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Comparative Effectiveness Study of Acute Ischemic Stroke Care between Stroke Belt and Non-Stroke Belt Hospitals Using the Get with the Guidelines-Stroke Program

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Walden University
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Abstract

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by

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MD, Caribbean Medical University School of Medicine, 2022

MPH, Brody School of Medicine-East Carolina University, 2005

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health-Epidemiology Specialization

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Abstract

Stroke is a leading cause of mortality in the United States, particularly in a cluster of states termed the stroke belt. This study examined the efficacy of the Get With The Guidelines (GWTG)-Stroke program in stroke belt hospitals (SBHs) compared to non-stroke belt hospitals (NSBHs) regarding disparities related to mortality and acute ischemic stroke (AIS) treatment (i.e., recombinant tissue-type plasminogen activator [r-tPA] rates, Door-to-Needle [DTN], Door-to-Imaging [DTI]). Use of the GWTG-Stroke program was assessed to determine if SBHs and NSBHs were quantitatively equivalent in terms of specific core stroke measures. This quantitative employed an equivalence study design with over 2.9 million cases of secondary data from 2015 to2019 contained in the GWTG. Two one-sided-tests statistical analysis was performed on the American Heart Association's Precision Management Platform using an R package. Inclusionary criteria were AIS diagnosis, age of 18 years or older, and treatment at a hospital using the GWTG-Stroke program. Hospital and patient-level analyses were completed for each research question and differed based on level of analysis. Patient-level analysis revealed SBHs and NSBHs using the GWTG-Stroke program were equivalent in terms of DTN time and ischemic stroke only mortality; DTI was not equivalent. Hospital-level analysis revealed that r-tPA administration was equivalent, while DTN, DTI, and mortality were not equivalent. Study results will aid in promoting awareness and expansion of the value of structured and data-driven quality-improvement interventions that the GWTG-Stroke program uses in other healthcare settings.

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Dedication

I would like to dedicate this dissertation to two individuals who have greatly influenced and motivated me to succeed.

To my older cousin Charlie Jackson, you saw in me what others did not. Although you have left this sacred earth, I will never forget you. To my grandmother Norris Brown, you have raised me from a small child, always supported me, and assured me that I participated in activities that allowed me to flourish.

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To my lovely wife Janise, you have supported me throughout my endeavors. Your support and motivation have helped to propel me through this dissertation process. This dissertation is one of two cumulative accolades that will assist our future; I love you with all my heart.

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Chapter 1: Introduction to the Study

Introduction

The purpose of this study was to compare the efficacy of the American Heart Association's (AHA) Get With the Guidelines (GWTG)-Stroke quality program implementation within stroke belt hospitals (SBHs) and its association with improving acute ischemic stroke (AIS) treatment, patient mortality, and eliminating tertiary treatment disparities in comparison with non-stroke belt hospitals (NSBHs) participating in the program. As illustrated in the literature review, prior research has examined related topics, particularly use of stroke quality improvement programs and stroke registry data to improve AIS treatment in small subsets of hospitals in the United States (US). Previous studies have demonstrated that the implementation and use of structured quality initiatives enhances use of stroke modalities and the rate of defect-free stroke care, reducing stroke-related mortality. What was unclear is how implementation of quality improvement programs has affected America's most afflicted region, the Stroke Belt. I examined if the GWTG-Stroke quality program effectively increased r-tPA usage, reduced door to needle (DTN) time, and decreased stroke mortality in hospitals within the Stroke Belt. There was a lack of research focused on the efficacy of GWTG-Stroke program implementation within SBHs in comparison with NSBHs regarding and their associations with improving AIS treatment, patient outcomes, and eliminating treatment disparities.

Background

Stroke is the fifth leading cause of mortality in the US (Centers for Disease Control and Prevention [CDC], 2017; Man et al., 2017). Between 2014 and 2016, the age-adjusted stroke mortality rate in the US for all causes (ischemic and hemorrhagic combined) was 72.2 per 100,000 and 37.9 per 100,000 for ischemic stroke in persons 35 years of age and older (National Center for Chronic Disease Prevention [NCCDP], 2018a; NCCDP, 2018b). Ischemic stroke is the most common type of stroke, accounting for 87% of cases (Benjamin et al., 2017). Statistically, one out of every 20 deaths in the US is stroke-related, or approximately 800,000 people annually (CDC, 2017; CDC, 2018). Americans suffer acute strokes once every 40 seconds, resulting in one death every 4 minutes. The effects of a stroke are devastating and often lead to other health problems, making them the leading cause of long-term disability and admission to long-term care facilities in the US. Public health experts estimate the costs of such care at $34 billion yearly; these costs include healthcare, pharmacotherapy, and wages lost due to missed days of work (CDC, 2017).

Since 1980, eight contiguously clustered states in the American Southeast have represented the stroke belt due to their disproportionately high stroke mortality rates, which are 10% higher than the national average (Karp et al., 2016). Researchers have termed a cluster of Eastern coastal counties composing the stroke belt as the stroke buckle; these counties have stroke mortality rates that are twice as high as the national average (National Institute of Neurological Disease and Stroke [NINDS], 2018). This region has a higher concentration of stroke risk factors like hypertension, diabetes

mellitus, and smoking. The study by Howard et al. (2005) entitled REasons for Geographic and Racial Differences in Stroke (REGARDS) sponsored by the National Institute of Health (NIH) identified Black Americans had the highest risk of stroke and mortality, and increased stroke incidence in rural areas, and increased stroke mortality in the US stroke belt. Howard et al. (2018) said hospitals participating in the GWTG-Stroke program were more extensive in size (425 vs. 289 beds on average) more likely to participate in graduate medical education (GME) resident training (59.9% vs. 40.7%). Additionally, patients were more likely to receive recombinant tissue-type plasminogen activator (r-tPA) in GWTG-Stroke participating hospitals (*OR* = 3.69). Although differences in vascular risk factors explain most of the excessive burden seen in the stroke belt, additional factors remain poorly understood (Karp et al., 2016).

Treatment of AIS is time-dependent, relying on various treatment modalities to avoid later complications and death. The Joint Commission on Accreditation of Healthcare Organization (JCAHO) enacted the Stroke Center certification program to study core stroke quality metrics, aligning evidence-based practices. Implementing JCAHO Certified Stroke Programs (CSPs) increased acute stroke intervention while reducing stroke mortality (JCAHO, 2018). These centers have implemented the AHA's GWTG-Stroke program and improved functional outcomes at discharge and reduced post discharge mortality. Nevertheless, states situated in the stroke belt experience significant accessibility problems in JCAHO-certified stroke centers, suggesting that diminished access to care may contribute to elevated stroke-related illness rates in that area (Karp et al., 2016). Johnson et al. (2014) said patients received defect-free care most consistently

at hospitals preparing for certification (52.8%), followed by JCAHO primary stroke centers (45%). This suggests that hospital adherence to guidelines is essential to effective stroke patient care. Timely evaluation and treatment initiation for AIS is crucial, and clinical practice often fails to meet established policies and goals. Rural hospitals, such as those within the stroke belt, struggle to meet time-based goals expected by JCAHO-certified centers in urban environments (Jauch et al., 2018). Implementation and use of structured quality initiatives improves use of stroke modalities and enhances the rate of defect-free stroke care, which reduces stroke-related mortality. What was unclear is how these policies have affected America's most afflicted region. A significant knowledge gap existed. In this study, AIS care and mortality rates of patients presenting to hospitals in the GWTG-Stroke program were compared both within and outside the stroke belt.

Problem Statement

The gap in the literature addressed in this study related to efficacy of implementing the GWTG-Stroke program among SBHs and its association with improving AIS treatment, patient outcomes, and eliminating tertiary treatment disparities compared to NSBHs participating in this program. Researchers noted treatment differences or similarities between SBHs and NSBHs regarding AIS patient care treatment and modalities as well as stroke mortality. This is an equivalence study to provide insight and analysis regarding the efficacy of the GWTG-Stroke program among SBHs compared to NSBHs. I examined whether GWTG-Stroke implementation differed based on geographical location and attendant demographical factors. This study involved assessing the performance of the GWTG-Stroke program to determine if SBHs and

NSBHs were quantitatively equivalent. A lack of substantial discrepancy in yield between the two comparison groups would suggest that the GWTG-Stroke quality intervention effectively decreases AIS treatment disparities and mortality. I addressed the problem by examining significant differences in terms of mean distribution of r-tPA administration, door-to-imaging (DTI) time, DTN time, and AIS mortality among GWTG-Stroke participating hospitals. I examined GWTG-Stroke implementation and component differences based on geography for convenience. Comparison between the GWTG-Stroke program among SBHs and NSBHs is more relevant than GWTG-Stroke hospitals and Non-GWTG-Stroke hospitals as evaluated in prior studies because of the lack of a standardized quality improvement program and data collection instrument implementation nationwide. Most hospitals nationwide use the GWTG-Stroke program, which has a valid and reliable data instrument, and led to improved outcomes (AHA, 2019a).

Purpose of the Study

The purpose of this study was to compare the efficacy of the GWTG-Stroke program in terms of reducing key AIS treatment disparities and AIS stroke-related mortality between SBHs and NSBHs. This study aids in identifying trends that fostered improved patient care outcomes for AIS patients.

Previous research has demonstrated the effectiveness of the GWTG-Stroke program in terms of improving stroke quality metrics, increasing r-tPA usage, and decreasing mortality in urban hospitals outside of the stroke belt. However, the effectiveness of the GWTG-Stroke program to improve outcomes and reduce mortality in

SBHs compared to NSBHs remains unknown; thus, a gap in research knowledge existed. Increasing adherence to evidence-based practice (EBP) should decrease the above-average stroke mortality rate within the stroke belt. However, numerous covariates can also affect outcomes: not-for-profit versus for-profit, academic versus community medical centers, and location. Use of secondary analysis of existing data limits available variables and data for comment. Through an equivalence study using secondary data, I explored the effectiveness of stroke treatment policies in the stroke belt, the region of the US that still exhibits the highest stroke-related mortality rates in the country. I postulated that SBHs have adequately implemented the GWTG-Stroke program and thus would have no significant differences in outcomes compared to NSBHs using this program. The lack of significant differences in outcomes between the two comparison groups would suggest that the GWTG-Stroke program effectively decreases AIS treatment disparities and mortality. By implementing evidence-based practice guidelines for SBHs in the GWTG program, stroke rates will diminish, and the stroke belt should follow national trends in terms of decreased DTI and DTN times, improved r-tPA administration rates, and reduced stroke mortality.

Research Questions and Hypotheses

Research questions for equivalence studies are quantitatively based and should compare interventions among comparison groups. The research questions and hypotheses for this study are:

RQ1: Is there a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs?

H_01: There is a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

H_a1: There is no difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

RQ2: Is there a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs?

$H_0$2: There is a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

H_a2: There is no difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

RQ3: Is there a difference regarding in-hospital DTI time between SBHs and NSBHs?

$H_0$3: There is a difference regarding in-hospital DTI time between SBHs and NSBHs.

H_a3: There is no difference regarding in-hospital DTI time between SBHs and NSBHs.

RQ4: Is there a difference in terms of GWTG ischemic stroke only mortality rates between SBHs and NSBHs?

$H_0$4: There is a difference in terms of GWTG ischemic stroke only estimated mortality rates between SBHs and NSBHs.

H_a4: There is no difference in terms of GWTG ischemic stroke only estimated mortality rates between NSBHs and SBHs.

Conceptual Framework

The conceptual framework used in this study is Donabedian's lasting framework for healthcare quality. The Donabedian framework involves structure, process, and outcomes, along with seven pillars of quality (efficacy, effectiveness, efficiency, optimality, acceptability, legitimacy, equity) to evaluate quality of treatment (Ayanian & Markel, 2016). Fundamentally, theories can help identify barriers between patient needs and effective treatment. Various agencies have used the Donabedian framework extensively throughout the US to improve quality and achieve desired health outcomes. The conceptual framework is a modified Donabedian casual chain of quality factors influencing improved AIS patient treatment and outcomes (see Figure 1) and includes the framework's three dimensions of quality. Quality of outcome measures associated with variables studied as part of this research were ischemic stroke mortality and disability rates, r-tPA usage, DTI time, DTN times, and disparity reduction related to SBHs and NSBHs. The Donabedian model was used to assess healthcare quality and was helpful for this quantitative equivalence study. More detailed information on the conceptual framework is in Chapter 2.

Nature of the Study

I used an equivalence study design with a quantitative cross-sectional nonexperimental approach. Secondary analysis of existing data was completed. GWTG-Stroke data was available and required region-specific interpretations. This study's data and results provide quantitative evidence that may be useful to create relevant public healthcare policies and EBP. The primary objective of this study was to compare the

efficacy of the GWTG-Stroke program in terms of reducing ischemic stroke mortality and foster improvements in AIS treatment (DTN, DTI, and r-tPA administration rates) among SBHs and NSBHs. The independent variable was GWTG-Stroke hospital type based on geographical location and attendant demographical factors (i.e., SBH, NSBH). Dependent variables were patient outcomes, DTN time, DTI time, and r-tPA administration. The unit of analysis was GWTG-Stroke quality program implementation and use within hospitals stratified by geographical location and attendant demographical factors.

Definition of Terms

The following terms are defined to help the reader understand the context of each term in this study.

Acute Ischemic Stroke (AIS): A subtype of cerebral vascular accident (CVA), better known as stroke. Ischemic stroke pathogenesis is due to obstruction or occlusion of vessels supplying blood to the brain, resulting in sudden loss of blood circulation to an area of the brain and the corresponding loss of neurological function (AHA, 2019b; Goljan, 2013). Ischemic stroke accounts for 70-80% of stroke incidences involving the atherosclerosis line vessel wall, subsequently forming obstructions. There are two obstructions: cerebral atherosclerotic (thrombotic) and cerebral embolic (Goljan, 2013). Cerebral atherosclerotic thrombotic stroke is the most common type of ischemic stroke. AIS as an ischemic stroke that presents within 4.5 hours of ischemic stroke symptom onset. AIS patients with symptom onset before 4.5 hours can be administered intravenous

(IV) or intra-arterial (IA) r-tPA by clinicians if no contraindications exist regarding the treatment modality.

Door-to-Imaging (DTI) Time: DTI time measures time from presentation to the hospital or activation of in-hospital code stroke to brain imaging (i.e., non-contrast computerized tomography [CT] or magnetic resonance imaging [MRI]). Prehospital imaging, as in the case with prehospital or Emergency Medical Services (EMS) mobile stroke units, is not considered.

Door-to-Needle (DTN) time: DTN time measures the timespan from initial arrival to hospital or activation of in-hospital code Stroke to administration of thrombolytic therapy (i.e., r-tPA) for patients with imaging completed, confirmed ischemic stroke, and no drug contraindications present. In this study, I did not consider prehospital administration of r-tPA (i.e., prehospital, EMS, and mobile stroke units).

Non-Stroke Belt Hospital (NSBH): Hospitals (i.e., academic and nonacademic medical centers, JCAHO CSPs, and noncertified programs) that participate in the GWTG-Stroke program and are located outside of the eight stroke belt states.

Recombinant Tissue Plasminogen Activator (r-tPA/Alteplase): r-tPA is a recombinant thrombolytic drug available in a synthesized endogenous tissue plasminogen form (Trevor et al., 2015). r-tPA is a serine protease; proteases are enzymes that cleave peptide bonds in proteins and are essential components of blood clot dissolution (Jilani & Siddiqui, 2019). The pharmacological mechanism of action of r-tPA is based on its enzymatic activity that directly converts plasminogen to plasmin by cleaving the zymogen plasminogen from fibrin in the coagulation cascade. Subsequently, plasmin

dissolves the thrombus (blood clot; Jilani & Siddiqui, 2019; Trevor et al., 2015). Alteplase (r-tPA) is a Food and Drug Administration (FDA)-approved human plasminogen activator authorized to manage AIS. The drug is administered at a 0.9 mg/kg dosage through an IV infusion; 10% of the total dosage is administered initially as a bolus over 1 minute. The remaining is gradually infused over 1 hour (Jilani & Siddiqui, 2019). Prompt r-tPA usage within 3 hours of initial stroke symptoms in patients with AIS and no contraindication for r-tPA (i.e., cerebral hemorrhage or increased bleed risk) has been associated with significantly better clinical outcomes (Trevor et al., 2015).

Stroke Belt: The stroke belt is a geographical area in the Southeastern US and Mississippi Valley with high stroke mortality rates (Stroke Center, 2019). Eight contiguously clustered states in the American Southeast have disproportionately high stroke mortality rates that are 10% higher than the national average (Karp et al., 2016). The eight states that compose the stroke belt are Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee.

Stroke Belt Hospital (SBH): Academic and nonacademic medical centers, JCAHO CSPs, and noncertified programs participating in the GWTG-Stroke program that are located within the eight stroke belt states.

Assumptions of the Study

I assumed that data collection and synthesis from GWTG-Stroke program during the specified timeframe was adequate for this study. Furthermore, I assumed that the GWTG-Stroke database had sufficient and appropriate data. I also assumed that diagnoses of ischemic stroke were correct and confirmed by a licensed physician or

physician extender. An additional assumption was that all healthcare data for tertiary healthcare systems was available and accurate. Hospitals participating in the GWTG-Stroke program were assumed to be pursuing a JCAHO Stroke Center certification.

Scope and Delimitation of the Study

I examined significant differences in terms of distribution of r-tPA administration, DTN time, DTI time, and AIS estimated mortality among SBHs compared to NSBHs using the GWTG-Stroke quality program. There were minimal studies in which researchers use GWTG-Stroke data to examine AIS treatment and outcome differences between SBHs and NSBHs. Secondary analysis of existing data was performed on a convenience sample. The secondary dataset included all patients who presented with stroke symptoms to a hospital that implemented and used the GWTG-Stroke program. The study population in this study included patients diagnosed with an ischemic stroke. This study did not focus on hemorrhagic stroke subtypes.

Limitations of the Study

Despite the advantages of the GWTG-Stroke quality program, which offers a platform for collecting core stroke measure data, quality indicators, and reportable data, the disadvantages of the registry component and its data are also noteworthy. Limitations of this study are associated with secondary analysis of existing data. The secondary data instrument, variables, and data collection were finalized; information pertaining to additional research inquiries was not possible because of prior data instrument and variable selection. Missing data and incorrect input by data abstractors also resulted in missing data identified as outliers. An additional limitation was that not all hospitals

within a specific region participate in the GWTG-Stroke program; thus, there was no way of knowing if the dataset represented all hospitals within an area. The data and study sample lacked homogeneity in terms of specific research questions due to stroke belt states being much smaller than non-stroke belt states.

Ethical Considerations

Information retrieved from the data source was deidentified secondary data. All data and information obtained were confidential and not divulged to any party or used for any other purpose apart from this research study. This research study was conducted per Institutional Review Board (IRB) ethical practices and AHA GWTG data request guidelines.

Significance of the Study

I sought to fill a significant gap in current understanding of stroke treatment. By focusing on treatment interventions and mortality rates in a single geographical treatment facility type, researchers and physicians will better understand stroke treatment programs in the region most severely affected by this health crisis. The GWTG-Stroke program has improved stroke care and critical process measures. However, the impact regarding SBH treatment and mortality remains limited. Howard et al., (2018) said 1,656 out of 5,564 (29.8%) of hospitals in the US currently use the GWTG-Stroke Program.

