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PREHOSPITAL TROPONIN TESTING PROTOCOL FOR ACCELERATED DIAGNOSIS AND EARLY INTERVENTION IN CHEST PAIN PATIENTS

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by

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Dedication

I would like to dedicate this to my wife, family, friends, and colleagues who supported and encouraged me through the implementation of this project.

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The completion of this project would not have been possible without the participation and assistance of many people not all of whom will be enumerated. Their contributions are sincerely appreciated and greatly acknowledged. I would like to express deep appreciation and indebtedness to the following: Beau L. McCrory, MD, Medical Director & Industry Mentor at Covenant Health Emergency Department of Plainview for his endless support, vast knowledge, and unrelenting drive to push this project forward. Marcie Lusk, DNP, APRN, FNP-BC, Associate Professor & Faculty Mentor at the University of Texas at Tyler for her understanding and support during the trials and tribulations that have occurred in pushing this project to completion. Timothy Gibson, LP, EFO, FSCEO, BAAS, Fire Chief of Plainview Fire-EMS for his unprecedented willingness to participate in this project and the excitement he instilled in his staff to be active participants in its completion. Without the support of Mr. Gibson and his department this project would not have come to fruition. All Emergency Medical Services staff of the Plainview Fire-EMS Department who were the first line implementers and whom approached this with enthusiasm and engagement. To all family, friends, co-workers, and fellow cohort members who supported me during the most challenging of times and who refused to let me give up, thank you from the bottom of my heart.

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Abstract

PREHOSPITAL TROPONIN TESTING PROTOCOL FOR ACCELERATED DIAGNOSIS AND EARLY INTERVENTION IN CHEST PAIN PATIENTS

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Non-ST elevation acute coronary syndromes (NSTE-ACS) have significant morbidity and mortality rates despite the progress made in diagnosis and management and represent a significant public health burden in the United States. Lengthy diagnostic algorithms contribute to emergency department over-crowding, increased health care costs, and adverse patient outcomes. A troponin assay instituted earlier in the diagnostic pathway of patients with chest pain suspected of NSTE-ACS will reduce time to definitive diagnosis and medical intervention. This will improve patient outcomes, decrease emergency department crowding through improved ED workflow, and reduce the economic burden. The Star Model of Knowledge Transformation was used to guide an understanding of the cycles, nature, and characteristics of knowledge of NSTE-ACS, organize previous and current concepts of improving care, and provided the framework to guide design, implementation, evaluation and sustainability. The Prehospital Troponin Testing Protocol (PHTTP) instituted a point-of-care troponin assay in the ambulances of the Plainview Fire-EMS department and used this value in an accelerated diagnostic

pathway in the Covenant Plainview Emergency Department. The PHTTP reduced the time to first troponin from 79 minutes (1.32 hours) to 22 minutes (0.37 hours) and time to disposition of patients from 191.00 minutes (3.18 hour) to 150.04 minutes (2.50 hours). Time to first troponin was reduced by 47.00 minutes (0.78 hours) and length of stay was reduced by 40.96 minutes (0.67 hours). The prehospital scene time was increased by 1 minute which was not statistically significant.

Keywords: non-ST segment elevation acute coronary syndrome, prehospital troponin, accelerated diagnostic pathway, and emergency department overcrowding.

Chapter 1

Development of the Clinical Question and Problem Identification

Introduction

The Prehospital Troponin Testing Protocol (PHTTP) for Accelerated Diagnosis and Early Intervention in Chest Pain Patients is an inter-professional, collaborative, biphasic evidenced-based practice implementation project (EPIP). The PHTTP is inter-professional as it requires the collaborative practice of prehospital personnel (Emergency Medical Technicians and Paramedics) and clinical emergency medicine staff (nurses, advanced practice providers, and physicians). The PHTTP has two distinct phases: the prehospital phase and the clinical emergency medicine phase with the collective goal of improving patient outcomes and improving ED workflow. This protocol is designed to concurrently improve patient outcomes and emergency department workflow without a significant increase in prehospital scene times. These improvements are accomplished through the utilization of a prehospital point-of-care troponin assay incorporated into an accelerated diagnostic algorithm for patients with chest pain who present to the emergency department (ED) via emergency medical services (EMS).

Background and Significance

Non-ST Elevation Acute Coronary Syndrome(NSTE-ACS) is one of three acute coronary syndromes (ACS) without significant ST segment elevations demonstrated on the electrocardiogram (ECG). NSTE-ACS is caused by a partial occlusion of a coronary artery. This patient population forms approximately two-thirds of all hospital admissions

for ACS in the United States each year and is associated with an in-hospital mortality of 5% (Bob-Manual, 2017). According to the American College of Cardiology/American Heart Association (ACC/AHA), despite the progress made in recent years in the diagnosis and management of NSTE-ACS, the rate of morbidity remains high and the rate of mortality is significant (Rodriguez, 2016) (see Appendix A). Previous research demonstrates the utilization of a prehospital testing protocol will reduce the public health burden of NSTE-ACS by decreasing the time required for final diagnosis; and utilization of early interventional strategies, and thus decreasing the percentage of major adverse cardiac events (MACE) over time.

In the United States (US), an NSTE-ACS event occurs every 25 seconds and an NSTE-ACS-related death occurs every minute (Amsterdam, 2014). Further, 9-19% of patients who experience an NSTE-ACS event die in the first six months after diagnosis and half of these deaths occur within the first 30 days (Amsterdam, 2014). There are two types of ACS events: (1) NSTE-ACS, and (2) unstable angina (UA). The economic impact of all NSTE-ACS-related causes of morbidity and mortality is estimated to $141 trillion annually (Vendanthon, 2014). Amsterdam (2014) estimated that more than 780,000 individuals will have an ACS event annually and approximately 71% of them will be diagnosed as NSTE-ACS. The diagnosis and treatment of NSTE-ACS represents a significant public health burden in the United States (Amsterdam, 2014). Emergency departments (ED) in the US are currently in crisis due to overcrowding and diagnostic delays (Barish, 2012). The current utilization of lengthy NSTE-ACS diagnostic algorithms contributes to these extended lengths of stay (LOS), poor ED workflow, and the overcrowding (Barish, 2012). Cullen (2013) found prolonged assessment of patients

with chest pain who were suspected of ACS; contributed to overcrowding, increased costs, and adverse patient outcomes, including increased incidence of MACE. As ED overcrowding adversely impacts patient morbidity and mortality, measures to decrease ED LOS and improve ED workflow have been advocated (Meek, 2016).

Amsterdam (2014) demonstrated that a delay in the diagnosis of NSTE-ACS is associated with increases in morbidity and mortality from MACE. Darling (2013) demonstrated that patients with acute myocardial infarction (AMI) experienced a better post-discharge prognosis than those with NSTE-ACS. The factors associated with increased mortality for each of these patient groups were slightly distinct. Therefore, NSTE-ACS events represent a significant economic and health burden in the US and much of this burden is due to the time required to diagnose and initiate appropriate treatments using current diagnostic algorithms.

The incidence of NSTE-ACS increases significantly after age 18 (Amsterdam, 2014). The American Heart Association (AHA) reported the age range for NSTE-ACS events in the United States is 56-79 years with a median age of 68. The ratio of males to females is 3:2. NSTE-ACS is more frequent in African Americans than Caucasians. The rate of NSTE-ACS also increases proportionally with the number of comorbidities (Amsterdam, 2014). Patients at greater risk for NSTE-ACS events present either the following major risk factors or a combination of them: high-serum cholesterol, hypertension, diabetes mellitus, obesity, and smoking. Moreover, 25% of NSTE-ACS patients have diabetes (Amsterdam, 2014).

An early invasive treatment strategy can postpone the occurrence of death or next acute coronary event by an average of 18 months and readmission to the hospital for

ischemic heart disease by 37 months as compared to a non-invasive strategy in patients with NSTE-ACS (Wallentin, 2016). Therefore, patients with longer transport time to a healthcare facility have increased risk of morbidity and mortality from MACE events than urban patients with shorter transport time.

The American College of Cardiology/American Heart Association, in their most current guidelines published in 2014, recommend that the utilization of early invasive strategies (EIS) is likely to improve patient outcomes (Khera, 2014). Morrow (2001) demonstrated that patients with clinically documented NSTE-ACS derive significant clinical benefit from EIS. Serial cardiac troponins should be obtained upon presentation of chest pain in patients after 90 minutes to two hours if using high-sensitivity troponin assays, and three hours later, if using non-high-sensitivity troponin assays (Amsterdam, 2014). This 90-minute to 3-hour algorithm contributes to the ED LOS, time required for definitive diagnosis, and associated costs (Luca, 2016). Khera (2014) in a meta-analysis of randomized, controlled trials demonstrated a consistent benefit in the utilization of EIS in the setting of NSTE-ACS, especially in setting high-risk populations. They further concluded that the earlier these strategies are employed, the better the patient outcomes are. Layfield (2014), in a systematic review, found that serial cardiac troponin sampling with one sample at presentation and at least one additional sample collected two hours later was necessary to identify a rise or fall in the troponin level. Testing with high-sensitivity cardiac troponin assays without other biomarkers at presentation and then at 90 minutes to two hours is the current testing algorithm for most accurate and timely NSTE-ACS diagnosis. Therefore, the PHTTP can decrease the diagnostic interval of

NSTE-ACS and initiate EIS sooner by obtaining the first troponin value in the ambulance instead of waiting until the patient arrives in the ED and delaying the diagnosis.

Troponin is a regulatory protein complex of striated cardiac and skeletal muscle. The troponin complex is divided into three subunits: Troponin C (TnC), Troponin I (TnI), and Troponin T (TnT). TnC is tissue-specific to skeletal muscle damage and TnI and TnT are tissue-specific to myocardial damage (Vasile, 2009). TnI and TnT are the standard cardiac diagnostic biomarkers referred to as cTnI and cTnT, respectively (Mahajan, 2011). Free forms of cTnI are released in the early stages of ischemia and bound forms are released from degradation as ischemia progresses (Vasile, 2009). Therefore, the PHTTP will utilize cTnI as the biomarker because of its increased specificity to myocardial ischemia.

The development of sensitive cardiac Troponin I (cTnI) assays permits the detection of lower concentrations of cTnI earlier as it begins to rise within three to four hours after the onset of myocardial injury (Sherwood, 2014). Sherwood (2014) demonstrated that the use of cTnI assays facilitates earlier diagnosis of NSTE-ACS and improves risk stratification. Borna (2016) demonstrated that cTnI testing was a superior biomarker to diagnose NSTE-ACS within three hours of the patients presenting to the ED with chest pain. POC testing equipment has provided portability and reliability to troponin evaluation which provides a stable platform to utilize in the prehospital setting. Therefore, the use of prehospital cTnI POC testing has the potential to reduce the diagnostic timeframe and streamline the care of NSTE-ACS patients beginning earlier in the treatment pathway. This reduction in diagnostic time will facilitate the utilization of

EIS and over time reduce the impact of MACE events following the diagnosis of NSTE-ACS.

Roffi (2015) reported chest discomfort as the leading symptom that initiates the diagnostic and therapeutic cascade in patients with suspected ACS. Patients reporting chest pain frequently use emergency medical services (EMS) for transport to the ED. For patients reporting chest pain due to NSTE-ACS, in the prehospital setting, current clinical guidelines offer in-hospital risk stratification and management as opposed to straightforward prehospital strategy for diagnosis, medication regimen, and logistics (Ishak, 2014).

Stengaard (2013) validated the feasibility of using prehospital troponin quantitative POC cardiac troponin testing and its capacity to predict mortality. They additionally demonstrated the potential to accelerate triage and diagnosis of NSTE-ACS patients using POC troponin testing is feasible. Stengaard also found that the diagnosis of NSTE-ACS in the prehospital phase impacts the mode of revascularization, is associated with earlier revascularization, and results in shorter hospital stays and improved long term outcomes. Venturini (2013) found that there was no statistical difference between prehospital and ED troponin results, thus concluding that POC-cTn is a stable and accurate biomarker testing platform (see Appendix B). Despite being used in a moving ambulance, POC testing reliably provided accurate results of troponin assays as compared to the results of those performed in the ED. Ezekowitz (2015) found that prehospital POC-troponin testing decreased the time from first medical contact (FMC) to final disposition in the ED by 0.29 hours. Ezekowitz additionally postulated that this 0.29-hour reduction time to final diagnosis within an urban setting with short transport

times could be applied in a rural setting with long transport times and the effect could be potentially magnified. Ezekowitz (2015) and Venturini (2013) demonstrated that prehospital troponin is a reliable diagnostic platform and has the potential to reduce diagnostic time for NSTE-ACS patients. The utilization of prehospital personnel to use POC devices to measure troponin levels during transport of patients to the ED may result in earlier diagnosis of NSTE-ACS (Venturini, 2013). Patel (2012) determined average ground EMS transport times of 43.3 minutes (urban) and 57.6 minutes (rural). Sorenson (2011) indicated that implementation of quantitative prehospital troponin testing by paramedics is feasible and effective. Therefore, prehospital POC testing can expedite the diagnosis of NSTE-ACS by reducing the two-hour ED diagnostic window.

Conclusions: 1) According to Darling (2013), NSTE-ACS patients have a 16.4% higher incidence of MACE than AMI patients, 2) high-sensitivity troponin is the biomarker of choice in the diagnosis of NSTE-ACS, 3) accelerated diagnostic pathways using high-sensitivity troponin testing can reduce the time to diagnosis of NSTE-ACS, 4) prehospital troponin testing can reduce the prevalence of MACE events by reducing time by utilizing EIS, 5) the use of prehospital troponin testing along with an accelerated diagnostic protocol can further reduce diagnostic time by as much as 0.29 hours in the urban setting according Ezekowitz (2015) and potentially higher in the rural setting, 6) treatment delays from current diagnostic pathways results in greater MACE for NSTE-ACS patients than AMI patients (see Appendix B). The use of prehospital troponin testing with an accelerated diagnostic protocol can further reduce diagnostic time by as much as 0.29 hours in the urban setting and potentially higher in the rural setting (Ezekowitz, 2015). Therefore, prehospital POC troponin testing can decrease the

diagnosing time of NSTE-ACS by a minimum of 0.29 hours and concomitantly reduce the incidence of MACE through utilization of NSTE-ACS patients from 12% to 8.9% MACE at 10 months according to Cantor (2005). In summary, based on the background evidence referenced, NSTE-ACS represent a significant public health burden and the utilization of a PHTTP can reduce this burden.

Development of the Clinical Question/Problem – PICOT Question

In patients with chest pain suspected of non-ST segments acute coronary syndromes (P), how does prehospital troponin testing (I), compared to no prehospital troponin testing affect time to diagnosis of acute coronary syndrome (O1) and utilization of early interventional strategies (O2), associated morbidities (O3), major adverse cardiac events (04), ED workflow and overcrowding (O5), and reduce economic burden (O6) over a thirty-day period (T)?

The Star Model of Knowledge Transformation

The Star Model of Knowledge Transformation is a model for understanding the cycles, nature, and characteristics of knowledge that are used in various aspects of evidence-based practice (Stevens, 2012). The Star Model organizes previous and current concepts of improving care and provides the framework to organize evidence-based practice (EBP) processes as follows: Star Point 1 (Discovery Research): This step presents information from the studies in the Evidence Table. Star Point 2 (Evidence Summary): Evidence summary is the first unique step in EBP and its purpose is to synthesize the body or research knowledge into a compact, meaningful statement of the state of the science. This stage reduces large quantities of information into a manageable form to establish generalizability across participants, setting, treatment variations, and

study design. Star Point 3 (Translation to Guidelines): The goal of the translation stage is to provide a useful and relevant package of summarized evidence to clinicians and clients in a form that suits the time, cost, and care standard. Based on this package of evidence, recommendations are made as clinical practice guidelines and may represent clinical pathway, protocols, and algorithms. Star Point 4 (Practice Integrations): This step involves changing both individual and organizational practices through formal and informal channels. Star Point 5 (Process, Outcome Evaluation): This is the final stage in knowledge translation where the impact of the EBP project on patient health outcomes, provider and patient satisfaction, efficacy, efficiency, economic analysis, and health status impact is evaluated (Stevens, 2012). The Star Model provides a systematic framework for the initiation of a PHTTP for an EBP change based on the best available evidence.

Systematic Search for Evidence Process and Results

A systematic search was conducted using three primary electronic databases: 1) the Cumulative Index to Nursing and Allied Health (CINAHL), 2) the Cochrane Database of Systematic Reviews (CDSR) and 3) PubMed. Three major searches were conducted in the CINAHL database: keyword, title, and subject heading. Two major searches were conducted in the Cochrane Database: combination (title/abstract/keyword) and keyword. Five major searches were performed in PubMed: MeSH terms, MeSH major topics, MeSH title title/abstract, and title (see Appendix C).

