directed in the Florida Statute and Administrative Code (Florida Administrative Code, 2016; Florida Statutes, 2012). This assumption includes initial and continuing EMS educational opportunities as dictated in public policy.

The second assumption is that all EMS responders used the trauma scorecard methodology with every trauma call, which required determination of Trauma Alert status. Use of the trauma scorecard methodology is also required by Florida Statute and Administrative Code.

Lastly, it is assumed that all data entered into the Florida Department of Health Trauma Registry database is accurate. The actual field patient care reports reflect the use of the trauma scorecard methodology during the selected time frame. As mentioned, the use of secondary data carries the risk of error in data entry.

Limitations

The Florida Trauma Registry data system relies on trauma centers throughout Florida to record and enter local information accurately using the format required by the 2014 Florida Trauma Registry data dictionary (Florida Department of Health, 2016b). The use of secondary data will present the risk that local data was not entered or documented correctly. The Florida Department of Health makes all efforts to ensure the correctness of the received data before publishing results to the National Trauma Data Bank (NTDB) (American College of Surgeons, 2018a).

Concerns about secondary data entry aside, observation and evaluation of actual EMS crews performing trauma triage using the Florida Adult Trauma Triage Methodology would be a monumental task statewide. Emergency calls requiring EMS response are random and unpredictable, making proactive assessment extremely difficult if not impossible. I would need to be in the right place at the right time to observe each

trauma call in the 65,755 square miles that make up the state of Florida. This study does not evaluate estimated air miles versus ground miles when transporting patients to the closest trauma center as these data are not considered a component of the Trauma Scorecard Methodology. The overall mileage and topographical terrain may be a valid consideration when a paramedic decides on a transportation modality, which is outside the parameters of this proposed study.

The Florida Trauma Scorecard Methodology allows discretionary requests for HEMS resources which are not associated with the listed criteria. These requests are determined to be EMS Discretion for classification purposes in the trauma triage process (Florida Department of Health, 2004). Discretionary requests for HEMS have been determined to be unreliable to predict the severity of the injury. Discretionary use of HEMS is discussed at length in the literature as accounting for a range of over triage between 20 and 30% (Cox et al., 2011; Fitzharris et al., 2012; Lin, Becker, & Lynn, 2012b; Mulholland et al., 2005)

Significance

There were 102,363 traumatic injuries transported to a trauma center of which 1,103 were fatal in the state of Florida in 2015. Medical management of patients who have suffered traumatic injuries starts with the use of the Florida Adult Trauma Scorecard Methodology for EMS responders. There has been a very limited amount of research dedicated to the Florida method of trauma triage to determine how patients are transported to a trauma center.

Researchers have studied various trauma triage methodologies outside of Florida to determine the accuracy of patient injury prediction (Barnett et al., 2013; Lin, Becker, & Lynn, 2012a). More research is needed to determine the extent that trauma triage can predict patient transportation decisions. This study would add to the literature to address a gap in understanding whether a lack of transportation criteria within trauma triage methodologies may result in inappropriate transportation decisions including the use of the HEMS aircraft specific to Florida.

Helicopter Emergency Medical Services are a very limited resource in Florida with 24 aircraft operating over 65,755 square miles (Florida Department of Health, 2016b). The limited availability of this resource requires accuracy in determining which patients would benefit most from receiving the service.

Summary

The Florida Adult Trauma Scorecard Methodology is a predetermined checklist for first responders to use when classifying a patient who has suffered a traumatic injury. The scorecard methodology uses specific physiological criteria that may indicate a patient is a Trauma Alert which requires transportation to the closest trauma center. The trauma scorecard does not contain information to help in terms of when a patient would benefit from helicopter transportation. Decisions regarding transportation method are left up to the first responder crew, usually a paramedic. The decision process for a paramedic outside of the guidance of the trauma scorecard is called paramedic discretion. Paramedic discretion has been determined to be an unreliable method of classification

(Mulholland et al., 2005; Smith et al., 2013). This study will explore if the physiological criteria on the trauma scorecard have any relationship with the use of HEMS as a transportation method outside of paramedic discretion. A review of related literature appears in Chapter 2.

Chapter 2: Literature Review

Introduction

This chapter offers a review of previous research, documents, and related public policy regarding trauma triage methodologies and mode of patient transportation. A historical review was also completed to provide context to this study. There is a sparse amount of research regarding the combination of trauma triage use and the selection of ambulance versus helicopter patient transportation.

Literature Search Strategy

A search was conducted to access peer-reviewed published studies regarding patient transportation decisions and the use of a trauma scorecard methodology using online databases, professional websites, and electronic government publications. Online databases included Thoreau, CINAHL & MEDLINE Simultaneous Search, LexisNexis, Taylor and Francis, Atlas & Database of Air Medical Services (ADAMS), and Science Direct. The keywords included singular and combined forms of the following terms: *trauma triage*, *trauma scorecard*, *Trauma Alert*, *trauma protocol*, *ambulance*, *patient transportation*, *helicopter emergency medical services*, *accreditation*, *aviation*, *MEDEVAC*, *ambulance*, *trauma center*, *air ambulance*, *over triage*, *under triage*, *injury severity score*, *ISS*, *golden hour*, and *ACSCOT*. Specific year limitations were not used for this literature search as a lack of published information exists regarding this topic within the past three years.

Websites were accessed from the following organizations/committees: the American College of Surgeons Committee on Trauma (ACSCOT), Commission on Accreditation of Medical Transport Systems (CAMTS), National Accreditation Alliance Medical Transport Applications (NAAMTA), Federal Aviation Administration (FAA), National Academies of Science, Engineering and Medicine, Centers for Disease Control and Prevention (CDC), United States Department of Transportation (USDOT), and the National Highway Traffic Safety Administration (NHTSA).

Theoretical Foundation

Ekmekci and Arda (2015) said that the theory of justice was not explicitly related to medical care but may have value in its application. Despite the lack of specific medical adaptations by Rawls, he specifically supported that variations in personal health are not unfair leading to injustice as long as the theory of justice is satisfied for all (Rhodes, 2018).

Current thought applying Rawls' theory of justice to critical medical incidents range from a discussion regarding how much medical treatment should be provided to terminally ill patients to a determination of if someone is at fault for an accidental injury. Daniels (2001) stated there are three conflicts that need to be resolved when determining justice in healthcare: (a) whether the definitive medical care of one can be outweighed by a moderate amount of care to many, (b) how much priority should be given to the most ill, and (c) whether the value of a medical treatment or service should be balanced by more cost-effective methods.

Daniels' concepts are expanded by those who support the concept of luck egalitarianism. Luck egalitarianism adds the consideration of fault when assessing scarce medical resources (Albertsen & Knight, 2014; Douglas, 2017). Assuming a medical responder has arrived at the scene of a single car versus a tree. When the crew approaches the vehicle, the driver is demonstrating signs of being intoxicated. Luck egalitarianism would theorize that this patient caused their own injury by driving while intoxicated so the driver vacated their right to equal justice of medical care. To advance this concept further, if the intoxicated driver collided with another car and hurt an innocent driver, luck egalitarianism would suggest the innocent driver receives medical care before the intoxicated individual as a matter of justice.

Rhodes (2018) said EMS providers disregard the concepts of fair and equal treatment for all in emergency situations, preferring to focus exclusively on the immediacy and severity of a patient's injuries. This is consistent with the application of the Florida Adult Trauma Scorecard and other trauma triage methodologies as a means of justice. However, the Florida trauma scorecard does not follow the triage based on the severity of patient injury in two ways: the scorecard allows for paramedic discretion to circumvent patient assessment through use of the scorecard and it does not offer guidance regarding which patients should receive HEMS transportation.

Helicopter Emergency Medical Services is a limited resource which makes decisions regarding triaging patients to air transportation dependent on compelling reasons to place patients onboard for medical conditions as well as unit availability.

Rhodes (2018) stated that some medical interventions such as HEMS transportation may have to be abandoned in favor of other patients. When applying luck egalitarianism, the driver who is not at fault for the accident would have the right to HEMS if both patients had equal injuries. Rhodes (2018) said that decisions regarding whether or not a patient received a specific medical treatment or not should not be a matter of chance but rather based on decisions to ensure the protection of the public through planning and stewardship.

Historical Military Concepts in Medicine

Childs (2013) described warfare as a hell on earth and crucible for the development of current trauma triage and treatment modalities. To understand the basic concepts of the Florida Trauma Scorecard Methodology and this study, a brief review of military history is necessary.

Warfare dictated the need for prioritizing as the number of incoming injured soldiers were usually higher in number than available medical personnel. The abundance of injured versus the number of those treating the injured meant that some patients would have to wait for treatment. Necessity required patient care to be delivered to those patients with the highest medical need rather than those who arrived at a treatment area first.

Triage

Triage is the dynamic process used when sorting injured patients by the severity of their injury. The first use of triage to help sort patients is attributed to Baron

Dominique Jean Larrey, who was the Surgeon in Chief to Napoleon's Imperial Guard in the late 1700s (MacKersie, 2006; Robertson-Steel, 2006). Robertson-Steel (2006) stated Larrey designed the ambulance volante or flying ambulance, which was a custom designed horse-drawn wagon used to move patients from the battlefield to a field treatment area located at a base encampment.

There were two triage criteria in terms of Larrey's methodology on the battlefield: the patients were dead where they lay, or the patients could walk. All others were transported by the Ambulance Volante to treatment. Larrey and his associates determined further triage after arrival at the camp. Larrey's concept of sorting and rapid transportation of the injured was continued and refined in military operations from the 19th century to the current day. The Florida Trauma Scorecard Methodology, as are all other accepted triage methodologies, are based on the same principle of triage that was first developed during the Napoleonic war. Getting patients to medical care as quickly as possible was and remained the goal of triage.

Ambulance Transportation

World War I (1914-1918) began the concept of a motorized ambulance to transport the injured to a field hospital (Mullins, 1999; Murray, 2011; Nieves & Stack, 2015). Motorized ambulances were faster than the horse-drawn wagon used previously, but the ambulance came with a different set of problems. Battlefields did not have accessible roadways in which to travel. This required soldiers to carry the wounded to the ambulance or for the ambulance to travel across the country. Military ambulances

continued to operate during World War II (1939-1945) with more advanced methods, but the problem of accessing the battlefield remained the same (Nieves & Stack, 2015). The issue of deciding which patients would be transported in the ambulance was still made through triage. The most seriously injured patients would be transported first to save time as had been developed in Napoleonic times.

Aeromedical Transportation

Varon et al. (2003) stated the first use of a fixed-wing aircraft to transport an injured soldier occurred in 1917. The use of aircraft was greatly expanded in World War II. Varon et al. (2003) reported the estimation that more than one million soldiers were transported via air from field treatment facilities to hospital ships or hospitals away from the theater of conflict. The problem of accessing battlefield causalities remained because fixed-wing aircraft needed an accessible field to land and take-off. Access issues were resolved upon the introduction of helicopters as patient vehicles during the Korean War in the early 1950s (MacKersie, 2006; Mullins, 1999; Murray, 2011; Nieves & Stack, 2015; Varon et al., 2003). The Vietnam War (1955-1975) expanded the use of helicopters as ambulances with the familiar Bell UH-1 Iroquois (commonly known as the Huey) seen on television news reports at the time. The UH-1 was the most widely used helicopter during the Vietnam War starting in 1963. The UH-1 carried a pilot, an aircraft commander, a crew chief, and a medic. With a medic on board, patient treatment could start before arrival at a field hospital. The combination of medical treatment while transporting via helicopter led to the modern-day terminology of MEDEVAC the short

version of medical evacuation (Varon et al., 2003). Time was saved for the patient to receive treatment through the use of helicopter transportation.

Establishment of EMS and HEMS in the United States

The 1966 National Highway Safety Act directed the United States Secretary of Transportation to cooperate with state, local, private interests and other federal agencies to improve safety on the nation's highways (National Highway Traffic Safety Administration, 1972). Sections 402 and 403 provided funding for research and projects about traffic safety, emergency medical care, and the suggested the use of helicopters for patient transportation. The initial 1967 studies on EMS were a means to determine the best way to get traffic accident patients to a hospital in the quickest manner possible.

Highway Safety Standard 11: Emergency Medical Services (1967)

The National Highway Traffic Safety Administration (1972) implemented the Highway Safety Standard 11: Emergency Medical Services on June 27, 1967. Standard 11 had four purposes: To provide quick response to accident scenes; to provide proper first aid measures on the scene of accidents; to provide first aid measures during patient transportation to a hospital; and, to provide the coordination necessary to bring patients to definitive care without creating an additional hazard.

The initial discussion of patient care and transportation from highway traffic incidents centered on the successes of military use of helicopters for fast and efficient evacuation in Korea and Vietnam (Mullins, 1999; National Highway Traffic Safety Administration, 1972). The issue of patient transportation within Safety Standard 11 was

not to replace ground ambulances but to enhance them with helicopters to save on transportation time.