Little research has compared regional differences in terms of efficacy of the GWTG-Stroke program on stroke mortality and r-tPA administration in hospitals within and outside the stroke belt. By analyzing management and treatment of AIS, researchers and physicians in stroke belt states may learn ways to improve quality and continuity of

stroke care and identify more productive ways to manage AIS patients while reducing stroke mortality rates and long-term disability. This study will lead to public health benefits and positive social change by reducing mortality and improving survivability among stroke victims in stroke belt states. By comparing the efficacy of the GTWG-Stroke program within and outside of stroke belt states, I examined the notion that elevated rates of stroke-related mortality in that region are reducible in terms of stroke-associated risk factors alone, rather than deficiencies in proper stroke treatments.

Within hospitals that have implemented the GWTG-Stroke program, there are reductions in stroke mortality rates, along with increases in intervention usage. The point where primary preventative methods are effective in terms of drastically reducing mortality in the stroke belt is no longer possible. Tertiary prevention, along with use and implementation of the GWTG-Stroke program, may reduce stroke mortality and increase intervention use within the stroke belt region.

Social Implications

Social implications related to public health benefits include reducing patient deficits, long-term disability, and stroke-related healthcare costs. This would lead to improved patient outcomes such as increased functionality status post-ischemic stroke and declines in ischemic stroke-related mortality rates. Furthermore, by identifying treatment methods that can decrease disproportionate stroke mortality rates within the stroke belt, hospital administrations and policymakers may assist in the reallocation of public health resources.

Summary

I sought to understand and compare the efficacy of the GWTG-Stroke quality program in terms of reducing stroke-related mortality and improving AIS treatment and patient outcomes in SBHs and NSBHs. Previous research has been done on related topics, particularly use of stroke quality improvement programs and stroke registry data to improve AIS treatment in small subsets of hospitals in the US. There was a gap in the literature related to the efficacy of the GWTG-Stroke program within SBHs compared to NSBHs regarding improving AIS treatment and outcomes and eliminating tertiary treatment disparities.

Four additional chapters follow. Chapter 2 is a comprehensive review of literature on the implementation of stroke quality improvement programs and use of stroke registry data to improve patient treatment and outcomes for AIS patients. In Chapter 2, the primary topic discussed is the gap in literature related to GWTG-Stroke implementation within SBHs specifically, and associated changes, if any, resulting from decreasing disparities in AIS patient treatments and outcomes. My goal was to clarify and fill this gap in literature. In Chapter 3, topics include an overview of the research design and methodology. Research results are provided in Chapter 4, followed by an interpretation of findings in Chapter 5.

Chapter 2: Literature Review

Introduction

Stroke is the fifth leading cause of mortality in the US (CDC, 2017; Man et al., 2017). Between 2014 and 2016, the age-adjusted ischemic stroke mortality rate in the US was 37.9 per 100,000 in persons 35 years of age and older (NCCDP, 2018a; NCCDP, 2018b). Ischemic stroke is the most common type of stroke, accounting for 87% of cases (Benjamin et al., 2017). Since 1980, eight contiguously clustered states in the American Southeast have represented the stroke belt due to disproportionately high stroke mortality rates, which are 10% higher than the national average (Karp et al., 2016). Researchers have termed a cluster of Eastern coastal counties within the Stroke Belt as the stroke buckle; these counties have stroke mortality rates that are twice as high as the national average (NINDS, 2018). Stroke is the leading cause of long-term disability and admission to long-term care facilities in the US. Public health experts estimate the costs of such care at $34 billion yearly; these costs include healthcare, pharmacotherapy, and wages lost due to missed days of work (CDC, 2017). Consequently, stroke has a detrimental impact on individual health status, public health, quality of life, and healthcare expenditure. Therefore, to minimize the damaging effect of stroke, it is of great importance that AIS patients in the stroke belt receive quality care based on EBP that is comparable to their counterparts outside the stroke belt.

I examined whether the GWTG-Stroke program differed based on geographical location and attendant demographical factors. The gap in literature that this study addressed was efficacy of the GWTG-Stroke program in terms of reducing ischemic

stroke-related mortality and improving AIS treatment in stroke belt hospitals compared to hospitals outside the stroke belt. Researchers may have noted various treatment differences or similarities between SBHs and NSBHs related to AIS patient care treatment modalities usage (i.e., intravenous r-tPA administration, DTN time, DTI time) and stroke mortality. A quantitative study design was used to provide insight and analysis on the efficacy of the GWTG-Stroke quality program within SBHs compared to NSBHs.

In Chapter 1, I discussed AIS as a leading cause of mortality. First, AIS was addressed as a significant public health issue that disproportionately affects the stroke belt. Secondly, I discussed stroke core measures and JCAHO CSPs. Finally, I discussed implementation of quality improvement programs and associations with improved stroke core measures. In this chapter, I discuss stroke belt history, JCAHO CSP development, stroke core measures, and the GWTG-Stroke program. As part of this chapter, I provided a literature review of quality improvement program implementation and associated improvements in terms of key stroke core outcomes. Furthermore, I identified existing gaps in literature and discuss the theoretical framework that was applicable to this research study. The following literature review includes evidence that quality improvement program implementation and use is associated with improved AIS patient care treatment and outcomes related to this study's measures.

Literature Search Strategies

A literature search was completed using the Medline, PubMed, and Google Scholar electronic databases. The following key terms were used in the literature: *acute ischemic stroke, door-to-imaging, door-to-needle, quality improvement, GWTG-stroke,*

get with the guidelines, *r-tPA*, and *stroke belt.* Sources were peer-reviewed articles published between 2015 and 2020. A limited number of articles published before 2015 were referenced to provide additional context pertaining to historical changes.

History of Stroke Performance Measures and Stroke Center Formation

The formation of clinical practice guidelines (CPGs) for AIS based on EBP started in 1994 with the AHA's first AHA stroke CPGs. A special study group from the National Institute of Neurological Disorders and Stroke (NINDS) in 1995 determined that rt-PA was the first effective therapy for AIS and was safe and effective within 3 hours of stroke symptom onset (Marler, 1995). The NINDS rt-PA study group incorporated its findings into the AHA stroke CPG the following year. A multidisciplinary working group of representatives from major stakeholder organizations involved in stroke care convened the Brain Attack Coalition (BAC) to strategize future initiatives. The BAC proposed criteria for Primary Stroke Center (PSC) and Comprehensive Stroke Center (CSC) certification. The BAC criterion for PSC stated centers should have outcomes and quality improvement, and a database or registry to track stroke type, treatment, timelines, and outcome and performance measures.

Additionally, the BAC also called for written stroke care protocols (Albert et al., 2000). The JCAHO began PSC certifications in 2003. Over the past decade, JCAHO has enacted certified stroke centers, along with JCAHO stroke core measures (STKs) that align with EBP to reduce mortality and disability status post-stroke. With policy development came the evolution of stroke systems of care and the possibility of AIS

patients in hospitals that lacked the capacity of certified stroke programs (CSPs, and many hospitals began to pursue certification.

CSCs

The JCAHO initially certified PSCs and then CSCs based on certification criteria from the BAC. Currently, Joint Commission disease-specific care (DSC) (CSPs) are inclusive of the following four types: Acute Stroke Ready Hospital (ASRH), PSC, Thrombectomy-Capable Stroke Center (TSC), and CSC. Various Joint Commission CSPs designations are ordered from entry-level (ASRH) to most comprehensive (CSC). All certified stroke programs have the capacity to, at a minimum, provide r-tPA as thrombolytic therapy for AIS (JCAHO, 2019).

Stroke Performance Measures

The BAC recommended that a certified center engages in outcomes and quality improvement (Albert et al., 2000). The BAC, in collaboration with the AHA/ASA, created the core stroke measures for PSCs initially. The JCAHO requires PSC, TSC, and CSC to submit data monthly to maintain certification; eight JCAHO STK core measures are currently required and are referenced as core stroke measures or STKs. The STK measures or core measures are venous thromboembolism (VTE) prophylaxis (STK-1), discharge on antithrombotic therapy (STK-2), anticoagulation therapy for atrial fibrillation/flutter (STK-3), thrombolytic therapy (STK-4), antithrombotic therapy by the end of hospital day two (STK-5), discharged on statin medication (STK-6), stroke education (STK-8), and assessed for rehabilitation (STK-10). The eight STK core measures set is also the national inpatient hospital quality measure set for stroke and

provides data for STK electronic clinical quality measures (eCQMs). The required core stroke measures for PSCs and higher were updated in 2019 to include two new measures: stroke outpatient (STK-OP-1), which measures door-to-transfer (DTF) time to another facility, and comprehensive stroke (CSTK-01) that, measures NIHSS score performed for ischemic stroke patients. The 2019 updates required measures for PSC-certified centers and higher, while ASRHs has three inpatient stroke measures that are not STK core measures.

GWTG-Stroke

The AHA and ASA created the GWTG-Stroke quality program and, after a successful pilot phase, began enrolling hospitals in April 2003 (Song et al., 2016). Since the GWTG-Stroke program's creation, more than 2,000 hospitals have entered over five million patient records that researchers have used to publish multiple studies documenting improved patient outcomes (AHA, 2019a). Hospital data submission and feedback reports are available through the AHA's Patient Management Tool (PMT), an online interactive platform provided by IQVIA (AHA, 2019a). IQVIA serves as the data collection and coordinating center for AHA GWTG (AHA, 2019a). The GWTG-Stroke program is a voluntary stroke registry and nationwide performance improvement program. The GWTG-Stroke platform fulfills the BAC PSC criterion recommendations that centers should have: outcomes and quality improvement, and have a database or registry to track stroke type, treatment, timelines, and outcome measures (i.e., performance measure) (Albert et al., 2000). Core Stroke Measures require submission to Centers for Medicare and Medicaid (CMS) and JCAHO using GWTG. The AHAs

GWTG-Stroke Program fulfills both requirements simultaneously while reinforcing written care protocols utilizing clinical tools and resources. The web based interactive PMT allows hospitals to download reports without delay for utilization in quality improvement projects (AHA, 2019a). The GWTG-Stroke Program is the most used stroke registry and quality improvement program throughout the United States.

Stroke Belt

The Stroke Belt is a geographical area in the Southeastern United States and Mississippi Valley, with high stroke mortality rates (Stroke Center, 2019). Eight contiguously clustered states in the American Southeast have represented the so-called "Stroke Belt" due to their disproportionately high stroke mortality rates—ten percent higher than the national average (Karp et al., 2016). The eight states that compose the Stroke Belt are Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee (Howard & Howard, 2020). The disproportionately high stroke mortality rates date back 40-years and persist despite an overall decline in stroke mortality rates Nationwide (Karp et al., 2016). The risk of AIS varies as it is region-specific, but the highest incidence of AIS has been noted in the "Stroke Belt" region (Howard & Howard, 2020). The disparity within the Stroke Belt compared to nationwide treads may be related to Primary Stroke Center (PSC) access being lower within the Stroke Belt regions, suggesting diminished access to care may be a contributing factor (Karp et al., 2016). This study must state that patients receiving r-tPA at an outside hospital or mobile stroke unit were excluded from this research study population.

Quality Initiative Implementation and Improved AIS Outcomes

Previous researchers have noted that structured quality improvement interventions like GWTG-Stroke increase the number of patients that receiver-tPA within the recommended 60-minute DTN (Jauch et al., 2018). While past research studies have focused on the systemic stroke quality initiatives such as GWTG-Stroke based on nationwide trends, there has not been an equivalence study that assesses GWTG-Stroke utilization in SBHs (Cumbler et al., 2014; Howard et al., 2018; Ormseth et al., 2017; Romano et al., 2018). Over the past five years, research suggests improved hospitals' adherence to stroke quality metrics has resulted in improved outcomes and reduced mortality for stroke patients. Based on REGARDS study data, Howard et al. (2018) concluded that the care of stroke patients admitted to hospitals participating in GWTG-Stroke were more likely to meet stroke quality care metrics. The AHA/ASA has conducted several studies utilizing its GWTG-Stroke Program; most have demonstrated that the GWTG-Stroke Program has improved stroke care and critical process measures (AHA, 2019a). However, the impact on Stroke Belt Hospital treatment and mortality remains limited. These previous studies compared JCAHO-certified stroke centers and non-certified hospitals implementing GWTG Stroke. Prior research studies examined the efficacy of IV-r-tPA, r-tPA administration rates, and status-post intervention outcomes such as hemorrhage, disability, and mortality. Stroke belt hospital data is readily available for the researcher to examine and housed within the GWTG-Stroke Registry.

Prior studies have examined the implementation of acute ischemic stroke quality initiatives regarding r-tPA administration rates and door-to-needle time. Fonarow et al.

(2014) examined the DTN time for r-tPA administration and clinical outcomes in AIS patients before and after implementing a quality improvement initiative. The study measured in-hospitality and all-cause mortality, discharge status, ambulatory status at discharge, r-tPA administration rates, and complication rates. The researchers utilized data obtained from the GWTG-Stroke national quality improvement program. Fonarow et al. (2014) study revealed that clinical outcomes, DTN time, and r-tPA administration rates improved significantly during the postintervention period. The mean DTN time for r-tPA administration during the preintervention period was 77 min (interquartile range [IQR]: 60-98 min) and decreased to 67 min (IQR: 51-87 min) during the postintervention period (P-value [P] < .001). Door-to-needle times for r-tPA administration of 60 min or less increased from 26.5 percent (95 percent CI, 26.0 percent-27.1 percent) of patients during the preintervention period to 41.3 percent (95 percent CI, 40.8 percent-41.7 percent) during the postintervention period (P < .001). The Fonarow study suggests the postintervention period is essential for reducing in-hospital mortality, minimizing symptomatic intracranial hemorrhages, decreasing r-tPA complications, improving independent ambulation at discharge, and increasing discharge-to-home rates. Moreover, appropriate treatment during the postintervention period reduced the likelihood of in-hospital mortality (adjusted OR, 0.89 [95 percent Confidence Interval [CI], 0.83-0.94], P < .001). Fonarow et al. (2014) concluded that implementing a national quality improvement initiative was associated with improved timeliness of r-tPA administration following AIS on a national scale. This improvement resulted in lower rates of in-hospital mortality and intracranial hemorrhage and an increase in the percentage of patients

discharged home. While Fonarow et al. (2014) found that implementing AIS quality initiatives significantly improved clinical outcomes, DTN time, and r-tPA administration rates, Jauch et al. (2018) approached the problem in another way.

Similarly, there are parallels to the study by Fonarow et al. (2014); Jauch et al. (2018) examined the effect of implementing a systematic quality initiative to improve outcomes in AIS care within a rural emergency department (ED). They obtained a convenience sample using a retrospective chart review for five non-primary stroke center (PSC) hospitals in the Stroke Belt between May 2015 and May 2017. At the baseline, clinical staff in participating emergency departments overestimated the proportion of patients with AIS administered alteplase (r-tPA) within their facility's recommended 60-min DTN window. At the end of the intervention (i.e., six months), there were significantly more AIS patients treated with alteplase within the recommended DTN window compared to the baseline across the entire sample (1.9 percent of patients at baseline versus 5.2 percent at six months; $P < 0.01$). There was a significant trend towards a decrease in the percentage of patients who received alteplase (r-tPA) more than 60 min after they arrived at the ED (67.3 percent at baseline vs. 22.2 percent at six months. The results of this initiative reaffirm the value of structured, data-driven quality-improvement interventions such as GWTG-Stroke in the administration of r-tPA within the 60 minutes DTN time. The Jauch et al. (2018) study rendered similar results to the Fonarow et al. (2014) concerning improved DTN times post quality initiative implementation. The Fonarow study focused on rural emergency departments, which are more analogous to SBHs in Southern and rural states. Providing evidence-based acute

stroke care at hospitals throughout the Stroke Belt is critically important to mitigate the adverse effects of patient morbidity and mortality. Residents of the southeastern United States generally have significantly less timely access to PSCs than individuals living in other regions of the United States. Specific to AIS identification and management, the GWTG-Stroke Quality Program within the AHA/ASA's "Target: Stroke Initiative" provided participating hospital teams with various resources resulting in a significant improvement in the number of patients with a DTN time of ≤ 60 min over ten years. The Jauch et al. (2018) study examined systemic quality improvement program implementation in rural emergency departments located in the Stroke Belt. Jauch and researchers' study results suggest that quality program implementation helps improve stroke outcomes and core measures; this study did not compare SBH and NSBH or focus on the GWTG-Stroke quality improvement program directly.

Building upon finding in the Jauch et al. (2018) and Fonarow et al. (2014) studies, Howard et al. (2018) added a level of complexity by examining GWTG-Stroke quality program implementation directly. Based on the REGARDS study data, Howard et al. (2018) examined differences in stroke care between patients in hospitals participating in the GWTG-Stroke program and those that were not. The Stroke Belt had fewer patients treated at GWTG hospitals (46.9 percent versus 60.8 percent). This discrepancy has a significant impact on treatment. Past studies have found that GWTG hospitals are significantly more extensive and more likely to participate in graduate medical education (GME) resident training (59.9 percent versus 40.7 percent). Patients treated in GWTG hospitals were more likely to be administered r-tPA (OR = 3.69), education on stroke risk

factors and warning signs (OR = 1.52), swallowing evaluation (OR = 1.26), lipid profile evaluation (OR = 1.17), and evaluation by a neurologist (OR = 1.12) (Howard et al., 2018). The researchers concluded that the care of stroke patients admitted to hospitals participating in the GWTG-Stroke was more likely to meet important stroke quality care metrics. Howard et al. (2018) posits that hospitals participating in GWTG-Stroke were more likely to meet stroke quality metrics. Fewer patients within the Stroke Belt presented to hospitals participating in GWTG-Stroke. The Howard et al. (2018) study did not compare SBH and NSBH participating in GWTG-Stroke. The Fonarow study coincided with REGARDS study findings; Fonarow et al. (2018) suggest that implementing AIS quality initiatives is efficacious in improving core stroke measures concerning r-tPA administration and DTN time in rural hospitals. Such as those identified by Howard et al. (2018) identified rural hospitals in the Stroke Belt as being less extensive regarding GWTG-Stroke participation, medical specialists, and graduate medical education.