The search across all databases was performed with terms from the PICOT question and their major synonyms, acronyms, coined phrases, and brand names. These terms include the following: acute coronary syndromes, ACS, non-ST segment elevation

myocardial infarction, NSTEMI, non-ST segment elevation acute coronary syndrome, NSTE-ACS, troponin, high sensitivity troponin, point of care troponin, prehospital troponin, early invasive strategies, and EIS. The only limitations implemented in the searches were English and humans. Appendix C demonstrates the systematic search through all three databases using the terms previously listed from the PICOT question.

Articles containing any of the following variables were deemed eligible for review related to the PICOT question: prehospital troponin testing, POC troponin testing, diagnostic windows for ACS diagnosis, NSTE-ACS morbidity and mortality, early EIS for ACS, accelerated diagnostic protocols for diagnosis of ACS, cardiac biomarkers for diagnosis of ACS, PCI strategies for ACS, treatment of hospitalized patients diagnosed with ACS, effectiveness of thrombolytics and percutaneous coronary intervention in ACS, MACE scoring of ACS patients, reliability of prehospital POC systems, and diagnostic delays in ACS patients. Articles were excluded if they contained the following variables: less than eighteen years of age, chest pain of non-cardiac origin, symptoms greater than 12 hours from onset, AMI without mention of NSTE-ACS, ACS without specific mention of NSTE-ACS, diagnostic pathways exceeding two hours, diagnosis without mention of troponin, prehospital transport via aeromedical services, in-patient management without mention of emergency department treatment, and articles without mention of outcomes related to ACS patients.

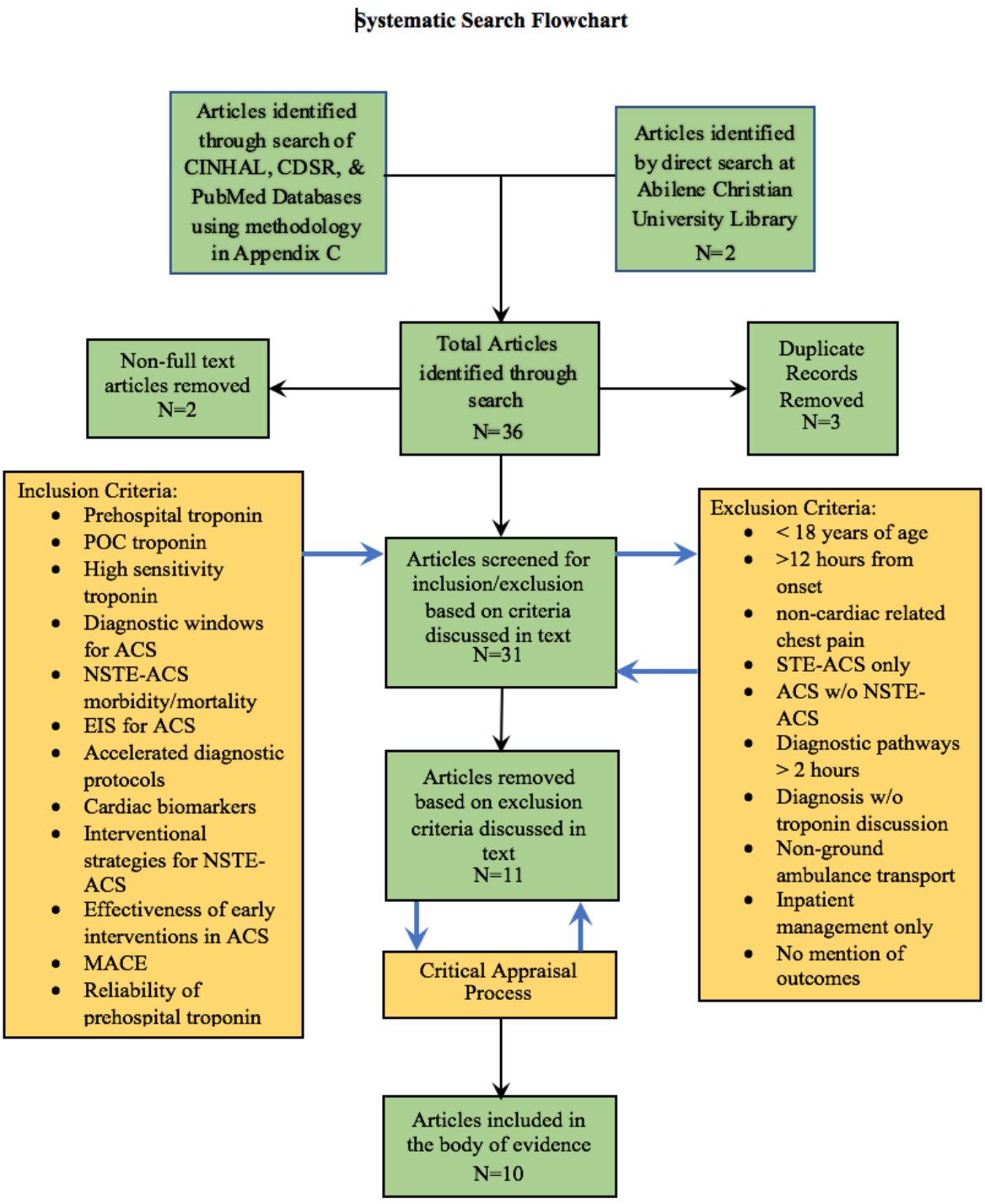

Figure 1. Systematic Search Results Flowchart

Conclusion

NSTE-ACS events represent a significant public health burden to not only the patients but also the health care systems that they access to seek care. NSTE-ACS events, despite advances in diagnostic pathways and interventional strategies, continue to have high morbidity and mortality rate than STE-ACS events. EMS are often the first medical providers who contact chest pain patients and represent an untapped resource to make improvements in patient outcomes using new technologies. These medical providers in the early assessment of cardiac biomarkers are an underutilized system to improve the outcomes of patients and the overall health care system.

Chapter 2

Critical Appraisal of the Evidence, Model, and Plan

Appraisal of Evidence

The scholarly articles obtained from the systematic search discussed in Chapter One were evaluated using the critical appraisal process to identify the strengths and weaknesses to assess the usefulness and validity of the research findings. Initially, a General Appraisal Overview (GAO) was completed, followed by a Rapid Critical Appraisal (RCA) to assess validity, reliability, and applicability. One article was excluded after completing the critical appraisal process as the study was incomplete and therefore the validity of proposed outcomes could not be validated, thus impairing its reliability and applicability to this project. The remaining 10 articles were determined to have conclusions adequately supported by the data presented and data evaluated had validity, reliability, and applicability to this project.

There were no ethical concerns resulting in the exclusion of any additional studies. All studies demonstrated (where applicable) that 1) Respect for Autonomy—participants freely participated of independent choice without evidence of coercion and informed consent was obtained from all participants, 2) Non-maleficence—there was no harm or the least possible harm to reach a beneficial outcome, 3) Beneficence—interventions are to benefit individuals outcomes, 4) Justice—fair selection of study participants without bias, 5) Equipoise—genuine uncertainty when assigning patients to treatment arms, 6) bias free trial in case of industry funded research, and 7) appropriate

Institutional Review Board (IRB) approval was acquired or waived as required.

Further, 36 articles were identified from the search of CINAHL, CDSR, and PubMed and the Abilene Christian University Library in Abilene, Texas that initially met criteria of the PICOT question. Additionally, two non-full text and three duplicate records were removed, yielding 31 articles for review using inclusion and exclusion criteria as previously discussed. After applying the inclusion/exclusion criteria, 20 articles were excluded. One article was removed article during the critical appraisal process as the study was incomplete at the time of publication and therefore reliable outcome data was not present. Therefore, the final yield was 10 articles included in the body of evidence (36 – 2 – 3 – 20 – 1 = 10).

Evaluation of the Body of Evidence

Ten studies were used to provide the body of evidence to address the components of the PICOT question. These studies supported the assertion that the implementation of a high-sensitivity troponin testing protocol can reduce the time to final diagnosis of NSTE-ACS, concomitantly reduce the time to EIS and therefore reduce the incidence of MACE and improve outcomes of patients with chest pain encountered in out-of-hospital setting. The following components of the PICOT question will be validated with the evidence compiled: 1) POC cTnI is the assay of choice for this implementation, 2) the appropriate diagnostic window is 90 minutes to two hours, 3) utilization of prehospital POC cTnI is accurate and reliable, and 4) reduction in the time from first medical contact to diagnosis of NSTE-ACS in patients with chest pain reduces the duration of the utilization of EIS, and 5) the utilization of EIS earlier in the diagnostic pathway of NSTE-ACS patients reduces MACE and improves patient outcomes.

The Study Methodology Synthesis Table in Appendix D demonstrates that cTnI is the assay of choice to utilize in the project implementation. Studies of Vasile (2009) and Sherwood (2014) demonstrated that cTnI assays permits the detection of lower concentrations of cTnI earlier than cTnT as cTnI begins to rise within three to four hours after the onset of myocardial injury. The 12 studies listed in the Study Methodology Synthesis Table in Appendix E demonstrated that the use of prehospital POC cTnI is a statistically reliable assay method to use on patients with chest pain. The 90 minute to two hour diagnostic testing window was an effective interval to make accurate diagnostic decisions regarding patients with chest pain. Therefore, the included studies support the assertion that the use of prehospital POC cTnI is a reliable methodology to diagnose NSTE-ACS in patients encountered outside the hospital ED.

The Outcome Synthesis Table in Appendix F demonstrates the evidence reviewed supports the PICOT question assertion that reducing the time to diagnosis of NSTE-ACS improves patient outcomes. The studies included demonstrate that a prehospital POC cTnI protocol can reduce the time to diagnosis of NSTE-ACS in patients with chest pain encountered outside the ED setting by reducing the time from first medical contact (FMC) to first troponin (T1). Ezekowitz (2015) demonstrated that prehospital POC-Troponin testing decreased the time from FMC to final disposition in the ED by 0.29 hours. Therefore, evidence suggests that the initiation of a prehospital POC cTnI testing protocol will reduce the duration of diagnosis of NSTE-ACS in patients with chest pain suspected of NSTE-ACS.

The Outcome Synthesis Table in Appendix F additionally demonstrates that as the time from FMC to T1 is decreased, the remainder of the time variables are concomitantly

reduced. The evidence demonstrates that if FMC to T1 is reduced then T1 to T2 is reduced, T2 to diagnosis is reduced, diagnosis to EIS is reduced. As the time from FMC to EIS is reduced, the evidence demonstrates that MACE is reduced. Therefore, the evidence demonstrates that prehospital POC cTnI testing reduces time from FMC to diagnosis and EIS.

Synthesis and Recommendation Based of the Body of Evidence

Institute a pre-hospital POC cTnI testing EPIP using an accelerated diagnostic protocol to reduce to LOS of chest pain patients that present to the ED via EMS with complaints of chest pain of suspected NSTE-ACS. The evidence demonstrated that prehospital POC troponin testing is a valid and reliable method which has been successful in reducing the time to disposition in a large urban emergency department. This reduction in disposition time can reduce ED LOS, improve ED workflow and reduce ED overcrowding, and reduce the morbidity and mortality rate of NSTE-ACS occurrences longitudinally.

Proposed Evidence-based Implementation Project and Operationalization

The Theory of Planned Change will be used as a conceptual framework to guide the evidence-based practice (EBP) change to initiate prehospital troponin testing with the goal of reducing the morbidity and mortality of chest pain patient, suspected of NSTE-ACS, encountered outside the hospital and time to final disposition (see Appendix G). Lippitt, Watson, and Westley's (1958) theory of Planned Change is a seven-step framework focusing on the role of the change agent throughout the evolution of a change. Lippitt's Change Theory (1958) is based on the introduction of an external change agent designing a program to effect change. This theory focuses on the role and responsibility

of the change agent where there is a continuous exchange of information throughout the process. The seven-steps are as follows: 1) Diagnose the problem, 2) Assess the motivation and capacity for change, 3) Assess the resources and motivation of the change agent, 4) Choose progressive change objects, 5) Select and clearly understand the role of the change agents for clear expectations, 6) Maintain the change, and 7) Gradually terminate from the helping relationship. The seven steps of this theoretical framework will be utilized in conducting an EBP change project regarding the NSTE-ACS all-cause mortality. Planned change theory in nursing is an important process ensuring the best practices are utilized to meet the advancing needs of the health care system and the patients it serves. Planned change is a purposeful, calculated, and collaborative effort led by a change agent to effect a positive change within a specific system (Roussel, 2006).

Application of the seven-steps of the TCP: 1) Problem: High > 30 day post NSTE-ACS mortality (see Appendix G)/ED overcrowding, 2) Assess Motivation: Are the EMS systems and ED willing to make a change? Are the EMS and ED systems willing to collaborate with each other? Is the return on investment substantial enough to justify the initial cost? Is the ED system willing to accept a troponin value obtained outside of the ED? Is the cardiology service or hospitalist service willing to accept a patient with a diagnosis of NSTE-ACS with an out-of-hospital troponin? 3) Change Agent and Motivation: Doctorate of Nursing Practice (DNP)-prepared nurse with emergency medical experience in both prehospital and ED setting with the best evidence to demonstrate that by reducing the time from T1 to T2, through the use of a prehospital troponin protocol, that patient outcomes will be improved, 4) Select Progressive Change Objects: Initiate prehospital troponin testing protocol that will systematically reduce the

variables in NSTE-ACS patients (see Appendix G), 5) Choose a Change Agent Role: DNP collaborative relationship with inter and intra-professional components, 6) Maintain Change: Assess data (variables listed in Appendix G), re-evaluate (are times decreasing as expected?) and adapt (if times are not decreasing why are they not and what intervention needs to be made to improve?), and sustain change (if times are decreasing and therefore patient outcomes are improving then distribute data to stakeholders for sustainability), and 7) Termination of Helping Relationship: DNP completes change and searches for new problems (see Appendix G).

The PHTTP will initiate and evaluate the effectiveness of a prehospital, POC troponin testing protocol. This project aims to reduce the burden of greater than thirty-day MACE of patients diagnosed with NSTE-ACS. Based on the evidence, the time to final disposition of chest pain patients encountered outside the hospital is expected to be reduced by at least 0.29 hours. In addition, the initiation of EIS earlier is expected to reduce the MACE in NSTE-ACS patients (see Appendix F). These results will be evaluated to determine if this project was as effective as hypothesized in the literature.

Conclusion

Based on the synthesis of the best available evidence the implementation of a prehospital POC cTnI protocol will reduce the time from FMC to disposition of patients with suspected NSTE-ACS. This reduction in diagnostic time will allow for initiation of EIS earlier in the treatment pathway of NSTE-ACS patient and improve outcomes by reducing the incidence of MACE as previously discussed. Based on this synthesis of the evidence, a prehospital cTnI testing protocol will be designed and a plan for implementation, evaluation, and sustainability outlined in the following chapters.

Chapter 3

Project Design and Methodology

This chapter discusses the implementation of the Prehospital Testing Protocol as guided by the ACE Star Model of Knowledge Transformation. The Star Model is a simple, parsimonious depiction of the relationships between various stages of knowledge transformation and places nursing's previous scientific work within the context of EBP, serves as an organizer for examining and applying EBP, and mainstreams nursing into the formal network of EBP (Stevens, 2012). This model was adapted and operationalized for the purposes of this implementation project. Star Point 1 and 2 were covered in Chapter 1 and 2 and Star Points 3–5 will be covered in this chapter. See Figure 2 on the following page.