There were two initial studies from 1968 that provided information on the utilization of helicopters in patient transportation from accident scenes: Economics of Highway Emergency Ambulance Service (Dunlap & Associates, 1968) and Emergency Care Systems Demonstration Projects (Franklin Institute Research Laboratories, 1968).

Economics of a Highway Emergency Ambulance Service (1968). Dunlap & Associates (1968) devoted much of their work toward a recommendation that objectivity was paramount to the overall discussion of the benefit of helicopter transportation. The basis for their recommendation was the presumed positive opinion expressed toward the military success of the helicopter in patient transportation. The positive opinions were formed without adequate data presented to the benefit and overall cost of operating a helicopter for patient transportation in the civilian population. The utilization controls and communications implemented within the military medical structure are not like that of the civilian EMS system, which may cause too many patients being transported by HEMS without a medical need. Additionally, the military communications model is exceptionally rapid which could not be duplicated in the civilian communication systems (Dunlap & Associates, 1968; Keneally et al., 2016; Murray, 2011)**.**

Emergency Care Systems Demonstration Project (1968). Franklin Institute Research Laboratories (1968) discussed findings of trial studies which implemented helicopters into EMS within Pennsylvania and Nebraska for one year. The overall

general outcome was that neither trial performed to the high expectations of the planners. The tendency for a positive outcome bias was also cautioned by Dunlap and Associates during the same year.

The Pennsylvania helicopter trial resulted in 49 patients transported during the one-year period from a fixed base of operation. Of the 49 patients, six were determined to have life-threatening injuries in a retrospective review. Two of the six were dead on arrival at the hospital. The remaining two were probably saved as a result of the rapid helicopter transport (Franklin Institute Research Laboratories, 1968). The helicopter time reduction was not critical to the survival of the remaining 44 patients who were transported.

The Nebraska study involved scheduled flights over highways for 15-minute periods during projected times of high traffic to search for vehicle accidents. The results showed that five patients were transported from an accident scene over 14 months by not operating from a fixed base. The Nebraska study did not evaluate any patient's injuries.

Franklin Institute Research Laboratories (1968) summarized the results of the Pennsylvania and Nebraska studies: there was a very high operating cost ratio versus perceived benefit; there is no universal standard to determine when a helicopter would benefit a patient; and, the needless expense will occur when a control is not available to determine when to utilize air transportation.

These early seminal projects identified what has become commonly known as over triage and undertriage. Over triage relates to a triage methodology that is overly

aggressive in determining when a patient should go to a trauma center. Trauma triage methodologies that send patients who have minor injuries to a trauma center when it is not indicated is over triage. Undertriage is the inverse. Undertriage occurs when the triage methodology does not indicate that a patient had severe injuries that would be benefitted by a trauma center. These concepts are often described with the broader concept of saving time to deliver the patient to a hospital in the most expedient manner possible.

Trauma Patients and Time

The concept of saving time and moving patients rapidly in prehospital trauma care was initially established within Highway Safety Standard 11 but eventually became the EMS paradigm of The Golden Hour. University of Maryland Medical Center (2017) attributes the concept of The Golden Hour to R. Adams Cowley (1917-1991) who established the first trauma system in the state of Maryland (Shock Trauma) during the late 1960s and 1970s. Cowley stated, "There is a golden hour between life and death. If you are critically injured, you have less than 60 minutes to survive" (Cowley, n.d., cited by University of Maryland Medical Center, 2017). Harmsen et al. (2015) discussed Cowley's desire to replicate the military system of trauma care which is rapid and efficiently moves patients to definitive care for civilians. One of the critical components of a trauma care system is the trauma triage methodology which determines which patients need specialized trauma services. In civilian trauma system development, the care system is built; then the triage method is developed. In the military trauma system,

the triage system is built to accommodate the triage method (Childs, 2013). This fundamental difference is shown with conflicting results in published studies on the effectiveness of trauma triage in the civilian medical system.

Establishment of Civilian Trauma Triage

Henry et al. (1996) discussed the concept that an ideal trauma triage methodology would send patients in need of expert trauma care to the closest trauma center while diverting patients with minor injuries to a local hospital. The ideal concept is very similar in concept to military trauma care, where the most critically injured receive a higher level of care than that of the walking wounded (Childs, 2013; Murray, 2011). MacKersie (2006) reported on the development of the civilian method of trauma triage credited to the American College of Surgeons (ACS) during the period from 1976 through the early 1980s. During the previous decade, the Highway Safety Standard 11 remained in place with little to no triage of traumatically injured patients. Patients were transported to the closest medical facility by ground or by helicopter if the facility had a place to land. The military model of triage advanced the patient to higher levels of care depending on the extent of the injury which was more effective in treating traumatic injury (Branas, MacKenzie, Williams, & et al., 2005; MacKersie, 2006). The ACS developed a method of establishing trauma care essential guidelines delivered through specially designated trauma centers in 1976. The ACS document *Optimal Resources for the Care of the Seriously Injured* set the groundwork for field triage methodologies based

on the specific recommendations for trauma centers (Demetriades et al., 2006; MacKersie, 2006; Newgard et al., 2011).

Evaluation of Prehospital Trauma Triage Methods

Hedges, Feero, Moore, Haver, and Shultz (1987) presented one of the first scientific studies on the effectiveness of prehospital trauma triage methodologies. This study used a combination of retrospective and prospective data evaluation to evaluate 11 different trauma triage methodologies. Hedges et al. (1987) evaluated 130 patients who were evaluated by paramedics in a semi-rural area of the United States. Of the 130 patients evaluated, 41 or 31.53% were determined to be accurately triaged to a trauma center for treatment. The authors summarized their findings to include that no triage instrument performed to expectations. Hedges et al. (1987) reported that the most significant area of underperformance was in patients who were stable at the time the triage methodology was utilized. There was no change in these findings when utilizing retrospective or prospective measures.

After Hedges et al. (1987) presented their findings, several studies followed utilizing either retrospective or prospective methodologies. Retrospective studies utilize data gathered from past use of trauma triage methodologies to determine the level of accuracy of selected triage instruments. Prospective studies create scenarios in which trauma triage methodologies are evaluated without retrospective patient care data. It became apparent during the review of this literature that there is a wide variation in trauma triage instruments as well as methods for implementing them into use. This

variation in methodology accounts for a substantial divergence in the interpretation of findings and relevance.

Retrospective Evaluation

Most of the literature selected for this research was based on a retrospective analysis of trauma triage methodologies as they were utilized during actual patient encounters. As discussed by Hedges et al. (1987), the focus of many of these studies attempted to determine the accuracy of the selected instrument to predict the need for specialized trauma services. The accuracy of the instrument(s) is of great importance as suggested in the 1968 developmental studies to reduce unnecessary cost and to do the best for patients who required trauma-specific medical services (Dunlap & Associates, 1968; Franklin Institute Research Laboratories, 1968).

Accuracy is often expressed as the ratio of over triage to undertriage with over triage being the most common finding (Fullerton et al., 2014; Lavoie, Emond, Moore, Camden, & Liberman, 2010; Lehmann et al., 2007; Newgard et al., 2013; Scerbo et al., 2014; Scheetz, 2003; van Laarhoven, Lansink, van Heijl, Lichtveld, & Leenen, 2014). Over triage is defined as the overestimation of patient injuries to determine if the patient is more likely to need specialized trauma care when that is not the case. Undertriage is the opposite, the determination that patient injuries are not severe when the patient was more severe than the methodology recognized (Henry et al., 1996). Newgard et al. (2013) discussed the 2006 recommendations of the ACSCOT that no more than 5% of trauma patients should be undertriaged and no more than 50% of trauma patients should

be over triaged by any trauma triage methodology. The authors studied 248,342 low-risk patients who did not meet triage guidelines to be transported to a trauma center. The chosen trauma triage methodology was as recommended by Sasser et al. (2011) Guidelines for Field Triage of Injured Patients: Recommendations of the National Expert Panel on Field Triage, 2011. Over triage rates are very costly monetarily, especially when considering the cost of HEMS transportation. Newgard et al. (2013) found that 85,155 or 34.3% of patients who did not meet the trauma triage methodology were transported to a trauma center with an estimated cost of $136.7 million in annual costs within the seven-region area included in their study (Newgard et al., 2013). The 34.3% over triage rate found by Newgard et al., is 15.7% lower than recommended by ACSCOT in 2006.

When evaluating the specific criteria listed on trauma triage methodologies, there is also little agreement on their effectiveness. Newgard et al. (2011) evaluated the age criteria present in the ACSCOT field trauma triage methodology. Their findings showed that older patients, defined as greater than 55 years old, were more likely to be undertriaged than those who are younger. Haider, Chang, Haut, Cornwell Iii, and Efron (2009) found that the mechanism by which the patient was injured is the most critical indicator of the level of severity of the patient injury. Boyle, Smith, and Archer (2008) presented opposing research that mechanism of injury was not an accurate means of determining the severity of patient injury. Yonge et al. (2016) determined a specific respiratory determinant should be added to trauma triage methodologies to prevent

undertriage while Lin et al. (2012b) stated the complexity of trauma triage is the reason for over triage.

Barnett et al. (2013) compared results from 260,027 patients transported by 48 EMS agencies to 105 hospitals within six separate regions of the United States in one of the most extensive published studies. Their data analyses showed a vast amount of inconsistency in the number of trauma triage methodologies utilized and how they were implemented. One of the most consistent findings presented was the issue of paramedic discretion which accounted for 26% of over triage determinations (Barnett et al., 2013).

Paramedic discretion is a specific criterion within trauma triage methodologies where the paramedic evaluating the patient has the option to exit the triage method to rely on their judgment (Cox et al., 2011; Fitzharris et al., 2012; Lin et al., 2012b; Mulholland et al., 2005). The issue of paramedic discretion is discussed at length in the literature as accounting for a range of over triage between 20% to 30%. The significant error in over triage led to research efforts to determine why paramedics chose to use discretion instead of following a trauma triage methodology. (Newgard et al., 2013)

Prospective Evaluation

Two prospective studies were found to be pertinent to this research. Both studies created staged trauma scenarios to evaluate the actions of emergency responders in a controlled environment (Cleveland, Colwell, Douglass, Hopkins, & Haukoos, 2014; Smith et al., 2013). The simulated scenarios attempted to create a controlled reality in

which the participants were asked to make determinations on patient assessment related to trauma.

Cleveland et al. (2014) created a Likert scale survey based on 100 pictures of motor vehicle crash scenes. A total of 183 emergency responders, including physicians, paramedics, and EMTs completed the survey in which they were asked to rate the severity of the suspected injury based on the associated picture. The authors discuss the limitations of their work by disclosing they had no information concerning the actual injuries sustained by the patient in each of the utilized pictures. The findings of the study showed agreement on the severity of injury for the pictures of minimal damage (paint scraped on the vehicle) versus significant damage (a destroyed car). There was little agreement on the potential injuries sustained in moderately damaged vehicles (Cleveland et al., 2014). While these findings were relatively predictable, the study is useful in demonstrating the difficulty in visually assessing a motor vehicle accident scene. These findings may help to suggest why paramedic discretion leads to over triage rates if the provider is relying only on visual cues.

Smith et al. (2013) studied the cognitive abilities of less experienced paramedics versus more experienced paramedics to manage two-staged scenarios, one non-trauma, and one trauma. The authors defined a less experienced paramedic as being employed for six months to one year ($n = 4$) and a more experienced paramedic as being employed for three years or more ($n = 6$) (Smith et al., 2013). The total number of paramedics evaluated was ten which is a tiny sample. The authors found that the more experienced

paramedics were better at assessing scenes and patients, which led to more accurate triage. The less experienced paramedics were not as proficient in their assessment skills which led to less accurate triage. The interesting aspect of this study was the authors studied the critical thinking ability of the study group which does not reflect on adherence to a triage algorithm.

Elapsed Time and Patient Outcome

There is reasonable agreement in 21st century literature that the most severely injured patients who are the furthest away from a trauma center should receive transportation via HEMS if sustained injuries and time savings warrant use (Brown et al., 2010; Bulger et al., 2012; Butler, Anwar, & Willett, 2010; Galvagno et al., 2013; Medvecz et al., 2013; Sullivent, Faul, & Wald, 2011; White, Cudnik, & Werman, 2011). Unfortunately, there are very few studies that address the total elapsed patient injury time in favor of comparing only the patient transportation segment between HEMS and ambulances. An example is presented by Diaz, Hendey, and Bivins (2005) who measured patient transportation by ambulance and HEMS in three combinations: (a) ambulance only, (b) ambulance and HEMS dispatched simultaneously, and (c) ambulance and HEMS dispatched separately. Ambulance transportation was faster than HEMS in all comparisons for distances of 10 miles or less. Helicopter Emergency Medical Services were faster in all other instances. As suggested by M. Abernethy MD, measurement of speed and time does not reflect on the care a patient received but how fast a machine can respond and travel (personal communication, August 17, 2017).