Acute ischemic stroke treatment and outcomes are time dependent. Efficient and well prime processes are needed to ensure that imaging is completed promptly, contraindications are assessed, and that door-to-needle time is within time parameters to avoid complications and mortality. Goldstein (2014) took an in-depth look at the medical management of AIS, including r-tPA-based data from a pooled analysis of four randomized trials. Goldstein identified that the main complication of treating AIS patients with IV-r-tPA is the potential for brain hemorrhage. In the pooled analysis, large-type intracranial hemorrhage occurred in 5.2 percent of patients in the IV-r-tPA group versus

1.0 percent in the control groups (OR 5.37, 95 percent CI, 3.22-8.95). There was no significant relationship between bleeding risk and time between onset to treatment time (OTT) up to 6 hours. This information significantly impacts intervention usage (i.e., r-tPA) and associated detrimental outcomes such as associated mortality. Building on Goldstein's finding, Saver et al. (2013) added complexity by evaluating how OTT time affects the outcome among AIS patients treated with intravenous r-r-tPA. The study's methodology included data from 58,353 AIS patients treated with r-tPA within 4.5 hours after symptom onset in 1395 hospitals participating in the GWTG-Stroke Program from April 2003 to March 2012. Saver et al. (2013) identified the relationship between OTT time and in-hospital mortality. They also concluded that the median OTT time was 144 min (IQR, 115-170), 9.3 percent (5404 patients) had an OTT time of 0 to 90 min, 77.2 percent (45,029 patients) had an OTT time of 91 to 180 min, and 13.6 percent (7920 patients) had OTT time of 181 to 270 min. Faster OTT times, in 15-minute increments, was associated with reduced in-hospital mortality (OR, 0.96; 95 percent CI, 0.95-0.98; P < .001), reduced symptomatic intracranial hemorrhage (OR, 0.96; 95 percent CI, 0.95-0.98; P < .001), increased independent ambulation at discharge (OR, 1.04; 95 percent CI, 1.03-1.05; P < .001), and increased discharge to home (OR, 1.03; 95 percent CI, 1.02-1.04; P < .001). The researchers concluded that earlier thrombolytic treatment (r-tPA) is associated with reduced mortality rates and reduced symptomatic intracranial hemorrhage.

These previous studies are essential for developing and implementing healthcare structure and public health intervention, initiatives, and communication, resulting in the improved health status of AIS patients.

Conceptual Framework

Donabedian Model

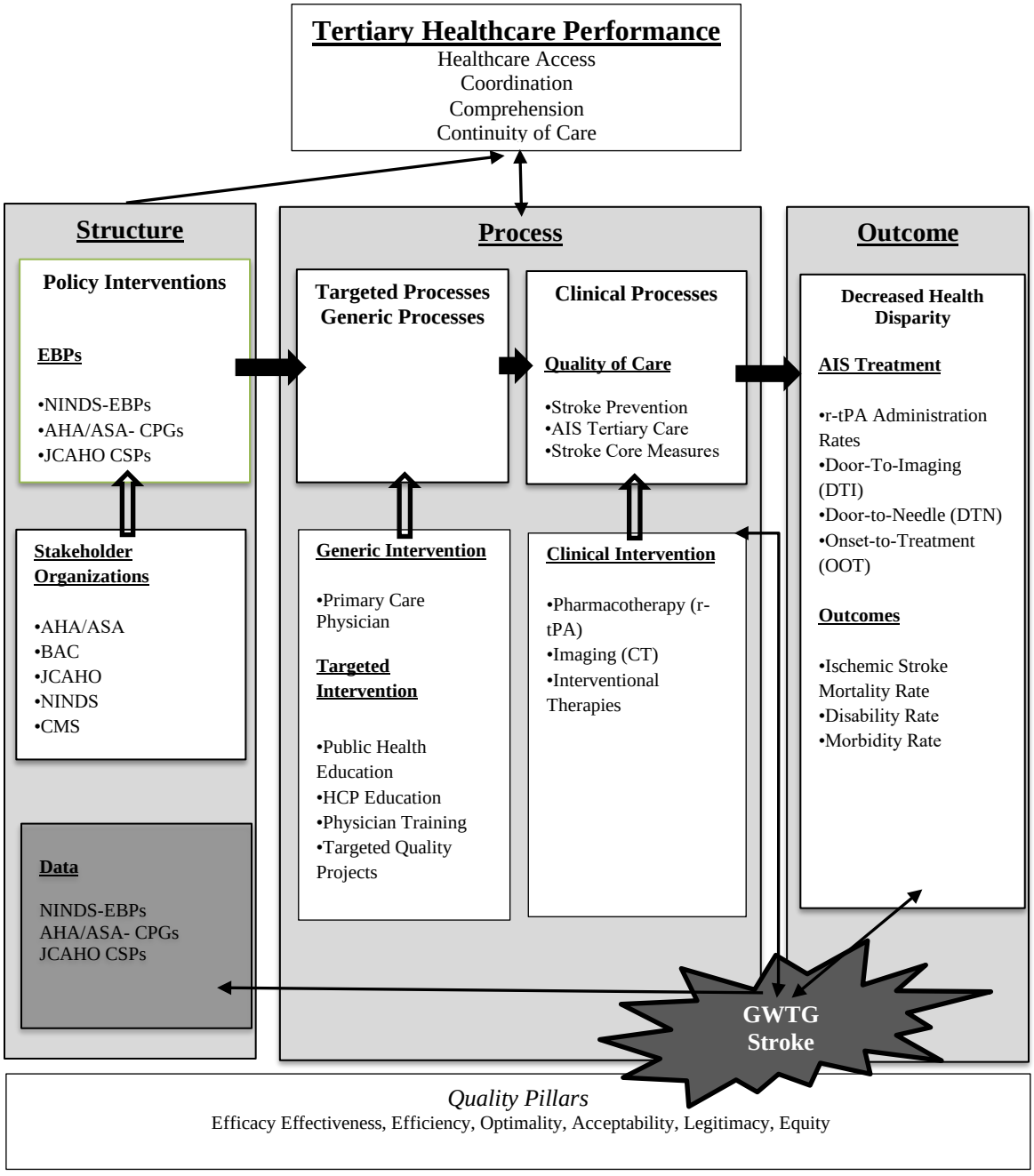
Growing evidence suggests that theory-based public health initiatives have increased efficacy when appropriately deployed in hospital settings. The health behavior of the patient population and the healthcare practitioner plays a significant part in dictating patient outcomes. Theories can guide patients and healthcare providers who may wonder why or why not specific health intervention is efficacious. Fundamentally, theories can also help identify barriers between patient needs and effective treatment. The specific focal aspect of healthcare is AIS treatment during the post-intervention period in GWTG-Stroke participating hospitals in the Stroke Belt. Healthcare professionals need to know more about improving the efficacy and administering treatments expediently. The barriers noted in past research studies are related to delays in patient presentation, imaging, and the completion of laboratory tests. To overcome these barriers, we will use Donabedian's lasting framework for health care quality, which utilizes a triad of structure, process, and outcome—along with seven pillars of quality (i.e., efficacy, effectiveness, efficiency, optimality, acceptability, legitimacy, equity)—to evaluate the quality of treatment (Ayanian & Markel, 2016). The theoretical framework illustrating a modified Donabedian casual chain of quality factors influencing improved AIS patient

treatment and outcomes (see Figure 1) includes the framework's three dimensions of quality: quality of structure, process, and outcomes.

Structure describes the context in which healthcare providers deliver patient care and is influenced by policy (i.e., hospital infrastructure, staffing, equipment, and financing) as implemented by stakeholders. *Process* denotes the delivery of healthcare services and transactions between providers and patients; targeted interventions (i.e., stroke education, training), clinical interventions (i.e., r-tPA, brain imaging, therapies), are integral components of the quality of the process. *Outcomes* are the effects of healthcare on the health status of patients and populations; examples are ischemic stroke mortality, disability rate, increased r-tPA usage, decreased DTI times, DTN times, and disparity related to SBHs and NSBHs. Healthcare providers have used this framework extensively throughout the United States by various agencies: the U.S. Public Health Service (USPHS) Health Services Research Section (HSRS), the Centers for Medicare and Medicaid (CMS), and the Institute of Medicine (IOM). The Donabedian framework assesses "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and consistent with current professional knowledge" (Ayanian & Markel, 2016, p. 206). Healthcare providers utilize alternative quality improvement frameworks, such as the World Health Organization's (WHO) "Quality of Care Framework" and the "Bamako Initiative Framework." Nevertheless, the Donabedian model remains the dominant framework utilized to assess healthcare quality and is helpful for this quantitative equivalence study.

Figure 1

Donabedian's Causal Chain of Quality Model



Summary and Conclusion

Findings from the literature review were that implementation of quality improvement programs is associated with improved AIS patient treatment and improvement in terms of stroke core measures. Stroke quality program implementation increases adherence to stroke core measures (Cumbler et al., 2014; Howard et al., 2018; Ormseth et al., 2017; Romano et al., 2018). Based on literature review results, implementation of stroke quality improvement programs, systemic non-GWTG programs, and the GWTG-Stroke program results in improved intervention usage, patient outcomes, and decreased mortality rates. Fonarow et al. (2014) said implementation of systemic quality improvement resulted in improved r-tPA DTN times and decreases in overall r-tPA administration complications, in-hospital mortality, and intracranial hemorrhage. Saver et al. (2013) said implementation of the GWTG-Stroke program improved OTT, resulting in decreased mortality, decreased intracranial hemorrhage status post r-tPA administration, and improved discharge disposition. Jauch et al. (2018) said implementation of the GWTG-Stroke program was associated with improvements in DTN time within hospitals that use quality improvement programs; furthermore, improvements in DTN should correlate with increases in the number of patients eligible for r-tPA administration. Howard et al. (2018) said hospitals that use the GWTG-Stroke program had increases in r-tPA administrations rate and adherence to stroke core measures.

At the time of the current study, there were no studies that compared implementation of the GWTG-Stroke program between SBHs and NSBHs. Past studies

have examined the performance of systemic quality improvement programs (non-GWTG) and GWTG-stroke in hospitals throughout the US. In this literature review, research has demonstrated the effectiveness of quality improvement program implementation and its association with improving stroke quality metrics, increasing r-tPA usage, and decreasing mortality in urban hospitals outside of the stroke belt. However, the effectiveness of the GWTG-Stroke program to improve outcomes and reduce mortality in SBHs compared to NSBHs remains unknown. Through an equivalence study involving secondary data, I examined the effectiveness of GWTG-Stroke implementation in the stroke belt by comparing SBHs and NSBHs to fill this gap in literature. Chapter 3 includes research methods used for secondary analysis of existing data within the GWTG-Stroke program. In Chapter 4, I provide results of the study. Chapter 5 includes study results, limitations, future research recommendations, and social change implications.

Chapter 3: Research Methods

Introduction

In Chapter 2, I provided a literature review involving quality improvement program implementation and associated improvements in terms of key stroke core outcomes and measures, identified an existing gap in literature, and provided a discussion of Donabedian's lasting framework for health care quality as it relates to this study. More specifically, I assessed if GWTG-Stroke implementation differed based on geographical location and attendant demographical factors. The purpose of this study was to compare the efficacy of the GWTG-Stroke quality program in terms of reducing key AIS treatment disparities and stroke-related mortality in SBHs as compared to NSBHs outside the stroke belt. As part of this research, I examined trends that foster improved patient care outcomes for AIS patients presenting to SBHs. Using an equivalence study design with secondary analysis of existing data, I explored the effectiveness of stroke treatment policies in the stroke belt.

I postulated that SBHs have adequately implemented the GWTG-Stroke program and thus there were no significant differences in terms of outcomes compared to NSBHs. I assumed no significant differences in terms of distribution of crucial AIS treatment measures (r-tPA administration, DTI time, DTN) and AIS-estimated mortality among GWTG-Stroke participating hospitals. I hypothesized the two intervention groups were equivalent. Evidence suggested that the GWTG-Stroke program effectively decreased AIS treatment disparities and mortality. This chapter includes an overview of the statistical methodology employed to compare efficacy of the GWTG-Stroke quality

program in terms of reducing stroke-related mortality and improving AIS treatment between SBHs and NSBHs. In this chapter, I discuss participants, methodology, instrumentation, procedures, and the data analysis plan. In addition, the research design, threats to validity, and protection of participants are discussed in this chapter.

Research Design and Rationale

I employed an equivalence study design using a quantitative cross-sectional nonexperimental approach. Secondary analysis of existing data was used. This equivalence research study involved comparing the efficacy of the GWTG-Stroke quality program in terms of reducing stroke-related mortality and improvements in AIS treatment (DTN time, DTI time, and r-tPA administration rates) within SBHs and NSBHs. The independent variables were GWTG-Stroke hospital type, geographical location, and attendant demographical factors. The dependent variables were patient outcomes, including mortality, DTN time, DTI time, and r-tPA administration. The unit of analysis was GWTG-Stroke quality program implementation and use within hospitals stratified by geographical location and attendant demographical factors.

An equivalence study design was employed in this study; this study design is most appropriate for measuring efficacy of medical therapies or interventions (Indrayan, 2013). Equivalence studies help in terms of examining mean responses to treatments or interventions (Rao & Chakraborty, 1991). Equivalence testing is the appropriate testing method to eliminate health disparities across different demographic groups and is helpful in public health policies (Ahn et al., 2013). Equivalence studies examine whether two groups are essentially equivalent or similar enough in terms of a particular endpoint, as

well as differences which result as medical consequences (Indrayan, 2013). I operationally defined the term equivalence in this study as the efficacy of two therapies or interventions being close or similar enough that one cannot be considered superior, or inferior compared to the other. I examined the efficacy of implementation of the GWTG-Stroke program in terms of demographics. I assessed comparisons of means between the two groups to identify if they were equivalent in terms of improving core stroke measures related to AIS patient treatments and outcomes. If implementation of the GWTG-Stroke program resulted in similar core stroke measures and outcomes among SBH and NSBHs, interventions would be equivalent. Thus, hospitals using the GWTG-Stroke program in the stroke belt will perform similar compared to hospitals outside the stroke belt.

Blair and Taylor (2009) described the equivalence study design and testing as a method rather than a statistical test. The rationale for the equivalence study design is that standard statistical tests test what is not true rather than what is true (Blair & Taylor, 2008). In equivalence testing, the null hypothesis is reversed, and the difference is a priori specified Δ or more; thus, rejection of the null hypothesis in the case of equivalence studies means equivalence, or the two groups are similar enough (Indrayan, 2013). Interventions are considered equivalent when the entire CI is between $-\delta$ and $+\delta$ (Indrayan, 2013). One intervention is considered medically equivalent to another when the difference between the two interventions does not exceed a predetermined medically unimportant difference; for this study, the predetermined difference or equivalence margin for the difference in proportion was five percentage points. The five-percentage point margin of difference in proportion is arbitrary but conceptualized based on the

notion that NSBHs using the GWTG-Stroke program perform at or above benchmark goals for core stroke measures. Core stroke measure benchmarks are based on clinical factors and EBP. In addition, If SBHs using the GWTG-Stroke program have outcome measures that differ from NSBHs by no more than plus or minus 5%, it can be argued that they are not meaningfully different. I employed a TOST procedure to test for equivalence. Equivalence could be established at the α-significance level if (1-2α) x 100% CI. The equivalence margin was predetermined as δ= five percentage points; thus, the interval is a -0.05 and 0.05 point difference, respectively. A 90% confidence interval is appropriate for the TOST procedure and will yield a significance level for the equivalence test of 0.05.

I used a quantitative cross-sectional nonexperimental approach. A quantitative method is appropriate when researchers test an objective theory through examining relationships between variables; variables may be documented and measured by an instrument to produce numerical data for statistical analysis (Creswell, 2014). Cross-sectional methods are observational and do not require researcher interactions with subjects. Additional benefits include cost-effectiveness and the ability to capture a specific point in time, resulting in saved time. Nonexperimental methods such as the correlational design involve a survey or instrument to capture data and generalize from samples to a population (Creswell, 2014). Statistical analysis was completed employing TOSTs in this study. Statistical analyses were performed on the AHA PMP using an R Package.

Methodology

Population

In this research study, the target population was patients with suspected stroke that presented to a hospital within the United States participating in the GWTG-Stroke Program and registry. All stroke patients presenting to a hospital utilizing GWTG-Stroke entered into the GWTG-Stroke registry through the Patient Management Tool™ (PMT). Stroke subtype (i.e., ischemic, hemorrhagic, transient ischemic attack (TIA)) were identified based on the final diagnosis after appropriate treatment had been rendered. The study population included patients treated and diagnosed with an ischemic stroke, as evident by the international classification of disease-10 (ICD-10) code at hospitals within the United States that have implemented the GWTG-Stroke Quality Program and its registry component. The target population was estimated to be over 100,000. The author stratified hospitals participating in the GWTG-Stroke into SBHs and NSBHs. The SBH comparison group is a hospital located within a geographical area in the Southeastern United States and Mississippi Valley, with high stroke mortality rates (Stroke Center, 2019). Eight contiguously clustered states in the American Southeast have represented the so-called “Stroke Belt” due to their disproportionately high stroke mortality rates—ten percent higher than the national average (Karp et al., 2016). The eight states that compose the Stroke Belt are Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee.

Sampling and Sampling Procedures

It was hypothesized that the two groups, SBHs and NSBHs, are independent and that the sample size of SBH and NSBH groups would be unequal. I also hypothesized that SBHs and NSBHs participating in GWTG Stroke would be equivalent or similar enough that there would be no significant differences in the mean distribution of r-tPA usage, DTN time, DTI time, and AIS only estimated mortality rates. A convenience sample was used for the secondary analysis of existing data. Study participants included patients treated at United States hospitals participating in GWTG Stroke, diagnosed with an ischemic stroke as evident by the international classification of disease-10 (ICD-10) code. Additionally, patients had a Patient Management Tool (PMT) completed by a credentialed GWTG- data abstractor. Study Participants included participants older than 18 years of age and patients with various means of hospital presentation or admission (i.e., Pre-hospital/EMS, direct self-admission to ED). This research study sample was not proportional; I started with the entire population then selected only cases specific to each research question.

Furthermore, the study sample was not inclusive of outliers that were identified. Outliers were identified using R-Package, and formulas were utilized to create statistical limits. Cases identified within limits for each specific research question were included in the study sample. The sampling timeframe had participants meeting the criteria stated above during the following cross-section: January 1, 2015- December 31, 2019 (4-years).

To effectively ensure reporting differences between SBHs and NSBHs will be statistically significant and not due to chance, I performed a sample size calculation for

an equivalence study based on the sample size needed to reject the hypothesis at alpha = 0.05 and beta = 0.10. The sample size was arbitrarily calculated based on r-tPA administration, as this research question fits best for sample size formulation and the overall scientific intent of this research study. I employed the following equivalence study sample size formula: $N=(Z_{\alpha} + Z_{\beta})^2 [P_s(1-P_s) + P_n(1-P_n)] / (P_s-P_n-D)^2$ (Blackwelder, 1982), where N corresponds to the sample size needed for each group (i.e., SBH, NSBH); Z_{α} corresponds to standard normal variate corresponding to a tail probability of size β (for a confidence level of 95% using TOST, α is 0.05 and the critical value is 0.975); Z_{β} corresponds to power and is the standard normal variant at β (for a power of 90%, β is 0.1. and the critical value is 0.975) Variables P_s and P_n are the respective proportions of the two groups of participants (where *s* denotes standard intervention (i.e., NSBHs) and *n* denotes novel intervention or comparison group (i.e., SBHs)); and *D* denotes the difference between the two interventions (Blackwelder, 1982). It is important to note that $P_s - P_n$ must be < *D*, and that all calculations assume alpha=0.05 and beta= 0.10 (power= 90%) (Blackwelder, 1982). Based on preliminary sample size calculations, with response rates set to 0.90 for both groups (i.e., P_s and P_n) and a hypothesized difference of *(0.05=D)*, the required sample size in each group is 616, and the total required sample size will be 1232. A total of 2,926,848 cases were analysed, data were in five datasets covering years 2015 to 2019.