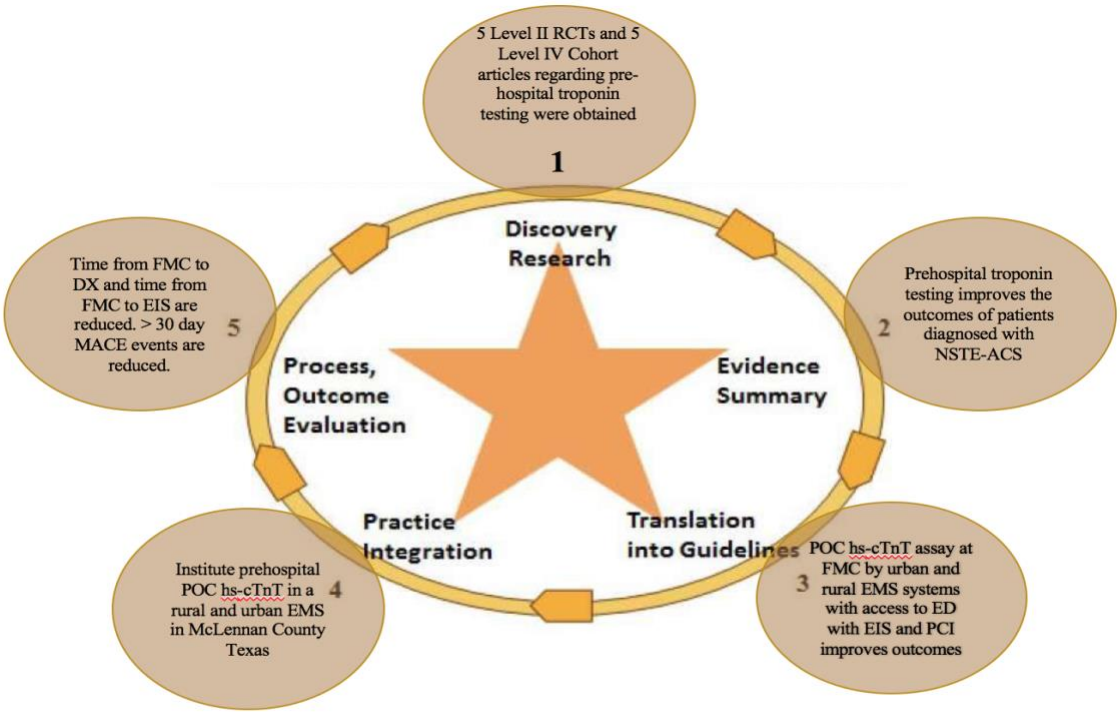

Figure 2. ACE Star Model of the Cycle Knowledge Transformation. Adapted from "ACE Star Model of EBP: Knowledge transformation," by K. R. Stevens, 2004, Academic Center for Evidence-based Practice, 2004 The University of Texas Health Science Center at San Antonio

Project Design and Methodology Overview

The project protocol will be applied to all patients encountered in the prehospital setting with chest pain, suggestive of an NSTE-ACS. Each patient will have a serum troponin level obtained and tested utilizing a POC platform according to the evidence discussed in Chapter One. T1 will be obtained by prehospital personnel expeditiously after FMC along with standard interventional therapies of the EMS system utilized in the protocol implementation. The results of this initial POC test will be provided to the receiving ED and incorporated into the patients ongoing treatment plan in an accelerated diagnostic protocol. This accelerated diagnostic protocol will include a T2 value obtained 90 minutes to two hours after T1 and a final disposition made based on the

comparison of the T1 and T2 values. Disposition includes: discharge from the ED, admission to the hospital, admission to interventional services, or transfer to higher level of care, if necessary services are not available at the receiving facility.

The population of interest for this project are patients above 18 years, who call EMS with complaints of chest pain of potential NSTE-ACS origin. Non-cardiac sources of chest pain include post traumatic chest pain, respiratory chest pain, chest pain of infective origin, and chest pain of gastrointestinal origin. This will include patients of all genders, races, and cultural backgrounds.

Fully Operationalized Project

The following diagram in Figure 3 (pages 26 & 27) represents an overview of the PHTTP Implementation Plan based on the Prehospital Troponin Logic Model (Appendix H). The specific details of the plan will be outlined following the figure.

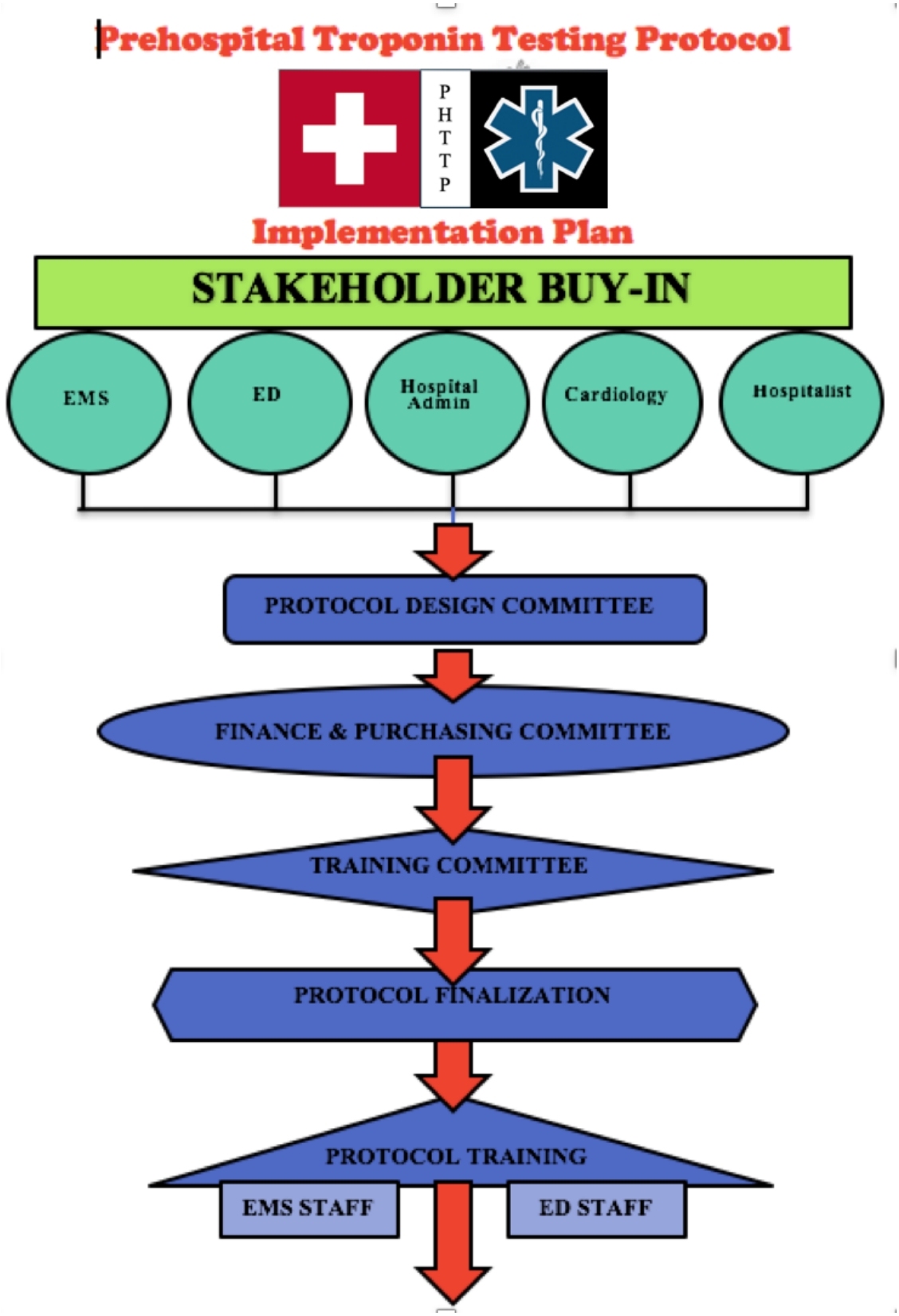

Figure 3. Prehospital Troponin Testing Protocol

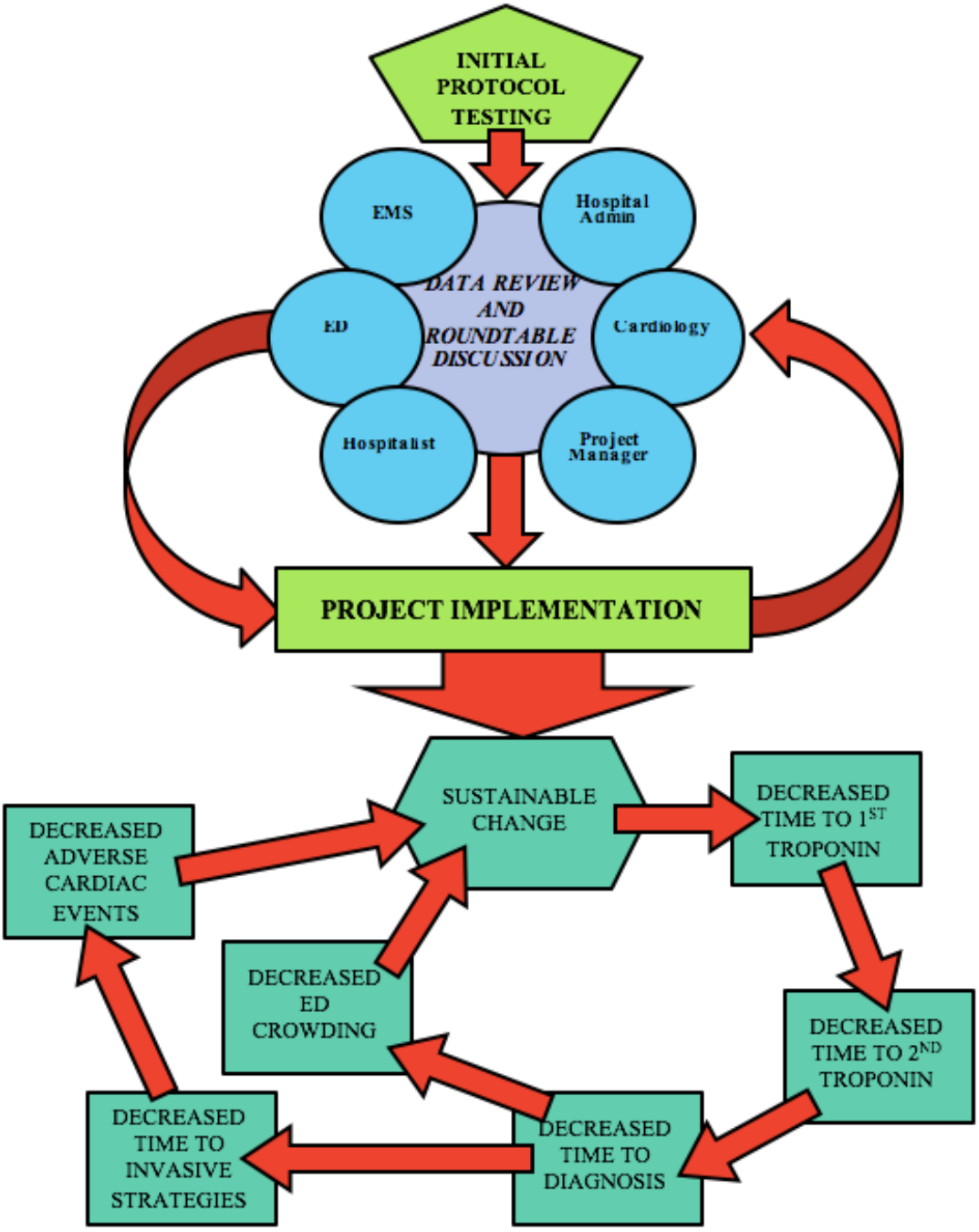

Figure 4. Prehospital Troponin Testing Protocol (Continued)

Detailed Implementation Plan

Ethical considerations.

- Ethics of the conducted research —all the studies incorporated in the body of evidence on which the implementation plan is based on met the requirements of the ethical research:
    - Scientific value—provided scientific benefit
    - Scientific validity—followed methodological rigor
    - Fair subject selection—ensured appropriate randomization
    - Favorable risk-benefit ratio—evaluates outcomes worth risks
    - Independent review—ensures no conflicts of interest
    - Respect for potential and enrolled subjects—adherence to the Declaration of Helinski
    - Informed consent—allowing voluntary informed consent to participate

Ethics of translating the body of evidence into practice.

- Only the studies that were deemed ethically sound were included in the body of evidence
- The evidence was translated directly into the practice protocol without modification
- The following questions were addressed in the evidence translation process to ensure ethical decisions were made:
    - What is the question you want to answer?
    - What are your existing thoughts and feelings about that topic?

- How might these thoughts affect your choices about evidence?
- What can you do to make those choices open and defensible?

Ethics of project planning.

- Patient confidentiality and safety are of utmost importance
- All planning was done with the best interest of the patient in mind and the ways in which the project will improve patient outcomes
- Financial benefit is considered, but it is not the highest end goal of implementing this project.
- Protection of the interests of all stakeholders.

Ethics of implementation of evidence (or not) and use of patient data.

- No evidence was included in the implementation plan that was previously not deemed ethical.
- The integrity of protected health information was maintained.
- All steps in the implementation process are based on ethical decision-making and the concepts of beneficence and non-beneficence.

Ethics of dissemination of the evidence (or not).

- Evidence will be presented objectively with no alterations to potentially skew the results into a more favorable direction.
- Personal opinions will be withheld from the dissemination of evidence.
- Patient information will be protected.

Ethics of sustainability.

- Does the project fulfill its initial goals?
- What benefits or harms are brought about by sustaining the project?

- Does the project support the system or context which makes it possible and meaningful?
- Does the project have the potential to consume all resources prior to deriving benefit?

Ethics of DNP role delivery.

- Always advocate for the best interests of the patient, their colleagues and the system as a whole
- Strengthen practice environments by improving practice processes based on the best evidence
- Strike a balance between personal and professional values in the implementation of practices
- Ensure that all human rights are protected and that the concept of justice is always foremost
- Employ strategies to maintain the highest ethical standards

Select project implementation setting.

- Geographical setting with both rural and urban EMS systems and a regional medical center with interventional cardiology services or transfer access to a tertiary center or an EMS system that services both rural and urban population
    - An urban EMS is a system that operates within the confines of a city or town with a more concentrated population per square mile
    - A rural EMS is a system operates outside of the confines of a city or town with a less concentrated population per square mile.

        - The purpose of utilizing both an urban and a rural EMS system is based on the average difference in transport times
    - A tertiary center with interventional cardiology services is one that has a continuously available cardiac catherization suite with an interventional cardiologist continuously on call.

Process indicators/Outcomes measures.

- Reduction in time from FMC to T1
- Reduction in facility LOS
- No significant increase in EMS scene times

Anticipated barriers.

- Collaboration between EMS and ED staff and medical directors – This barrier was addressed through collaborative training and round table meetings.
- ED physicians, CV Physicians, and Hospitalists unwilling to use a prehospital troponin value – data on the reliability of prehospital troponin testing was provided to all ED physician and APP staff
- Administration of either EMS system unwilling to participate in protocol due to initial equipment costs and training expenses – there was no cost to the EMS system as all cost was assumed by the project manager.
- Emergency Department unwilling to participate in project – after an extensive search a willing ED Medical Director and ED manager were found and provided extensive literature from the EPIP body of evidence.

Stakeholder Recruitment and Buy-in.

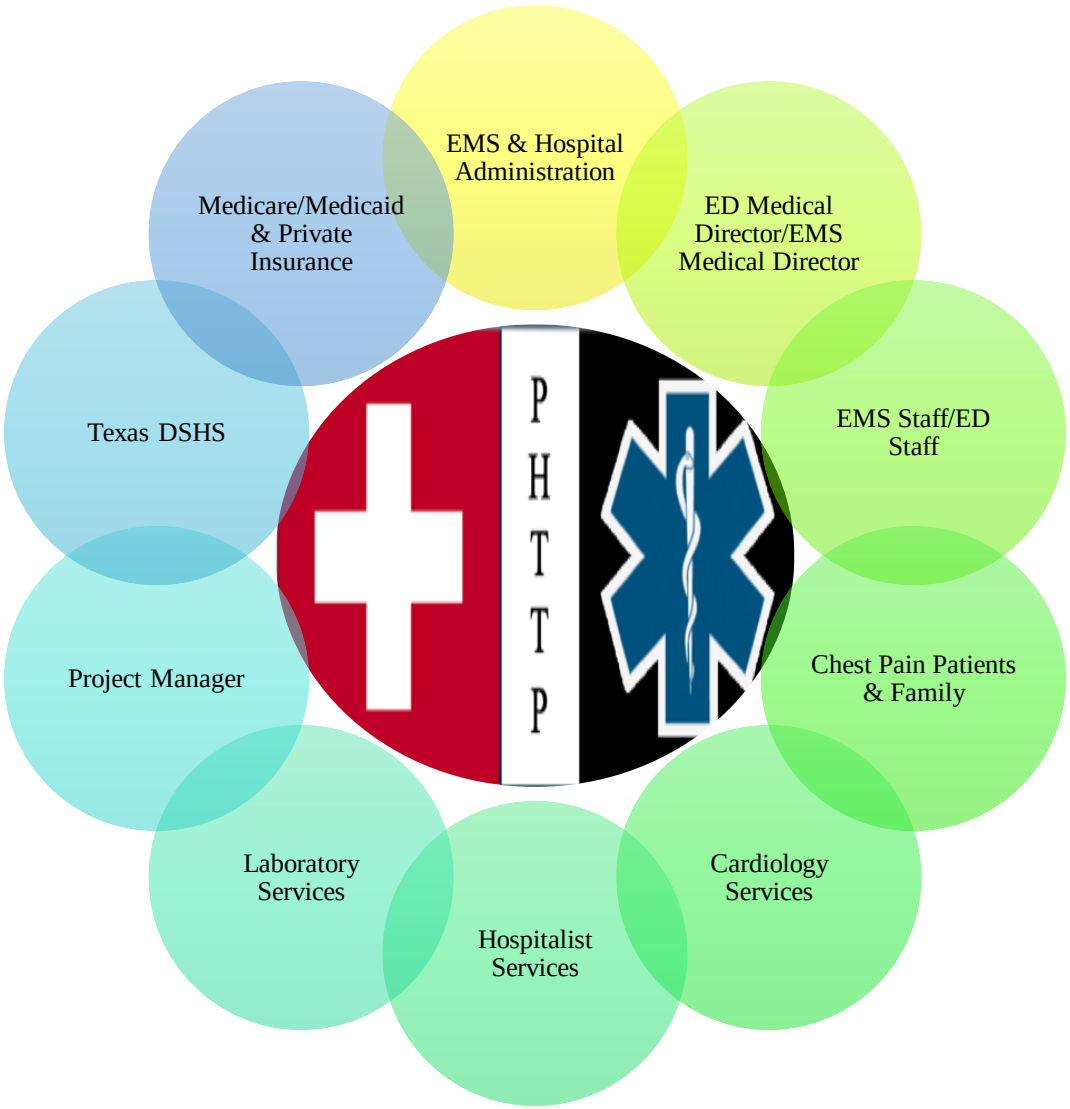

Figure 5. Prehospital Troponin Project Stakeholder Interaction

- Organizational Recruitment, Buy-in, and Approval to participate
- Texas Department of State Health Services EMS & Trauma Bureau
- Plainview Fire-EMS
- Covenant Plainview Hospital Administration

Establishment organizational structure.