Helicopter Emergency Medical Services lift off time is an often overlooked time consideration when requesting a HEMS unit to respond. Clark, Corey, Hutchison, Lalonde, and Dunn (2017) studied how often HEMS was able to meet a 10-minute lift-off time for non-interfacility transport requests. Their results showed HEMS was only able to meet the ten-minute standard 59% of the time with a range of one minute to over 22 minutes (Clark et al., 2017). When adding lift-off time with HEMS response time, the overall suggestion is that HEMS may have an equivalent response time to that of a ground ambulance up to a given distance (M. Abernethy, personal communication, August 17, 2017).

The golden hour revisited. As suggested by R. Adams Cowley in the early 1970s, each trauma patient has a Golden Hour after which survival is less likely. (University of Maryland Medical Center, 2017) Rogers et al. (2015) asked if time alone is responsible for patient survival. They concluded that patients referenced by Cowley in the early 1970s did not have access to EMS systems and Advanced Life Support Paramedics as are in place today. It is essential to discuss prehospital patient care in a continuum from incident occurrence to patient arrival at a receiving hospital. The total elapsed time in combination with the medical care provided during this interval is the measure of effectiveness, efficiency, and safety for the patient (M. Abernethy, personal communication, August 17, 2017). In the 21st century, it is unreasonable to transport every trauma patient lights and siren or onboard a HEMS unit solely because of a time limit. Consideration must be given to the level of care and treatment the patient will

receive in the field (Brown et al., 2016; Medvecz et al., 2013; Newgard et al., 2015; Rogers et al., 2015). Newgard et al. (2015) demonstrated this concept by concluding little relationship exists between 60 minutes of elapsed time and trauma patient survival except in a subgroup of patients in shock who required critical hospital intervention. Critical interventions included surgery and dynamic circulatory stabilization. Brown et al. (2016) presented very consistent findings with Newgard when evaluating scene time for trauma patients. Those patients who demonstrated signs and symptoms of shock, penetrating injuries, and chest injuries that required critical hospital interventions were dependent on decreased elapsed time.

HEMS Operations

There are three types of HEMS providers: (a) hospital owned and operated; (b) for-profit corporations; and, (c) government-operated such as state or local emergency response agencies (Perritt, 2016). Helicopter Emergency Medical Services are not subject to the same standards and regulations that ambulance services must follow. HEMS corporations are regulated as a passenger aircraft falling under the Airline Deregulation Act of 1978 without any requirement to have a relationship with health care providers (Abernethy, 2017; Federal Aviation Administration, 2015; National Association of State EMS Officials, 2015, 2017; United States Congress. House Committee on Transportation and Infrastructure. Subcommittee on Aviation., 2009; United States. Federal Aviation Administration., 1991).

HEMS Cost

Fleck (2011) described the concept called the Rule of Rescue in which the theory of public reason would dictate that preparation and budgeting would spend whatever it takes to safely and efficiently rescue an injured person. The de facto justification is a successful rescue is always assumed, and the injured person will go on to live a healthy and productive life after being rescued. Mains (2013) discussed how the assessment of cost within the aeromedical system does not consider the loss of life of crew members within their balance sheets. Effectiveness in rescue operations should weigh the morals essential to extending the life of all parties involved in the effort relative to the necessary cost (Badano, 2018; Daniels, 2001; Fleck, 2011).

Helicopter Emergency Medical Services operations increased profitability when The Centers for Medicare & Medicaid Services (CMS) changed HEMS reimbursement in 2002 by increasing the rate to 434% of the previous reimbursement rate. This increase in revenue caused an increase in the number of helicopters from 377 to over 900 in 2014 most of which are operated by three publicly traded for-profit corporations: (a) Air Medical Group Holdings, (b) PHI Air Medical and (c) Air Methods Corporation (Abernethy, 2017). The reimbursement increase did little to decrease the amount charged per patient flown on HEMS with a typical launch fee ranging from $12,000 to over $30,000 with an additional fee of $110 to $190 per air mile flown with the patient aboard. These substantial fees are often beyond what health insurance will pay, leaving the remainder to be billed to the patient.

The financial practice called balance billing places the burden of paying any amount above the reimbursement provided by insurance to the patient. Balance billing is a common practice by HEMS providers across the United States to recover the high cost of operations. These bills frequently reach over $40,000 to $50,000 above the received insurance reimbursement. (Association of Air Medical Services, 2017; Cates-Carney, 2016; Eavis, 2015; Galli, Zimmermann, & Ross, 2016; Perritt, 2016, 2017). Newgard et al. (2013) offered results that continued to indicate that over triage of trauma patients is driving the cost to patients higher. The average over triage rate of 34.3% accounted for 40% of patient costs. The estimated annual cost savings would add up to be $136.7 million within the seven regions studied (Newgard et al., 2013).

HEMS Safety

Perritt (2016) reported that FAA statistics showed a historic number of HEMS accidents occurred from 2003 to 2008 with 2008 being the deadliest on record. Five HEMS aircraft incidents accounted for 21 people killed, including patients and crew in 2008 alone. From 1991 to 2010, 62 HEMS aircraft crashed due to four common causes: (a) inadvertent flight into Instrument Weather Conditions (IWC); (b) loss of control; (c) controlled flight into terrain and (d) night operations (Perritt, 2016).

A seminal presentation that offered a startling visual representation of the death toll caused by HEMS accidents occurred at the 2011 Air Medical Transport Conference in St. Louis, Missouri. Helicopter Emergency Medical Services authority Randolph Mains gave the keynote presentation on HEMS safety. A total of 358 sealed envelopes

were randomly distributed as the 700 attendees entered the room. Toward the end of the presentation, Mains asked all of those with an envelope to stand. Each of the 358 envelopes contained the name of one pilot, crew member, or patient who had died between 1990 and 2011 (Mains, 2013).

The issue of whether the requests these 358 professionals were responding to patients who may have benefitted through the use of HEMS is not discernable, but incidental accounts may indicate HEMS may not be requested for the most severe injuries. A recent news report from Marquette Michigan stated State Representative Beau LaFave sponsored legislation that would require patients to be asked if they want air ambulance service before they are transported after a member of his family was transported via HEMS for a broken thumb and received an $18,000 bill (Nexstar, 2018).

Mains (2017) discussed the differences between HEMS in the United States in comparison with operations in many other countries around the world. Helicopter Emergency Medical Services operators in the United States are not required to fly with more than one pilot or fly helicopters that have more than one engine. The added margin of crew and patient safety are apparent. One pilot must rely on their training and their abilities rather than having a co-pilot aboard to assist and having a second engine allows for a margin of safety in the instance of engine failure (Mains, 2017). Additionally, continued competency testing of pilot skills in Instrument Flight Rules (IFR) are voluntary as is the use of night vision equipment.

The National Transportation Safety Board (2018) report ERA16FA140 discussing the preliminary cause of a HEMS crash that killed four people on board in Enterprise Alabama from 2016 stated, “The pilot's decision to perform visual flight rules flight into night instrument meteorological conditions, which resulted in loss of control due to spatial disorientation [*sic*]. Contributing to the accident was the pilot's self-induced pressure to the complete the mission despite the weather conditions and the operator's inadequate oversight of the flight by its operational control center (para. 7)”. Both causes may have been avoided if there was a co-pilot on board, and IFR flight was utilized.

The Centers of Medicare and Medicaid Services (CMS) reimbursement is the medical care delivered onboard the aircraft. There is no monetary incentive for a HEMS corporation to partake in extra safety precautions based on reimbursement (Abernethy, 2017).

Trauma Triage Adaptation for HEMS Response

As discussed by Dunlap & Associates (1968), the use of helicopter transportation for severely injured patients may be beneficial if the service is used only for patients who require it. Additionally, the cost of operating the helicopter, both mechanically and safety should be considered. Hirshon et al. (2016) reiterated many of the same concerns listed in Dunlap’s 1968 work. The Maryland State Police Aviation Command discovered that nearly 50% of patients transported by HEMS were not seriously injured (Hirshon et al., 2016; JEMS, 2008). Literature between 1996 and 2014 on determining which patients would best be served through HEMS remained consistent: trauma triage

methodologies may not be aligned with HEMS (Barnett et al., 2013; Bledsoe, Wesley, Eckstein, Dunn, & O'Keefe, 2006; Brown, Forsythe, Stassen, & Gestring, 2012; Cheung, Delgado, & Staudenmayer, 2014; Delgado et al., 2013; Fullerton et al., 2014). A definitive methodology has yet to be developed and studied to prove effectiveness in reducing the number of patients over triaged to a trauma center.

Fleck (2011) offered that there are no perfect healthcare rationing protocols when applying them to the real world because of the burden of judgment necessary in public policy formation. When determining the public good, effectiveness is a moral necessity. Patients are expected to be able to successfully recover to meet societal expectations (Daniels, 2001). The question remains as to how to attain a balance between morally just trauma triage methodologies and the overall cost in lives and currency if the methodology is incorrect.

Two recent studies offer verifiable results to improve trauma triage methodologies, and the overall rate of over triage: (a) The Maryland State Police Aviation Command and the (b) Air Medical Prehospital Triage (AMPT) score from Pennsylvania.

The Maryland State Police Aviation Command

The Maryland State Police is unique in the United States as the only statewide HEMS service supported by tax dollars allotted through public policy beginning service in 1970. The HEMS units were considered part of the Maryland Shock Trauma System

developed by R. Adams Crowley (Maryland State Police Aviation Command, 2017; University of Maryland Medical Center, 2017).

In 2008, the *Journal of Emergency Medical Services* published an article on the amount of over triage within the Maryland State Police HEMS system, which was reported as near 50% (JEMS, 2008). Since the Maryland system is supported by tax dollars, elected representatives were concerned that the cost of operating HEMS could be lower and more cost-effective. The University of Maryland and statewide EMS medical direction began studying why the over triage rate was so high.

Hirshon et al. (2016) studied the Maryland State Police Aviation Command from 2000 to 2011. During the study period, adjustments were made to the statewide dispatching system and associated trauma triage protocols to evaluate over triage rates (Hirshon et al., 2016; Maryland Institute for EMS Systems, 2017). An overall reduction of 59% in over triage to HEMS was accomplished when altering the trauma triage protocol and associated dispatching methods. There was a correlated increase of 21% in patients transported by ambulance instead of HEMS. Additionally, patients transported by HEMS were acuter, resulting in increased patient mortality. The modifications to the trauma triage system improved patient care with a substantial reduction in cost for the Maryland State Police Aviation Command (Hirshon et al., 2016; Maryland Institute for EMS Systems, 2017). It is important to note that the Maryland State Police HEMS component of trauma care is unique in the United States in the fact that it is a single service dispatched by a single communications center. This singularity creates an ideal

situation in which changes to methodology can occur and be evaluated rapidly. Other states and locations do not have this type of singularity with multiple HEMS operators, ambulance providers, and regional trauma centers.

The Pennsylvania Trauma Outcomes Study

Brown et al. (2017) studied the Air Medical Prehospital Triage (AMPT) methodology applied retrospectively to data contained in the Pennsylvania Trauma Outcomes Study from 2000 to 2013. The AMPT offers a simplified trauma scorecard methodology with seven criteria that had been considered for national use.

Table 1

Air Medical Prehospital Triage (AMPT) Score

Criterion	Points
Glasgow Coma Scale <14	1
Respiratory rate <10 or >29 breaths/min	1
Unstable chest wall fractures	1
Suspected hemothorax or pneumothorax	1
Paralysis	1
Multisystem trauma	1
Any 1 physiological + 1 anatomical criteria from ACSCOT field triage guidelines	1

The study evaluated the AMPT with 222,827 total retrospective patient records. Those patients transported by HEMS had a 6.7% increase in the potential for patient survival. Those patients transported by HEMS which were triaged into ambulance transportation by AMPT illustrated an over triage situation had occurred in the field

(Brown et al., 2017). This study is the most recent and offers a definitive option for a viable trauma triage methodology that would accurately help to eliminate over triage in HEMS transportation. Brown et al. (2017) carefully noted that the AMPT score does not include other logical factors such as distance, weather, and traffic patterns which would play a critical role in the decision to use HEMS resources.

Florida's Trauma Care System

Florida Administrative Code 64J-2.004 established the development and mandatory use of the Adult Trauma Triage Criteria and Methodology through the rulemaking process ascribed in Chapter 120, The Administrative Procedures Act of the State of Florida (Florida Administrative Register, 2017). The administrative code provides public notice and requires public comment before filing rules for adoption. The Florida Administrative Register publishes a daily edition which is accessible for all public notices, hearings, and other actions as required (Florida Administrative Register, 2017). The Florida Adult Trauma Scorecard Methodology traveled through the administrative code process with the opportunity for public participation most recently in December 2002 without a determinant for HEMS transportation or other changes in content (Florida Department of Health, 2004).