Data Collection Procedures

I used secondary analysis of existing data contained within the GWTG-Stroke PMT. The AHA GWTG Stroke Quality Program provides hospital data submission and

feedback reports through the Patient Management Tool (PMT) (Appendix A), which is part of the GWTG-Stroke online interactive platform (AHA, 2019a). The GWTG-Stroke program is the most used voluntary stroke registry and performance improvement program within the United States. The GWTG-Stroke platform fulfills the BAC PSC criterion recommendations that centers should have: outcomes and quality improvement, and have a database or registry to track stroke type, treatment, timelines, and outcome measures (i.e., performance measure) (Albert et al., 2000). Core Stroke Measures require submission to Centers for Medicare and Medicaid (CMS) and JCAHO by the GWTG-Stroke Platform; therefore, data is part of quality improvement efforts and does not require informed consent. The GWTG-Stroke platform allows hospitals to submit required STK or core stroke measures to CMS and JCAHO as part of quality improvement efforts. As such, non-identifiable patient data is collected and inputted into the GWTG-Stroke PMT.

This study included PMT data submitted by credentialed GWTG-Stroke Data Abstractors and uploaded into the GWTG-Stroke online PMT portal. The study's sample population was inclusive of the follows: (a) patients presenting to GWTG-Stroke participating hospitals within the United States with suspected stroke (i.e., ischemic stroke, hemorrhagic stroke) or Transient Ischemic Attack (TIA), (b) patients with a stroke or TIA diagnosis as indicated by ICD-9 or ICD-10 code, (c) patients with a completed prospective PMT or retroactive chart review based. Data collected and inputted into the GWTG-Stroke PMT online interface contained no patient identifiers. The web-based interactive PMT allows hospitals to download reports without delay for utilization in

quality improvement projects (AHA, 2019a). Additionally, GWTG-Stroke PMT aggregate datasets can be accessed and analyzed on the American Heart Association®'s Precision Management Platform with prior approval.

As a Stroke Registry, the GWTG-Stroke Quality Program also provided a source of secondary data for research purposes. The author gained access to GWTG-Stroke data by completing and submitting the Get With The Guidelines Data Request Form titled "Proposal for a Scientific Manuscript using American Heart Association® Quality Improvement Program Registry" (Appendix B). The Data request included acknowledging proprietary rights, non-disclosure agreement, data use agreement, obligations of data recipients, permitted usages, disclosures, breach notifications, non-commercial usage, data recipient contact, and program registry usage. I was required to provide information related to the research target group, working research study title, research questions, goals, hypotheses, study population, study variables, primary outcomes, and a brief description of proposed analyses. The approval of the Get With The Guidelines data request occurred after eight months; this significant delay was due to the SARS CoV-2 pandemic.

Upon approval of the Get With The Guidelines Data Request Form, the American Health Association Quality Publications and Precision Management Platform Statistical Staff provided five datasets based on inclusion/exclusionary criteria provided by the research time. The study's inclusion criteria were as follows: (a) patients older than 18 years of age, (b) patients treated and diagnosed with an ischemic stroke as evident by the international classification of disease-10 (ICD-10) code, (c) AIS patients treated at

GWTG Stroke participating hospital in the United States, (c) patients with various means of hospital presentation or admission (i.e., Pre-hospital/EMS, direct self-admission to ED), (d) patients with a PMT completed by a credentialed GWTG- data abstractor. I excluded patients from the study sample if patients had an ICD-10 of Hemorrhagic stroke or documented r-tPA contraindications.

I conducted data analysis by utilizing specific datasets requested from and approved by the AHA. Upon Approval of the GWTG Data Request Form titled "Proposal for a Scientific Manuscript using American Heart Association Quality Improvement Program Registry" (Appendix B), AHA Statisticians uploaded the datasets onto the AHA's Precision Management Platform for researcher access and analysis. Data were in five datasets covering 2015 to 2019 and in SAS format (sas7bdcat). These files were converted to R using the function "sas7dbcat" from the library *sas7dbcat*. In total, there were 2,926,848 cases. After that, the author selected the variables of interest and joined all the files into one.

Instrumentation and Operationalization of Constructs

The American Heart Association and American Stroke Association created the Get With The Guidelines-Stroke Quality Program and, after a successful pilot phase, began enrolling hospitals in April 2003 (Song et al., 2016). Since creating the GWTG-Stroke program, more than 2,000 hospitals have entered over five-million patient records to publish multiple studies documenting improved patient outcomes (AHA, 2019a). Hospital data submission and feedback reports are provided using the AHA’s PMT, an online interactive platform. Data analysis for research purposes is conducted and

completed on the AHA's Precision Management Platform (PMP). The GWTG-Stroke Program is a voluntary stroke registry and nationwide performance improvement program. The GWTG-Stroke platform fulfills the BAC PSC criterion recommendations that centers should have: outcomes and quality improvement, and have a database or registry to track stroke type, treatment, timelines, and outcome measures (i.e., performance measure) (Albert et al., 2000). Core Stroke Measures require submission to Centers for Medicare and Medicaid (CMS) and JCAHO by the GWTG-Stroke Platform. The AHAs GWTG-Stroke platform fulfills both requirements simultaneously while also reinforcing written care protocols utilizing clinical tools and resources. The GWTG-Stroke Program is the most used stroke registry, and quality improvement program hospitals use throughout the United States.

I conceptualized the operationalization of research question variables, as stated below. The primary variable [tPA administration] was defined as an answer of "Yes" to the relevant question "IV t-PA initiated at this hospital?" on page 5 of the GWTG PMT. In addition to a stated answer of "No" for "IV tPA at an outside hospital or Mobile Stroke Unit?" on page 6 of PMT, and "No" for "documented exclusions (i.e., contraindication) for not initiating thrombolytics in the 0-3 hour treatment window?" on page 5 of PMT. The primary variable [DTN Time] was measured in (MM/DD/YYYY, hour, minutes format (00:00)). It was calculated by subtracting the "arrival time" shown on Page 1 of the PMT and the "Date/Time IV tPA initiated" shown on Page 5. The primary variable [DTI time] was measured in (MM/DD/YYYY, hour, minutes format (00:00)). It was calculated by subtracting the "arrival time" shown on Page 1 of the PMT and the

"Date/Time Brain Imaging Initiated" shown on Page 4. The primary variable [GWTG ischemic stroke only estimated mortality rates] was calculated within the PMT for each GWTG Stroke hospital, based on "GWTG Ischemic Stroke-Only Estimated Mortality Rate" under Discharge information on page 7 of the PMT.

Data Analysis Plan

This study utilized secondary analysis of existing data contained within the GWTG-Stroke PMT. The GWTG-Stroke platform allows hospitals to submit required Core Stroke Measures to CMS and JCAHO as part of quality improvement efforts. As such, non-identifiable patient data is collected and inputted into the GWTG-Stroke PMT. This study included PMT data submitted by credentialed GWTG-Stroke Data Abstractors and uploaded into the GWTG-Stroke online PMT portal. Data was collected and inputted into the GWTG-Stroke PMT online interface. The data did not contain patient identifiers and was available stratified for individual site usage or national comparison. The web-based interactive PMT allows hospitals to download reports without delay for utilization in quality improvement projects (AHA, 2019a).

I conducted data analysis by utilizing specific datasets requested from and approved by the AHA. Upon Approval of the GWTG Data Request Form titled "Proposal for a Scientific Manuscript using "American Heart Association Quality Improvement Program Registry" (Appendix B). After AHA study approval, Statisticians uploaded the datasets to the AHA Precision Management Platform for researcher access and analysis. The AHA approved the GWTG data request after eight months. This significant delay was due to the SARS CoV-2 pandemic. Data were in five datasets covering 2015 to 2019

and SAS format (sas7bdcat). These files were converted to R using the function "sas7dbcat" from the library *sas7dbcat*. In total, there were 2,926,848 cases. After that, the author selected the variables of interest and joined all the files into one.

The study's inclusion criteria were as follows: (a) patients older than 18 years of age, (b) patients treated and diagnosed with an ischemic stroke as evident by the international classification of disease-10 (ICD-10) code, (c) AIS patients treated at GWTG Stroke participating hospital in the United States, (c) patients with various means of hospital presentation or admission (i.e., Pre-hospital/EMS, direct self-admission to ED), (d) patients with a PMT completed by a credentialed GWTG- data abstractor. I excluded patients from the study sample if patients had an ICD-10 of Hemorrhagic stroke or documented r-tPA contraindications.

Before requesting GWTG-Stroke data and commencing the secondary analysis of existing data, approval from the IRB was sought and obtained (12-22-20-0047087). Upon receiving IRB approval (Appendix C), the five data described above were accessed and analyzed on the AHA's Precision Management Platform.

Primary Research Questions

Research questions for equivalence studies are quantitatively based and should compare interventions amongst comparison groups. The set of statistical hypotheses that is tested is as follows:

$H_0: |p_{1.0} - p_2| \geq \delta$ versus$H_1: |p_{1.0} - p_2| < \delta$

The composite hypothesis, as stated above, can further be reduced to two one-sided hypotheses as follows:

$H_{0L}: p_{1.0} - p_2 \leq \delta_L$ versus $H_{1L}: \delta_L \leq p_{1.0} - p_2$

$H_{0U}: p_{1.0} - p_2 \geq \delta_L$ versus $H_{1L}: \delta_L \geq p_{1.0} - p_2 H_A: \delta_L \leq p_{1.0} - p_2 \leq \delta_U$

Parameter = difference computed as $\delta = p_{1.0} - p_2$

The research questions for this study are as follows:

RQ1: Is there a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs?

H01: There is a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

Ha1: There is no difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

RQ2: Is there a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs?

$H_0$2: There is a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

H_a2: There is no difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

RQ3: Is there a difference regarding in-hospital DTI time between SBHs and NSBHs?

$H_0$3: There is a difference regarding in-hospital DTI time between SBHs and NSBHs.

H_a3: There is no difference regarding in-hospital DTI time between SBHs and NSBHs.

RQ4: Is there a difference in terms of GWTG ischemic stroke only mortality rates between SBHs and NSBHs?

$H_0$4: There is a difference in terms of GWTG ischemic stroke only estimated mortality rates between SBHs and NSBHs.

H_a4: There is no difference in terms of GWTG ischemic stroke only estimated mortality rates between NSBHs and SBHs.

I employed an equivalence study design utilizing a quantitative cross-sectional non-experimental approach. Secondary analysis of existing data was used. Blair and Taylor (2009) describe the equivalence study design and testing as a method rather than a statistical test. The rationale for equivalence study design is that standard statistical tests are designed to test what is *not* true rather than what *is* true (Blair & Taylor, 2009). In equivalence testing, the null hypothesis is reversed, and the difference is a priori specified Δ or more; thus, rejection of the null hypothesis in the case of equivalence studies means equivalence or that the two groups are similar enough (Indrayan, 2013). Interventions are considered equivalent when the entire confidence interval (CI) is within $-\delta$ and $+\delta$ (Indrayan, 2013). One intervention is considered medically equivalent to another when the difference between the two interventions does not exceed a predetermined medically unimportant difference (i.e., no medical consequence); for this study, the predetermined difference or equivalence margin for the difference in proportion is δ= 5 percent points. The five-percentage point margin of difference in proportion is arbitrary. Still, it is conceptualized based upon the notion that NSBHs utilizing the GWTG-Stroke program perform at or above benchmark goals for core stroke measures based on clinical factors

and evidence-based practice. In addition, If SBH using the GWTG-Stroke program have outcome measures that differ from NSBH by no more than plus or minus 5%, it can be argued that they are not meaningfully different. The two one-sided test (TOST) procedure was utilized to test for equivalence. Equivalence could be established at the α-significance level if (1-2α) x 100% confidence interval (CI) for the difference in efficacy between SBHs and NSBHs is contained within the interval ($-\delta$, δ) (Nowacki & Walker, 2010). The equivalence margin has been predetermined as δ= five percentage points; thus, the interval is (-0.05, 0.05) point difference, respectively. A 90% confidence interval is appropriate for the TOST procedure and will yield a significance level for the equivalence test of 0.05 (Steiger, 2004)

The primary objective of this study was to compare the efficacy of the GWTG-Stroke Program in reducing ischemic stroke mortality (i.e., GWTG Ischemic Only Estimated Mortality Rate) and fostering improvements in AIS treatment (i.e., DTN, DTI, and r-tPA administration rates) within SBHs in comparison to NSBHs. The independent variable was GWTG-Stroke hospital type, geographical location, and attendant demographical factors (i.e., SBH, NSBH). In contrast, the dependent variables were patient outcome (i.e., mortality), DTN, DTI, and r-tPA administration. The unit of analysis was GWTG-Stroke Quality Program implementation and usage within the hospital stratified by geographical location and attendant demographical factors (i.e., SBH, NSBH). Statistical analysis employing two one-sided t-tests (TOST) was utilized. Statistical analysis was performed using an R Packages add-on package (TOSTER) on the AHA Performance Management Platform. Results are presented in tabular format and

figures comparing SBHs and NSBHs for each primary variable related to the research questions.

Threats to Validity

This study employed an equivalence study design utilizing a quantitative cross-sectional non-experimental approach to analyze secondary data. The use of secondary data may present threats to validity related to under-reporting, misclassification bias, and issues related to generalizability. Furthermore, since the dataset is secondary, limited information about the sample may be problematic with this study design (Alexander et al., n.d.).

Study data was initially inputted into the GWTG-Stroke PMT by Certified Data Abstractors. Internal validity may be affected by abstractor inputting incorrect data such as incorrect ICD-9 or ICD-10 related to ischemic stroke diagnosis (i.e., ischemic stroke vs. transient ischemic attack (TIA)). An incorrect diagnosis of ischemic stroke may result in a misclassification bias related to the research outcome of interest. Additional threats to internal validity may be present as it relates to experimental mortality (i.e., mortality variable) as it was calculated in the GWTG-Stroke PMT as a GWTG Ischemic Only Estimated Mortality Rate. Equivalence studies require the researcher to determine a zone of clinical equivalence related to standardized and novel interventions; this is defined as $\pm\Psi$ and can be problematic as it relates to internal validity (Penn State Eberly College of Science, n.d.). Equivalence studies do not provide a natural check for internal validity; this is because equivalence of the standard and novel/experimental intervention does not

imply that either is effective in their own right (Penn State Eberly College of Science, n.d.).

The primary objective of this study was to compare the efficacy of the GWTG-Stroke Program in reducing ischemic stroke mortality (i.e., GWTG Ischemic Only Estimated Mortality Rate) and fostering improvements in AIS treatment (i.e., DTN time, DTI time, and r-tPA administration rates) within SBHs and NSBHs. The data analyzed was from hospitals within the United States participating in GWTG-Stroke (i.e., SBH and NSBH). I should note that not all hospitals participate in the GWTG-Stroke Quality Program; this can threaten external validity as it relates to the generalizability of research results from the sample to the population. Furthermore, the test of statistical assumptions found that homogeneity of variance was unequal for Research Question 3 (i.e., patient-level) and Research Question 4 (i.e., hospital-level and patient-level).

Ethical Procedures

Procedures for researchers to gain access to GWTG-Stroke data required the researcher to complete and submit the Get With The Guidelines Data Request Form titled "Proposal for a Scientific Manuscript using American Heart Association Quality Improvement Program Registry" (Appendix B). Given that the GWTG-Stroke data is available to the public and de-identified, it is impossible to trace back the original data to patients or providers. Since these data are de-identified and open to the public, the subsequent use of such data would not constitute human subject research as defined by 45 CFR 46. 102 and does not require Institutional Review Board (IRB) approval but should be reviewed by IRB (University of Connecticut, 2020). Moreover, since this research

study utilizes secondary analysis of existing data, participant recruitment was not required. The elimination of participate recruitment also excluded recruitment of vulnerable populations, including but not limited to the following: children under the age of 18, pregnant women and fetuses, physically disabled persons, emotionally disabled persons, hospitalized persons, incarcerated persons, persons under community supervision for a crime, elderly persons, active-duty military personnel, victims or witnesses of violent crime or trauma, individuals who may not be able to protect their right or interests, and individuals within the United States that may not be fluent in English (Walden University, 2020a).

Furthermore, this research study was not be inclusive of the following sensitive topics, which could present significant ethical challenges requiring early ethics consultation with the Walden University Office of IRB: questions pertaining to professional work leading to disclosures of behaviors/views that could potentially get the person's job terminated or passed over for promotion (i.e., lack of compliance with policies, disagreement with leadership style or discissions); question pertaining to substance use, mental health state, or violence that might obligate a referral and/or intervention to prevent harm to participate (e.g., addiction, severe depression, suicidal or homicidal ideations, physical threats); illegal activities that may incriminate the participate by means of the research data (e.g., illicit drug use, illegal immigration, child abuse/neglect, assault, cyber bullying); personal issues that could distress an individual if framed in a judgmental, dismissive, non-inclusive, or insensitive manner (i.e., religion, ethnicity, etc.); race or ethnicity as a variable or inclusionary criterion; outcomes of a new

intervention or program that is not already part of a standard offering in specific environment (e.g., education, psychological, and/or clinical settings) (Walden University, 2020b).

Doctoral research studies or projects that utilize a secondary analysis of existing data are non-inclusive of interaction or intervention with human subjects. Still, they require review by the Walden University IRB as defined by 45 CFR 46. 102 (f) (University of Connecticut, 2020). Human subjects are defined in 45 CFR 46. 102 (e)(1) as a living individual about whom an investigator (professional or student) is conducting research (United States Department of Health and Human Services: Office of Human Research Protection [HHS-OHRP], 2020). As noted, secondary analysis of existing data and de-identified data available to the public does not require IRB review if the research study meets these stated criteria; it falls outside the regulatory definition of research involving human subjects (University of Connecticut, 2020) (HHS-OHRP, 2020). While IRB approval is not required for this research study, an IRB application was submitted to the Walden University IRB for review and was subsequently approved (12-22-20-0047087) (Appendix C).

Summary

I employed an equivalence study design using a quantitative cross-sectional nonexperimental approach. Secondary analysis of existing data was performed using TOSTs. In this chapter, I discussed methodological and statistical strategies related to efficacy of the GWTG-Stroke program in terms of reducing stroke-related mortality and fostering improvements in AIS treatment between SBHs and NSBHs. submission and

approval of the GWTG data request form resulted in requested datasets for research access and analysis. I assessed the datasets based on the study's inclusion/exclusionary criteria. Statistical analysis was performed using TOSTER on the AHA's PMP. Chapter 4 include study results, limitations, implications of social change, and recommendations for future research.

Chapter 4: Results

Introduction

I employed an equivalence study design using a quantitative cross-sectional nonexperimental approach. Secondary analysis of existing data was used. The purpose of this study was to compare efficacy of the GWTG-Stroke program in terms of reducing ischemic stroke mortality and fostering improvements in AIS treatment between SBHs and NSBHs. The independent variables were GWTG-Stroke hospital type, geographical location, and attendant demographical factors. Dependent variables were patient outcomes, DTN time, DTI time, and r-tPA administration. The unit of analysis was GWTG-Stroke quality program implementation and use within the hospital stratified by geographical location and attendant demographical factors. The Chapter 4 includes the sample and variables used in statistical analyses, examination of research questions, and testing of hypotheses. I employed TOSTs and statistical analysis was performed using the TOSTER R-Package. Study findings are presented in tables and figures comparing SBHs and NSBHs for each primary variable related to the research questions. Furthermore, test of statistical assumptions found that homogeneity of variance was unequal for RQ3 and RQ4.