- Lead by Project Implementation Manager (DNP-trained Nurse Scholar)
- Includes all components from both EMS systems and receiving hospital systems
    - Administrators
    - Medical Directors
    - Units
    - Personnel

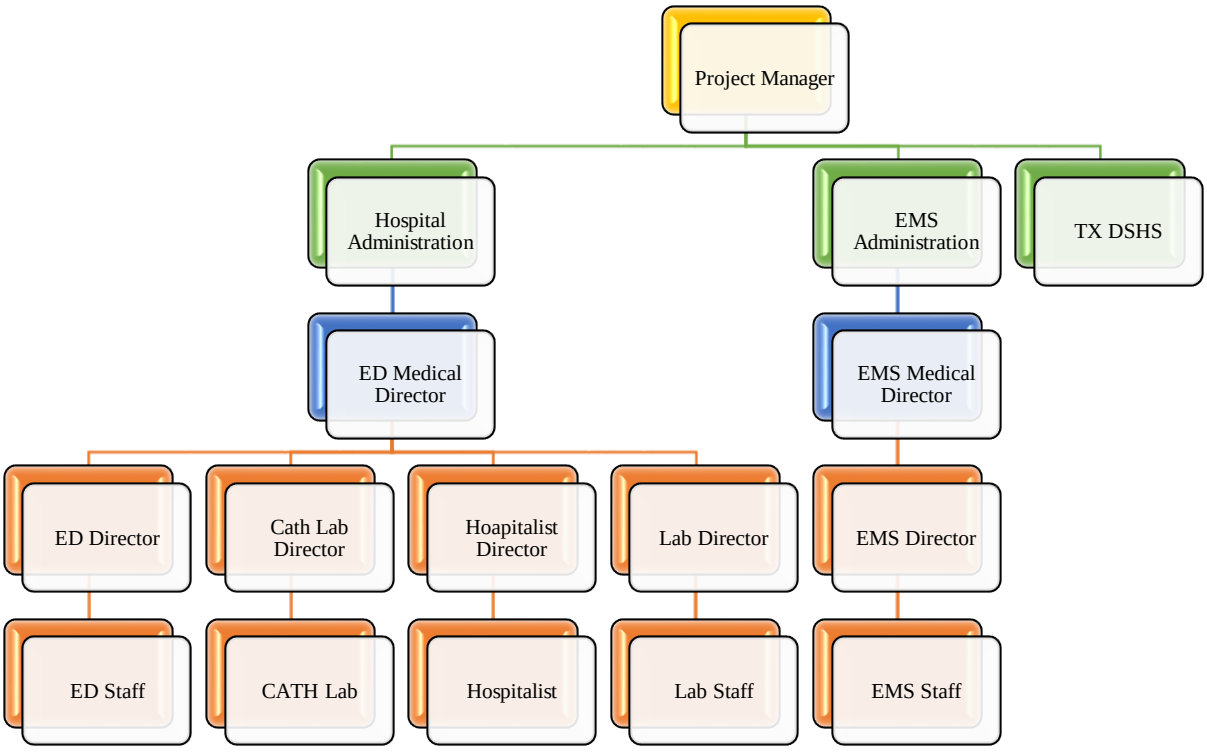

Figure 6. Prehospital Troponin Project Organizational Chart

Establishment of committee structure.

- Protocol Design Committee (PDC) creates a consensus protocol to utilize in the implementation of prehospital troponin testing
- Finance & Purchasing Committee (FPC) explores options for the most cost effective attainment of the selected POC assay platform either through grant, direct purchase, or rental and then make necessary arrangements to acquire the platform
- Training Committee (TC) develops training protocols, training materials, select sites for training sessions, creating a training calendar, and table top and simulation trials on the selected and acquired POC platform
- Implementation and Review Committee determines baseline data, selects exact implementation criteria, oversees implementation, and engages in process marker monitoring, data review, and protocol adjustment as needed based on the process markers.

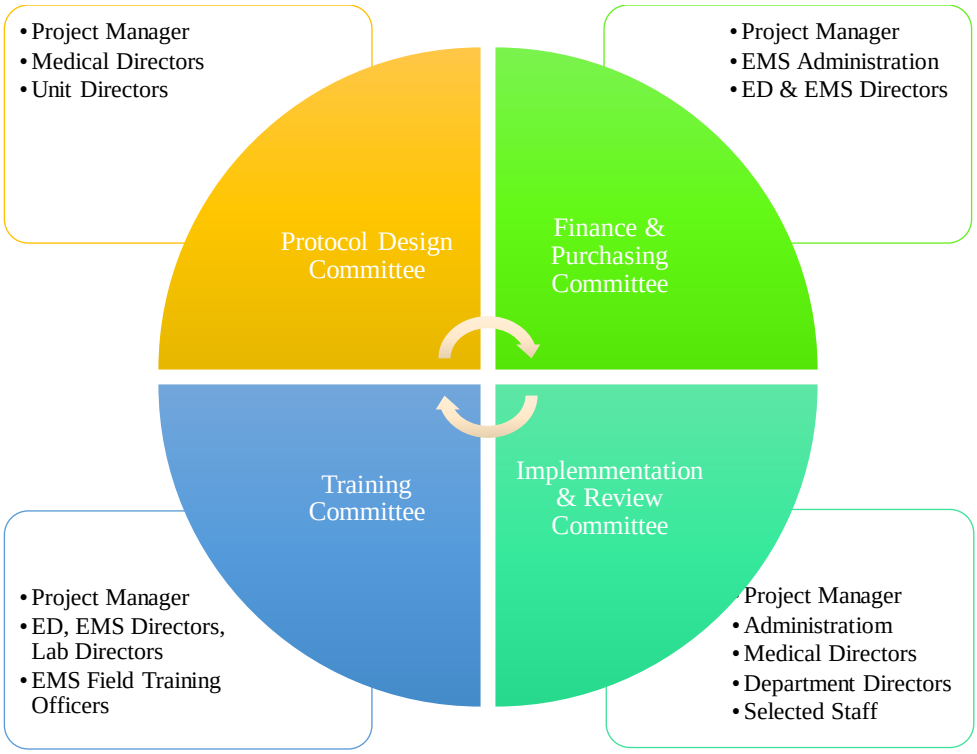

Figure 7. Prehospital Troponin Project Committee Structural Organization

- PDC finalizes proposed protocol call design based on assumptions from synthesis of evidence discussed in Chapter 2:
- Troponin I is the biomarker of choice in the diagnosis of NSTE-ACS
- Accelerated diagnostic pathways, utilizing high-sensitivity troponin testing can reduce the time to diagnosis of NSTE-ACS
- The use of prehospital troponin testing in combination with an accelerated diagnostic protocol can further reduce diagnostic time by as much as 0.29 hours in the urban setting according Ezekowitz (2015) and potentially higher in the rural setting
- POC troponin testing in moving ambulances is not statistically different from POC troponin

Establishment of protocol and training structure

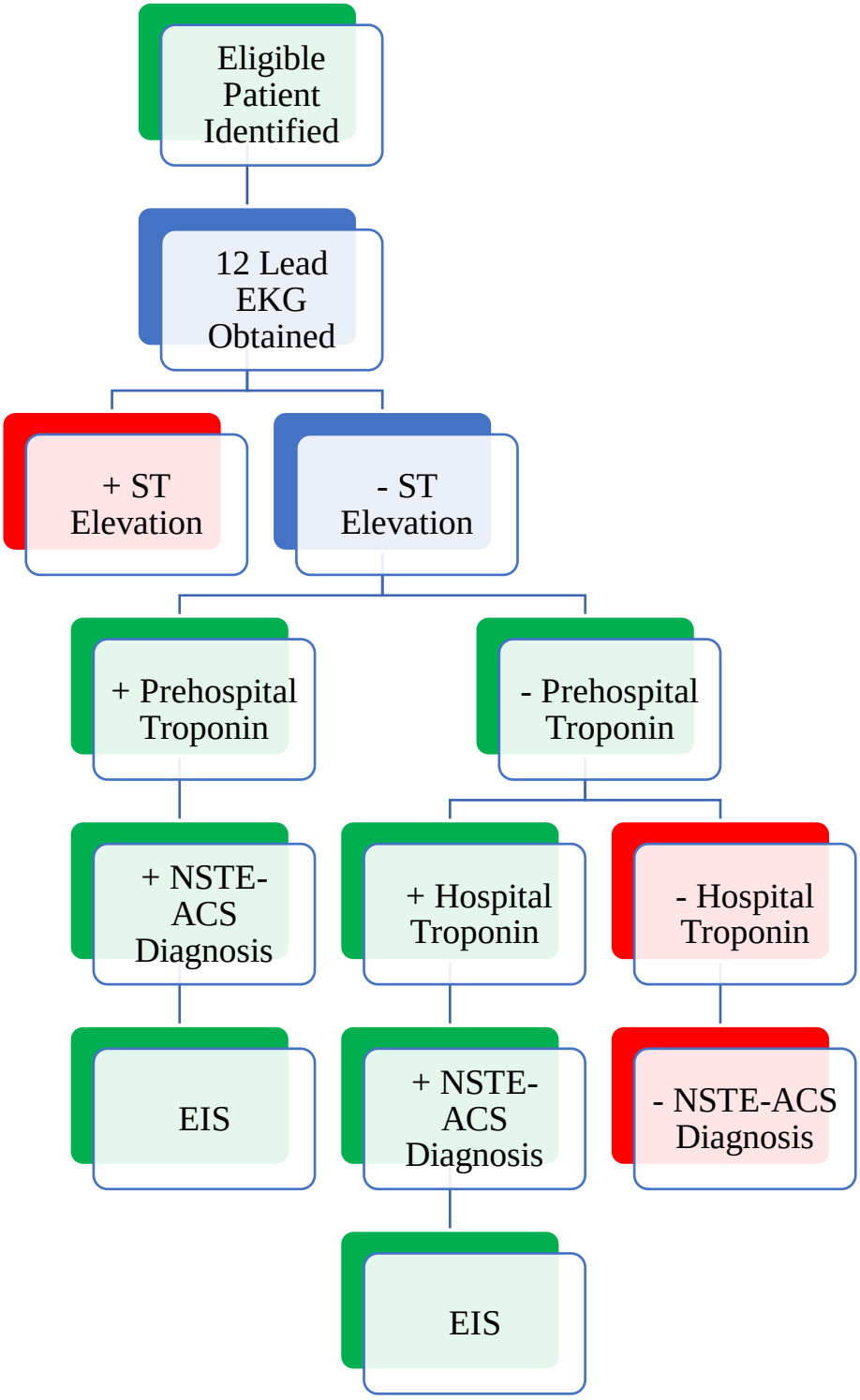

Figure 8. Prehospital Troponin Testing Protocol

- FPC meets, evaluates, selects, and obtains a POC cTnI assay platform
- TC meets and finalizes training protocol based on equipment obtained

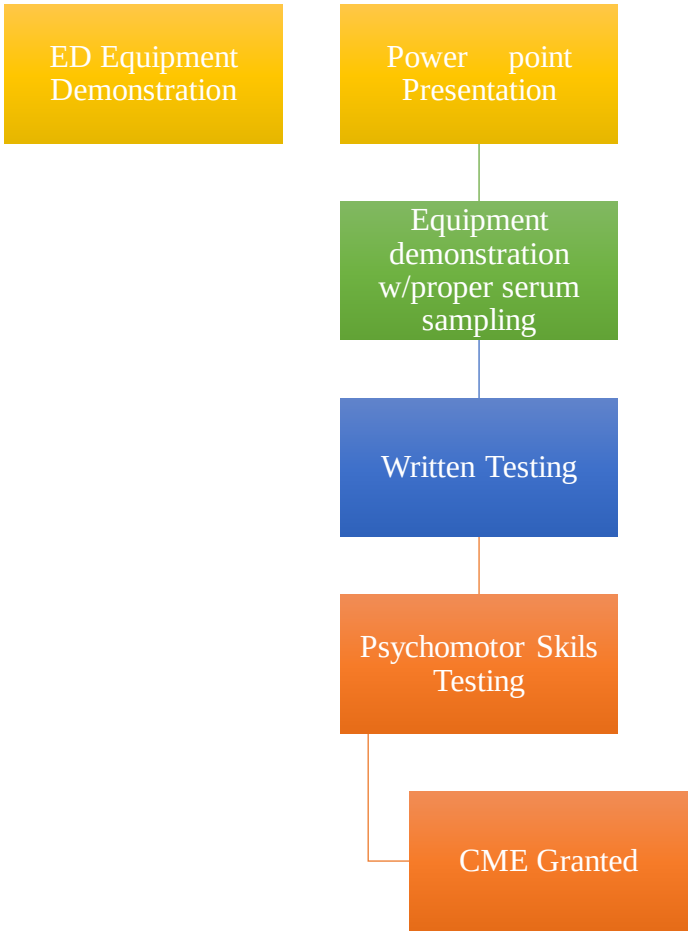

Figure 9 Prehospital Troponin Testing POC Training protocol

Training of EMS personnel.

- EMS Medical Director
- EMS Supervisors
- EMS Field Training Officer
- EMS Field Personnel
- Protocol Compliance Officer

- Exact training details will be determined by the exact POC testing platform selected and serum sampling will be based on existing EMS protocols.

Dissemination of project implementation progress to stakeholders.

- Final Approved Protocol
- POC Testing Platform
- Training Plans
- Request for feedback

PDC & TC review feedback from stakeholders.

- Testing Protocol
- POC Testing Platform
- Training Protocol
- Appropriate adjustments made

Tabletop simulations of POC platform with EMS personnel.

- TC members perform 10 tests on POC platform with same samples tested by receiving ED for validation

Field simulations performed in ambulances.

- TC members perform 10 tests on POC platform in moving ambulance simulation with same samples tested by receiving ED for validation

Dissemination of simulation results to stakeholders from simulations.