Florida Home Rule and Prehospital Services

Florida is a Home Rule state meaning that each of the 67 county governments decides how EMS services are to be delivered within their jurisdiction. The state delegates this statewide authority to each county government through mandating the

Certificate of Public Convenience and Necessity (COPCN) process. Each EMS transportation agency or Air-Medical operator must apply for and be formally approved to operate in each county of operation through the authority of the county council public process (Florida Department of Health, 2017).

The Department of Health provides minimum standards for EMS providers to meet to apply and maintain compliance with a COCPN. Items such as Advanced Life Support (ALS) minimum staffing on an ambulance shall be one paramedic, and one EMT and a helicopter shall have a minimum of one paramedic with a pilot. The Trauma Scorecard Methodology is one of the minimum standards applied to all EMS agencies in the state (NHTSA Technical Assistance Team, 2013). Many agencies exceed the minimum staffing standards and other minimum standards, but rural counties may rely on the minimum option alone.

Committee on Trauma Florida Consultation Report 2013

The American College of Surgeons, Committee on Trauma (ACSCOT) conducted a review of the Florida trauma system in February 2013 (Florida Department of Health, 2013). The review came after two years of contentious legal battles concerning regulations that determine where and how new trauma centers can open. The American College of Surgeons, Committee on Trauma evaluators stated that Florida had been a leader in the development of trauma care since the 1980s but had now become stagnant due to political circumstances. The report contained detailed information about trauma centers and the law, which is beyond the scope of this paper. The ACSCOT evaluators

did include relevant information about prehospital trauma care including a call for a more comprehensive EMS review by the National Highway Traffic Safety Administration, Technical Assistance Team which followed in November 2013.

ACSCOT (2013) stated that the EMS system of prehospital care is often the critical association between the location of a critical injury and optimal trauma care. The primary concern voiced in the report is the lack of a mandatory statewide prehospital care protocol for EMS providers. The only mandatory protocol related to trauma care that is required by the state is the Florida Trauma Scorecard Methodology which is listed in the Florida Administrative Code (Florida Department of Health, 2013). As mentioned previously, the Trauma Scorecard Methodology has not been updated since December 2002. An additional citation results from a lack of statewide control of how patients flow from EMS to hospitals.

National Highway Traffic Safety Administration (NHTSA)

Technical Assistance Team Evaluation 2013

The last NHTSA Technical Assistance Team evaluation was conducted in 1993 or 20 years previous to this report. The issue of Home Rule was discussed at length as both a positive and a negative aspect of prehospital patient care in Florida. The positive aspect of Home Rule is that each county is fully informed about their EMS providers and how they operate. The negative aspect of Home Rule is a lack of regionality of care and data analysis across county lines (Florida Department of Health, 2013; NHTSA Technical Assistance Team, 2013).

The NHTSA Technical Assistance Team (2013) discussed the lack of a statewide minimum EMS protocol for all operations to use as a baseline. There was an effort in south Florida called the Florida Regional Common EMS Protocols for use as a statewide minimum, but the effort failed due to differences in opinion within individual county leadership (Broward County, 2014; Florida Administrative Code, 2016; Florida Department of Health, 2013; NHTSA Technical Assistance Team, 2013).

Florida Atlantic University 2017 HEMS Trauma Triage Evaluation

Madiraju, Catino, Kokaram, Genuit, and Bukur (2017) offered an evaluation of the Trauma Hawk HEMS service operated by the Palm Beach County Healthcare District in southeastern Florida (Palm Beach County Health Care District, 2017). Palm Beach County operated the ambulance service through the Palm Beach Fire Rescue Department and approved both operations under the COCPN approval process. Palm Beach County has two Level 1 Trauma Centers within their jurisdiction with a total of ten Level 1 Trauma Centers in Florida (Florida Department of Health, 2016d).

A retrospective analysis spanning six years was conducted using data from the Level 1 Trauma Centers to show that a complex trauma algorithm may lead to significant over triage of patients to HEMS with a substantial monetary cost (Madiraju et al., 2017). The authors defined over triage for this study as those who were discharged from the Emergency Department medically admitted without injuries or admitted to the hospital for observation only. Palm Beach County developed its detailed version of the trauma triage methodology using the basis provided by the Florida Administrative Code (Florida

Administrative Code, 2016). The decision to request HEMS in the Palm Beach County Protocol are three criteria: (a) the closest trauma center is > 20 minutes away, (b) ground transportation is unavailable in a reasonable amount of time, and (c) >15 minutes of extrication time is required (Emergency Medicine Learning & Resource Center, 2017). Madiraju et al. (2017) concluded substantial over triage exists. Out of a total of 4,218 patients, 28% arrived by HEMS accounting for 78% of the over triage rate. The estimated monetary amount per year is greater than $1.3 million.

The Palm Beach study provides insight into some of the cautions issued by the ACSCOT Consultation Report and the NHTSA Technical Assistance Team Report of 2013. The lack of state EMS oversight and comparison of data at the state level may lead to a county incurring increased costs or making the decisions that other counties have already experienced as less than desirable. The Palm Beach conclusion evaluated a variation of the Florida Trauma Scorecard Methodology, which made it more complicated without determining the base capabilities of the original form.

Summary and Conclusions

Brown et al. (2017) commented that HEMS had been around for 50 years, and the most appropriate use has yet to be determined. This study attempts to add meaningful literature that is specific to the state of Florida. Triage and military history in battlefield medical care has been very successful, but the same success remains elusive in the civilian medical system. Time as an indicator of survival in trauma patients is a hallmark of military care which is referred to as the golden hour in early trauma treatment. The

Golden Hour has been concluded to be a false metric to determine patient survival (Newgard et al., 2015; Rogers et al., 2015). Studies have agreed upon the high monetary cost and lives lost in HEMS crashes over decades of study (Abernethy, 2017; Cates-Carney, 2016; Delgado et al., 2013; Madiraju et al., 2017; Mains, 2013, 2017; Perritt, 2016; Taylor et al., 2013). Other studies have discussed results that disagree on whether there is a survival benefit for trauma patients who are transported by HEMS in place of a traditional ambulance except for a few select groups of patients (Brown et al., 2010; Butler et al., 2010; Medvecz et al., 2013; White et al., 2011; Wuerz, Taylor, & Stanley-Smith, 1996). These studies also refer to the use of a traditional trauma scorecard methodology such as ACSCOT, or self-developed methods which have not shown any trending toward the accuracy of HEMS determination in past reviews. Hirshon et al. (2016) found success in altering their statewide trauma triage methodology with the Maryland State Police and the University of Maryland Medical Center to reduce HEMS over triage by 50%. The Maryland system is unique as the HEMS service is provided by a state entity and is the sole provider within the state. As most other states have multiple HEMS operations, their results may not translate easily. The most recent studies from 2017 show mixed results. Brown et al. (2017) demonstrated success with the AMPT which is hybrid trauma scorecard methodology and suggests more research is needed. Madiraju et al. (2017) chose their title by summarizing the results of their study evaluating a modified version of the Florida Trauma Scorecard Methodology*: In by helicopter out by cab: The financial cost of aeromedical over triage of trauma patients.*

My work added to the literature as a current review of the standard Florida Adult Trauma Scorecard Methodology and use of HEMS.

Chapter 3: Research Method

Introduction

The goal of my study was to investigate the extent that a lack of specific transport criteria within the Florida Adult Trauma Scorecard Methodology may result in the inappropriate use of HEMS. This study evaluated the stated Florida adult trauma triage criteria in association with HEMS use. A retrospective quantitative methodology was used to analyze 2015 data from the Florida Department of Health Trauma Registry (Florida Department of Health, 2016b).

Research Design and Rationale

Creswell (2014) described the quantitative research methodology as a means for testing relationships between variables using statistical principles. My study used the quantitative methodology as an appropriate means for gaining meaning from retrospective data collected by the Florida Trauma Registry (Florida Department of Health, 2016b). The selected 2015 dataset contained the independent variables (IV) found in the patient assessment section of the trauma scorecard and the dependent variables (DV) dichotomized regarding whether patients were transported to the hospital via HEMS or ground ambulance. Since my research was designed to determine if the trauma scorecard criteria may lead to inappropriate use of HEMS resources, a logistic regression analysis was used to determine the likelihood for each IV, collective or individual, in terms of predicting transport methods.

Logistic Regression

Logistic regression examinations allow a means to predict dependent variable values through information gathered from the independent variables (Laerd Statistics, 2017; O'Sullivan, Rassel, & Berner, 2008; Wagner, 2017). Dichotomous dependent variables (DVs) are used in logistic regression, meaning each variable has two specific values, such as gender with dichotomized attributes of male versus female (Field, 2012; Laerd Statistics, 2017). The IV used in logistic regression may be categorical or continuous (Vogt & Johnson, 2011). The IVs in my study are categorical as they are directly associated with the anatomical and physiological criteria quantification listed on the trauma scorecard. These data points are either yes, a trauma scorecard category was selected, or no, it was not selected. In contrast, continuous variables may assume any value in a continuum which does not apply to these data. My study related to the dichotomous nature of logistic regression as the DV; patient transportation will be evaluated with a dichotomous division of attributes HEMS vs. ground ambulance. The trauma scorecard criteria, as listed in the trauma registry, are also considered dichotomous as they are either positive or negative depending on the findings of the patient assessment.

It is important to note that logistic regression results do not provide a conclusion, but rather a prediction (Field, 2012). This is a critical distinction in medical research. O'Sullivan et al. (2008) said that probability is much different from conclusive evidence.

The logistic regression predicts a probability, illustrated as a likelihood, that an event may occur based on correct categorization.

Methodology

The following research question is:

RQ: Is there a likelihood of field scoring for red (single criterion), blue (two criterion), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard to predict scene responder request for use of HEMS versus ground ambulance transport when controlling for trauma center location?

H_0: There is no significant likelihood that field scoring for red (single criterion), blue (two criterion), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard predicts scene responder request for use of HEMS versus ground ambulance transport when controlling for trauma center location.

H_a: There is a significant likelihood that field scoring for red (single criterion), blue (two criterion), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard predicts scene responder request for use of HEMS versus ground ambulance transport when controlling for trauma center location.

Data Collection Process

Retrospective data from 2015 was obtained through the defined process as documented in the Florida Department of Health Bureau of Emergency Medical Oversight Data Use Agreement (see Appendix C). The Florida Department of Health Trauma Registry statewide database obtains information from all licensed trauma centers

within the state of Florida through a secure upload process. (Florida Department of Health, 2016b) Each trauma patient who is seen at a trauma center has information entered at the hospital level which corresponds with data coding as listed in the Trauma Registry 2014 Data Dictionary (Florida Department of Health, 2016b). The population selected for this study were patients who were declared a Trauma Alert and transported via air or ground to a Florida trauma center during the calendar year of 2015. Patient confidentiality was assured through the use of a de-identified dataset.

Ethical Procedures

My study was subject to scrutiny by two Institutional Review Boards (IRB)from Walden University, and the Florida Department of Health. The IRB from the Florida Department of Health has specific requirements and documentation as outlined in their approval form and associated policies to safeguard patient confidentiality. My data set did not contain identifiable patient data. Variables considered only assessment findings of the declaration of Trauma Alert status, method of transportation, and patient outcomes with the covariate of trauma center location.

All received data was kept in a safe and undisclosed location during the data evaluation period. The Florida Department of Health IRB requires that all obtained data must be destroyed upon completion of use. (Florida Department of Health, 2016a) The Walden University IRB requires that the obtained data be secured for a period of five years. Conflicts concerning the amount of time data must be archived defaulted to Florida Department of Health requirements. The Florida Department of Health

maintained the position of the lead IRB for my research since two IRBs are involved with the release of archival data. By request of the Department of Health, the Walden University IRB provided the initial approval of my research to the Department of Health IRB for their consideration in granting permission to obtain the data necessary for my research. All received data was destroyed as directed by the Florida Department of Health through a degaussing method. Degaussing is a method of data destruction which erases the magnetic field of the storage media and scrambles the remaining data, rendering it useless (Securis, 2018).

Reliability and Validity

Reliability considers the extent to which a measuring instrument contains variability errors (Stoltzfus, 2011). Reliability not only is a determination of instrument consistency but also how the raw data was gathered and delivered to the master database, Reliability also depends on the researcher's ability to account for missing or incomplete data within the dataset and proper coding. Frankfort-Nachmias, Nachmias, and DeWaard (2015) stated that validity is determined by how well the evaluation measured what was intended.

The Florida Administrative Code 64J-2 sets forth the requirements for all state trauma centers to utilize the data management practices and training from the National Trauma Data Bank (NTDB)as well as participation in the American College of Surgeons (ACS) Trauma Quality Improvement Program (TQIP) (American College of Surgeons, 2018b; Florida Administrative Code, 2018) The TQIP provides training, certification and

oversight for each hospital's trauma registrars and managers with the goal of reducing data handling errors.

After the approval of both IRBs, the requested data for this study was received from the Department of Health electronically in a Microsoft Excel format. The data was sorted to locate missing values. Any missing or incomplete values were coded with the identifier -1. Once the incomplete values were coded, the resulting data was uploaded and analyzed using IBM SPSS Version 24.0.