Primary Research Questions

Research questions for equivalence studies are quantitatively based and should compare interventions between comparison groups. The following set of statistical hypotheses were tested is as follows:

$H_0: |p_{1.0} - p_2| \geq \delta$ versus $H_1: |p_{1.0} - p_2| < \delta$

The composite hypothesis can further be reduced to two one-sided hypotheses as follows:

$H_{0L}: p_{1.0} - p_2 \leq \delta_L$ versus $H_{1L}: \delta_L \leq p_{1.0} - p_2$

$H_{0U}: p_{1.0} - p_2 \geq \delta_L$ versus $H_{1L}: \delta_L \geq p_{1.0} - p_2$

$$H_A : \delta_L \leq p_{1.0} - p_2 \leq \delta_U$$

Parameter = difference computed as $\delta = p_{1.0} - p_2$

The research questions for this study are as follows:

RQ1: Is there a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs?

$H_0$1: There is a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

H_a1: There is no difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

RQ2: Is there a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs?

*H_0*2: There is a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

*H_a*2: There is no difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

RQ3: Is there a difference regarding in-hospital DTI time between SBHs and NSBHs?

*H_0*3: There is a difference regarding in-hospital DTI time between SBHs and NSBHs.

H_a3: There is no difference regarding in-hospital DTI time between SBHs and NSBHs.

RQ4: Is there a difference in terms of GWTG ischemic stroke only mortality rates between SBHs and NSBHs?

$H_0 4$: There is a difference in terms of GWTG ischemic stroke only estimated mortality rates between SBHs and NSBHs.

$H_a 4$: There is no difference in terms of GWTG ischemic stroke only estimated mortality rates between NSBHs and SBHs.

Data Collection

Data analysis was conducted by using specific data contained within datasets requested from and approved by the AHA. Upon Approval of the GWTG data request form (see Appendix B), statisticians from the AHA uploaded data to the PMP for researcher access and analysis. Approval of the GWTG data request occurred after 8 months. This significant delay was due to the SARS CoV-2 pandemic. I used five datasets covering the years 2015 to 2019 in SAS format (SAS7BDAT). These files were converted to R using the function “sas7dbcat” from the library *SAS7DBAT*. In total, there were 2,926,848 cases. After that, I selected the variables of interest and joined all files into one.

Table 1

Study Variables and their Dataset Coding

Variable	Code of the variable
Hospital Id	SITE_ID
Hospital's State	SITE_STATE
Age of the patient	GS_AGE
Type of stroke	GS_STROKETYPE
GS_ZIP1	Patient's ZIP code
Arrival time	JC_ARRDATETIME
Date and time brain imaging	GS_CTCOMPDATETIME
Date and time IV tPA initiated	JC_IVTHRODTTM
IV tPA initiated at this hospital	gs_ivthroinit
IV tPA at an outside hospital	GS_IVTPAOUTSIDE
Documented exclusions	GS_ITVPANC
How patient arrived to hospital	GS_PATIENTARRIVAL
Mortality rate	GS_ISCHEMICRISK

Three initial filters were applied (GS_AGE > 18, GS_STROKETYPE = "Ischemic stroke," and SITE_ID with empty values). After that, the author transformed the numeric values of the time data to date and time readable values. The next stage involved the creation of three of our independent variables (IV): *tPA administration,* *DTN time,* and *DTI time*. In this operation, I created two categorical variables to identify

whether a hospital or a patient belonged to the *Stroke Belt*. Following this procedure, I selected the positive values of the variables DTN time, DTI time, and Ischemic risk (negative values of time and ischemic risk lacked meaningful value and represented a probable error). The evaluation of the outliers of those three quantitative IVs was the next step. The limits were determined using the following formulas:

$$Upper\ Limit\ = Q_3 + 1.5\ (Q_3 - Q_1)$$

$$Lower\ Limit\ = Q_1 - 1.5\ (Q_3 - Q_1)$$

Once the limits were applied to the data, I created four new datasets, one for each research question. I obtained the descriptive values grouped at the hospital-level only for the first research question. For the other research questions, descriptive results are at the hospital-level and patient-level. The following limits of outliers for each variable were utilized. Research cases within these limits are valid: Ischemic risk [Min 0.400-13.100 Max], DTI time [Min 60-6960 Max], DTN time [Min 60-2400.0 Max]. Time variable cleaning was performed to remove missing or inaccurate time data related to negative data, missing data, and outliers. The rate for tPA Administration was calculated based on the percentage of people who were administered tPA inside each hospital. The sample was not proportional. I started with the whole population and selected only specific cases relevant to each research question.

Results

RQ1

RQ1: Is there a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs?

H_01: There is a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

H_a1: There is no difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

Table 2

Distribution of r-tPA Administration Rates for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019

Stroke Belt	N	Mean	Median	SD	SE
No	562	64.84	76.92	33.36	1.41
Yes	100	62.58	72.22	33.18	3.32

For RQ1, I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent in tPA administration rates for patients meeting criteria. Demographics for RQ1, pertaining to r-tPA administration stratified by hospital type were NSBHs (N=562) and SBHs (N=100), as shown in Table 2. A two-one side t-test (TOST) analysis was conducted. Equivalence test results for RQ1 can be seen in Table 3. As seen in table 3, the equivalence test was non-significant, $t(660) = -.271$, $p = .393$, given equivalence bounds of -3.242 and 3.242 (on a raw scale) and an *alpha* of .05. The null hypothesis test was non-significant, $t(660) = .625$, $p = .532$, given an *alpha* of .05. Based on the equivalence test and the null-hypothesis test combined, I concluded that the observed effect is statistically not different from zero and statistically not equivalent to zero. The final decision is both groups are not equivalent and not statistically different. According

to Mecklin (2003, 331), the result must be termed as *equivocal*. Under this situation, "there is insufficient evidence to conclude that the groups are either equivalent or different. This would most likely occur when the samples are very small and/or the group variances are very large."

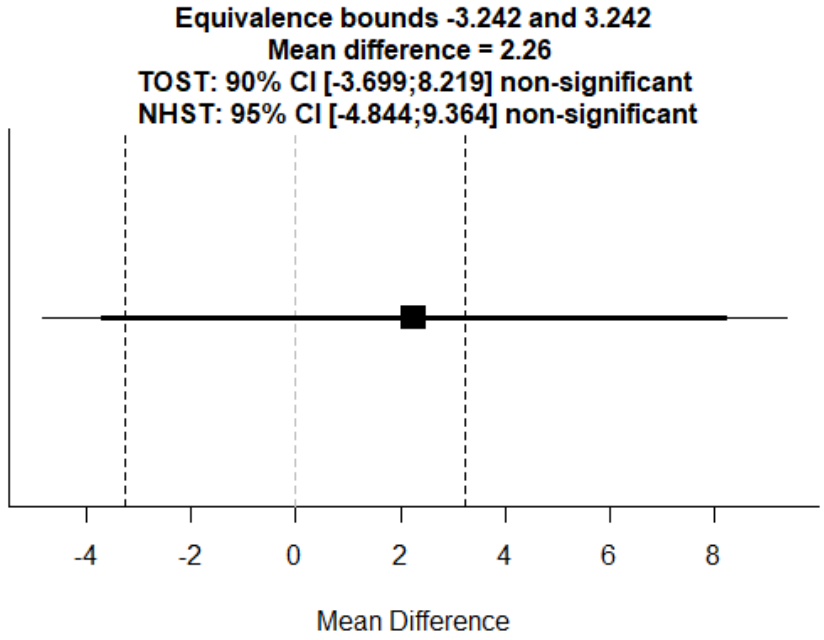
Table 3

Equivalence Test of r-tPA Administration Rates for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019

Null Hypothesis	DF	*t*-value	*p*-value
Difference <= -3.242	660	1.52	.064
Difference >= 3.242	660	-.27	.393

Figure 2

Plot of Equivalence Test of r-tPA Administration Rates for AIS Patients in NSBHs and SBHs Utilizing GWTG-Stroke, 2015-2019



RQ2

RQ2: Is there a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs?

$H_0$2: There is a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

H_a2: There is no difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

Table 4

Distribution of in-hospital DTN time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

Stroke Belt	N	Mean	Median	SD	SE
No	617	3350.96	3315.19	661.34	26.62
Yes	112	3411.77	3318.40	746.34	70.52

For RQ2, I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent regarding in-hospital DTN time. Demographics for RQ2, pertaining to in-hospital DTN time stratified by hospital type were NSBHs (*N*=617) and SBHs (*N*=111) at the hospital-level, as shown in Table 4. A two-one side t-test (TOST) analysis was conducted at the hospital-level and patient-level. As shown in Table 5, at the hospital-level, the equivalence test was non-significant, $t(727) = 1.540$, $p = 0.0621$, given equivalence bounds of -167.548 and 167.548 (on a raw scale) and an alpha of .05. The null hypothesis test was non-significant, $t(727) = -0.877$, $p = 0.381$, given an alpha of .05. Based on the equivalence test and the null-hypothesis test combined, I concluded that the observed effect is statistically not different from zero and statistically not equivalent to zero, as illustrated in Figure 3. The final decision is: both groups are not equivalent and not statistically different.

Table 5

Equivalence Test of in-hospital DTN time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

Null Hypothesis	DF	*t*-value	*p*-value
Difference <= -167.55	727	1.54	.06
Difference >= 167.55	727	-3.29	<.001

Figure 3

Plot of Equivalence Test of in-hospital DTN time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

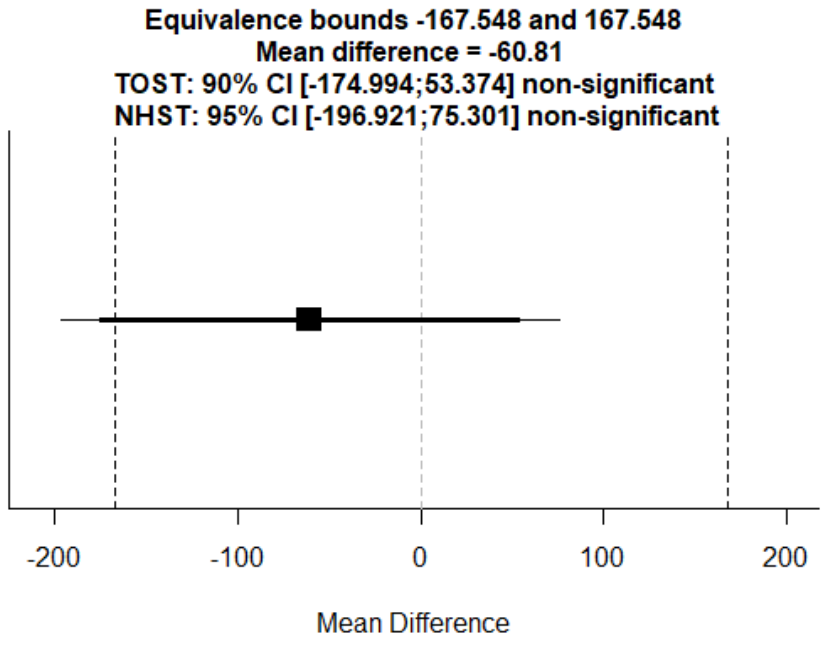


Table 6

Distribution of in-hospital DTN time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Patient Level

Stroke Belt	N	Mean	Median	SD	SE
No	45669	3040.75	2880	1279.86	5.99
Yes	8777	3003.32	2820	1276.87	13.63

For RQ2, I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent regarding in-hospital DTN time. Demographics for RQ2, pertaining to in-hospital DTN time stratified by hospital type, were NSBHs (*N*=45669) and SBHs (*N*=8777) at the patient-level as shown in Table 6. A two-one side t-test (TOST) analysis was conducted at the hospital-level and patient-level. As can be seen in Table 7, at the patient-level, the equivalence test was significant, $t(54444) = -8.726$, $p < .001$, given equivalence bounds of -167.538 and 167.538 (on a raw scale) and an *alpha* of .05. The null hypothesis test was significant, $t(54444) = 2.510$, $p = .0121$, given an *alpha* of .05. I concluded that the observed effect is statistically different from zero and statistically equivalent to zero based on the equivalence test and the null-hypothesis test combined. The final decision is: both groups are equivalent and statistically different, as illustrated in Figure 4. According to Mecklin (2003), "a simultaneous rejection of both inferential procedures, could happen in a situation where large samples provide too much power, resulting in a trivial difference in means being statistically significant. The equivalence

test (and the effect size) should detect the small magnitude of these mean differences" (p. 331).

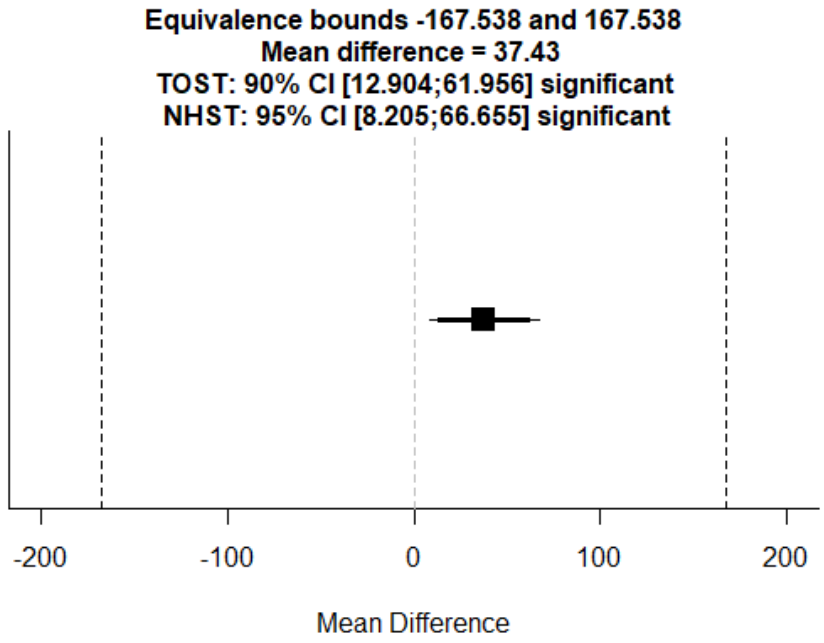
Table 7

Equivalence Test of in-hospital DTN Time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Patient Level

Null Hypothesis	DF	*t*-value	*p*-value
Difference <= -167.54	54,444	13.75	< .001
Difference >= 167.54	54,444	-8.73	< .001

Figure 4

Plot of Equivalence Test of In-Hospital DTN Time for Acute Ischemic Stroke Patients in NSBHs and SBHs Utilizing GWTG-Stroke, 2015-2019 - Patient Level



RQ3

RQ3: Is there a difference regarding in-hospital DTI time between SBHs and NSBHs?

$H_0$3: There is a difference regarding in-hospital DTI time between SBHs and NSBHs.

H_a3: There is no difference regarding in-hospital DTI time between SBHs and NSBHs.

Table 8

Distribution of DTI time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

Stroke Belt	N	Mean	Median	SD	SE
No	617	853.52	846.32	243.62	9.81
Yes	112	879.18	847.49	267.78	25.30

For RQ3, I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent in DTI time. Demographics for RQ3, pertaining to in-hospital DTI time stratified by hospital type were NSBHs (*N*=617) and SBHs (*N*=112) at the hospital-level, as shown in Table 8. A two-one side t-test (TOST) analysis was conducted at the hospital- level, and patient-level. As can be seen in Table 8, at the hospital-level the equivalence test was non-significant, $t(727) = 0.669$, $p = .252$, given equivalence bounds of -42.676 and 42.676 (on a raw scale) and an *alpha* of .05. The null hypothesis test was non-significant, $t(727) = -1.010$, $p = .313$, given an *alpha* of .05. Based on the equivalence test and the null-hypothesis test combined, I concluded that the observed effect is statistically not different from zero and statistically not equivalent to zero, as illustrated in Figure 5. The final decision is both groups are not equivalent and not statistically different.

Table 9

Equivalence Test of DTI time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

Null Hypothesis	DF	*t*-value	*p*-value
Difference <= -42.68	727	.67	.25
Difference >= 42.68	727	-2.69	< .01

Figure 5

Plot of Equivalence Test of DTI time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

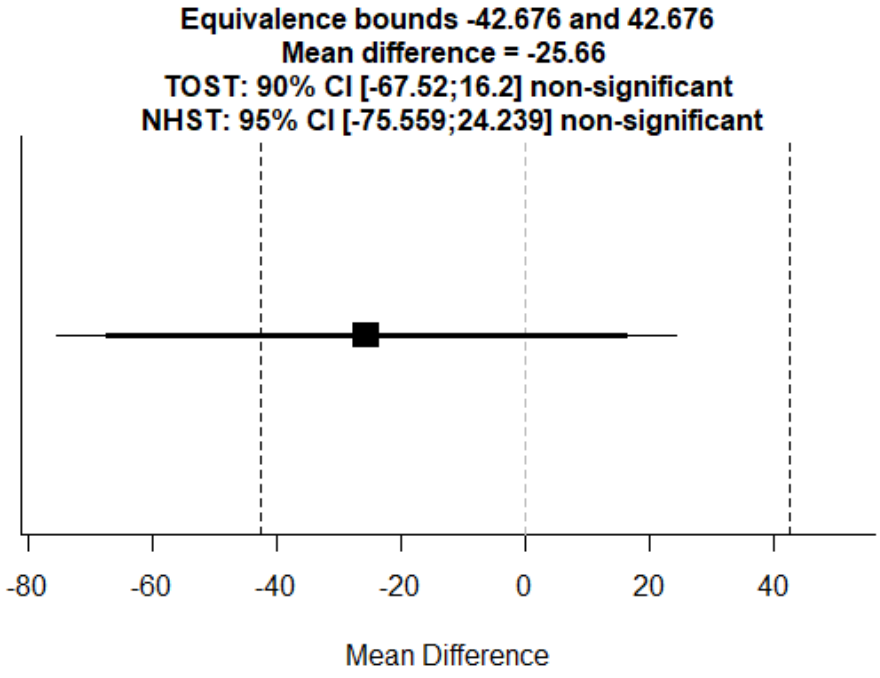


Table 10

Distribution of DTI time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke (01 January 2015 - 31 December 2019) - Patient Level

Stroke Belt	N	Mean	Median	SD	SE
No	45669	845.84	720	510.91	2.39
Yes	8777	884.55	780	550.87	5.88

For RQ3, I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent in DTI time. Demographics for RQ3, pertaining to in-hospital DTI time stratified by hospital type, were NSBHs (*N*=45669) and SBHs (*N*=8777) at the patient-level as shown in Table 10. A two-one side t-test (TOST) analysis was conducted at the hospital-level and patient-level. As can be seen in Table 11, at the patient-level the equivalence test was non-significant, $t(11{,}855.21) = .560$, $p = .288$, given equivalence bounds of -42.292 and 42.292 (on a raw scale) and an *alpha* of .05. The null hypothesis test was significant, $t(11{,}855.21) = -6.103$, $p < 0.001$, given an *alpha* of .05. Based on the equivalence test and the null-hypothesis test combined, I conclude that the observed effect is statistically different from zero and statistically not equivalent to zero, as illustrated in Figure 6. The final decision is: both groups are not equivalent and statistically different. According to Mecklin (2003, 331), they must be considered different.