- Review Prehospital Troponin Testing Protocol
- Review training records
- Review simulation results

- Implementation plan developed
- Implementation date determined

Table 1. Prehospital Troponin Testing Protocol

PREHOSPITAL TROPONIN TESTING PROTOCOL (PTTP)	**EVIDENCE**
STEP 1: Eligible Patient Selected (Patient Population) who is > 18 years of age with chest pain of suspected cardiac origin with onset of symptoms < 12 hours.	Amsterdam (2014) – Guidelines of ACC/AHA for Management for NSTE-ACS: ○ Risk for NSTE-ACS ↑ > 18 y/o ○ Other causes of non-NSTE-ACS chest pain: trauma, neurological, respiratory, gastrointestinal, genitourinary ○ Symptoms > 12 hours from onset make troponin assays unreliable Roffi (2015) - chest discomfort is leading symptom that initiates the diagnostic and therapeutic cascade in patients with suspected ACS and chest discomfort patients frequently utilize emergency medical services (EMS) for transport to the ED
STEP 2: Initial 12 Lead EKG Obtained and send to receiving ED. If ST segment elevation is present STOP PTTP and proceed with STE-ACS Management	Amsterdam (2014) – Guidelines of ACC/AHA for Management for NSTE-ACS: ○ Obtained as soon as possible after onset of symptoms ○ ST elevation indicates STE-ACS – alert ED & PCI Services. Medications according to Level II guidelines.
STEP 3: First troponin obtained via POC cTnI troponin testing platform. If troponin is + NSTE-ACS Diagnosis – alert ED for EIS initiation	Amsterdam (2014) – Guidelines of ACC/AHA for Management of NSTE-ACS: ○ Obtain first troponin as soon as possible after onset of symptoms Appendix D – Study Methodology Synthesis Table Borna (2016) they demonstrated that cTnI testing was a superior biomarker to diagnose NSTE-ACS

Table 1. *Prehospital Troponin Testing Protocol*

	Ezokowitz (2015) use of prehospital troponin testing reduces the time to diagnosis and intervention Morrow (2001) demonstrated patients with clinically documented NSTE-ACS derive a large clinical benefit from the utilization of an EIS Sorenson (2011) indicated implementation of quantitative prehospital troponin testing by paramedics is feasible and effective Venturini, 2013 - utilization of prehospital personnel to use POC devices to measure cTnI levels during transport of patients to the ED may result in earlier diagnosis of NSTE-ACS
STEP 4: Patient transport to receiving ED and second troponin is obtained in 90 minutes to 2 hours	Amsterdam (2014) – Guidelines of ACC/AHA for Management for NSTE-ACS - Diagnostic pathway for NSTE-ACS should be less than 2 hours from FMC Khera (2014) - consistent benefit in the utilization of EIS in the setting of NSTE-ACS especially in the setting of high-risk populations Layfield (2014) - serial cTnI sampling with one sample at presentation and at least one additional sample collected two hours later was necessary to identify a rise or fall in the troponin level Wallentin (2016) - early EIS postponed the occurrence of death or next acute coronary event by an average of eighteen months, and readmission to the hospital for ischemic heart disease by thirty-seven months, compared with a non-invasive strategy in patients with NSTE-ACS

Feedback results from stakeholders reviewed.

- Necessary revisions made based on feedback

Data collection.

- Time of First Medical Contact (FMC)
- Time of First Troponin (T1)
- Time of second troponin (T2)
- Time of Disposition
- FMC to T1
- FMC to Disposition (LOS)

Baseline ED and EMS data to be obtained.

- ED Electronic Medical Records (EMR)
- EMS EMR/Written records and Computer-aided Dispatch (CAD) records

Table 2. Project Implementation Timeline with Process Markers

WHEN:	
January 15, 2019	**WHAT**: Secure buy-in and willingness to participate in project implementation from key stakeholders. Refer to stakeholder diagram for key stakeholders. **WHO**: Project Implementation Manager **WHERE**: Plainview, Texas **HOW**: Presentation of EPIP slideshow and distribution of key point pamphlets. Obtain appropriate contact information and schedule subsequent meetings either in person, via Zoom or WebEx, or email.
January 21, 2019	**WHAT:** Revisit stakeholders and obtain necessary agreements to participate. **WHO:** Project Implementation Manager from Texas DSHS, EMS administration, and ED administration. These include the EMS Medical Director, Fire Chief, ED Medical Director and ED Director. Select committee members for each of the four committees. **WHERE:** Plainview, Texas

Table 2. Project Implementation Timeline with Process Markers (Continued)

	HOW: In person, via Zoom, WebEx, or email
January 28, 2019	**WHAT:** Finalization of protocol design **WHO:** Project protocol design committee and PIM. **WHERE:** Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email
February 1, 2019	**WHAT:** Disseminate results from both Protocol Design Committee and Finance Committee to all stakeholders and elicit feedback. Compile feedback for next round of committee meetings. **WHO:** PIM **WHERE:** Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email
February 5, 2019	**WHAT:** Finalizes protocol with consideration of equipment selected by Finance Committee and distributes final protocol to direct stakeholders and requests feedback. **WHO:** Protocol Design Committee and PIM **WHERE:** Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email
February 12, 2019	**WHAT:** Make final decision regarding equipment, financial acquisition plan is made based on financial resources selected (grant, rent, or purchase). The i-STAT POC platform offers a rental option in addition to a purchase option. **WHO:** Finance Committee & PIM **WHERE:** Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email
February 15, 2019	**WHAT:** Design training program in coordination with manufacturer guidelines. Training materials are created and finalized. The training program will include serum sample acquisition, POC platform usage, POC cartridge handling and storage, and serum sample handling. **WHO:** Training Committee and PIM **WHERE:** Plainview, Texas

Table 2. Project Implementation Timeline with Process Markers (Continued)

	HOW: In person, via Zoom, WebEx, or email
February 21, 2019	**WHAT;** Equipment orientation and training begins with EMS staff and demonstration to ED staff. This training will include testing on actual POC platform and will include skills testing and CEU hours for EMS staff. **WHO:** PIM, Training Committee, EMS Training Officers. PIM coordinates with EMS Director and EMS training staff and ED Director. **WHERE:** At preselected and secured sites in the local area. **HOW:** In person with psychomotor skills lab. Recorded for internet distribution to staff that could not attend.
February 22, 2019	**WHAT:** Equipment training is completed and table top testing initiated. Table top testing is testing with POC platform quantitative testing solutions in simulated EMS scenarios. Table top results will be disseminated to stakeholders and feedback requested. **WHO:** PIM, Training Committee, Implementation & Review Committee, EMS Medical Director, and EMS Training Staff. **WHERE:** Plainview, Texas **HOW:** In person in the local area.
February 23, 2019	**WHAT:** Mach patient testing in EMS vehicle patient simulations with comparison to ED values on same serum samples. Serum samples will be testing in a moving ambulance and the same sample will then be testing in the ED setting to validate the accuracy of prehospital troponin testing. These results will be disseminated to all stakeholders and feedback requested. **WHO:** PIM, Training Committee, EMS Training Staff, Equipment Committee, Medical Directors, Laboratory staff, ED & EMS Directors. **WHERE:** Ambulances from the local EMS selected for the project

Table 2. Project Implementation Timeline with Process Markers (Continued)

	implementation. Receiving ED utilized for project. **HOW:** In person
February 25, 2019	**WHAT:** Protocol reviewed and finalized for implementation. Revisit with direct and indirect stakeholders and provide status reports and request feedback. All testing results and feedback review and any suggested changes implemented and final protocol disseminated to stakeholders and final approval obtained. **WHO:** PIM, Protocol Design Committee, Training Committee, Implementation & Review Committee, Interested stakeholders, Medical Directors, Administrators and Industry Mentor. **WHERE:** Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email
February 28, 2019	**WHAT:** Full scale protocol initiation. **WHO:** An expert group consisting of PIM, Implementation & Review Committee, Training Committee, EMS Medical Director, ED Medical Director, Project Manager, EMS Director and ED Director. **WHERE:** EMS ambulances and ED. **HOW:** In person
March 5, 2019	**WHAT:** Process markers evaluated. First data set compiled and reviewed. Stakeholders notified of results and feedback requested. Review the process markers and make adjustments as necessary. **WHO:** PIM and all interested parties. **WHERE:** Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email
March 10, 2019	**WHAT:** Second data set compiled and evaluated. Data charts updated and variances identified and protocol adjustments made if needed. **WHO:** PIM, Implementation & Review Committee, Industry Mentor, Medical Directors, Administrators, and interested stakeholders

Table 2. Project Implementation Timeline with Process Markers (Continued)

	WHERE: Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email
March 17, 2019	**WHAT:** Third data set compiled and evaluated. Data charts updated and variances identified and protocol adjustments made if needed. **WHO:** PIM, Implementation & Review Committee, Industry Mentor, Medical Directors, Administrators, and interested stakeholders **WHERE:** Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email
March 26, 2019	**WHAT:** Initial implementation complete **WHO:** PIM, Implementation & Review Committee, Industry Mentor, Medical Directors, Administrators, and interested stakeholders **WHERE:** Plainview, Texas **HOW:** In person, via Zoom, WebEx, or email

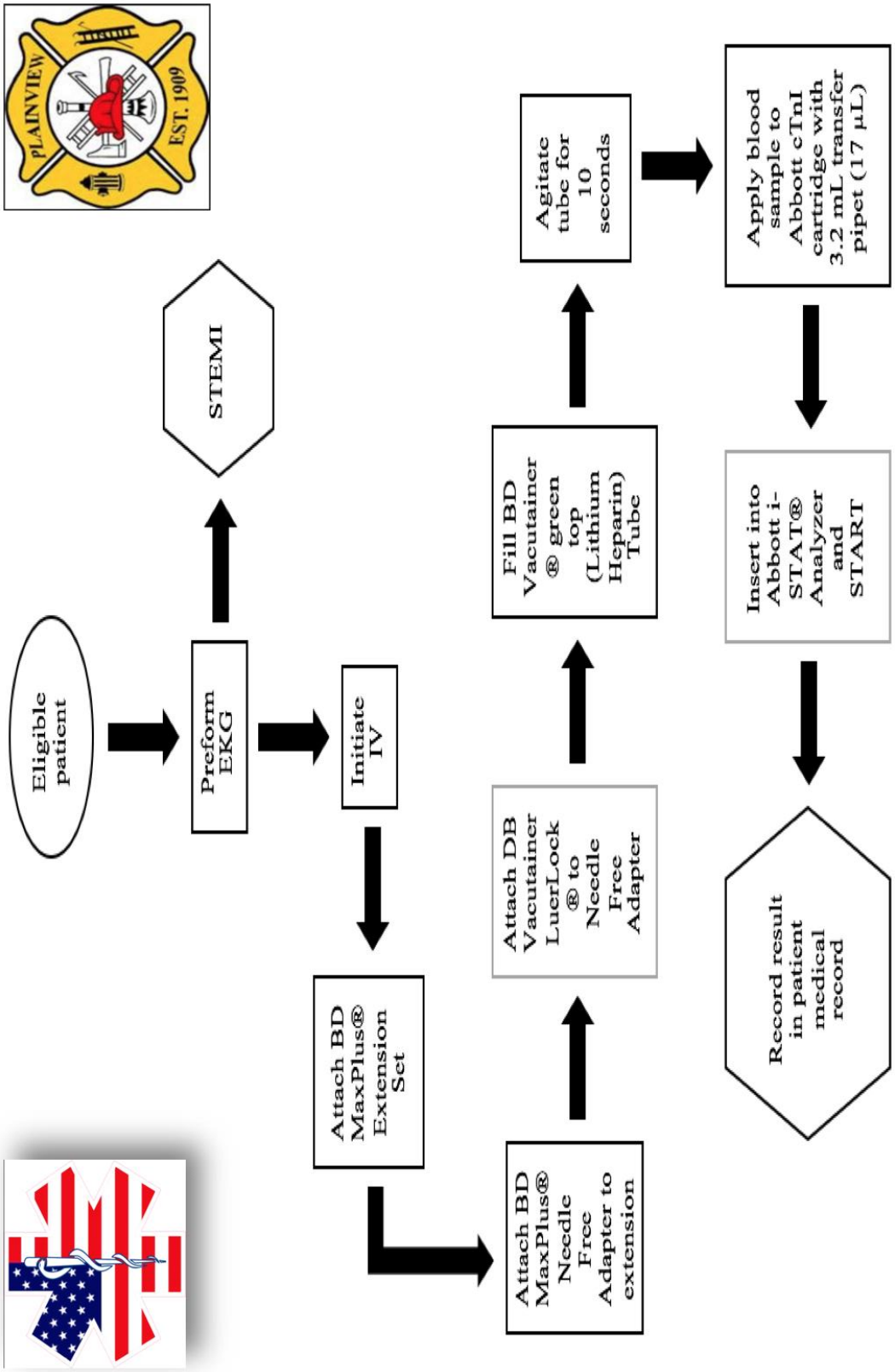

Figure 10. Final Prehospital Troponin Testing Protocol Project resources.

- EMS service with ambulances and at least one Texas Department of State Health Services certified/licensed paramedic or Nationally Registered Emergency Medical Technician – Paramedic
- IV start equipment
- Blood sampling equipment
- POC Troponin Test Platform with storage system
- Appropriate Troponin I Cartridges
- Printer Paper for POC Platform
- Green Top Serum Blood Tubes
- Serum Blood Sampling Pipets
- Training Materials (Pamphlets)
- Training Sites
- Serum Blood Samples or manufacturer testing solutions
- EMS Vehicles for simulation testing
- Computer or tablet for data set storage, email, and presentation
- Computer Aided Dispatch System capable of documenting EMS response variables
- EMR capable of accurately documenting patient care and times
- Printer
- Office Supplies (Paper, Ink, Legal Pads, Pens, etc.

Financial analysis for 30-day implementation.

i-STAT Analyzer Rental/month ($599X2) = $1,198

i-STAT Printer Rental/month ($125X2) = $250

i-STAT cTnI Cartridges/25 ($629.95X2) = $1,259.90

i-STAT Rental Deposit ($7500X2) = $15,000

3 mL Plastic Pipet (200) = $8.99

BD Vacutainer Blue Citrate 2.7 mL Tubes (100) = $16.74

DB Vacutainer (100) = $33.95

Biohazard Bags (100) = $12.65

TOTAL = $17,780.23

- $15,000.00

NET = $ 2,780.23

Evaluation of Models in PHTTP

The ACE Star Model for Knowledge Transformation and Lippitt's Change theory were both effective in ensuring success for this implementation. The steps of the change theory were congruent with this type of implementation and the Star Model was beneficial as a tool to justify changes in the current ways of thinking regarding troponin testing, utilization of EMS in this change, and the knowledge shift necessary to create this shift. The Star Model was particularly useful in that it organized both old and new concepts to improve care into a collective unit and provided a framework to organize the process. The PHTTP was a combination of older concepts (two troponin values must be performed in the ED) and a newer concept (performing one troponin outside the ED) into its current form (one troponin in the prehospital environment and one in the ED).

Conclusion

The PHTTP has the potential to save significant annual health care expenses with only a limited initial investment and limited continuing expenses in relation to potential

benefits. These benefits can be realized through the reduction in time from FMC to T1, reduction in LOS, and reduction in time to EIS. This protocol will also reduce the impact of MACE events in NSTE-ACS patients over its widespread implementation. These benefits will improve patient outcomes and reduce the economic impact of patients with NSTE-ACS diagnosis. American EDs are currently in crisis as they have become the health care safety net, which has led to dangerous overcrowding. Projects such as this one that aim not only at improving patient care but also at reducing ED overcrowding through improvement in ED workflow could be pivotal in managing the ED crisis.

Chapter 4

Project Outcomes, Impact, and Results

Completion Outcomes

The completion outcomes to be measured by the PHTTP include:

- Reduction in mean time from FMC to T1
- Reduction in mean LOS
- No significant change in mean EMS scene times

Data Collection, Measurement, and Analysis

All implementation data points were recording in minute format (XX.XX minutes). EMS times were obtained from written run reports, POC equipment and computer-aided dispatch (CAD) equipment used by the Plainview Fire-EMS Department for 30 days preceding implementation of the PHTTP. ED times were acquired from the Covenant Plainview ED Meditech EMR for 30 days preceding implementation of the PHTTP. Change in FMC to T1 = (mean pre-implementation FMC to T1 - mean post implementation FMC to T1). Change in LOS = (mean pre-implementation LOS - mean post implementation LOS). Change in EMS scene time = mean pre-implementation scene time - pre-implementation scene times). Times were converted to fractional hours by divided by 60 minutes. Percent change = (post implementation value/pre-implementation value) X 100. Statistical significance was calculated using a Single Sample *t*-Test with a two-tailed hypothesis and a 0.05 significance level.

Pre-implementation data.

The mean ED LOS for 30 days preceding the project implementation was 191-minutes (3.18 hours) and mean FMC to T1 was 79-minutes (1.32 hours). Mean EMS scene time for 30 days preceding implementation was 13 minutes (0.22 hours).

Project results and impact.