Assumptions and Power Analysis

There are numerous assumptions that must be met for logistic regression analysis to include a) independence of errors; b) absence of multicollinearity; and c) lack of outliers (Frankfort-Nachmias et al., 2015; Laerd Statistics, 2017). The overall number of events for each independent variable is essential to validity considerations. Stoltzfus (2011) recommended a minimum data set of 10 to 20 events per variable as a "rule of thumb" for logistic regression analysis while Peduzzi, Concato, Kemper, Holford, and Feinstein (1996) recommend a sample size of at least 100 per events per variable rather than a calculated power analysis through use of software such as G*Power (Faul, Erdfelder, Lang, & Buchner, 2007).

Variables

In my trauma triage study, the independent variables (IV) were derived from the Florida Adult Trauma Triage Scorecard Methodology sections. The dependent variable (DV) was transport mode dichotomized as HEMS or ground transport aligned with the

Florida Trauma Registry 2014 Data Dictionary coding criteria (Florida Department of Health, 2016b). The total population considered was Trauma Alert (EDF_01). The total population of this data selection from 2015 was further divided into the Independent Variables (IV): (a) EDF_01 Trauma Alert Type 1 Red; (b) EDF_01 Trauma Alert Type 2 Blue; (c) EDF_01 Trauma Alert Type 3 GCS ≤ 12; (d) EDF_01 Trauma Alert Type 4 Judgement EMS; (e) EDF_01 Trauma Alert Type 6 Local Criteria and (f) EDF_01 Trauma Alert Type 7 NTA (Not A Trauma Alert). It is important to note that EDF_01 Trauma Alert Type 5 Judgement Hospital was not a consideration on the trauma scorecard methodology and was not be included in the evaluation.

Covariates

The Florida Department of Health (2016b) lists 35 designated and provisional Florida trauma centers as of March 2015 (see Appendix B). Each trauma center is listed by a) the facility name; b) trauma center level including provisional status, and c) the county in which the facility operates. The location of each trauma center served as covariates due to the various population centers throughout Florida. It is important to note that two trauma centers that receive only pediatric patients were excluded from the covariate list as only adult patients are considered in this study.

Post Hoc Analysis

The results of the initial data evaluation to determine HEMS transportation based on the trauma scorecard criteria was further evaluated in a post hoc analysis to determine the patient outcome from the receiving Emergency Department. The basis to

determine the inappropriate use of HEMS transportation was patient discharges from the Emergency Department after transportation. The Florida Trauma Registry 2014 codes ED release patients as follows: (a) ED_19 ED Discharge Disposition 4- Home with services; (b) ED_19 ED Discharge Disposition 6- Other (jail, institutional care, mental); (c) ED_19 ED Discharge Disposition 9– Home without services; and, (d) ED_19 ED Discharge Disposition 10- Left Against Medical Advice (AMA).

Appropriate use of HEMS was based on patient admission to the hospital (or transfer to another hospital) for further treatment or if the patient was so critically injured that they expired in the Emergency Department. These variables are shown below as well as in Table 3: (a) ED_19 ED Discharge Disposition 1- Floor bed (general admission, non-specialty unit bed); (b) ED_19 ED Discharge Disposition 2- Observation unit (unit that provides < 24-hour stays); (c) ED_19 ED Discharge Disposition 3- Telemetry/step-down unit (less acuity than ICU) (d) ED_19 ED Discharge Disposition 5- Died/Expired; (e) ED_19 ED Discharge Disposition 7- Operating Room; (f) ED_19 ED Discharge Disposition 8- Intensive Care Unit (ICU); and (g) ED_19 ED Discharge Disposition 11- Transferred to another hospital.

Table 2

Initial Variables with Correlation to the Florida Trauma Registry 2014 Data Codes

Total Population Trauma Alert for 2015	P_07 Transport Mode 1 Ground Ambulance (DV)	P_07 Transport Mode 2 Helicopter (DV)
EDF_01 Trauma Alert Type 1 Red (IV)	0	1
EDF_01 Trauma Alert Type 2 Blue (IV)	0	1
EDF_01 Trauma Alert Type 3 GCS ≤ 12 (IV)	0	1
EDF_01 Trauma Alert Type 4 Judgment EMS	0	1
EDF_01 Trauma Alert Type 6 Local Criteria	0	1
EDF_01 Trauma Alert Type 7 NTA (Not a Trauma Alert)	0	1

Table 3

Determination of Patient Outcomes Based on HEMS Transportation

Total Population Trauma Alert for 2015	P_07 Transport Mode 2 Helicopter (DV)	ED_19 ED Discharge Admitted (fields 1, 2, 3, 5, 7, 8, 11)	ED_19 ED Discharge Released (fields 4, 6, 9, 10)
EDF_01 Trauma Alert Type 1 Red (IV)	1	0	1
EDF_01 Trauma Alert Type 2 Blue (IV)	1	0	1
EDF_01 Trauma Alert Type 3 GCS ≤ 12 (IV)	1	0	1
EDF_01 Trauma Alert Type 4 Judgment EMS (IV)	1	0	1
EDF_01 Trauma Alert Type 6 Local Criteria (IV)	1	0	1
EDF_01 Trauma Alert Type 7 NTA (Not a Trauma Alert) (IV)	1	0	1

Summary and Conclusion

This chapter presented the selected research questions, data collection, analysis methods, and ethical considerations. Procedures to determine if there is a relationship

between the Florida Adult Trauma Scorecard Methodology and how a patient is transported to a trauma center are discussed in detail in Chapter 4.

Chapter 4: Results

Introduction

The purpose of my study was to investigate the current Florida Adult Trauma Scorecard Methodology concerning the field-selected mode of patient transportation (either ground ambulance or HEMS) to a trauma center. Specifically, my study investigated the relationship between the listed anatomical and physiological criteria listed on the trauma scorecard and the paramedic decision for a selected mode of patient transportation. The research question and hypotheses follow:

RQ: Is there a likelihood of field scoring for red (single criterion), blue (two criterion), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard to predict scene responder request for the use of HEMS versus ground ambulance transport when controlling for trauma center location?

H_0*:* There is no significant likelihood that field scoring for red (single criterion), blue (two criterion), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard predicts scene responder request for use of HEMS versus ground ambulance transport when controlling for trauma center location.

H_a*:* There is a significant likelihood that field scoring for red (single criterion), blue (two criterion), GCS ≤ 12, or EMS judgment (individually or collectively) from the Florida Adult Trauma Scorecard predicts scene responder request for use of HEMS versus ground ambulance transport when controlling for trauma center location.

Within this chapter, I discuss the data collection process, descriptive statistics involving the data set, the results of my data analysis, and a post hoc analysis of patient hospital outcomes.

Data Collection

Descriptive Statistics

I used the Florida Department of Health Trauma Registry from the calendar year 2015 for my analyses. A total of 102,160 cases were available through the supplied database bounded by the year. Of the 102,160 cases, there were 65,329 cases where a ground ambulance was documented and 5,932 cases where helicopters were referenced. The total case evaluation contains 71,261 incidents (see Table 4). The remaining case data (n = 30,899) either did not have a transport mode identified or transport was not needed for the incident response; both categories were excluded from analyses.

Table 4

Transportation Method

	Frequency	Percent
Ground Ambulance	65,329	91.7
Helicopter	5,932	8.3
Total Cases	71,261	100.0

Dependent Variable Encoding: Ground Ambulance 0; Helicopter 1

The IV data showed 102,363 valid results for prehospital triage classification of which 7,103 were excluded in the EDF_01 Trauma Alert type 5 hospital judgment category, as explained in Chapter 3 (see Table 5).

Table 5

Prehospital Triage Classifications

	Frequency	Percent
Alert Type 1 Red	9,652	13.5
Alert Type 2 Blue	3,378	4.7
Alert Type 3 GCS ≤12	1,008	1.4
Alert Type 4 Judgment EMS	6,265	8.8
Alert Type 6 Local Criteria	2,215	3.1
Alert Type 7 NTA (Not a Trauma Alert)	48,743	68.4
Total	71,261	100.0

Covariates

The Florida Department of Health (2016b) listed 25 designated Florida trauma centers as of May 2015 (see Appendix B). My study used the location of each trauma center as a covariate due to the various population centers throughout Florida. As a condition of the Florida Department of Health's ethical approval process, trauma center identities were randomized and made unidentifiable prior to data release. As a result, a table of covariates was received with a total of 168 facility identification numbers in place of the 25 trauma center locations. The resulting frequencies showed the ID number with the highest frequency of received cases at 3,481, or 4.9% of the total transport volumes of either category and the lowest at 1 received case; no setting was identified to significantly contribute to the percent change of R^2 variance distribution based on transport mode, and thus there was no influence in the regression modeling. No single

facility ID number accounted for more than 4.9% of the 71,261 total incidents (see Table 6).

Table 6

Facility Identification Summary

	Frequency	Percent
ID# 12018	3481	4.9
ID# 100049/100153	1	0.0
ID# Total Count	168	100.0

Results

Research Variable Assumptions

There are seven primary assumptions that must be met when evaluating data for logistic regression. These are: one DV that is dichotomous, one or more IVs that are continuous or nominal, independence of observations and mutual exclusivity, a minimum of 15 cases per IV, assumption of linearity between the IV and the DV, no multicollinearity, and no significant outliers exist.

The IVs in my study are categorical data and reflect individual coding by pre-transport emergency medical personnel of anatomical and physiological criteria listed on the trauma scorecard. These IV data assessments were coded yes, a trauma scorecard category was selected, or no, a trauma scorecard category was not selected. My DV of patient transportation method was dichotomized as ground ambulance vs. HEMS. A sufficient case threshold was obtained, no outliers were identified based on frequency

distribution analysis, and no multicollinearity associations were observed. Therefore, I accepted my data as meeting the required data assumptions for logistic regression analyses.

Statistical Power

As mentioned in Chapter 3, the total number of cases that would be received from the Florida Department of Health, Trauma Registry was unknown. As such, the Stoltzfus (2011) recommendation of a minimum data set of 10 to 20 events per variable or the Peduzzi et al. (1996) recommends a sample size of at least 100 per events per variable was adopted for my research. After receipt of the data, the events per variable far exceeded either criterion as exemplified by the total number of cases $n = 71,261$. Using a test alpha of 0.01, $n = 71,261$ [achieving at least 100 events per variable], and a small [0.02] effect size, a resulting post hoc power computation of 1.0 was achieved.

Inferential Statistics

Having established that the required assumptions for regression modeling were sufficiently met, I then proceeded to organize and conduct the logistic regression, using a *LR* Forward approach. The basis for my logistic regression was to determine if the trauma scorecard criteria (IV) significantly predicted a likelihood of a particular transport method used by pre-hospital emergency medical services in 2015 – ground vs. HEMS.

Logistic regression. Using SPSS v. 24, a binary logistic regression analysis was constructed using a two-step approach. My IVs included six of the seven criteria listed on the trauma scorecard. The IV Type 5 Hospital Judgment was removed from consideration

as this criterion is not part of the pre-hospital decision matrix. Tables 7 and 8 display the model classifications, which serve two purposes: (1) documentation of variable coding, and (2) illustration of the SPSS model predictions.

Table 7

Dependent Variable Encoding

Original Value	Internal Value
Ground Ambulance	0
Helicopter	1

Table 8

Classification Table

Observed			Predicted		
			Transportation Method		Percentage
			Ground Ambulance	Helicopter	
Step 0	Transportation Method	Ground Ambulance	65,329	0	100.0
		Helicopter	5,932	0	.0
	Overall percentage				91.7

Note: The constant is included in the model, and the cut value is .500

The baseline analysis (see Table 8) shows a predictive result of only the default dependent variable (0 = Ground Ambulance) without the independent variables added to the model. In this instance, the classification table assumes that all patients were

transported via ground ambulance. This evaluation illustrated a finding of 91.7% accuracy in predicting ground transportation without other variables present.

Part of the logistic regression model in a stepwise fashion begins with an assessment of the Hosmer-Lemeshow goodness-of-fit result as an assumption foundation (Field, 2009). Significance values of less than 0.05 are indicators of a good model fit (Field, 2009). Table 9 illustrates the values meet the required significance threshold to consider my *LR* models as valid.

Table 9

Hosmer-Lemeshow

Step	Chi-square	*df*	Sig.
1	32.167	8	.000

Step 0 of my regression model included an output assessment of all variables in the equation as well as the model summary output. These outputs are presented in Tables 10 and 11. Step 0 is the computed values of the constant without the influence of my predictor variables. Table 11 illustrates the summary statistics of triage score predictors added.