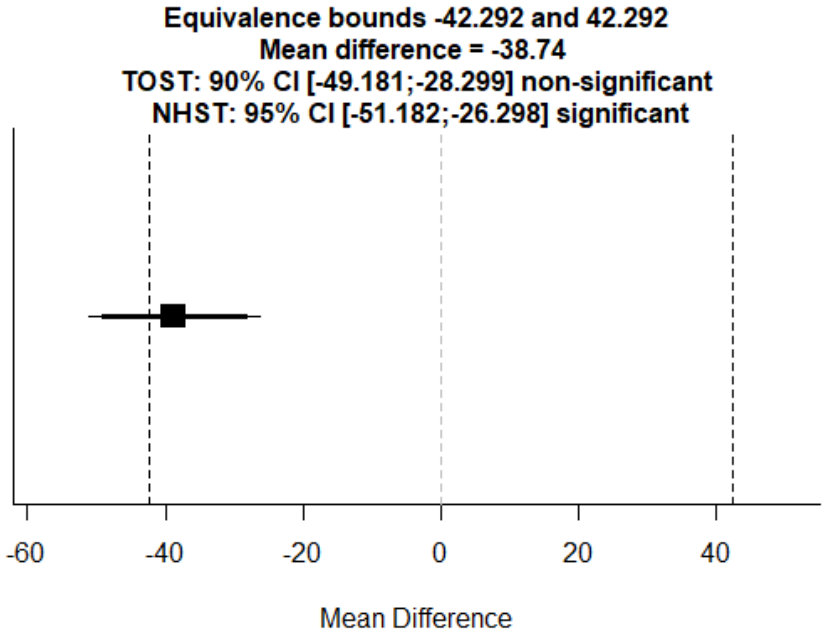
Table 11

Equivalence Test of DTI time for AIS Patients in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Patient Level

Null Hypothesis	DF	*t*-value	*p*-value
Difference <= -42.29	11,855.21	.56	.28
Difference >= 42.29	11,855.21	-12.77	<.001

Figure 6

Plot of Equivalence Test of DTI Time for AIS Patients in NSBHs and SBHs Utilizing GWTG-Stroke, 2015-2019 - Patient Level



RQ4

RQ4: Is there a difference in terms of GWTG ischemic stroke only mortality rates between SBHs and NSBHs?

$H_0$4: There is a difference in terms of GWTG ischemic stroke only estimated mortality rates between SBHs and NSBHs.

H_a4: There is no difference in terms of GWTG ischemic stroke only estimated mortality rates between NSBHs and SBHs.

Table 12

Distribution of GWTG Ischemic Stroke Only Mortality Rate in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

Stroke Belt	N	Mean	Median	SD	SE
No	617	3.46	3.46	.85	.03
Yes	112	3.46	3.38	1.10	.10

For RQ4, I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent in GWTG Ischemic Stroke Only Mortality Rate. Demographics for RQ4, pertaining to GWTG Ischemic Stroke Only Mortality Rate stratified by hospital type were NSBHs (N=617) and SBHs (N=112) at the hospital-level as shown in Table 12. A two-one side t-test (TOST) analysis was conducted at the hospital-level and patient-level. As can be seen in Table 13, at the hospital-level the equivalence test was non-significant, $t(137.54) = -1.587$, $p = .0574$, given equivalence bounds of -.173 and .173 (on a raw scale) and an *alpha* of .05. The null hypothesis test was non-significant, $t(137.54) = 0.000$, $p = 1$, given an *alpha* of .05. Based on the equivalence test and the null-hypothesis test combined, I concluded that the observed effect is statistically not different from zero and statistically not equivalent to zero, as illustrated in Figure 7. The final decision is: both groups are not equivalent and not statistically different.

Table 13

Equivalence Test of GWTG Ischemic Stroke Only Mortality Rate in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

Null Hypothesis	DF	*t*-value	*p*-value
Difference <= -.173	137.54	1.59	.06
Difference >= .173	137.54	-1.59	.06

Figure 7

Plot of Equivalence Test of GWTG Ischemic Stroke Only Mortality Rate in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Hospital Level

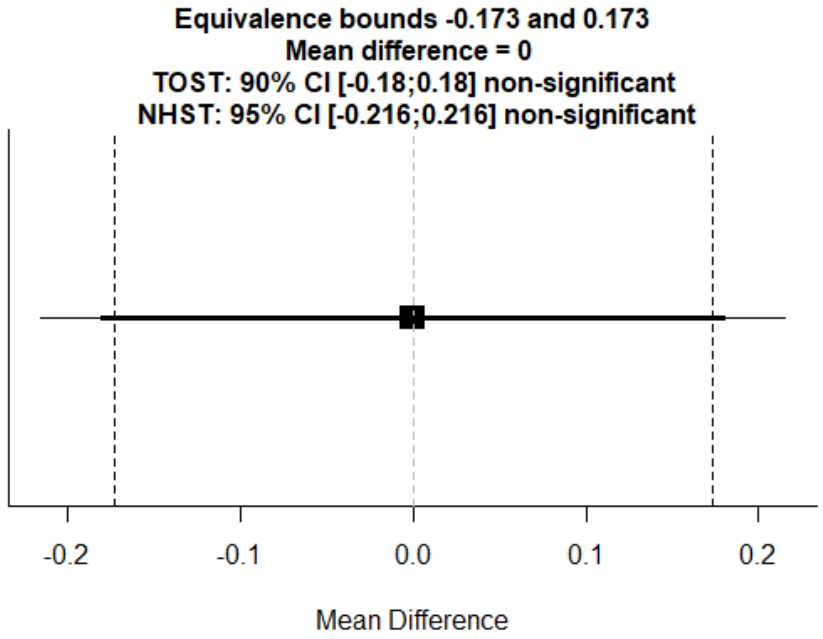


Table 14

Distribution of GWTG Ischemic Stroke Only Mortality Rate in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Patient Level

Stroke Belt	N	Mean	Median	SD	SE
No	45669	3.60	2.6	2.82	.01
Yes	8777	3.59	2.5	2.85	.03

For RQ4, I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent in GWTG Ischemic Stroke Only Mortality Rate. Demographics for RQ4, pertaining to GWTG Ischemic Stroke Only Mortality Rate stratified by hospital type were NSBHs (*N*=45669) and SBHs (*N*=8777) at the patient-level as shown in Table 14. A two-one side t-test (TOST) analysis was conducted at the hospital-level and patient-level. As can be seen in Table 15, at the patient-level the equivalence test was significant, $t(54{,}444) = -5.164$, $p < .001$, given equivalence bounds of -0.180 and 0.180 (on a raw scale) and an *alpha* of .05. The null hypothesis test was non-significant, $t(54444) = 0.304$, $p = .761$, given an *alpha* of .05. Based on the equivalence test and the null-hypothesis test combined, I concluded that the observed effect is statistically not different from zero and statistically equivalent to zero, as illustrated in Figure 8. The final decision is: both groups are equivalent and not statistically different. According to Mecklin (2003, 331), they should be considered equivalent.

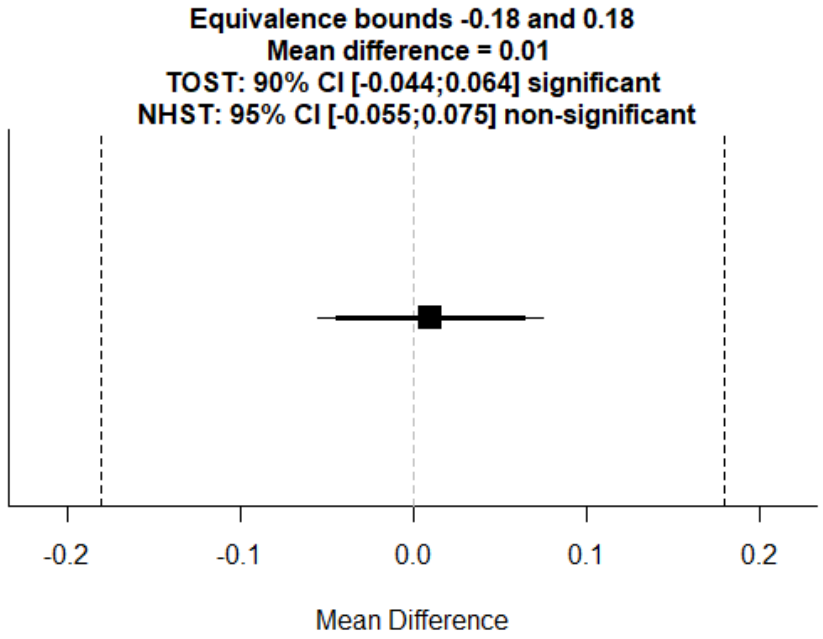
Table 15

Equivalence Test of GWTG Ischemic Stroke Only Mortality Rate in NSBHs and SBHs utilizing GWTG-Stroke, 2015-2019 - Patient Level

Null Hypothesis	DF	*t*-value	*p*-value
Difference <= -.18	54,444	5.78	< .001
Difference >= .18	54,444	-5.16	< .001

Figure 8

Plot of Equivalence Test of GWTG Ischemic Stroke Only Mortality Rate in NSBHs and SBHs Utilizing GWTG-Stroke, 2015-2019 - Patient Level



Summary

Data analysis was conducted by using datasets requested from and approved by the AHA. I used five datasets covering the years 2015 to 2019 which were in SAS format (SAS7BDAT). In total, there were 2,926,848 cases examined in this study. A TOST at the hospital and patient level was completed for each research question as part of the equivalence study.

Equivalence study results varied based on the research question and stratification by hospital versus patient-level analysis. For RQ1, I examined only hospital-level data regarding r-tPA administration stratified by stroke belt hospital type. RQ2 examined DTN time at the hospital and patient level for SBHs and NSBHs. For RQ2 at the hospital

level, equivalence and null hypothesis test results were nonsignificant. I concluded based on results that DTN time in both groups were not equivalent or statistically different. For RQ2 at the patient level, the equivalence and null hypothesis test results were significant. I concluded based on results that DTN for both SBHs and NSBHs at the patient level were equivalent and statistically different. For RQ3 examining DTI time at the hospital level, equivalence and null hypothesis tests were nonsignificant. I concluded based on results that DTI time for NSBHs and SBHs at the hospital level were not equivalent or statistically different. For RQ3 at the patient level, the equivalence test was non-significant, and the null hypothesis test was significant. I concluded based on results that DTI time for NSBHs and SBHs were not equivalent or statistically different. For RQ4, the equivalence test and null hypothesis test both were nonsignificant. I concluded based on results that GWTG AIS mortality rates among at the hospital level were not equivalent or statistically different. For RQ4 at the patient level, the equivalence test was significant, and the null hypothesis test was nonsignificant. I concluded based on results that GWTG AIS mortality rates for SBHs and NSBHs at the patient level both were equivalent and not statistically different and should be considered equivalent.

Next, in Chapter 5, I discuss results, study limitations, implications for social changes, and recommendations for future research.

Chapter 5: Discussion, Conclusion, and Recommendations

Introduction

The purpose of this study was to compare the efficacy of the GWTG-Stroke quality program in terms of reducing key AIS treatment disparities and AIS stroke-related mortality between SBHs and NSBHs. I employed an equivalence study design using a quantitative cross-sectional nonexperimental approach. Secondary analysis of existing data was used. As part of this study, I examined if implementation and use of the GWTG-Stroke program resulted in differences in terms of mean outcomes based on geographical location and attendant demographical factors. Implementation of the GWTG-Stroke program was reviewed to determine if SBHs and NSBHs were quantitatively equivalent. A lack of significant differences in terms of outcomes between the two comparison groups would suggest that the GWTG-Stroke quality program effectively decreases AIS treatment disparities and mortality as it relates to the stroke belt. This chapter includes a discussion of significant findings related to differences in the mean distribution of r-tPA administration, DTI time, DTN time, and AIS-specific mortality between SBHs and NSBHs participating in the GWTG-Stroke program. The discussion will include implications which may be beneficial for legislators, hospitals, and other stakeholders which will lead to positive social change. This chapter concludes with a discussion of conceptual frameworks, implications for positive social change, study limitations, identification of future research, and a conclusion.

This chapter assists in answering the following research questions:

RQ1: Is there a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs?

H_01: There is a difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

H_a1: There is no difference between in-hospital r-tPA administration rates for AIS patients meeting criteria for SBHs and NSBHs.

RQ2: Is there a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs?

$H_0$2: There is a difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

H_a2: There is no difference regarding in-hospital DTN time for AIS patients' administered r-tPA between SBHs and NSBHs.

RQ3: Is there a difference regarding in-hospital DTI time between SBHs and NSBHs?

$H_0$3: There is a difference regarding in-hospital DTI time between SBHs and NSBHs.

H_a3: There is no difference regarding in-hospital DTI time between SBHs and NSBHs.

RQ4: Is there a difference in terms of GWTG ischemic stroke only mortality rates between SBHs and NSBHs?

$H_0$4: There is a difference in terms of GWTG ischemic stroke only estimated mortality rates between SBHs and NSBHs.

H_a4: There is no difference in terms of GWTG ischemic stroke only estimated mortality rates between NSBHs and SBHs.

Equivalence study results varied based on the research question and hospital level versus patient level analysis. I examined only hospital-level data regarding r-tPA administration stratified by Stroke Belt hospital type for RQ1. Based on the results, I concluded both groups were not equivalent and not statistically different and were thus equivocal. RQ2 involved DTN time at the hospital and patient level for SBHs and NSBHs. For RQ2 at the hospital level, I concluded that DTN time in both groups was not equivalent. For RQ2 at the patient level, I concluded that DTN time for both SBHs and NSBHs was equivalent. For RQ3, I concluded that DTI for both SBHs and NSBHs was not equivalent. For RQ3 at the patient level, I concluded that DTI time for NSBHs and SBHs was not equivalent. For RQ4, I concluded that GWTG ischemic stroke only mortality rates for SBHs and NSBHs were not equivalent. For RQ4 at the patient level, I concluded that GWTG ischemic stroke only mortality rates for SBHs and NSBHs were equivalent and not statistically different and should be considered equivalent. As part of this study, trends that fostered improved patient care outcomes for AIS patients presenting to SBHs were identified.

Interpretation of Findings

This study has a specific focus on the stroke belt. I attempted to fill a significant gap in terms of current understanding of stroke treatments. By focusing on treatment interventions and mortality rates between geographical treatment facility types,

researchers and physicians will better understand stroke treatment programs in the region that are most severely affected by this health crisis.

Implementation of a quality improvement program such as the GWTG-Stroke program is associated with improved AIS patient treatment and improvements in terms of stroke core measures. Stroke quality program implementation increases adherence to stroke core measures (Cumbler et al., 2014; Howard et al., 2018; Ormseth et al., 2017; Romano et al., 2015). Based on literature review results, implementation of both systemic non-GWTG programs and the GWTG-Stroke program results in improved r-tPA administration and patient outcomes and decreased mortality rates. Structured quality improvement interventions like the GWTG-Stroke program increases the number of patients that receive r-tPA within the recommended 60-minute DTN time (Jauch et al., 2018). Over the past 5 years, improved hospital adherence to stroke quality metrics has improved outcomes and reduced mortality for stroke patients. Howard et al. (2018) said care of stroke patients in the GWTG-Stroke program was more likely to meet stroke quality care metrics. Howard et al. (2018) said 1,656 out of 5,564 (29.76%) of hospitals in the US currently use the GWTG-Stroke program. Many hospitals implementing the GWTG-Stroke program are JCAHO-certified stroke centers or have plans to become certified.

There has not been an equivalence study that concentrates on GWTG-Stroke use among SBHs. The GWTG-Stroke program has improved stroke care and critical process measures (AHA, 2019a). However, the impact of the program on AIS treatment and mortality within SBHs compared to NSBHs remains limited. As previously mentioned,

most hospitals using the GWTG-Stroke program are JCAHO CSPs or have implemented clinical guidelines to become a JCAHO CSP. Previous studies examined the efficacy of r-tPA administration rates and status-post intervention outcomes such as hemorrhage, disability, and mortality. However, minimal research has compared regional differences in terms of effectiveness of the GWTG-Stroke Program on stroke mortality and r-tPA administration in hospitals within and outside stroke belt until this study.

In this study, I examined whether SBHs and NSBHs were equivalent in terms of tPA administration rates for AIS patients meeting criteria. Demographics for RQ1, are shown in Table 2. RQ1 was analysed only at the hospital-level (see Table 3). Based on the equivalence test and the null-hypothesis test combined, I concluded that the observed effect was statistically not different from zero and statistically not equivalent to zero. The conclusion is SBHs and NSBHs were not equivalent and not statistically different regarding r-tPA administration for AIS patients meeting criteria. Regarding r-tPA administration, the result suggests that "there is insufficient evidence to conclude that the groups are either equivalent or different. This would most likely occur when the samples are very small and/or the group variances are very large." must be termed *equivocal* according to Mecklin (2003, 331). The demographic data for Research Question 1 suggests that the sample size for SBHs (N=100) is significantly smaller than NSBH (N=562) regarding r-tPA administration rates.

Prior research studies such as Howard et al. (2018) and Fonarow et al. (2014) suggest that implementing quality improvement programs such as GWTG-Stroke is associated with an increase in r-tPA administration rates DTN time or OTT time. The

studies performed by Howard et al. (2018) and Fonarow et al. (2014) utilized similar data from the GWTG-Stroke Quality Improvement Program but different analysis methods in comparison to this research study. The assumption is that implementation of a systemic stroke quality improvement program would improve r-tPA administration in SBHs utilizing such an intervention. This study's finding suggests that r-tPA administration in SBHs and NSBH are neither equivalent nor different. Study findings related to r-tPA administration may be due to various factors. As stated, one reason the results are equivocal may be due to small sample size or substantial group variance. While study results are equivocal regarding r-tPA administration in SBHs compared to NSBHs, the study finding suggests there is insignificant evidence to say the two groups are different in the rate of r-tPA administration.

Regarding r-tPA administration amongst hospitals utilizing GWTG-Stroke, the observed effect was statistically not different between SBHs and NSBHs. This *equivocal* research finding does align with the past study finding that implementation of systemic stroke quality improvement programs such as GWTG-Stroke is associated with increased r-tPA administration rates in hospitals that have implemented such programs. In addition, the smaller sample size related to r-tPA administration within the Stroke Belt and SBHs has been reported in prior research studies such as the REGARDS Study.

The REGARDS study by Howard et al. (2018) examined differences in stroke care between patients in hospitals participating in the GWTG-Stroke program and those not. The same authors found that patients treated in hospitals participating in the GWTG Stroke Program were more likely to receive r-tPA (OR = 3.69) and evaluation by a

neurologist (OR = 1.12) (Howard et al., 2018). Howard et al. (2018) found that the Stroke Belt had fewer patients treated at GWTG hospitals (46.9 percent versus 60.8 percent). This discrepancy has a significant impact on treatment because past studies have found that GWTG hospitals are significantly more extensive and more likely to participate in graduate medical education (GME) resident training (59.9 percent versus 40.7 percent) (Howard et al., 2018). This research study examined r-tPA administration, DTN time, and AIS mortality similar to the REGARDS study. This study's findings regarding r-tPA administration rates for SBHs and NSBHs utilizing GWTG-Stroke align with REGARDS study findings. Howard et al. (2018) concluded that the care of stroke patients admitted to hospitals participating in the GWTG-Stroke was more likely to meet important stroke quality care metrics such as r-tPA administration and DTN time. The REGARDS study's implications suggest that GWTG-Stroke utilization effectively increases r-tPA administration rates and other core stroke measures such as DTN time. While Howard et al. posit that hospitals participating in GWTG-Stroke were more likely to meet stroke quality metrics, the researchers also suggest fewer patients within the Stroke Belt presented to hospitals participating in GWTG-Stroke. In contrast to the current study, the REGARDS study did not compare SBH and NSBH participating in GWTG-Stroke.