Table 3. Prehospital Troponin Testing Protocol - Field Data

ID	AGE	SEX	FMC	DEPART ED	T1	RESULT	ARRIVE ED
001	48	M	10:04	10:18	10:28	NEG	10:30
002	39	M	4:44	4:55	5:07	NEG	5:07
003	70	F	15:22	15:37	15:45	NEG	15:47
004	44	F	8:22	8:35	8:46	NEG	8:48
005	69	M	22:53	23:08	23:10	POS	NA
006	52	F	6:14	6:24	6:30	NEG	6:31
007	61	M	10:19	10:35	10:44	NEG	10:44
008	29	F	5:21	5:41	5:46	NEG	5:48
009	39	M	16:27	16:39	16:47	NEG	16:50
010	60	M	18:10	18:28	18:35	NEG	18:52
011	57	M	7:01	7:16	7:23	NEG	8:04
012	66	F	5:10	5:28	5:22	NEG	5:37
013	40	F	11:14	11:33	11:32	NEG	11:33
014	66	M	8:01	8:20	8:23	NEG	8:21
015	79	M	5:32	5:44	6:01	NEG	6:09
016	47	M	12:12	12:28	12:35	NEG	12:31
017	66	M	19:08	19:35	19:32	NEG	19:36
018	81	F	6:15	6:31	6:41	NEG	6:36
019	59	F	11:15	11:33	11:39	NEG	11:39
020	54	F	21:14	21:30	21:40	NEG	21:48
021	90	M	4:22	4:37	4:39	NEG	4:50
022	51	F	12:01	12:16	12:18	NEG	12:20
023	30	M	16:23	16:35	16:47	NEG	16:50
024	49	M	8:10	8:21	8:35	NEG	8:33
025	60	F	14:17	14:29	14:40	NEG	14:44

LEGEND:			
AD	Admission	FMC	First Medical Contact
ARRIVE ED	Arrival at ED	ID	Unique Patient Identifier
DC	Discharge	LOS	Length of Stay
DEPART ED	Depart to ED	M	Male
DISPO	Disposition	T1	First Troponin Value
F	Female	T2	Second Troponin Value

Table 4. Prehospital Troponin Testing Protocol - ED Data

T2	RESULT	DISPO		LOS	DIFF
11:55	NEG	13:01	DC	151.00	40.00
6:32	NEG	7:48	DC	161.00	30.00
17:17	NEG	17:51	AD	124.00	67.00
10:00	NEG	11:01	DC	133.00	58.00
NA	NA	NA	NA	NA	NA
7:40	NEG	8:44	DC	133.00	58.00
12:01	NEG	13:19	AD	155.00	36.00
6:05	NEG	8:33	DC	165.00	26.00
18:09	NEG	19:10	DC	140.00	51.00
18:43	NEG	21:21	AD	149.00	42.00
8:45	NEG	10:34	DC	150.00	41.00
6:59	NEG	8:52	DC	195.00	-4.00
12:59	NEG	14:12	DC	159.00	32.00
10:02	NEG	10:47	DC	146.00	45.00
8:00	NEG	9:12	T	183.00	8.00
14:07	NEG	14:25	DC	114.00	77.00
21:17	NEG	22:01	AD	145.00	46.00
8:30	NEG	9:05	AD	149.00	42.00
13:28	NEG	14:20	DC	161.00	30.00
23:25	NEG	23:52	DC	124.00	67.00
6:35	NEG	7:10	AD	140.00	51.00
14:17	NEG	14:54	DC	154.00	37.00
18:30	NEG	19:12	DC	142.00	49.00
10:24	NEG	11:33	DC	180.00	11.00
16:20	NEG	17:12	DC	148.00	43.00
LOS 150.04		**AVERAGE LOS CHANGE**			**40.96**

LEGEND:			
AD	Admission	FMC	First Medical Contact
ARRIVE ED	Arrival at ED	ID	Unique Patient Identifier
DC	Discharge	LOS	Length of Stay
DEPART ED	Depart to ED	M	Male
DISPO	Disposition	T1	First Troponin Value
F	Female	T2	Second Troponin Value

Table 5. Prehospital Troponin Testing Project Age Distribution

ID	AGE
001	48
002	39
003	70
004	44
005	69
006	52
007	61
008	29
009	39
010	60
011	57
012	66
013	40
014	66
015	79
016	47
017	66
018	81
019	59
020	54
021	90
022	51
023	30
024	49
025	60
AVERAGE	**56.24**

Table 6. Prehospital Troponin Testing Project Gender Distribution

MALE	14	56%
FEMALE	11	44%

Table 7. Prehospital Troponin Testing Project FMC to First Troponin Average

ID	FMC	T1	DIFF
001	10:04	10:28	0:24
002	4:44	5:07	0:23
003	15:22	15:45	0:23
004	8:22	8:46	0:24
005	22:53	23:10	0:17
006	6:14	6:30	0:16
007	10:19	10:44	0:25
008	5:21	5:46	0:25
009	16:27	16:47	0:20
010	18:10	18:35	0:25
011	7:01	7:23	0:22
012	5:10	5:22	0:12
013	11:14	11:32	0:18
014	8:01	8:23	0:22
015	5:32	6:01	0:29
016	12:12	12:35	0:23
017	19:08	19:32	0:24
018	6:15	6:41	0:26
019	11:15	11:39	0:24
020	21:14	21:40	0:26
021	4:22	4:39	0:17
022	12:01	12:18	0:17
023	16:23	16:47	0:24
024	8:10	8:35	0:25
025	14:17	14:40	0:23
		AVERAGE	**0:22**

Table 8. Prehospital Troponin Testing Project FMC to Arrival at Emergency Department

ID	FMC	ARRIVE ED	DIFF
001	10:04	10:30	0:26
002	4:44	5:07	0:23
003	15:22	15:47	0:25
004	8:22	8:48	0:26
005	22:53	NA	NA
006	6:14	6:31	0:17
007	10:19	10:44	0:25
008	5:21	5:48	0:27
009	16:27	16:50	0:23
010	18:10	18:52	0:42
011	7:01	8:04	1:03
012	5:10	5:37	0:27
013	11:14	11:33	0:19
014	8:01	8:21	0:20
015	5:32	6:09	0:37
016	12:12	12:31	0:19
017	19:08	19:36	0:28
018	6:15	6:36	0:21
019	11:15	11:39	0:24
020	21:14	21:48	0:34
021	4:22	4:50	0:28
022	12:01	12:20	0:19
023	16:23	16:50	0:27
024	8:10	8:33	0:23
025	14:17	14:44	0:27
		AVERAGE	**0:27**

Table 9. Prehospital Troponin Testing Project Troponin 1 to Troponin 2 Average

ID	T1	T2	DIFF
001	10:28	11:55	1:27
002	5:07	6:32	1:25
003	15:45	17:17	1:32
004	8:46	10:00	1:14
005	23:10	NA	NA
006	6:30	7:40	1:10
007	10:44	12:01	1:17
008	5:46	6:05	0:19
009	16:47	18:09	1:22
010	18:35	18:43	0:08
011	7:23	8:45	1:22
012	5:22	6:59	1:37
013	11:32	12:59	1:27
014	8:23	10:02	1:39
015	6:01	8:00	1:59
016	12:35	14:07	1:32
017	19:32	21:17	1:45
018	6:41	8:30	1:49
019	11:39	13:28	1:49
020	21:40	23:18	1:38
021	4:39	6:35	1:56
022	12:18	14:17	1:59
023	16:47	18:30	1:43
024	8:35	10:24	1:49
025	14:40	16:20	1:40
		AVERAGE	**1:29**

Table 10. Prehospital Troponin Testing Project Troponin 2 to Disposition Average

ID	T2	DISPO	DIFF
001	11:55	13:01	1:06
002	6:32	7:48	1:16
003	17:17	17:51	0:34
004	10:00	11:01	1:01
005	NA	NA	NA
006	7:40	8:44	1:04
007	12:01	13:19	1:18
008	6:05	8:33	2:28
009	18:09	19:10	1:01
010	18:43	21:21	2:38
011	8:45	10:34	1:49
012	6:59	8:52	1:53
013	12:59	14:12	1:13
014	10:02	10:47	0:45
015	8:00	9:12	1:12
016	14:07	14:25	0:18
017	21:17	22:01	0:44
018	8:30	9:05	0:35
019	13:28	14:20	0:52
020	23:25	23:52	0:27
021	6:35	7:10	0:35
022	14:17	14:54	0:37
023	18:30	19:12	0:42
024	10:24	11:33	1:09
025	16:20	17:12	0:52
		AVERAGE	**1:05**

Table 11. Prehospital Troponin Testing Project EMS Scene Time

ID	FMC	DEPART	DIFF
001	10:04	10:18	0:14
002	4:44	4:55	0:11
003	15:22	15:37	0:15
004	8:22	8:35	0:13
005	22:53	23:08	0:15
006	6:14	6:24	0:10
007	NA	10:35	NA
008	5:21	5:41	0:20
009	16:27	16:39	0:12
010	18:10	18:28	0:18
011	7:01	7:16	0:15
012	5:10	5:28	0:18
013	11:14	11:33	0:19
014	8:01	8:20	0:19
015	5:32	5:44	0:12
016	12:12	12:28	0:16
017	19:08	19:35	0:27
018	6:15	6:31	0:16
019	11:15	11:33	0:18
020	21:14	21:30	0:16
021	4:22	4:37	0:15
022	12:01	12:16	0:15
023	16:23	16:35	0:12
024	8:10	8:21	0:11
025	14:17	14:29	0:12
		AVERAGE	**0:15**

There were 25 eligible patients included in the 30 day preliminary PHTTP data set. One patient was excluded for a positive T1 and ST segment elevation on ECG and a subsequent diagnosis of STEMI. The average ago of the study participants was 56.24 years and 56% male and 44% female. The PHTTP preliminary data demonstrated a reduction in the time of mean FMC to T1 from 79 minutes (1.32 hours) to 22 minutes (0.37 hours) and mean FMC to disposition of patients from 191.00 minutes (3.18 hour) to 150.04 minutes (2.50 hours). Mean FMC to T1 was reduced by 47.00 minutes (0.78 hours) and LOS was reduced by 40.96 minutes (0.67 hours). This equated to a 21.19% reduction in mean ED LOS of this subset of patients in the Covenant Plainview ED. The mean EMS scene time increased from 14 minutes (0.23 hours) to 15 minutes (0.25 hours). During the implementation period the mean time to return of T1 was reduced to 10 minutes (0.17 hours) through POC testing which equated to a reduction of 57 minutes (0.95 hours) or a 14.9% improvement. Mean return time of T2 was not significantly different at 78 minutes (1.32 hours), compared to 79 minutes (1.32 hours) as it was processed in the Covenant Plainview Lab with via the same instrumentation and protocol. The mean LOS was reduced from 191 minutes (3.18 hours) to 150.04-minutes (2.5 hours) which equated to a reduction of 40.96-minutes (0.67 hours) or a 21.19% improvement.

Analysis.

The sample data was analyzed using a Single Sample *t*-Test with a two-tailed hypothesis and a 0.05 significance level. This test was used to determine if the post implementation values were statistically different from the pre-implementation values. The time from mean FMC to T1 *t*-value = -10.665324 at $p = < 0.00001$ and LOS *t*-value = -72.249049 at $p = < 0.00001$ which are both statistically significant at $p = 0.05$. Mean

EMS scene time *t*-value = 1.790249 at $p = 0.086588$ which is not statistically significant at $p = 0.05$.

Conclusion

The preliminary results of the PHTTP corresponded with the postulated outcome measures by reducing the mean time to final disposition and mean LOS of chest pain patients that arrived at the ED via EMS. These measures were attained through the introduction of a prehospital troponin value that reduced the time from mean FMC to T1. The reduction in time from mean FMC to T1 concomitantly reduced the mean LOS without a significant increase in mean EMS scene time of chest pain patients transported by Plainview Fire-EMS to Covenant Plainview ED.

Chapter 5

Project Sustainability, Discussion, Conclusions, and Dissemination Recommendations

Discussion of Results and Impact

The PHTTP preliminary data demonstrated a reduction in the time from mean FMC to T1 and mean FMC to disposition of patients who were transported to the Covenant Plainview ED via Plainview Fire-EMS from 191 minutes (3.18 hour) to 150.04 minutes (2.50 hours). This reduced the mean LOS by 40.96 minutes (0.67 hours). This equated to a 21.19% reduction in mean ED LOS for this subset of patients in the Covenant Plainview ED. This reduction in time to T1 had the following immediate impacts: 1) reduced the time from mean FMC to T2, 2) reduced the time from mean FMC to T2, and 3) reduced the time from mean FMC to final disposition which could include discharge, admission, or transfer. Its intermediate impacts include the following: 1) reduction in time to EIS and 2) reduction in ED overcrowding and improved ED workflow. Long-term impacts potentially include the following: 1) improved patient outcomes through reduction in 90-day MACE events, 2) improved ED patient satisfaction, 3) improved Fire-EMS and ED collaboration and satisfaction, and 4) reduced institutional costs from subsequent hospitalization related to 90-day MACE. The potential long-term impacts require ongoing implementation of the PHTTP to validate.

Project Sustainability Plans and Implementation

Sustainability occurs through standardization and conservation of new practices over time requiring stakeholders, including management and staff to fundamentally alter

their thinking and attitudes towards a process innovation. Sustainable change in health care must be dynamic and adaptive to meet contextual needs and maintain desirable patient outcomes (Scheirer & Dearing, 2011). Refer to *Figure 9* for PHTTP sustainability plan.

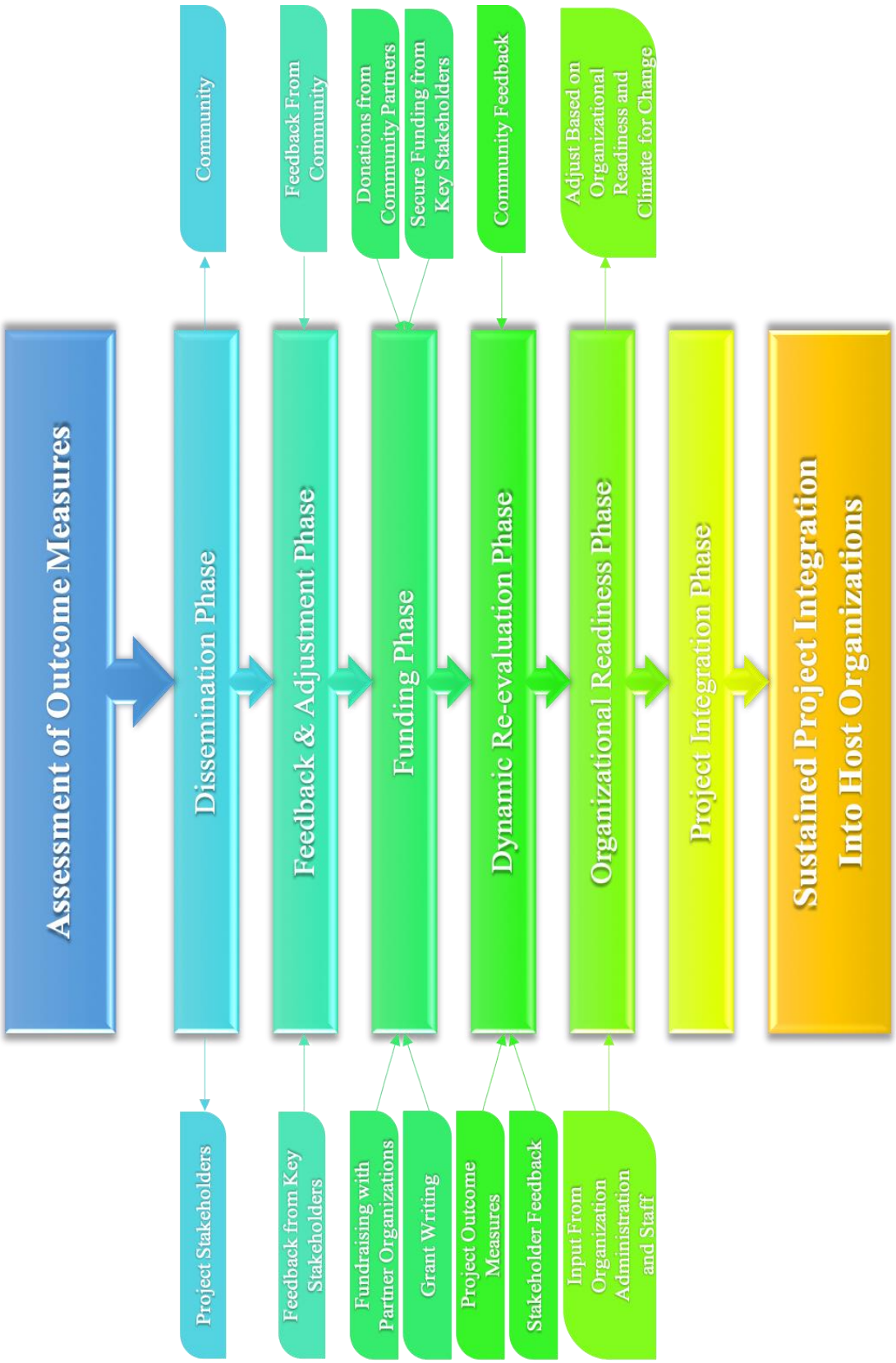

Figure 11. Prehospital Troponin Testing Project Sustainability Plan

Dissemination, feedback, and adjustment phases.