Table 10

Variables in the Equation Step 0

		B	S.E.	Wald	*df*	Sig.	Exp(*B*)
Step 0	Constant	-2.399	.014	31299.886	1	.000	.091

Table 11

Variables in the Equation Step 1

Step 1	*B*	S.E.	Wald	*df*	Sig.	Exp(*B*)	95% C.I. for EXP(*B*)	
							Lower	Upper
Pre-Hospital Triage Classification			2761.056	5	.000			
Pre-Hospital Triage Classification (1) Red	2.360	.049	2345.127	1	.000	10.592	9.627	11.654
Pre-Hospital Triage Classification (2) Blue	2.022	.063	1027.724	1	.000	7.552	6.674	8.546
Pre-Hospital Triage Classification (3) GCS	2.209	.103	460.844	1	.000	9.105	7.442	11.139
Pre-Hospital Triage Classification (4) Judgment	2.389	.053	2026.881	1	.000	10.900	9.823	12.094
Pre-Hospital Triage Classification (6) Local	1.185	.153	59.666	1	.000	3.270	2.421	4.417
Constant	21.131	8807.957	.000	1	.998	.000		

Note: None of the 168 Facility ID Numbers resulted in significant influence on the *LR* model as covariates, and they were subsequently removed from the final model.

Interpretation

When interpreting the *LR* results, it is essential to note that the addition of the covariate trauma center locations was not relevant to the results. As mentioned previously, the data set for trauma center location was deidentified by the Florida Department of Health prior to receipt. The addition of the 168 supplied Facility Identification Numbers resulted in no significance to the resulting logistic regression model.

The Odds Ratio for my logistic regression Step 1, displayed in column output Exp(*B*), shows a value greater than 1, indicative of a positive relationship between the IVs and the DV. When interpreting the significant predictors, all five of the Pre-Hospital Triage Classifications resulted in a positive relationship (see Table 11). In order, the Red criteria resulted in positive likelihood of predicting helicopter transportation (*B* = 2.360, Wald = 2345.127, Exp(*B*) = 10.952, *p* = .000, CI [9.627, 11.654]). The Blue criteria resulted in positive likelihood of predicting helicopter transportation (*B* = 2.022, Wald = 1027.724, Exp(*B*) 7.552, *p* = .000, CI [6.774, 8.546]). The GCS ≤12 criteria resulted in positive likelihood of predicting helicopter transportation (*B* = 2.360, Wald = 2345.127, Exp(*B*) 9.105, *p* = .000, CI [9.627, 11.654]). Judgment EMS resulted in positive likelihood of predicting helicopter transportation (*B* = 2.360, Wald = 2345.127, Exp(*B*)10.900, *p* = .000, CI [9.627, 11.654]), and Local Criteria resulted in positive likelihood of predicting helicopter transportation (*B* = 2.360, Wald = 2345.127, Exp(*B*) 3.270, *p* = .000, CI [9.627, 11.654]). In other words, patients classified using the trauma

scorecard were significantly more likely to be transported by helicopter than by ground ambulance when applying any of the listed criteria. One significant and unexpected result of the *LR* analysis illustrated that Classification Level IV – Judgement – is the highest likelihood criteria for transport mode selection – HEMS, overshadowing other objective patient assessment criteria scoring. These findings are consistent with those discussed in Chapter 2 and will be discussed further in the next chapter. Table 12 provides a simple summary of the predicted positive relationship between the trauma scorecard criteria and the decision to transport patients via helicopter.

Table 12

Relationship Between IV and DV Summary

IV	Relationship	Helicopter	Sig.
Alert Type 1 Red	Positive	10.6% greater	.000
Alert Type 2 Blue	Positive	7.5% greater	.000
Alert Type 3 GCS ≤12	Positive	9.1% greater	.000
Alert Type 4 Judgment EMS	Positive	10.9% greater	.000
Alert Type 6 Local Criteria	Positive	3.3% greater	.000

Post Hoc Analysis

The results of the initial data evaluation to determine transportation method based on scene evaluation trauma scorecard criteria was further evaluated in a *post hoc* analysis to investigate patient outcome destinations from the receiving Emergency Department-specific to HEMS transport. Patient release from the Emergency Department after HEMS transportation was the criterion of interest. The Florida Trauma Registry 2014 codes. ED release patients are as follows: (a) ED_19 ED Discharge Disposition 4- Home with services; (b) ED_19 ED Discharge Disposition 6- Other (jail, institutional care, mental) (c) ED_19 ED Discharge Disposition 9– Home without services; and, (d) Left Against Medical Advice (AMA).

Appropriate use of HEMS was based on patient admission to the hospital (or transfer to another hospital) for further treatment or if the patient was so critically injured that they expired in the Emergency Department. These variables are shown below: (a) ED_19 ED Discharge Disposition 1- Floor bed (general admission, non-specialty unit bed); (b) ED_19 ED Discharge Disposition 2- Observation unit (unit that provides < 24-hour stays); (c) ED_19 ED Discharge Disposition 3- Telemetry/step-down unit (less acuity than ICU) (d) ED_19 ED Discharge Disposition 5- Died/Expired; (e) ED_19 ED Discharge Disposition 7- Operating Room; (f) ED_19 ED Discharge Disposition 8- Intensive Care Unit (ICU); and (g) ED_19 ED Discharge Disposition 11- Transferred to another hospital.

The ED variables were recoded in SPSS to reflect three categories: (a) Admission from the ED; (b) Discharge from the ED, or (c) expired in the ED. The reclassification of variables allowed for, precise analysis and crosstabulation relating to mode of transportation and trauma scorecard criteria (see Table 13).

Table 13

Trauma Registry ED Disposition Data

Admitted Classifications	Discharge Classifications	Expired ED
ED_19_1 General Admit	ED_19_4 Home w/Services	ED_19_5 Died/Expired
ED_19_2 Observation Unit	ED_19_6 Other Discharge	
ED_19_3 Telemetry	ED_19_9 Home no Services	
ED_19_7 Operating Room	ED_19_10 Left AMA	
ED_19_8 ICU		
ED_19_11 Transferred		

In a review of my initial findings, patients classified using the trauma scorecard were significantly more likely to be transported by helicopter than by ground ambulance when applying any of the listed criteria. Additionally, Category 4- EMS Judgment, which allows the responder to bypass the trauma scorecard had the highest likelihood of HEMS transportation when compared to other objective physiological assessment criteria.

When comparing these findings with the ED Discharge rate by the Trauma Scorecard criteria, the patients who were transported by HEMS had a corresponding relationship with being discharged from the ED (see Table 14). These data show that the

highest rate of discharge comes from the Alert Type 4 EMS Judgment as well as Alert Type 6 Local Criteria.

Table 14

Increased Likelihood of HEMS Transportation vs. ED Discharge

	Alert Type 1 Red	Alert Type 2 Blue	Alert Type 3 GCS <12	Alert Type 4 Judgment EMS	Alert Type 6 Local Criteria
Increased Likelihood HEMS	10.6%	7.5%	9.1%	10.9%	3.3%
ED Discharge within Alert Type for HEMS	8.6%	8.7%	4.4%	14.7%	25.8%

When evaluating ground ambulance and HEMS in relation to ED admission vs discharge, the results show Alert Type 6 Local Criteria had the highest rate of ED Discharges (42.8% for Ground Ambulance; 25.8% for HEMS) followed by Alert Type 4 EMS Judgment (22.5% for Ground Ambulance; 14.7% for HEMS; see Table 15).

Table 15

Transportation Method Compared to ED Admit/Discharge

Transportation Method			Pre-Hospital Triage Classifications				
			Alert Type 1 Red	Alert Type 2 Blue	Alert Type 3 GCS <12	Alert Type 4 Judgment EMS	Alert Type 6 Local Criteria
Ground Ambulance	Admitted from ED	Count	5661	2320	665	3386	1113
		% within Alert Type	75.9%	85.3%	87.5%	76.9%	51.7%
	Discharged from ED	Count	1352	385	61	990	1038
		% within Alert Type	18.1%	14.2%	8.0%	22.5%	48.2%
	Expired ED	Count	450	15	34	26	2
		% within Alert Type	6.0%	0.6%	4.5%	0.6%	0.1%
Helicopter	Admitted from ED	Count	1887	598	224	1578	46
		% within Alert Type	86.2%	90.9%	90.3%	84.7%	74.2%
	Discharged from ED	Count	188	57	11	274	16
		% within Alert Type	8.6%	8.7%	4.4%	14.7%	25.8%
	Expired ED	Count	114	3	13	11	0
		% within Alert Type	5.2%	0.5%	5.2%	0.6%	0.0%

Summary

Having concluded my *LR* interpretation, I have rejected my null hypothesis in favor of the alternate through the demonstrated significance in all of the IVs. Each of the five Florida Adult Trauma Scorecard criteria used in this analysis showed an increased likelihood of transportation via HEMS.

When evaluating the data concerning patients who were discharged from the ED after HEMS transportation, the results were significantly and unexpectedly similar to the *LR* results except for Alert Type 6 Local Criteria which is substantially higher for both Ground Ambulance and HEMS transportation. The implications of these results on public policy as well as impact to patients will be discussed in Chapter 5.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this study was to investigate the Florida Adult Trauma Scorecard methodology concerning the use of HEMS versus ground ambulance for accident scene transport method selection. The trauma scorecard contains specific anatomical and physiological criteria divided into color-coded categories but does not contain direction regarding when to transport a patient by air or via ground ambulance. Currently, decisions regarding mode of patient transportation rest on the discretion of the paramedic or EMS on the scene of a traumatic injury. However, responder discretion is unreliable when determining the extent of patient injury (Fitzharris et al., 2012; Mulholland et al., 2005; Smith et al., 2013).

My study was based on data obtained from the Florida Department of Health Trauma Registry for the calendar year of 2015, involving all patients transported to a trauma center. A total of 102,363 records were received from the data request, of which 71,261 were evaluated to meet study inclusion criteria. Of the 71,261 records, 65,329 patients were transported via ground ambulance, and 5,932 patients were transported via HEMS.

Using SPSS v. 24, a binary logistic regression analysis was constructed using a two-step approach. My IVs included six of the seven criteria listed on the trauma scorecard. The IV type 5 hospital judgment was removed from consideration as this criterion is not part of the prehospital decision matrix. The odds ratio for the logistic

regression step 1 displayed an Exp(*B*) value greater than 1, indicative of a positive relationship between the IVs and DV. When interpreting the significant predictors, all five of the prehospital triage classifications exhibited a significantly positive likelihood for HEMS transport as the selected transport method. These significant likelihoods ranged from 3.3% (alert type 6 local criteria) to 10.9% (alert type 4 EMS judgment).

A post hoc analysis was conducted to determine the patient outcome based on ED admission, discharge, or expiration of the patient. When evaluating ground ambulance and HEMS in relation to ED admission versus discharge, the results showed alert type 6 local criteria has the highest rate of ED discharge (42.8% for ground ambulance and 25.8% for HEMS) followed by alert type 4 EMS judgment (22.5% for ground ambulance vs 14.7% for HEMS) indicating significant over triage is occurring.

This chapter will discuss interpretations of the findings, implications for public policy and social change, recommendations for actions, and recommendations for future studies.

Interpretation of the Findings

Accuracy of Triage

Over triage is defined as the overestimation of patient injuries to determine if the patient is more likely to need specialized trauma care when that is not the case. Undertriage is the opposite, the determination that patient injuries are not severe when the patient had more severe injuries than the methodology recognized (Henry et al., 1996). The findings of my study showed a significant likelihood that patients would be

transported via HEMS for any of the five selected Florida trauma scorecard categories. The ED discharge rate corresponds with the rate of over triage, indicating that some trauma patients were not as acute as initial assessments suggested.

Results in Relation to The Theory of Justice

Rawls (1999) discussed the theory of justice as a fair distribution of social resources with corresponding elements of public reason. Rhodes (2018) said EMS providers disregard the concepts of fair and equal treatment for all in emergency situations, preferring to focus exclusively on the immediacy and severity of a patient's injuries. This is consistent with the application of the Florida Adult Trauma Scorecard and other trauma triage methodologies as a means of justice. However, my study showed that the use of the Florida trauma scorecard may lead to discretionary use of HEMS transportation in all triage categories. When considering Rawls' theory, overuse of HEMS resources results in higher costs for patients who were transported and less availability for those who may need the resource. These higher costs may place an unnecessary financial burden on those HEMS-transported patients than what was needed based on the triage criteria. Additionally, these excess costs may result in organizational bad debt when HEMS-transported patients are uninsured or otherwise lack the financial means to cover HEMS transport costs. The public then bears the burden of these bad debt cases through the diversion of tax revenues to cover shortfalls that might otherwise be spent on prevention, road works, and other public goods. Helicopter services that are owned by governmental or municipal agencies, like Trauma Hawk in Palm Beach

County, are operationally funded, in part, by taxes, thus relying on direct patient billing to make up any budgetary shortfalls specific to medical transport services (Palm Beach County Health Care District, 2017).

Rowland (2019) said the cost of HEMS and fixed-wing medical transportation rose 60% from 2012 to 2016 to a median cost of $39,000, 10 times what Medicare pays for each billable service. Bai, Chanmugam, Suslow, and Anderson (2019) described complicating cost and reimbursement factors for HEMS, given that many operators are not members of insurance networks, leaving transported patients responsible for any noncovered amounts.