The Stroke Belt is a contiguous region in the Southern United States, composed of many rural areas and rural hospitals compared to Non-Stroke Belt states. Hospitals outside the Stroke Belt are more urban, large academic medical centers with specialized staff (i.e., Neurologist, Neurosurgery, Neuro-Interventionalist, Neuro-Radiologists) within closer proximity to patients. Administration of r-tPA is dependent on various

factors such as time of symptom onset, timely hospital access, and other associated delays regarding DTI and DTN/OTT time constraints, all of which have been concluded in prior studies (Fonarow et al., 2014; Howard et al., 2018). Regardless of hospital type, research on nationwide data suggests that implementing quality program initiatives decreased DTN time and OTT time. Decreasing DTN and OTT times should result in more r-tPA administration for patients meeting diagnostic criteria and time constraints.

To address patients that presented with AIS to a hospital utilizing GWTG-Stroke that is outside of their catchment areas (i.e., States of residence); for example, patients that reside in a Stroke Belt States or Non-Stroke Belt state that presented to a hospital within another state operationally defined as the opposing study groups (i.e., SBHs, NSBHs). Data for RQ4 was examined with hospital-level and patient-level analysis. Hospital-level analyses were based on Hospital State in contrast to patient-level analyses based on residency locale. Data was assessed at the hospital and patient levels to accurately group patients who may live within the Stroke Belt but live close to hospitals within a Non-Stroke Belt state and vice-versa. A situation like the aforementioned may occur if an AIS patient visits out of state at the time of symptom onset or when the closest hospital is located with another state (i.e., border cities).

This study examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent regarding in-hospital DTN time. RQ2 was analysed at the hospital-level and patient-level. Demographics for RQ2, about in-hospital DTN time at the hospital-level were NSBHs (N=617) and SBHs (N=111), as shown in Table 4. The equivalence test result for Research Question 2 is shown in Table 5. Based on the equivalence test and the

null-hypothesis test combined, I concluded that the observed effect was statistically not different from zero and statistically not equivalent to zero, as illustrated in Figure 3. The conclusion is SBHs and NSBHs utilizing GWTG-Stroke were not equivalent and not statistically equivalent to zero regarding DTN time at the hospital-level. Within this study, I also assessed whether SBHs and NSBHs using GWTG-Stroke were equivalent regarding in-hospital DTN time at the patient-level. Demographics for RQ2 at the patient-level pertaining to in-hospital DTN time were NSBHs (*N*=45669) and SBHs (*N*=8777), as shown in Table 6. Equivalence test results for RQ2 can be seen in Table 7. We concluded that the observed effect was statistically different from zero and statistically equivalent to zero based on the equivalence test and the null-hypothesis test combined. The conclusion is SBHs and NSBHs utilizing GWTG-Stroke were equivalent and statistically different regarding DTN time at the patient-level. The final decision, according to Mecklin (2003, 331), "a simultaneous rejection of both inferential procedures, could happen in a situation where large samples provide 'too much power,' resulting in a trivial difference in means being statistically significant. The equivalence test (and the effect size) should detect the small magnitude of these mean differences."

One of the notable differences in this study's results, compared to existing studies, was DTN time hospital-level results. Study results about in-hospital DTN time at the hospital-level and patient-level differ. Hospital-level analysis results related to DTN time were not equivalent and not statistically equivalent, in juxtapose to patient-level analysis results indicating equivalent and statistically difference. The difference in outcome may be attributed to a difference in demographic attendant or locale, as mentioned prior.

Patients with AIS may reside in border cities or towns, rural or urban settings, and present to a GWTG-Stroke hospital or the opposing group (i.e., SBH, NSBH). Patients residing within the Stroke Belt may also live within rural settings with an associated increased hospital presentation time and decreases in stroke-specific Specialists (Neurologists, Neuro-Interventionalists, Neuroradiologists) as noted by prior literature (Howard et al., 2018). Jauch et al. (2018) indicated that provisions of evidence-based acute stroke care at hospitals throughout the Stroke Belt is critically important to mitigate the adverse effects of patient morbidity and mortality, as residents of the southeastern United States generally have significantly less timely access to PSCs than individuals living in other regions of the United States. Results from this study at the hospital-level regarding DTN time contradict previous studies that suggest the implementation of quality improvement programs such as GWTG-Stroke aid in decreasing DTN times (Fonarow et al., 2014; Jauch et al., 2018). Patient-level results regarding DTN time align with previous study findings as DTN time for SBHs and NSBHs utilizing GWTG-Stroke were equivalent and statistically different (Jauch et al., 2018).

Jauch et al. (2018) examined the effect of implementing a systematic quality initiative to improve outcomes in AIS care within a rural emergency department (ED). The researchers obtained a convenience sample using retrospective chart review for five non-primary stroke center (PSC) hospitals in the Stroke Belt. The Jauch et al. (2018) study suggest at the end of the intervention (i.e., six months), there were significantly more AIS patients treated with alteplase with the recommended DTN window, compared to the baseline across the entire sample (1.9 percent of patients at baseline versus 5.2

percent at six months; $P < 0.01$). There was a significant trend towards a decrease in the percentage of patients who received alteplase (r-tPA) more than 60 minutes after arriving at the ED at six months. The results of this initiative reaffirm the value of structured, data-driven quality-improvement interventions such as GWTG-Stroke in the administration of alteplase within 60 minutes DTN. The researchers of Jauch et al. (2018) study concluded that quality program implementation helps improve stroke outcomes and core measures. Still, the study did not compare SBH and NSBH nor focus on the GWTG-Stroke program directly as in the current study.

Based on REGARDS study data, Howard et al. (2018) concluded that the care of stroke patients admitted to hospitals participating in GWTG-Stroke were more likely to meet stroke quality care metrics such as DTN time. Furthermore, DTN time results at the patient-level regarding DTN time coincide with previous research findings presented in Fonarow et al. (2014), suggesting that clinical outcomes and DTN for r-tPA administration improved significantly post-intervention period, in comparison to the pre-intervention period. Differences in DTN time based on hospital and patient-level analyses may be due to patients for one demographical region or catchment area presenting to a hospital outside the catchment region of interest (i.e., Stroke Belt vs. the Non-Stroke Belt States). Study results pertaining to DTN time at SBHs vs. NSBHs at the hospital level were not equivalent, but patient-level results were concluded to be equivalent. The study finding at the patient level coincides with prior research that suggests an associated decrease in DTN time and OTT time in hospitals that utilize systemic stroke quality improvement initiatives and programs such as GWTG-Stroke.

Furthermore, it should be mentioned that while hospital-level data suggests SBHs versus NSBHs regarding DTN time is not equivalent, this does not mean that the study result differs from prior studies such as Jauch et al. (2018), which suggest quality improvement programs decrease DTN time. Study results about DTN time at the hospital-level may not be equivalent, but this does not indicate a lack of improvement in DTN time related to SBHs. Examining data at the patient level might have elucidated that the two are equivalent after data was analyzed based on the demographic region per zip code and state of residence (i.e., Stroke belt vs. Non-Stroke Belt State).

I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent regarding DTI time with RQ3. Research Question 3 was analysed at the hospital-level and patient level. Demographics for RQ3, about in-hospital DTI time, were NSBHs (*N*=617) and SBHs (*N*=112) at the hospital-level, as shown in Table 8. Equivalence test results for RQ3 can be seen in Table 9. Based on the equivalence test and the null-hypothesis test combined, we concluded that the observed effect was statistically not different from zero and statistically not equivalent to zero, as illustrated in Figure 5. The conclusion is SBHs and NSBHs utilizing GWTG-Stroke were not equivalent and not statistically different regarding DTI time at the hospital-level. Within this study, I also assessed whether SBHs and NSBHs using GWTG-Stroke were equivalent regarding in-hospital DTI time at the patient-level. Demographics for RQ3 at the patient-level pertaining to in-hospital DTI time were NSBHs (*N*=45669) and SBHs (*N*=8777), as shown in Table 10. Equivalence test results for RQ3 at the patient-level can be seen in Table 11. Based on the equivalence test and the null-hypothesis test combined, I

concluded that the observed effect was statistically different from zero and statistically not equivalent to zero, as illustrated in Figure 6. The conclusion is SBHs and NSBHs utilizing GWTG-Stroke were not equivalent and statistically different regarding DTI time. According to Mecklin (2003, 331), they must be considered different. Study results about RQ3 and DTI time equivalence at the hospital-levels and patient-level were both concluded to be not equivalent. Concerning DTI time, one notable difference in this study's results as compared to existing studies was that implementation of a stroke quality program did not result in an improved stroke measure (i.e., DTI time) as referenced in the literature (Howard et al., 2018; Jauch et al., 2018).

For RQ4, I examined whether SBHs and NSBHs utilizing GWTG Stroke were equivalent in GWTG Ischemic Stroke Only Mortality Rate. Research Question 4 was analysed at the hospital-level and patient level. Demographics for RQ4, pertaining to GWTG Ischemic Stroke Only Mortality Rate, were NSBHs (N=617) and SBHs (N=112) at the hospital level, as shown in Table 12. Equivalence test results for RQ4 can be seen in Table 13. Based on the equivalence test and the null-hypothesis test combined, I concluded that the observed effect is statistically not different from zero and statistically not equivalent to zero, as illustrated in Figure 7. The conclusion is SBHs and NSBHs utilizing GWTG-Stroke were not equivalent and not statistically different regarding GWTG Ischemic Stroke Only Mortality Rate. Research Question 4 was also assessed at the patient-level to examine whether SBHs and NSBHs utilizing GWTG Stroke were equivalent in GWTG Ischemic Stroke Only Mortality Rate. Demographics for RQ4 at the patient-level, pertaining to GWTG Ischemic Stroke Only Mortality Rate were NSBHs

(*N*=45669) and SBHs (*N*=8777) as shown in Table 14. Equivalence test results for RQ4 can be seen in Table 15. Based on the equivalence test and the null-hypothesis test combined, I can conclude that the observed effect is statistically not different from zero and statistically equivalent to zero, as illustrated in Figure 8. The conclusion is SBHs and NSBHs utilizing GWTG-Stroke were equivalent and not statistically different regarding GWTG Ischemic Stroke Only Mortality Rate. According to Mecklin (2003, 331), they should be *equivalent.*

Study results about RQ4 and GWTG Ischemic Stroke Only Mortality Rate at the hospital-level and patient-level differ. At the hospital-level, SBHs and NSBHs were concluded as not equivalent and not statistically different, in contrast to patient-level results, which I concluded was equivalent and not statistically different. The difference in equivalency as it pertains to GWTG Ischemic Stroke Only Mortality Rate at the hospital-level and patient-level may be due to patients for one demographical region or catchment area presenting to a hospital that is outside the catchment region of interest (i.e., Stroke Belt vs. the Non-Stroke Belt States) as previously discussed. The GWTG Ischemic Stroke Only Mortality Rate at the patient-level more accurately identifies patients with a primary residence within a Stroke Belt State or Non-Stroke Belt State. I concluded based on results that SBHs and NSBHs utilizing GWTG Stroke at the patient-level were equivalent and not statistically different in GWTG Ischemic Stroke Only Mortality Rate. This conclusion aligns with prior literature and research results suggesting a decline in AIS mortality (i.e., AIS in-hospital mortality, AIS all-cause mortality) status post-stroke quality program implementation (Fonarow et al., 2014).

The Fonarow et al. (2014) study concluded that implementing a national quality improvement initiative was associated with improved timeliness of r-tPA administration following AIS *on a national scale*. Fonarow et al. (2014) examined the DTN time for r-tPA administration and clinical outcomes in AIS patients before and after implementing a quality improvement initiative. The study measured both in-hospitality and all-cause mortality, r-tPA administration rates, discharge status, ambulatory status at discharge, and complication rates. Similar to this study, researchers utilized data obtained from the GWTG-Stroke program. The study revealed that clinical outcomes and DTN for r-tPA administration improved significantly during the postintervention period compared to the preintervention period (Fonarow et al., 2014). The post-intervention period was crucial for reducing in-hospital mortality, minimizing symptomatic intracranial hemorrhages, decreasing overall r-tPA complications, improving independent ambulation at discharge, and increasing discharge-to-home rates. Moreover, appropriate treatment during the postintervention period was associated with a reduced likelihood of in-hospital mortality (adjusted OR, 0.89 [95 percent Confidence Interval [CI], 0.83-0.94], $P < .001$) (Fonarow et al., 2014). An improvement in DTN time and r-tPA administration resulted in lower rates of in-hospital mortality and intracranial hemorrhage, along with an increase in the percentage of patients discharged home (Fonarow et al., 2014). The Fonarow et al. (2014) study utilized GWTG Stroke data. It examined similar variables (i.e., DTN time, mortality) in comparison to this study. Still, the Fonarow research did not examine the implementation of GWTG-Stroke as it relates to SBHs compared to NSBHs.

Limitations of the Study

Despite the advantages of the GWTG-Stroke quality improvement program and registry, which offers a solid structure for collecting core stroke measure data, quality indicators, and reportable data, disadvantages of the registry component and its data are also noteworthy to discuss. Disadvantages related to limitations of this study are associated with secondary analysis of existing data. The secondary data instrument, variables, and data collection have been finalized, information pertaining to additional research inquires was not possible because of prior data instrumentation and variable selection. Missing data and incorrect data input by data abstractors also resulted in missing data which was identified as outliers and corrected. Example noted relate to time variables (i.e., Arrival time, DTN time, DTI time) with incorrect input values which may result in negative numerical time values after analysis. An additional limitation was that not all hospitals within a specific region participate in GWTG-Stroke; thus, there was no way of knowing if the dataset was representation of all hospitals within a region. Additional limitations related to the data and the study sample is that it lacked homogeneity due to the Stroke Belt being much smaller in comparison to Non-Stroke Belt states. Since the study used quantitative methods, perceptions of AIS treatment and outcomes were not assessed.

Recommendations

Studying findings suggest differences in mean outcome measures, highlighted when the researcher examined the comparison groups (SBH vs. NSBH) with patient-level analysis based on the patient state of residence (i.e., zip code). Researchers may examine

GWTG-Stroke data and identify opportunities for decreasing acute ischemic stroke treatment disparities in the most adversely affected regions. By further examining acute ischemic stroke quality of care at SBHs compared to NSBHs, Researchers can note existing disparities requiring quality improvement or decreases in disparities confirming quality interventions were efficacious. Future studies focusing on acute ischemic stroke regarding the Stroke Belt should also assess data at the patient-level based on the state of residence. Data analysis at the patient level may differ from hospital-level results. Analysis at the patient-level accurately groups patients according to their state of residence (i.e., Stroke Belt state or Non-Stroke Belt state); this assures correct grouping of patients living in border communities and allows state-level assessment if Stroke Belt states change. Howard & Howards (2020) suggest that the definition of the Stroke Belt based upon stroke mortality rates may be changing, welcoming new states, and discharging others. Future studies should focus on GWTG-Stroke data regarding Stroke Belt Hospitals and examine data at the patient-level concerning all core stroke measures (e.g., STKs) to better assess treatment disparities and opportunities for systemic quality improvement initiatives. An assessment of all core stroke measures (STKs) regarding SBHs compared to NSBHs utilizing GWTG-Stroke would be helpful to ascertain an overall perspective.

Implications

Social implications related to public health benefits at the individual level include reductions in patient deficits, long-term disability, and mortality. Additionally, individuals presenting to SBHs utilizing GWTG-Stroke have decreased odds of

experiencing AIS treatment disparities related to r-tPA administration and DTN times. Positive social change at the organizational level relates to SBHs utilizing GWTG-Stroke may experience improvements in reportable quality and stroke performance measures. Social implementations at the societal level include reduced stroke-related health care costs, as patient outcomes and functionality improve, associated long-term disability, and healthcare expenditures decrease. Furthermore, by identifying treatment methods that can decrease the disproportionate stroke mortality rates within the Stroke Belt, hospital administrations and policymakers may assist in the reallocation of public health resources. The social and personal implications of positive social change coincide with Walden University's scholar-practitioner mindset.

The conceptual framework that was employed in this study was Donabedian's lasting framework for health care quality. Growing evidence suggests that public health initiatives based on theory have increased efficacy when appropriately deployed in hospital settings. The health behavior of not only the patient population but also the healthcare practitioner plays a significant part in dictating patient outcomes. Fundamentally, theories can also help to identify barriers between patient needs and effective treatment. The specific focal aspect of healthcare is AIS treatment during the post-intervention period for hospitals utilizing GWTG-Stroke within the Stroke Belt. The barriers noted in past research studies were related to delays in patient presentation, imaging, and the completion of laboratory tests. To overcome these barriers, I employed Donabedian's lasting framework for health care quality, which utilizes a triad of structure, process, and outcome—along with seven pillars of quality (i.e., efficacy, effectiveness,

efficiency, optimality, acceptability, legitimacy, equity)—to evaluate the quality of treatment (Ayanian & Markel, 2016).

The conceptual framework illustrating a modified Donabedian casual chain of quality factors influencing improved AIS patient treatment and outcomes in hospitals using GWTG-Stroke (*Figure. 1*) includes the framework's three dimensions of quality: quality of *structure*, *process*, and *outcomes*. Implementation of the modified Donabedian relates to this study in the following manner. *Structure* describes the context in which healthcare providers deliver patient care and is influenced based on policy (e.g., JCAHO CSPs, CMS, evidence-based practice, hospital infrastructure, staffing, equipment, and financing) as implemented by stakeholders. *Process* denotes the delivery of healthcare services and transactions between providers and patients; targeted interventions (i.e., stroke education, training), clinical interventions (i.e., r-tPA, brain imaging, therapies), are integral components of the quality of the process. *Outcomes* are the effects of healthcare on the health status of patients and populations; examples are ischemic stroke mortality, disability rate, increased r-tPA usage, decreased DTI times, decreased DTN times, and disparity reduction as it relates to SBHs and NSBHs. Healthcare providers have used this framework extensively throughout the United States by various agencies: the U.S. Public Health Service (USPHS) Health Services Research Section (HSRS), the Centers for Medicare and Medicaid (CMS), and the Institute of Medicine (IOM). Nevertheless, the Donabedian model remains the dominant framework utilized to assess the quality of healthcare and is helpful for this quantitative equivalence study.