The initial step of ensuring the sustainability of the PHTTP is to maintain the engagement and investment of the key stakeholders, as well as identifying additional stakeholders and potential barriers to ongoing sustainability. The dissemination of the preliminary results of the PHTTP to stakeholders will be done through a combination of media formats including print, electronic, and in-person presentations via presentation platforms such as Microsoft PowerPoint. This media will be distributed to the administration of both the Covenant Plainview Hospital, the Plainview Fire-EMS Department, and the City of Plainview. An article will be written for publication in the Plainview Daily Herald detailing the PHTTP and the involvement of both the fire department and the hospital ED. This process of preliminary result and project dissemination will identify any potential stakeholder, financial, political, or organization-related barriers and aid in developing potential strategies necessary to overcome these barriers and facilitate ongoing implementation of the PHTTP.

Potential barrier and their solutions are as follows:

- Stakeholder: All major stakeholders involved in the PHTTP were initially vested and discussions of their preliminary results demonstrated continued investment. The official dissemination of the preliminary data in additional to the concurrent data collection will assist in continuing their involvement and participation.
- Financial: Ongoing expense of sustaining the PHTTP. There is an initial durable and ongoing consumable equipment cost, but it can be offset over the long-term as troponin testing is a reimbursable intervention by major insurance providers, Medicare, and Medicaid (Kip, 2017). The Texas Department of State Health

Services has many grant services available for licensed EMS providers in the State of Texas and the preliminary data from PHTTP will be utilized with grant writing (Texas Department of State Health Services, 2019). In conjunction with the Plainview Fire-EMS, grant applications will be made to U.S. and Texas Department of State Health Services (DHS) and Department of Homeland Security Federal Emergency Management Agency (FEMA) to obtain permanent durable POC and consumable equipment to fund the ongoing training and education. Additionally, a billing policy will be implemented to ensure appropriate reimbursement to the Plainview Fire-EMS for POC troponin testing to sustain ongoing consumable equipment procurement. These steps will support the continuation of the PHTTP until adequate reimbursement has been obtained and the PHTTP is self-sustained.

- Political: There was a concern regarding the increased liability of the City of Plainview using the fire department to perform tests previously completed by the hospital laboratory. The city attorney was provided the literature that demonstrated no increase in liability from the utilization of POC testing and that POC testing is the standard of care in the management of chest pain patients (Juliano, 2017).
- Organizational: Plainview Clinical Laboratory resisted the continuation of PHTTP. The Plainview Clinical Laboratory demonstrated initial resistance to troponin values being obtained outside of their facility due to potential lack of reliability, loss of revenue, and lack of Clinical Laboratory Improvement Amendments (CLIA) certification. These issues were addressed via in-person

meetings and the provision of literature regarding the reliability of out-of-laboratory troponin results (Juliano, 2017), demonstration of troponin testing platform, cost benefit analysis regarding reagents, cartridges, staff, and equipment maintenance cost regarding potential billing amounts, and documentation of POC troponin testing being a CLIA-waived test (Center's for Medicare and Medicaid Services, 2018).

Plan for initial dissemination of preliminary data.

This plan includes the following: 1) In-person or round table meeting with key stakeholders to disseminate the preliminary results of the PHTTP and address any potential barriers to continued implementation, 2) presentation to city council and publication of preliminary results and involvement of important stakeholders in city newspaper and fire department, hospital, and city website, 3) meetings with financial officers of City of Plainview and Covenant Plainview Hospital as well as meeting with Texas Department of State Health Services EMS Grants Division, 4) community presentation to interested individuals, and 5) publication in selected journals.

Dissemination.

- Oral presentation with PowerPoint Slides to DNP cohort, UT Tyler DNP Faculty, Covenant Plainview ED staff and administration, Plainview Fire-EMS and Plainview City Council
- Newspaper articles presentation
- Poster presentation to stakeholders
- Community meetings
- Media announcements: Radio/Television

- Presentation at Texas EMS conference
- Article publications in scholarly journals:
    - Academic Emergency Medicine
    - Journal of Advanced Emergency Nursing
    - Journal of the American College of Cardiology
    - Journal of Prehospital Emergency Care
    - Journal of Emergency Medical Services

Funding phase.

Sustainability of the PHTTP requires ongoing funding from the host organizations. This funding can be secured from internal as well as external sources. Internal sources of funding include inclusion in departmental and organizational budgetary planning meetings with the Chief Financial Officers of both host organizations and meetings with billing agencies to procure appropriate reimbursement for POC testing as outlined by CMS. External sources of funding include donations from community partners identified through dissemination of preliminary results at town hall meetings and media, private funding organizations such as Abbott Point-of-Care, and grant applications that will be made to the United States and Texas Department of State Health Services (DHS), and Department of Homeland Security Federal Emergency Management Agency (FEMA).

Dynamic re-evaluation phase.

As the PHTTP continues within the host organizations a continual evaluation and of project outcomes and dynamic adjustment to problems or new barriers is necessary.

Sustainability cannot be maintained within a static situation and continual dynamic change based on outcomes measures and stakeholder feedback must occur.

Organizational readiness phase.

The readiness of the host organizations for sustained change must be assessed prior to full project integration to assess organizational strengths and weaknesses. The Organizational Readiness for Change Assessment (ORCA) tool will be utilized to re-evaluate the readiness of the host organizations prior to full and sustained implementation following the initial implementation phase. The ORCA tool is utilized to identify and monitor the organizational strengths and weaknesses to support a sustain implementation of evidence-based practices (Helfrich, 2009). Any weaknesses identified will be addressed with organizational leadership and adaptations made to facilitate complete project integration and sustainability.

Project integration phase.

PHTTP is integrated in the budget, facility protocols, and training practices at both host organizations as a Standard Operating Procedure (SOP) through Project Integration Management (PIM). PIM is the process of integrating new processes into a complex, fully functional system to minimize system interruption and create sustainable system change (Project Management Institute, 2017).

The utilization of the PHTTP sustainability plan will create a sustainable change within both the Plainview Fire-EMS Department and the Covenant Plainview ED. This sustainable change will improve inter-professional collaboration between these organizations, improve outcomes of chest pain patients, improve ED workflow, and reduce ED overcrowding.

Implications of PHTTP Results

The preliminary results of the PHTTP have implications in the ongoing management of chest pain patients transported to the Covenant Plainview ED via Plainview Fire-EMS. Further, improved inter-professional collaboration between the prehospital staff and ED staff can improve the patient outcomes and facilitate patient transition from the prehospital to the hospital setting (Reeves, 2017). The PHTTP demonstrated that prehospital personnel are important in the patient progression through emergent evaluation through the inclusion and reliance upon troponin values obtained outside the ED as well as the hospital clinical laboratory (Venturini, 2013). The PHTTP preliminary results demonstrated that a prehospital troponin value is reliable and effective in decreasing the throughput time of chest pain patients in the ED which would concomitantly decrease the time to disposition and utilization of EIS if it is required. The utilization of prehospital personnel to use POC devices to measure troponin levels during transport of patients to the ED may result in earlier diagnosis of ACS (Venturini, 2013). Moreover, EIS leads to a statistically significant decrease in mortality and refractory ischemia (Li, 2017). Additionally, the PHTTP will reduce healthcare costs by using interventions earlier in the patient treatment algorithm and reduce readmissions and mitigate adverse outcomes. In fact, readmission costs are $14,300 following discharge from an NSTE-ACS events (Patel, 2018). With early intervention, the re-hospitalization rate was decreased by 9% (Meadows, 2012). The PHTTP can reduce re-hospitalizations by 9% by reducing the time to interventional strategies and readmission costs of $14,300/event. Finally, the PHTTP preliminary results improved ED workflow and reduced ED overcrowding by decreasing the LOS of chest pain patients that arrive by

EMS. EDs in the US are in crisis from overcrowding as it has become the safety net for health care (Freibott, 2017). Therefore, this PHTTP has the potential to create sustainable change within the local healthcare environment and if implemented on a larger scale will have positive ramifications in the larger health care environment.

Key Lessons Learned from Implementation Process

Many lessons were learned during the design, recruitment, and implementation of the PHTTP: 1) resistance to inter-professional collaboration, 2) financial investment of the health care components, and 3) investment in innovation. Collaboration between EMS systems and hospital EDs can often be turbulent and strained and the PHTTP required extensive cooperation between these two systems. Additionally, dealing with the administrative structure of one component of the health care system can often be taxing, but dealing with the administration of two components concurrently was the real challenge. The investment of financial capital in the current strained health care system was a major hurdle to implementation of the PHTTP. The exploration of grants and organizational donations would be beneficial for the implementation of future projects of this type that involve more than one health care component. Even in the contemporary evidence-based emergency health care system, barriers still exist against the implementation of innovative approaches to established treatment algorithms and many systems are uncomfortable in straying from the established norms. This variation from the established norms represented a challenge through the process of this project and required greater adaptation than what was previously anticipated.

Recommendations

The preliminary results of the PHTTP demonstrated a reduction in the time to final disposition of chest pain patients suspected of NSTE-ACS that present to the Covenant Plainview ED via Plainview Fire-EMS. The ongoing implementation demonstrated a 40.96 minute (0.67 hour) reduction in time to final disposition which could create sustainable change is patient outcomes and ED workflow. Future recommendations for this project are as follows: 1) the current PHTTP should be continued in the host organizations and additional data obtained, 2) the PHTTP Sustainability Plan should be enacted in the host organizations while the additional data is obtained, and 3) once adequate sustainability is obtained within the host organizations, considerations can be made for project implementation in other organizations.

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Appendix A. All-cause Mortality

Mortality Post Discharge	NSTE-ACS	AMI
30 day	**2.6%**	**7.99%**
90 day	**12.6%**	**6.1%**
180 day	**18.3%**	**10.2%**
1 year	**23.5%**	**11.5%**
2 year	**33.2%**	**16.4%**

Appendix B. Prehospital Troponin Evaluation Table Template

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Citation: author(s), date of publication& title	Purpose of Study	Conceptual Framework	Design/ Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement of Major Variables	Data Analysis	Study Findings	Appraisal of Worth to Practice Strength of the Evidence (i.e., level of evidence + quality [study strengths and weaknesses]) RECOMMENDATIONS
Cantor, W., et al. *Em Medicine* 2005; 16(1), 1-9.	Evaluate PCI impact	None	RCT OPUS TIMI-16 Trial	N= 10,288 in 10 months Setting: hospitalized patient in 29 countries Attrition: 1855 excluded due to previous PCI 147 had STEMI & PCI before randomization	IV = EIS DV1 = OT DV2 = PCI	Event rates mortality at 10 months in OT & PCI groups	Percent Hazard Ratios Pearson test – EIS & OT/PCI	PCI is associated with lower MACE MACE st 10 months was: 1.3% (low risk), 2.2% (intermediate risk), & 11.4% (high risk)	Limitations: - Bias: decision to utilize EIS was at the discretion of the treating physician - some non-fatal outcomes Re-infarction, stroke) may have occurred before EIS Strengths: -large sample (8286 after exclusions) -identified that EIS effect varies with risk stratification Conclusion: -EIS ↓↓ MACE in high-risk and little effect in low-risk Feasibility: -EIS is feasible to implement in high-risk patients -Benefits outweighs risk in high risk patients
Cox, D., et al. *Am J Card.* 2006; *149*(2): 275-283	PCI with & without thrombolytics reduces MACE	None	RCT STEMI & NSTEMI randomized equally into 1 of 4 groups: -BA+T -BA-T -SC+T -CS-T	N = 2082 over 1 year Setting: 76 medical centers in 9 countries Attrition: 36 lost to 15 year follow-up	IV = PRS DV1 = BA+T DV2 = BA-T DV3 = CS+T DV4 = CS-T	15 year mortality rate was measured for all intervention groups based on occurrence of MACE	Percent ITT Chi-square test for 4-way comparison of groups Survival technique and log rank for MACE	PCI improves MACE versus OT NSTEMI had delayed arrival to hospital (2.4 hours) versus STEMI (1.8 hours) 1 year NSTEMI MACE of 24% versus STEMI MACE of 16.6%	Limitations: - small sample size for medication evaluation - retrospective analysis was not included in original study design Strengths: -29 center trial Conclusion: -PCI strategies with & without thrombolytics are effective in reducing MACE -delays in intervention lead to > MACE for NSTEMI Feasibility: -reasonable to implement into ED practice

									-benefits of ↓MACE outweighs risk of both PCI & thrombolytics
Ezekowitz, J., et al. *JAHA*, 2015; 4(12): 1-11	PTT accelerates TTD	None	RCT PROACT-4 was a prospective, open-label, blinded-endpoint (PROBE). Patients were randomized in the prehospital setting 1:1 into POCT or UC groups.	N = 601 in 19 months UC=296 POCT=305 Setting: 25 ambulances in Edmonton, Alberta, Canada Attrition: UC=2 – withdrew consent POCT=57 – 55 no POCT result & 2 withdrew consent	IV = PTT DV1 = POCT DV2 = TTD	+POCT > 0.03 ng/mL Prehospital +POCT > 0.01 ng/mL Hospital TTD = FMC to FD measured in hours	ITT Analysis Per Protocol Analysis 2 sided statistical tests with 5% level of significance	0.29 reduction in TTD POCT = 38 minutes UC = 139 minutes POCT TTD = 8.8 hrs (P=0.069; $P_{adjusted}$=0.074) UC TTD = 9.0 hrs (P=0.05; $P_{adjusted}$=0.059) Sensitivity of POCT=44%, specificity=96%, positive predictive value=73.3%, and negative predictive value=87.2%	Strength: in a less-advanced EMS systems, or greater distances or durations of EMS transport, there may be an even greater magnitude of the effect than observed in this study Weakness: 18% device failure with no POCT results and patients, EMS personnel and physicians treating the patient were aware of the allocated arm Conclusion: POCT prehospital troponin testing resulted in 0.29 hour reduction in time to TTD Feasibility: this intervention is feasible to implement into practice and has potential for even greater positive results in longer transport scenarios. Risk to patients is minimal and benefit outweighs risk.
Than, M., et al, *JAMA 2013;* 4(12): 1-11	Utilize ADP without increasing MACE	None	RCT Randomized 1:1 to APD and UC	N = 544 in 19 months ADP=271 UC=273 Setting: Christchurch Hospital ED in Christchurch, New Zealand Attrition: UC-1 ADP=1 withdrew consent	IV1 = ADP IV2 = SCP IV1 = hs-cTn IV2 = SD IV3 = MACE	hs-cTn < 0.03 ng/mL SD < 2 hours MACE standard classification	ITT Chi-square Odds ratio Percentage	ADP doubled the proportion of patient with early discharge 19.3% of ADP patients discharged by 6 hours 11% of UC patients discharged in 6 hours 52 of 270 patients in the experimental group were	Limitations: -single center trial ↓ generalizability & limited sample size -cannot exclude small differences in risk of MACE Strengths: -safety of ADP was demonstrated in 1975 patients Conclusion: -Trial demonstrated that the experimental pathway is an effective and practical strategy to improve early discharge rates for some patients with chest pain.

								successfully discharged within 6 hours compared with 30 of 272 patients in the control group (19.3% vs 11.0%; odds ratio, 1.92; 95% CI, 1.18-3.13; *P* = .008)	Feasibility: - ADP is feasible to facilitate early discharge -Benefits of utilizing ADP outweigh calculated risks of MACE in chest pain patients
Wallentin, L., et al. *Lancet* 2016; 388(10054:1903-1911	EIS reduces MACE	None	RCT Prospective, randomized, open and double-blind, placebo-controlled study with parallel groups Patients randomized to EIS or non-EIS	N = 2457 in 22 months Setting: 58 Scandinavian Hospitals in Sweden, Denmark, & Norway Attrition: 36 – death & loss to follow-up for unknown reason	IV = EIS DV1 = PCI DV2 = MACE	PCI – met criteria or did not meet criteria for cardiac catherization; upper limit of normal	Mean Gain Analysis Regression analysis Odds ratio Hosemer-Lemeshow Test	PCI reduced MACE by a mean of 549 days at 2 years PCI postponed MACE by average of 18 months and readmission by 37 months compared to UC PCI postponed MACE by 1128 days (95% CI 830-1366) More than 5 factors for invasive strategy reduced mortality from 15.4% (20 of 130) to 5.2% (7 of 134) (risk ratio (RR) 0.34, 95% confidence interval (CI) 0.15 to 0.78, p = 0.006) Death/MI was also reduced in patients with 3–4 factors from 15.7% (80 of 511) to 10.8% (58 of 538) (RR 0.69,	Limitations: -bias towards selection of medium to high risk patients limiting applicability to low risk. -confined to Scandinavian patients with limited prior revascularization -only risk factors present on admission were included – excluding factors that developed during hospitalization Strengths: -15 year follow-up Conclusion: -PCI reduced occurrence of MACE events over 15 years Feasibility: -feasible to implement protocol to accelerate time to EIS -benefits of EIS(↓ MACE) outweigh risks (cardiac arrhythmias, bleeding, vessel perforation)