Efforts to adjust public policy to respond to HEMS costs to patients have been unsuccessful as these aircrafts are regulated by the federal Airline Deregulation Act of 1978, which does not allow for states to intervene in HEMS rate settings as these rotary-winged aircraft are treated as passenger aircraft rather than any form of specialized medical transport units (Rowland, 2019). Save Our Medical Resources, a citizens' advocacy group, has inferred that a decision to use HEMS transportation is always dependent on an emergency request to respond from prehospital crews or a physician in a hospital. Taken at face value, this position places the onus of these high-cost responses directly on the requesting agency (Rowland, 2019). Discretionary use of HEMS is discussed at length in the literature as accounting for a range of over triage between 20 to 30 % (Cox et al., 2011; Fitzharris et al., 2012; Lin, Becker, & Lynn, 2012b; Mulholland et al., 2005). My research supports these scholarly findings, as well. Sending patients via

HEMS when it is not clinically indicated increases overall cost of care for patients and the cost of operations to HEMS operators. When these costs are not covered by insurance or private pay funding, society is potentially left bearing these bad debt costs. Worse yet is the potential cessation of private company HEMS transport operations due to budgetary losses, leaving only tax-supported HEMS options when and where available. Rawls' theory of distributive justice would argue this to be an unfair distribution for the public good.

Patient and Crew Safety Considerations

When Mains stood at the 2011 Air Medical Transport Conference and asked attendees to open 358 randomly distributed envelopes, he was making an obvious point about the danger of HEMS operations. Each of the envelopes contained the name of one pilot, crew member, or patient who died in a HEMS accident between 1990 and 2011. If that same demonstration exercise were conducted in 2019, more envelope names would be present, including a HEMS pilot and nurse in Brainerd, Minnesota (CBS Minnesota, 2019).- These lives might have been lost due to a patient not meeting HEMS-level transport criteria but instead receiving services due to scene responder preference or convenience.

Patients theoretically have the right to refuse HEMS transportation through the right of refusal protocols found in all prehospital standing orders (Emergency Medicine Learning & Resource Center, 2017). In order to refuse, patients must be fully conscious, of clear mind and be fully informed of the consequences of refusal; in short, the refusal

for HEMS transport must be conducted using an informed consent process. Many trauma patients are not in a position to provide informed consent. As such, field assumptions and paramedic decisions may be overriding objective physiological criteria for HEMS transport.

Impact of Locally Developed Criteria

Some counties within Florida have written Local Criteria into the trauma scorecard methodology (Alert Criteria 6). The local criteria may designate mandatory fly zones which may be determined by time or location. Madiraju et al. (2017) found attempts by Palm Beach County to use a modified version of the Florida Trauma Scorecard Methodology resulted in an estimated a cost of $1.3 million when a 78% over triage rate was found on HEMS transportation for their helicopter service. The decision to request HEMS in the Palm Beach County Protocol are three criteria: (a) the closest trauma center is > 20 minutes away, (b) ground transportation is unavailable in a reasonable amount of time, and (c) >15 minutes of extrication time is required (Emergency Medicine Learning & Resource Center, 2017). Other counties designate a geographical boundary in which patients are to be transported by air such as an interstate roadway or a body of water.

As suggested by R. Adams Cowley in the early 1970s, each trauma patient has a golden hour after which survival is less likely (University of Maryland Medical Center, 2017). Rogers et al. (2015) asked if time alone is responsible for patient survival. They concluded that patients referenced by Cowley in the early 1970s did not have access to

mature EMS systems and Advanced Life Support Paramedics that are present in prehospital care today. The total elapsed time in combination with the medical care provided during this interval is the measure of effectiveness, efficiency, and safety for the patient (M. Abernethy, personal communication, August 17, 2017).

Liftoff time for HEMS is an often overlooked time consideration when requesting these units to respond. Clark, Corey, Hutchison, Lalonde, and Dunn (2017) studied how often HEMS was able to meet a 10-minute lift-off time for non-interfacility transport requests. Their results showed that HEMS was only able to meet the 10-minute standard, 59% of the time with a range of one minute to over 22 minutes (Clark et al., 2017). When adding lift-off time with HEMS response time, the overall suggestion is that HEMS may have an equivalent response time to that of a ground ambulance up to a given distance (M. Abernethy, personal communication, August 17, 2017). In the case of Palm Beach County, distance and time may have been the common factor in over triage and the resulting cost estimation for unnecessary HEMS responses.

Limitations of the Study

This study used secondary data which was provided by the Florida Department of Health Trauma Registry. The trauma registry obtained the records through data submissions made by individual trauma centers throughout Florida. As discussed above, all five of the Pre-Hospital Triage Classifications had a significantly positive likelihood of HEMS use, but the evaluation of this data could not determine why a helicopter was

chosen over the use of ground transportation by EMS personnel. The data was limited to a basic Yes or No reporting of trauma triage criteria selection.

The Florida Trauma Registry data system relies on trauma centers throughout Florida to record and enter local information accurately utilizing the format required by the 2014 Florida Trauma Registry data dictionary (Florida Department of Health, 2016b). The use of secondary data presented the risk that local data was not entered or documented correctly. Of 102,363 records in the dataset, 14,314 were missing various records (ED Discharge: 899; Transport Mode: 635; Expired ED: 203 and Hospital Discharge: 12,577).

A substantial limitation found during this study is the lack of tracking for local triage criteria developed by counties throughout the state of Florida. While Madiraju et al. (2017) discussed their specific local criteria within their work, most of these criteria are not reported to the Department of Health. Significant findings were found relating to local criteria in which 25.5% of HEMS and 42.8% of ground transportation resulted in over triage without the ability to reference what criteria was used.

Recommendations

My study was not able to evaluate each of the custom local trauma triage criteria because they are not tracked within the Florida Trauma Registry. The Florida EMSTARS reporting system also does not obtain data concerning local trauma triage criteria as referenced in Data Dictionary 3.4. The category of ctat104 Local Agency/Medical Director Criteria does not have a corresponding area for specific

information on the contents of the local criteria (EMSTARS, 2017). It is important to note that the over triage rate within local criteria was found to be: ground ambulance (48.2%) and HEMS (25.8%). This over triage rate is very high when compared to the other trauma scorecard criteria and is potentially doing a disservice to patients who do not need expensive trauma services at all. The disservice is compounded when patients are placed aboard a helicopter who do not have a medical need. Without additional information on what is being asked of local EMS providers, it is impossible to say for sure what is happening to justify this over-triage rate. Based on the results of my study, it is recommended that the EMSTARS data collection criteria be amended to gather specific data on locally developed trauma triage criteria.

There were two studies of the Florida trauma system in 2013, one conducted by the American College of Surgeons Committee on Trauma and the other by the National Highway Traffic Safety Administration Technical Assistance Team (Florida Department of Health, 2013). Both reports discussed stagnancy in relation to Florida's trauma triage system. While it is beyond the purview of my study, it was noted in both external reports that the political emphasis within trauma care in Florida has been on individual trauma centers rather than how effectively patients get to trauma centers (Florida Department of Health, 2013). Regardless of the political environment, the fact remains that the Florida Trauma Scorecard has not been studied or revised since 2002. There are other promising versions of trauma triage that have emerged since 2002 that should be evaluated against the current version mandated in Florida. It is recommended that the Florida Department

of Health conduct pilot studies of other trauma triage methodologies, such as the Air Medical Prehospital Triage (AMPT; Brown et al., 2017), to evaluate the sensitivity and specificity of the current method against alternatives in an effort to determine the most effective and efficient criteria for Florida's use and update where applicable. Additionally, a formalized, state-level evaluation of locally developed trauma triage criteria should be considered in order to review practices and recommend changes specific to patient needs concerning locale if reviewed evidence warrants the same.

As mentioned previously, the issue of paramedic discretion has been proven to lead to over triage of trauma patients in studies within the United States (Mulholland et al., 2005; Smith et al., 2013). My research has also indicated that paramedic discretion has similar results within Florida. It is generally agreed upon that responder discretion should be a component of patient-based triage but determining why the discretion is inaccurate would indicate a need for further scientific study. This recommendation would require the proactive study of trauma responses to determine why on-scene personnel chose to deviate from the trauma scorecard methodology in favor of discretion.

Nationally, research should be conducted to gather more information examining specifically applied patient triage criteria in cases were a HEMS aircraft was used for transport, and the craft subsequently crashed. This recommendation provides a basis for further research to determine whether a patient needed air transportation, for which HEMS was requested, or was ground transportation more applicable when triage criteria were applied. Patient data compared with the flight conditions present at the time of a

HEMS crash incident could be evaluated to determine medical need versus flight conditions in an effort to evaluate risks and benefits of said flight. Any loss of life in a HEMS crash is tragic, but it would be senseless if the patient's condition did not warrant air transportation at all. National public policymakers, to include the Federal Aviation Administration and National Institutes of Health, in conjunction with various national medical, trauma, and medical transport interest groups, should be assessing these incidents and acting on peer-reviewed research to determine a unified guidance policy for HEMS operating standards for field and routine transport responses with a greater reliance on clinical presentation over scene responder's preferences.

Implications for Social Change

Rhodes (2018) discussed that chance should not be the deciding factor when providing specific or limited medical treatment. The protection of the public should be planned and carefully implemented to ensure fair distribution. The development and use of the Florida Adult Trauma Scorecard is mandated public policy in the Florida Administrative Code 64J-2.004. The code was designed and implemented for the express purpose of defining equitable assessment of trauma patients through a scripted set of determinants (Florida Administrative Code, 2018). The Trauma Scorecard undermines this script by allowing locally determined trauma criteria as well as responder discretion within the same document. Madiraju et al. (2017) determined the efforts of Palm Beach County to further define the Florida Trauma Scorecard through local criteria resulted in an increase in helicopter use for patients who did not need the service. Local

governments, as well as state policymakers, have the responsibility to serve their citizens in offering services that are equally distributed, cost-conscious, and adequate for their needs. As Palm Beach County determined, the over triage cost of placing patients on HEMS when it was not needed resulting in a substantial monetary cost to the county as well as to the patients who received large medical bills when they did not need HEMS or trauma services (Madiraju et al., 2017).

The issue of over triage of trauma patients and the inappropriate use of HEMS is not unique to Florida as it has been documented throughout the United States (Brown et al., 2010; Butler et al., 2010; Medvecz et al., 2013; White et al., 2011; Wuerz, Taylor, & Stanley-Smith, 1996). Public policy should be evaluated on the national level as well to ensure the public receives appropriate services.

Conclusion

Time savings was the initial indication for the use of HEMS and is a hallmark of military care which became the golden hour in early trauma treatment. The Golden Hour has been concluded to be a false metric to determine patient survival (Newgard et al., 2015; Rogers et al., 2015) although recent authors have taken issue with discarding the concept (Schroeder, Napoli, Barnhardt, Barnes, & Young, 2018). Madiraju et al. (2017) chose the title of their research, *In by helicopter out by cab: The financial cost of aeromedical over triage of trauma patients* to demonstrate the financial cost of HEMS to patients. Additionally, reimbursement for HEMS transportation has been well documented (Bai, Chanmugam, Suslow, & Anderson, 2019; Rowland, 2019). Efforts of

state legislators to intervene and regulate the cost has been stymied because HEMS operations are covered under the federal Airline Deregulation Act of 1978 (United States Congress. House Committee on Transportation and Infrastructure. Subcommittee on Aviation. 2009). In short, HEMS units are considered passenger aircraft and are regulated as such. State governments cannot regulate the cost of the major air carriers, and similarly they cannot regulate the cost of HEMS transportation.

There are other costs associated with HEMS which come in the form of safety. Mains (2013) said 358 deaths were associated with HEMS incidents while addressing a conference in 2011. It is unknown if each of these individuals who died was on a flight for a patient who did not need HEMS transportation, but it does beg the question. HEMS responders must be specifically summoned in order to respond to an emergency inferring that a medical assessment was made to fly the patient (Rowland, 2019). The results of my study demonstrated that a determination was made to transport patients via HEMS when it may not have been medically necessary. Elected officials who are responsible for the safety and wellbeing of the public they serve should not ignore the obvious which unfortunately occurs at an unacceptable rate. Public policy at the state level, such as Florida's Statute 401 (Florida Statutes, 2012) and the Florida Administrative Code 64J-2 (Florida Administrative Code, 2018) have failed to address HEMS response. Additionally, federal public policy has maintained that HEMS services should operate like passenger airlines. thus, turning a blind eye to the fact that passenger airlines do not respond to emergency scenes to retrieve the sick or injured (United States Congress.

House Committee on Transportation and Infrastructure. Subcommittee on Aviation. 2009). It is genuine regrettable that Mains likely will stand before future audiences and demonstrate once again that unnecessary events and a lack of public policy oversight may have resulted in additional HEMS related fatalities of patients and crew.

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Appendix A: Florida Adult Trauma Triage Criteria & Methodology

Adult Trauma Triage Criteria & Methodology

The EMT or paramedic shall assess the condition of those injured persons with anatomical and physiological characteristics of a person sixteen (16) years of age or older for the presence of at least one of the following four (4) criteria to determine whether to transport as a trauma alert. These four criteria are to be applied in the order listed, and once any one criterion is met that identifies the patient as a trauma alert; no further assessment is required to determine the transport destination.

Criteria:

- ☐ 1. Meets color-coded triage system (see below)
- ☐ 2. GCS ≤ 12 (Patient must be evaluated via GCS if not identified as a trauma alert after application of criterion 1.)
- ☐ 3. Meets local criteria (specify): _____
- ☐ 4. Patient does not meet any of the trauma criteria listed above but, in the judgement of the EMT or paramedic, should be transported as a trauma alert (document)_____

_____

_____

COMPONENT		
AIRWAY	RESPIRATORY RATE OF 30 or GREATER ☐ B	ACTIVE AIRWAY ASSISTANCE[1] ☐ R
CIRCULATION	SUSTAINED HR OF 120 BEATS PER MINUTE or GREATER ☐ B	LACK OF RADIAL PULSE WITH SUSTAINED HEART RATE (>120) or BP <90 mmHg ☐ R
BEST MOTOR RESPONSE	BMR =5 ☐ B	BMR = 4 or LESS or PRESENCE OF PARALYSIS, or SUSPICION OF SPINAL CORD INJURY or LOSS OF SENSATION ☐ R
CUTANEOUS	SOFT TISSUE LOSS[2] or GSW TO THE EXTREMETIES ☐ B	2ND OR 3RD [5] BURNS TO 15% or MORE TBSA or AMPUTATION PROXIMAL TO THE WRIST or ANKLE or ANY PENETRATING INJURY TO HEAD, NECK, or TORSO[3] ☐ R
LONGBONE FRACTURE[4]	SINGLE FX SITE DUE TO MVA or FALL 10 ' or MORE ☐ B	FRACTURE OF TWO or MORE LONGBONES ☐ R
AGE	55 YEARS or OLDER ☐ B	
MECHANISM OF INJURY	EJECTION FROM VEHICLE[5] or DEFORMED STEERING WHEEL[6] ☐ B	

R = any one (1) - transport as a trauma alert B = any two (2) - transport as a trauma alert

1. Airway assistance beyond administration of oxygen
2. Major degloving injures, or major flap avulsion (>5 in.)
3. Excluding superficial wounds in which the depth of the wound can be determined
4. Longbone (Including humerus, (radius, ulna), femur, (tibia or fibula).
5. Excluding motorcycle, moped, all terrain vehicle, bicycle, or open body of a pickup truck
6. Only applies to driver of vehicle)

12/4/2002

Appendix B: Florida Trauma Centers as of March 2015

FLORIDA TRAUMA CENTERS

Update March 2015

TRAUMACENTER	LEVEL	COUNTY
All Children's Hospital	Pediatric	Pinellas
Baptist Hospital	Level II	Escambia
Bay Medical Center	Level II	Bay
Bayfront Health St. Petersburg	Level II	Pinellas
Blake Medical Center	Level II	Manatee
Broward Health Medical Center	Level I	Broward
Broward Health North	Level II	Broward
Delray Medical Center	Level I	Palm Beach
Halifax Medical Center	Level II	Volusia
Holmes Regional Medical Center	Level II	Brevard
Kendall Regional Medical Center	Level II	Miami-Dade
Jackson Memorial Hospital/ Ryder Trauma Center	Level I	Miami-Dade
Lakeland Regional Medical Center	Level II	Polk
Lawnwood Regional Medical Center	Level II	St. Lucie
Lee Memorial Hospital	Level II	Lee
Memorial Regional Hospital	Level I	Broward
Nicklaus Children's Hospital	Pediatric	Miami-Dade
Ocala Regional Medical Center/ Marion Community Hospital	Level II	Marion
Orlando Regional Medical Center	Level I	Orange
Regional Medical Center Bayonet Point	Level II	Pasco
Sacred Heart Hospital	Level II / Pediatric	Escambia
St. Joseph's Hospital	Level II / Pediatric	Hillsborough
St. Mary's Hospital	Level I	Palm Beach
UF Health Shands Jacksonville	Level I	Duval
UF Health Shands Gainesville	Level I	Alachua
Tallahassee Memorial Hospital	Level II	Leon
Tampa General	Level I	Hillsborough

Appendix C: Florida Bureau of Emergency Medical Oversight Data Use Agreement

FLORIDA DEPARTMENT OF HEALTH
Division of Emergency Preparedness and Community Support
Bureau of Emergency Medical Oversight

Florida HEALTH

Bureau of Emergency Medical Oversight Data Use Agreement

I. INFORMATION FOR DATA USE AGREEMENT

Trauma registry records submitted to the department from licensed hospitals are made confidential and exempt from public records requests by section 395.404(b), Florida Statutes. A list of data elements available is can be found at http://www.floridahealth.gov/certificates/trauma-registry/index.html. Certain data elements are confidential, as they could be used to identify individuals. Applicants should review these data elements carefully when requesting data, as the use of each data element must be justified in this application. ***Please note that data may not be released unless there is a documented need demonstrating the advancement of medical research or medical education in the interest of reducing morbidity or mortality pursuant to Chapter 405 Florida Statutes.***

Application approvals for the use of trauma registry data are not granted automatically, but are reviewed by the department based upon their potential to reduce morbidity and mortality and advance medical research and medical education. Review and approval by the Florida Department of Health, Institutional Review Board (IRB) is required for all data that is released.

Send completed application to:

Health Information and Policy Analysis Section
Bureau of Emergency Medical Oversight
Florida Department of Health
4052 Bald Cypress Way, Bin A-22
Tallahassee, FL 32399-1722
Phone: (800) 224-4440
Fax: (850) 488-2512
E-mail: trauma.registry@flhealth.gov

FOR DOH BEMO USE:

Date Received_____

Status:

☐ Passes initial review, refer to DOH IRB
☐ Does not pass initial review

Request #:_____

Comments:_____

_____

_____

_____

_____

_____

II. APPLICANT INFORMATION.

A. Project Director/ Principal Investigator:	
Title:	
Organization:	
Address:	
Phone:	
Fax:	
E-mail:	
B. Data Custodian (to whom the data should be released):	
Title:	
Organization:	
Address:	
Phone:	
Fax:	
E-mail:	

Please attach a curriculum vitae for each individual listed above and for each co-investigator.

C. Provide the names and titles of all proposed data release agreement signatories.

Please indicate the study group(s) below that best describe(s) the applicant			
☐	Research groups (universities)	☐	Medical associations and societies
☐	In-hospital medical staff committees	☐	Other Governmental health agencies
☐	Other Agency not listed: (Please Explain)		
Tax Status: ☐ Not-For-Profit ☐ For-Profit			

III. PROJECT SUMMARY.

A.	Title of Study or Project.
B.	List names of organizations, consultants, subcontractors, or any other external collaborators involved with this study or project, other than the project director and his or her staff.
C.	List all sources of funding for this study or project.
D.	In the space below or on a separate sheet, please provide a summary of the study protocol or project activities that addresses each of the items below. You may also attach a copy of your proposed study or project protocol, or any other supporting documentation, in addition to this summary. **Note:** All items below *must* be addressed in this summary. • Demonstrate how this study or project will reduce morbidity and mortality; • A description of the analysis to be conducted **using Florida Trauma Registry data**, including the specific health or medical conditions to be examined, and specific testable hypotheses, if any; • A listing of all other data sources to be used in this study or project, and any proposed linkages to these data sources; • A timetable for completion of this study or project; and • A description of how, when, and to whom research results will be released, including publication or presentation of findings, and how results will advance medical research and medical education. Please describe the *least* aggregate results to be released.

Attach examples as needed to demonstrate that the information will be properly aggregated and/or de-identified.

IV. REQUESTED DATA SPECIFICATIONS AND REQUIREMENTS.

The collection of records into the Next Generation Trauma Registry started in 2014. Data collected prior to this date did not receive any formal validation to prevent errors and is generally considered not appropriate for release. The data elements collected is based around the National Trauma Data Standard and is supplemented with the Florida Specfic elements. The data elements collected can be found at www.ntdbdictionary.com and http://www.floridahealth.gov/certificates/trauma-registry/index.html.

A. Date Range Requested:				
B. Data Selection/Extraction Criteria				
☐	None (you will receive all unrestricted data within the Trauma Registry database)			
☐	Specific patient population			
Identify specific patient population requested in the space below (e.g. age > 65, specific ICD-9-CM codes), if applicable.				
C. Data Format Requested				
☐	SAS	☐ Excel	☐ XML	
☐	Other-Not Listed			

V. DATA USE

Trauma Registry data may only be used for the specific purpose(s) described in this agreement. All persons with data access must maintain the confidentiality of the data and prevent release to unauthorized parties. The applicant agrees as follows:

1. The applicant will not, nor permit others to, attempt to link records with personally identifiable records from any other source, with the purpose of identifying an individual patient or hospitals unless otherwise approved by the department;
2. The applicant will not, nor permit others to, release any information that identifies individuals, directly or indirectly;
3. The applicant will not, nor permit others to, use the data for any study of human subjects that was not specifically approved by the Florida Department of Health Institutional Review Board;

4. The applicant will not, nor permit others to, make statements indicating or suggesting that interpretations drawn from the data are those of the Florida Department of Health;
5. The applicant will indemnify, defend, and hold the Florida Department of Health, its members, employees, and contract vendors, harmless from any and all claims and losses accruing to any person as a result of violation of this agreement;
6. The applicant will not, nor permit others to, copy, sell, rent, license, lease, loan, or otherwise grant access to the data covered by this agreement to any other person or entity;
7. The applicant will not, nor permit others to, release individual records, either in part or in their entirety, to any person who is not a member of the research or study group identified in this agreement;
8. The applicant will not, nor permit others to, make follow-back of any type to any individual, institution, or firm without the prior knowledge and approval of the Florida Department of Health Institutional Review Board;
9. The applicant will delete the data according to one of the approved data destruction methods indicated in this agreement;
10. The applicant may be audited by the BEMO at any time to ensure that the data are being used as approved and deleted upon conclusion of the approved study or project;
11. The applicant will abide by, in addition to this data use agreement, all terms and conditions of the Florida Department of Health Institutional Review Board, BEMO, and, if applicable, the applicant's own organizational Institutional Review Board, and is solely responsible for the timely submission of all review application materials and the payment of all applicable review fees; and
12. The applicant will furnish a copy of the results of the study to BEMO within 60 days of the completion of the study or project.

VI. DATA DESTRUCTION METHOD

Applicants must make provisions for the destruction of records at the conclusion of their project, or when the data is no longer required. Maintaining the privacy of the individuals whose personal information is included in prehospital data is essential to preserving the integrity of the data sharing process.

Please detail the manner and timeline for destruction. If you are following a data destruction policy set by your organization or agency, please attach that policy to your application.

VII. SIGNATURE OF PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR.

By signing below, I understand that upon passing initial review of this data use agreement, I agree to submit a separate online application to the Florida Department of Health, Institutional Review Board (DOH IRB), for review and approval of my proposed study or project. I understand that the DOH IRB must review and approve my proposed study or project, that I must pay the applicable review fee, and that not to share the data externally or internally with unauthorized persons. I agree to use the data only for the purpose stated in this form. I agree to secure the data and any reports containing the data, including disposition of the data and reports, so that confidentiality will not be breached. I acknowledge that it is my responsibility to obtain IRB review and approval of my proposed study or project from my own institution, if my institution does not defer to the authority of the Department of Health's accredited IRB.

**** All persons who come in direct contact with the data requested in this form are required to sign this agreement. If additional signatures are required, please provide them on the last page of this agreement.*

Principal Investigator's or Primary Custodian's Name (Please Print)

_____

Principal Investigator's or Primary Custodian's Signature (Notarization Required)

_____

*Attest (If applicant is a corporation):*_____
(As Corporate Secretary)

Subscribed and sworn before me _____ *this* _____*day of*_____, *20*_____

Notary Public, State of _____
Notary Public Signature ***(Affix Notary Stamp)***

FOR OFFICE USE ONLY

_____
Signature of BEMO Bureau Chief ***Date***

_____
Signature of Division Director ***Date***

Signatures below, by individuals who will access the data requested in this agreement, acknowledge agreement to the terms of the Data Use Agreement.

Name: _____
(Please Print)
Signature: _____

Name: _____
(Please Print)
Signature: _____

Name: _____
(Please Print)
Signature: _____

Name: _____
(Please Print)
Signature: _____

Name: _____
(Please Print)
Signature: _____

Name: _____
(Please Print)
Signature: _____

Name: _____
(Please Print)
Signature: _____

Name: _____
(Please Print)
Signature: _____