								95% CI 0.50 to 0.94, p = 0.02)	
Cullen, L., et al. *JACC, Lancet* 2013; *62*(14): 1242-1249	Validate POCT	None	Prospective Cohort 2 cohorts: -ADAPT -APACE	N = 2885 Setting: 2 urban ED in Brisbane, Australia & Christchurch, New Zealand Attrition: -ADAPT: TIMI incomplete or no stored serum (341) -APACE: CP not ACS of hs-cTnT above cut-off(46); no stored serum(655; no ECG(6)	IV = hs-cTn DV1 = MACE DV2 = TIMI	MACE = any TIMI < 1	Chi-square analysis McNemar analysis	ADP protocol reduced 30 day MACE by 40% ADAPT = 15.1% of MACE st 30 days APACE = 17.1% MACE at 30 days	Limitations: -applicability of risk limited to CP patient and excludes atypical presentations -most were Caucasian limiting generalizability Conclusion: An early-discharge strategy using an hs-TnI assay and TIMI score < 1 is safe and has the potential to decrease the observation periods and admissions for approximately 40% of patients with suspected ACS Feasibility: -applicable to integration into practice in the ED to reduce TTD -Benefits of reducing TDD has limited risk of MACE
Meek, R., et al. *Em Med Aus.* 2016; 28(3): 279-286	Evaluate ADP in reducing MACE and ED discharge	None	Prospective Cohort	N = 1547 in 54 days Setting: 3 Montash Health ED in Clayton, Victoria, Australia & Dandenong, Victoria, Australia Attrition: No follow-up = 114	IV = ADP DV = MACED	MACED = successful discharge	Percentage	ADP supports safe early discharge MACED = (0.09%, 95% CI 0.002–0.5) UC = (0.3%, 95% CI 0.08–0.8)	Limitations: -subjective physician selection of eligible patients Conclusions: - The ADP supports safe, early discharge of low-risk chest pain patients from the ED. Feasibility: - the use of and ADP is a safe method of ED discharge of chest pain patients - ADP demonstrated limited risk of MACE
Stengaard, C., et al. *ACC*, 2013;112	Evaluate POCT in identifying ACS	None	Observational Prospect	N = 985 in 19 months	IV = POCT protocol	POCT > 50 ng/L	Percentage Chi-square test	Prehospital quantitative POCT was statistically successful	Limitations: -inclusion in the study at the discretion of the paramedics creating potential selection bias

(9): 1361-1366	and reducing MACE		ive Cohort Patients with CP < 70 minutes in duration	Setting: ambulances in Central Denmark Attrition: -12 lost to follow-up	DV = +POCT		Kurskal-Wallis Test 1-way sample t-test 2-proportion Z-test	Diagnostic accuracy of POCT values was 0.67 +prehospital POCT troponin = MACE of 23%/yr -prehospital POCT MACE = 5%/yr	-baseline data retrieved from incomplete databases Strengths: -demonstrated adequate correlation of prehospital POCT results Conclusions: -large-scale quantitative prehospital POC-cTnI testing by paramedics is feasible Feasibility: -is applicable to utilization of prehospital troponin testing protocol
Venturini, J., et al. *Prehosp Em Care*, 2013; 17*:* 89-91	Validate POCT in ambulance versus EDT	None	Observational Cohort EMS Cohort Hospital Cohort	N= 42 in 60 days Setting: Loyola University Hospital & EMS in Maywood, Illinois Attrition: 3 – 1 cartridge error & 2 interfering substances	IV = PTT DV1 = POCT DV2 = EDT	POCT in ng/mL EDT in ng/mL	Intra-class correlation	POCT in moving ambulance provided accurate results coefficient 0.997; 95% confidence interval 0.994 to 0.998; $p < 0.005$	Limitations: -small sample size -devices were not subject to normal adverse conditions -device had 7.2% failure rate Strengths: -results were highly correlated Conclusions: - When used in a moving ambulance, the i-STAT point- of-care device reliably provided accurate results of troponin assays when compared with the results of those performed in the ED Feasibility: -applicable to the practice of prehospital troponin testing
Darling, C., et al. *Clin Epi*. 2013; 5*:* 229-236	Evaluate MACE after ACS	None	Descriptive Study Reviewed medical records of residents of Worcester, MA, USA metropolitan area hospitalized at eleven	N = 3762 in 2001, 2003, 2007, & 2007 Setting: Data from Worcester Heart Attack Study (WHAS) in Massachusetts Attrition: -NA	IV = ACS DV = MACE		Percentages	Post discharge MACE was higher for NSTEMI than STEMI NSTEMI MACE: -90 days=12.6% -1 years=23.5% -2 years=33.2% STEMI MACE: -90 days=6.1% -1 year=11.5% -2 years=16.4% STEMI were significantly more likely to have	Limitations: -primary Caucasian limits generalizability -non-randomized Strengths: -large sample size N=3762 Conclusions: - patients with STEMI experienced a better post-discharge prognosis than those with NSTEMI Feasibility: -provides validity to the assertion that NSTEMI patients are at higher risk for MACE and an intervention is needed to mitigate this risk

			central Massachusetts medical centers for acute myocardial infarction (AMI) during 2001, 2003, 2005, and 2007					survived at 3 months (OR 1.38; 95% CI 1.01–1.87), 1 year (OR 1.38; 95% CI 1.09–1.74), and 2 years (OR 1.53; 95% CI 1.23–1.89) (all *P*-values ,0.05) NSTEMI were significantly more likely to have died during the years under study than patients with STEMI (adjusted HR = 1.28; 95% CI 1.14–1.44) (*P*-value ,0.05)	

ACS-Acute Coronary Syndrome; ADAPR-Accelerated Diagnostic Protocol to Assess Patients with Chest pain with Troponin; ADP-Accelerated Diagnostic Protocol; APACE-Advantageous Predictors of Acute Coronary Syndromes Evaluation; BA+T-Balloon Angioplasty w/Thrombolytics; BA-T-Balloon Angioplasty w/o Thrombolytics; CS+T-Cardiac Stent w/Thrombolytics; CS-T-Balloon Angioplasty w/o Thrombolytics; EDT-Emergency Department Troponin; EIS-Early Invasive Strategy; EMS-Emergency Medical Services; FMC-First Medical Contact; FD-Final Diagnosis; hs-cTn-high-sensitivity Troponin; ITT-Intention to Treat; MACE-Major Adverse Cardiac Events; MACED-MACE with ED Discharge; NSTEMI-non-ST segment Elevation Myocardial Infarction; OT-Oral Thrombolytics; PCI-Percutaneous Cardiac Intervention; POCT-Point-of-Care Troponin; PRS-Prehospital Stratification; PTT-Prehospital Troponin Testing; RPD-Rapid Diagnostic Pathway; SD-Successful Discharge; STEMI-ST-segment Elevation Myocardial Infarction; TIMI-Thrombolysis in Myocardial Infarction; TTD-Time to Final Diagnosis; UC-Usual Care;

Appendix C. Search Results Synthesis Table

DATABASE	CINAHL			COCHRAN		PUBMED				
	KEYWORD	**TITLE**	**SUBJECT**	**COMBO:**	**KEYWORD**	**MESH**	**MESH MAJOR**	**TITLE/**	**TITLE**	**MESH**
SEARCH TERM				**TI/AB/KW**		**TERMS**	**TOPIC**	**ABSTRACT**		**TITLE**
Acute Coronary Syndrome	3956	2292	1291	4455	3128	22646	25079	14051	6207	11609
ACS	1859	0	162	2542	2	25079	2006	12319	976	717
non-ST segment elevation myocardial infarction	339	0	0	947	456	2006	1744	990	347	1454
NSTEMI	195	0	23	289	0	1744	1457	1382	111	163
non-ST segment acute coronary syndrome	315	0	66	727	321	1457	695	465	244	1679
NSTE-ACS	98	0	4	245	0	695	2205	695	45	0
Troponin	2377	1874	832	2638	2064	14627	14627	12523	5023	10672
High Sensitivity Troponin	327	0	130	418	21	2205	2205	493	250	1817
Prehospital Troponin	118	35	0	190	146	431	431	16	13	342
Point of Care Troponin	15	7	0	14	11	48	48	44	13	31
Early Invasive Strategies	212	0	7	1289	439	9018	9018	56	2	8352
EIS	216	0	4	106	2	1129	1129	929	70	0

Appendix D. Study Methodology Synthesis Table

	1	2	3	4	5	6	7	8	9	10	11	12
Troponin Isotype	NS	NS	cTn	cTnT	cTnI	cTnI	cTnT	cTnI	Both	cTn	cTnT	cTnT
Troponin Sensitivity	NS	NS	Standard	High	Standard	Standard	High	High	High	NS	High	Standard
Analysis Setting	NS	IPH	Lab	ED	PH	PH/ED/IPH	ED/IPH	ED	ED	PH	ED	PH & ED
Inclusion Criteria	NS	NSTEMI	Typical Chest Pain	Typical Chest Pain	Typical Chest Pain	Typical Chest Pain	Typical & Atypical Chest Pain	Typical Chest Pain	Typical Chest Pain	Typical Chest Pain	Typical & Atypical Chest Pain	Typical Chest Pain
Exclusion Criteria	NS	STEMI	NS	STEMI, CA	STEMI, Trauma, Syncope, CNS, CA, VT, AFRVR	Syncope, dyspnea, AMS	< 1 value below 99% URL	Pregnancy, < 18 yrs, terminal illness, inter-facility transfer	< 18 yrs, symptoms > 12 hrs, CKD	Atypical Chest Pain	Symptom onset > 6 hours	Symptom onset > 70 minutes
Analysis Interval	NS	NS	Variable	3-4 hrs	15 minutes	NS	up to 6 hr	2 hr	0,1,2,3, & 6 hrs	NS	0,2,4, & 6 hrs	0 & 2 hrs
Assay Range Cut-off	NS	NS	99% URL	99% URL	99% URL	NS	99% URL	99% URL	99% URL	NS	99% URL	99% URL

1 = Amsterdam, E., et al. (2014), 2 = Khera, S., et al. (2014), 3 = Layfield, C., et al (2015), 4 = Ezokowitz, J, et al. (2015), 5 = Venturini, J, et al. (2013), 6 = Borna, C., et al. (2016), 7 = Bierner, M., et al, (2015), 8 = Cullen, L, et al, (2013), 9 = Gimenez, M, et al. (2014), 10 = Ishak, M, et al. (2015), 11 = Saad, Y, et al. (2015), 12 = Stengaard, C, et al. (2013).

AMI-Acute Myocardial Infarction, AMS-Altered Mental Status, AFRVR-Atrial Fibrillation with Rapid Ventricular Response, CA-Cardiac Arrest, cTn-Cardiac Troponin Unspecified, cTnI-Cardiac Troponin I, cTnT-Cardiac Troponin T, CKD-Chronic Kidney Disease, CNS-Central Nervous Symptomology, ED-Emergency Department, IHP-In-patient Hospitalization, PH-Pre-hospital, NS-Not Specified, NSTEMI-non-ST Segment Elevation Myocardial Infarction, STEMI-ST Segment Elevation Myocardial Infarction, URL-Upper Reference Limit, VT-Ventricular Tachycardia

Appendix E. Levels of Evidence Synthesis Table

LEVELS OF EVIDENCE	1	2	3	4	5	6	7	8	9	10
Level I: Systematic review or meta-analysis										
Level II: Randomized Controlled Trial	X	X	X	X					X	
Level III: Controlled Trial without Randomization										
Level IV: Case-control or Cohort Study					X		X	X		X
Level V: Systematic Review of Qualitative or Descriptive Studies						X				
Level VI: Qualitative or Descriptive Study										

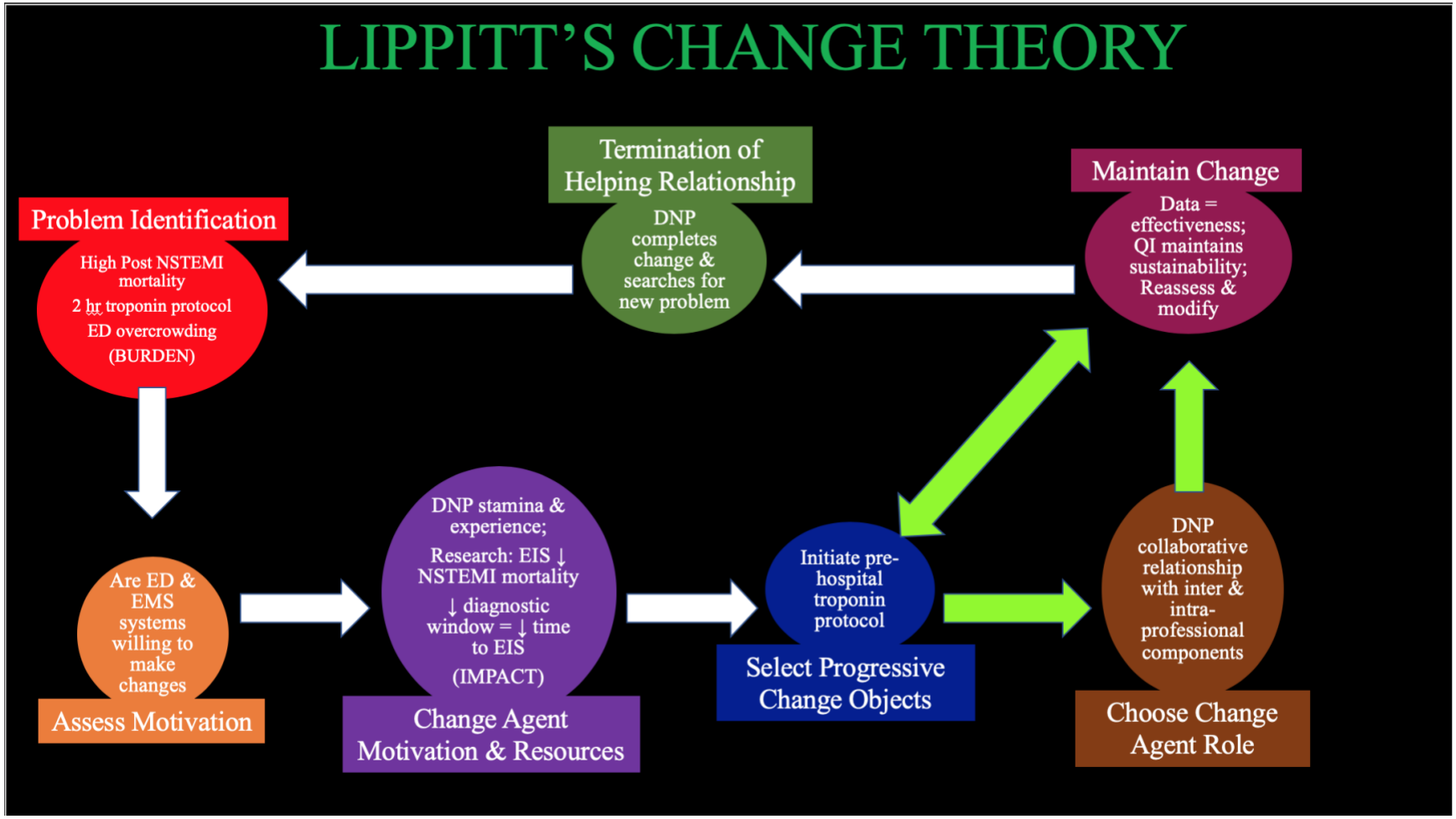
1 = Amsterdam, E., et al. (2014), 2 = Khera, S., et al. (2014), 3 = Layfield, C., et al (2015), 4 = Ezokowitz, J, et al. (2015), 5 = Venturini, J, et al. (2013), 6 = Borna, C., et al. (2016), 7 = Bierner, M., et al, (2015), 8 = Cullen, L, et al, (2013), 9 = Gimenez, M, et al. (2014), 10 = Ishak, M, et al. (2015), 11 = Saad, Y, et al. (2015), 12 = Stengaard, C, et al. (2013).

Appendix F. Outcome Measures Synthesis Table

	FMC to T1	T1 to T2	T2 to Dx	FMC to Dx	Dx to EIS	MACE
1	—	—	—	↓	↓	↓
2	—	—	↓	↓	↓	
3	↓	—	↓	↓	↓	—
4	—	—	↓	—	↓	↓
5	↓	↓	↓	↓	↓	↓
6	↓	↓	↓	↓	↓	↓
7	—	—	—	↓	↓	↓
8	↓	↓	↓	↓	↓	—
9	↓	↓	↓	↓	↓	—
10	↓	—	—	↓	↓	↓

FMC = First Medical Contact, T! = First Troponin, T2 = Second Troponin, Dx = Diagnosis, EIS = Early Invasive Strategy, MACE = Major Adverse Cardiac Events

Appendix G. Lippitt's Change Theory



Appendix H. Prehospital Troponin Logic Model