This study has shown that implementation of stroke quality programs such as GWTG Stroke may be beneficial in SBHs by decreasing disparities associated with AIS patient treatment and outcomes related to specific core stroke measures such as r-tPA administration, DTN time, and in-hospital ischemic stroke only mortality. Study results impact positive social change at the individual level and the tertiary care, societal, policy, and public health levels. Stroke is the fifth leading cause of mortality in the United States (Centers for Disease Control and Prevention [CDC], 2017); (Man et al., 2017). Between 2014 and 2016, the age-adjusted stroke mortality rate in the United States for all causes (i.e., ischemic, and hemorrhagic combined) is 72.2 per 100,000 and 37.9 per 100,000 for ischemic stroke in persons 35 years of age and older (NCCDP, 2018a; NCCDP, 2018b). Ischemic stroke is the most common type of stroke, accounting for 87% of cases (Benjamin et al., 2017). Statistically, one out of every 20 deaths in the United States are stroke-related, some 800,000 people annually (CDC, 2017; CDC, 2018).

The effects of a stroke are devastating and often lead to other health problems, making strokes the leading cause of long-term disability and admission to long-term care facilities in the United States. Public health experts estimate the costs of such care at $34 billion yearly; these costs include health care, pharmacotherapy, and wages lost due to missed days of work (CDC, 2017). eight contiguously clustered states in the American Southeast have represented the so-called "Stroke Belt" due to their disproportionately high stroke mortality rates—ten percent higher than the national average (Karp et al., 2016). The risk of AIS varies as it is region-specific; but, the highest incidence of AIS has been noted in the "Stroke Belt" region (Howard & Howard, 2020). A cluster of

Eastern coastal counties that are part of the Stroke Belt has been termed the "Stroke Buckle"; these counties have stroke mortality rates twice as high as the national average (NINDS, 2018).

This study addressed the problem mentioned earlier by examining potential significant differences in the mean distribution of r-tPA usage, DTI time, DTN time, and AIS mortality amongst GWTG-participating hospitals (i.e., SBHs versus NSBHs). In this study I examined whether GWTG-Stroke implementation differed based on geographical location and attendant demographical factors. Implementation of GWTG-Stroke was examined to determine if SBH and NSBH were quantitatively equivalent if components were not an issue. The hypothesis was that hospitals within the Stroke Belt have adequately implemented the GWTG-Stroke program and thus will have no significant difference in outcomes in comparison to Non-Stroke Belt hospitals utilizing the GWTG-Stroke Program. A lack of significant difference in outcome between the two comparison groups would suggest that the GWTG-Stroke Quality Program effectively decreases AIS treatment disparities and mortality. Individuals and stakeholders can benefit from this study's identification of both deficits and accomplishments related to core stroke measures and mortality. Increasing adherence to evidence-based practice should assist in decreasing the above-average stroke mortality rate within the Stroke Belt. At the tertiary or acute care level (e.g., hospital), healthcare providers treating AIS patients at SBHs can utilize evidence-based practice to focus on AIS treatment disparities more appropriately, as identified with this study.

Findings from this study suggest that GWTG-Stroke implementation may decrease AIS treatment disparities and mortality within SBHs, as evident by equivalency with NSBHs in specific core stroke measures. The equivalence study results varied based upon the research question and hospital-level and patient-level analyses. Concerning r-tPA administration, based on study results at the hospital-level, we concluded that SBHs and NSBHs were *equivocal* for AIS patients meeting criteria. The *equivocal* decision may be due to the following, as explained by Mecklin (2003, 331), "a simultaneous rejection of both inferential procedures, could happen in a situation where large samples provide 'too much power,' resulting in a trivial difference in means being statistically significant. The equivalence test (and the effect size) should detect the small magnitude of these mean differences.". While this equivocal decision regarding r-tPA administration does not state equivalence amongst SBHs and NSBHs; it does not state that the two groups are statistically different or not equivalent. Clinical implications regarding GWTG-Stroke implementation and r-tPA administration in SBHs should focus upon the results that did not identify a disparity in treatment compared to NSBHs.

Additionally, hospitals within the Stroke Belt may benefit from implementation of GWTG-Stroke. Study findings align with previous literature such as Howard et al. (2018), which concluded that care of stroke patients admitted to hospitals participating in the GWTG-Stroke was more likely to meet important stroke quality care metrics such as r-tPA administration and DTN time. In addition, Fonarow et al. (2014) suggest that implementation of quality improvement programs such as GWTG-Stroke is associated with an increase in r-tPA administration rates and DTN time or OTT time.

In regard to DTN time at the hospital-level and patient-level for SBHs in comparison to NSBHs, study findings at the hospital-level suggest that both groups were not equivalent. Study findings at the patient-level indicate that SBHs and NSBHs were equivalent. Study finding at the patient-level indicate that GWTG-Stroke implementation may be beneficial in decreasing disparities in AIS treatment as it relates to Hospitals within the Stroke Belt and DTN time. The finding of this study at the patient-level with regards to DTN time and implementation of stroke quality programs align with previously literature. Previous researchers have noted that structured quality improvement interventions like the GWTG-Stroke program increases the number of patients that receive r-tPA within the recommended 60-minute DTN (Jauch et al., 2018). Clinical implications related to DTN time have been associated with increased r-tPA administration rates, decreases in mortality, and better patient outcomes status-post stroke. Fonarow et al. (2014) concluded in their study that improvements in DTN time and r-tPA administration resulted in lower rates of in-hospital mortality and intracranial hemorrhage, along with an increase in the percentage of patients discharged home. (Fonarow et al., 2014).

Acute ischemic stroke treatment is a time-dependent process that includes multiple processes and procedures working simultaneously to provide treatment modalities within specific time frames. Patient symptom onset to hospital presentation, DTI time, DTN time and OTT time are all dependent on a healthcare system and healthcare providers working efficaciously and collaboratively. As part of this study, I examined whether SBHs and NSBHs utilizing GWTG-Stroke were equivalent to DTI

time at the hospital and patient levels. Study results pertaining to DTI time equivalence at the hospital-levels and patient-level were both concluded to be not equivalent. In regard to DTI time, one notable difference in this study's results as compared to existing studies, was that implementation of a stroke quality program did not result in an improved stroke measure (i.e., DTI time) (Howard et al., 2018; Jauch et al., 2018). Based on findings in this study, a disparity remains regarding DTI time in SBHs in comparison NSBHs. Clinical implications associated with DTI time in SBHs should be prioritized, as delays in imaging present a dilemma as it is a vital component in r-tPA administration and DTN time.

I examined the GWTG Ischemic Stroke Only Mortality Rate at the hospital and patient levels in this study. Study findings revealed that NSBHs and SBHs were not equivalent at the hospital-level. Study finding at the patient level, suggest SBHs and NSBHs were equivalent. Results from this study at the patient-level corroborate previous research suggesting that the implementation of stroke quality programs aid in decreasing stroke mortality. In the study by Fonarow et al. (2014), researchers found that appropriate treatment during the postintervention period was associated with a reduced likelihood of in-hospital mortality (adjusted OR, 0.89 [95 percent Confidence Interval [CI], 0.83-0.94], $P < .001$).

Additionally, over the past five years, research has shown improved hospital adherence to stroke quality metrics has resulted in improved outcomes and reduced mortality for stroke patients. Study finding in this study at the patient-level suggest that implementation of GWTG-Stroke in SBHs may be beneficial in decreasing disparities in

AIS patient mortality in comparison to NSBHs. Implementations of GWTG-Stroke may also decrease ischemic stroke only mortality by means of improving DTN times and r-tPA administration rates as suggested in this study by patient-level finding of equivalent or equivocal as noted (i.e., r-tPA, DTN time, GWTG Ischemic Stroke Only Mortality Rate).

Conclusion

In the United States stroke is the fifth leading cause of mortality, with ischemic stroke being the most common stroke subtype accounting for 87% of cases (CDC, 2017; Benjamin et al., 2017). The effects of a stroke are devastating and often lead to other health issues, making strokes the leading cause of long-term disability and admission to long-term care facilities in the United States. Public health experts estimate the costs of such care at $34 billion yearly; these costs include health care, pharmacotherapy, and wages lost due to missed days of work (CDC, 2017). Treatment of acute ischemic stroke (AIS) is time-dependent and reliant on various treatment modalities (i.e., tissue plasminogen activator (Alteplase/IV r-tPA) to avoid later complications and death. Since 1980, eight contiguously clustered states in the American Southeast have represented the so-called "*Stroke Belt*" due to their disproportionately high stroke mortality rates—ten percent higher than the national average (Karp et al., 2016).

Previous studies have demonstrated that the implementation and usage of structured quality initiatives such as the American Heart Association® GWTG Stroke Quality Program enhances utilization of stroke treatment modalities, rate of defect-free stroke care, and functional outcomes while reducing stroke-related mortality. A review of

the literature suggests that a hospital's adherence to guidelines is essential to effective stroke patient care. Timely evaluation and treatment initiation for AIS is crucial, and clinical practice often fails to meet established policies and goals. Rural hospitals, such as those within the Stroke Belt, struggle to meet the time-based goals expected by JCAHO certified centers in urban environments (Jauch et al., 2018). What was unclear is how these policies have affected America's most afflicted region and if GWTG-Stroke implementation effectively increased r-tPA usage, reduced "door to needle time" (DTN), and decreased stroke mortality in hospitals within the Stroke Belt. I examined if SBHs and NSBHs were providing similar or equivalent care.

This study addressed the problem as mentioned earlier by examining significant differences in the mean distribution of r-tPA administration, door-to-imaging (DTI) time, Door-to-Needle (DTN) time, and AIS mortality amongst GWTG-Stroke participating hospitals (i.e., SBHs versus NSBHs). This study aimed to examine the efficacy of GWTG-Stroke in reducing key AIS treatment disparities and AIS stroke-related mortality (i.e., GWTG Ischemic Only Estimated Mortality Rate) in SBHs in comparison to NSBHs. Through an equivalence study utilizing secondary data, this research study explored the effectiveness of stroke treatment policies in the Stroke Belt: the region of the United States that still exhibits the highest stroke-related mortality rates in the country. An equivalence study was used to provide insight and analysis on the efficacy of GWTG-Stroke within SBHs compared to NSBHs. In this study, I assessed the performance of the GWTG-Stroke to determine if SBH and NSBH were quantitatively equivalent if components were not an issue. I hypothesized that SBHs have adequately implemented

the GWTG-Stroke program and thus had no significant difference in outcomes compared to NSBHs utilizing GWTG-Stroke. A lack of substantial discrepancy in yield between the two comparison groups would suggest that the GWTG-Stroke quality intervention effectively decreases AIS treatment disparities and mortality.

This study has shown that GWTG-Stroke implementation within SBHs is efficacious and association with improving AIS treatment, patient outcomes, and eliminating tertiary treatment disparities compared to NSBHs participating in GWTG-Stroke. The equivalence study results varied based upon the research question and level of analysis (i.e., hospital-level and patient-level). The results of this study have revealed that implementation of the American Heart Association® GWTG Stroke Quality Program is efficacious at decreasing disparities related to acute ischemic stroke treatment disparities and mortality in SBH as compared to NSBHs at the patient-level. Study findings at the hospital-level differed from patient-level analysis. Regarding DTN time, patient-level analysis of SBHs and NSBHs utilizing GWTG-Stroke revealed both groups were equivalent and statistically different. Patient-level analysis of SBHs and NSBHs utilizing GWTG-Stroke revealed both groups were equivalent and not statistically different regarding GWTG Ischemic Stroke Only Mortality Rate. Hospital-level analysis of r-tPA administration rates at the hospital-level reveal that SBHs and NSBHs utilizing GWTG-Stroke were equivocal.

The results from prior research suggested that implementation of systemic stroke quality improvement initiatives improvement acute stroke treatment, increased the rate of r-tPA administration and defect free care, and decreased stroke related mortality. Results

of this research study coincide with prior studies results at the patient-level for DTN time and Ischemic Stroke Only Mortality. Given the detrimental effects status post-stroke, the findings from this study suggest that implementation of GWTG-Stroke is effective at decreasing disparity related to acute ischemic stroke treatment and outcomes (i.e., mortality) as evident by SBH and NSBHs performing similarly regarding specific core stroke measures at the patient-level. Implementation of quality improvement cycles is a continuous process involving data, policy, stakeholder interactions, and ongoing incremental improvements. Hence, the finding from this study revealed the significance of GWTG Stroke on improving acute ischemic stroke treatment and outcomes within the hardest hit region known as the Stroke Belt.

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Appendix A: GWTG-Stroke PMT Case Record Form

Case Record Form
Active Form Groups: Stroke, Diabetes

Updated January 2021

Patient ID:		**Bold Question = Required**

DEMOGRAPHICS *Demographics Tab*

Gender	○ Male ○ Female ○ Unknown
Date of Birth: ____/____/_____	**Age:** _____
Zip Code: _____ - _____ ☐ Homeless	
Payment Source	☐ Medicare Title 18 ☐ Medicaid Title 19 ☐ Medicare – Private/ HMO/ PPO/ Other ☐ Medicaid – Private/ HMO/ PPO/ Other ☐ Private/ HMO/ PPO/ Other ☐ VA/ CHAMPVA/ Tricare ☐ Self Pay/ No Insurance ☐ Other/ Not Documented/ UTD

RACE AND ETHNICITY

Race (Select all that apply):	☐ American Indian/Alaska Native ☐ Asian [if Asian selected] ☐ Asian Indian ☐ Chinese ☐ Filipino ☐ Japanese ☐ Korean ☐ Vietnamese ☐ Other Asian ☐ Black or African American ☐ Native Hawaiian or Pacific Islander [if native Hawaiian or pacific islander selected] ☐ Native Hawaiian ☐ Guamanian or Chamorro ☐ Samoan ☐ Other Pacific Islander ☐ White ☐ UTD
Hispanic Ethnicity:	○ Yes ○ No/UTD
If Yes,	☐ Mexican, Mexican American, Chicano/a ☐ Puerto Rican ☐ Cuban ☐ Another Hispanic, Latino or Spanish Origin

ADMIN *Admin Tab*

Final clinical diagnosis related to stroke	○ Ischemic Stroke ○ Transient Ischemic Attack (<24 hours) ○ Subarachnoid Hemorrhage ○ Intracerebral Hemorrhage ○ Stroke not otherwise specified ○ No stroke related diagnosis ○ Elective Carotid Intervention only
If not Stroke Related Diagnosis:	○ Migraine ○ Seizure ○ Delirium ○ Electrolyte or metabolic imbalance ○ Functional disorder ○ Other ○ Uncertain
Was the Stroke etiology documented in the patient medical record:	○ Yes No
Select documented stroke etiology (select all that apply):	○ 1: Large-artery atherosclerosis (e.g., carotid or basilar stenosis) ○ 2: Cardioembolism (e.g., atrial fibrillation/flutter, prosthetic heart valve, recent MI) ○ 3: Small-vessel occlusion (e.g., subcortical or brain stem lacunar infarction <1.5 cm) ○ 4: Stroke of other determined etiology (e.g., dissection, vasculopathy, hypercoagulable or hematologic disorders. ○ Dissection ○ Hypercoagulability ○ Other ○ 5: Cryptogenic stroke (stroke of undetermined etiology) ○ Multiple potential etiologies identified ○ Stroke of undetermined etiology ○ Unspecified
When is the earliest documentation of comfort measures only?	○Day 0 or 1 ○Day 2 or after ○Timing unclear ○Not Documented/UTD
Arrival Date/Time: ____/____/_____:____	☐ MM/DD/YYYY only ☐ Unknown **Admit Date:** ____/____/_____

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Not Admitted:	○ Yes, not admitted ○ No, patient admitted as in patient	Reason Not Admitted:	○ Transferred from your ED to another acute care hospital ○ Discharged directly from ED to home or other location that is not an acute care hospital ○ Left from ED AMA ○ Died in ED ○ Discharged from observation status without an inpatient admission ○ other

If patient transferred from your ED to another hospital, specify hospital name	[Select hospital name from picker list] ☐ Hospital not on list ☐ Hospital not documented
Select reason(s) for why patient transferred	☐ Evaluation for IV alteplase up to 4.5 hours ☐ Post Management of IV alteplase (e.g. Drip and Ship) ☐ Evaluation for Endovascular thrombectomy ☐ Advanced stroke care (e.g., Neurocritical care, surgical or other time critical therapy) ☐ Patient/family request ☐ Other advanced care (not stroke related) ☐ Not documented
Discharge Date:	____/____/_____:____ ☐ MM/DD/YYYY only
Documented reason for delay in transfer to referral facility?	○ Yes ○ No/ND
Specific reason for delay documented in transfer patient (check all that apply):	☐ Social/religious ☐ Initial refusal ☐ Care team unable to determine eligibility ☐ Management of concomitant emergent/acute conditions such as cardiopulmonary arrest, respiratory failure (requiring intubation) ☐ Investigational or experimental protocol for reperfusion ☐ Delay in stroke diagnosis * ☐ In-hospital time delay * ☐ Equipment-related delay * ☐ Need for additional imaging* ☐ Catheter lab not available* ☐ Other *
For patients discharged on or after 04/01/2011: What was the patient's discharge disposition on the day of discharge?	☐ 1 – Home ☐ 2 – Hospice – Home ☐ 3 – Hospice – Health Care Facility ☐ 4 – Acute Care Facility ☐ 5 – Other Health Care Facility ☐ 6 – Expired ☐ 7 – Left Against Medical Advice / AMA ☐ 8 – Not Documented or Unable to Determine (UTD)
If Other Health Care Facility	○ Inpatient Rehabilitation Facility (IRF) ○ Skilled Nursing Facility (SNF) ○ Intermediate Care facility (ICF) ○ Other ○ Long Term Care Hospital (LTCH)

DIAGNOSIS CODE	***Clinical Codes Tab***
ICD-9CM or ICD-10-CM Principal Diagnosis Code ICD-9CM or ICD-10-CM Other Diagnosis Codes	_____
ICD-9-CM Discharge Diagnosis Related to Stroke ICD-10-CM Discharge Diagnosis Related to Stroke	
No Stroke or TIA Related ICD-9-CM Code Present No Stroke or TIA Related ICD-10-CM Code Present	☐ ☐

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ARRIVAL AND ADMISSION INFORMATION						*Admission Tab*
During this hospital stay, was the patient enrolled in a clinical trial in which patients with the same condition as the measure set were being studied (i.e. STK,VTE)?					O Yes	O No
Was this patient admitted for the sole purpose of performance of elective carotid intervention?					O Yes	O No
Patient location when stroke symptoms discovered	O Not in a healthcare setting O Another acute care facility O Chronic health care facility		O Outpatient healthcare setting O Stroke occurred after hospital arrival (in ED/Obs/inpatient) O ND or Cannot be determined			
How patient arrived at your hospital	O EMS from home/scene	O Mobile Stroke Unit	O Private Transportation/Taxi/Other from home/scene	O Transfer from another hospital	O ND or Unknown	
Referring hospital discharge Date/ Time	____/____/_____:____	☐ MM/DD/YYYY only	☐ Unknown			
If transferred from another hospital, specify hospital name	[Select hospital name from picker list] ☐ Hospital not on list ☐ Hospital not documented					
Referring hospital arrival date/ time	____/____/_____:____	☐ MM/DD/YYYY only	☐ Unknown			
If patient transferred to your hospital, select transfer reason(s)	☐ Evaluation for IV alteplase up to 4.5 hours ☐ Post Management of IV alteplase (e.g. Drip and Ship) ☐ Evaluation for Endovascular thrombectomy ☐ Advanced stroke care (e.g., Neurocritical care, surgical or other time critical therapy) ☐ Patient/family request ☐ Other advanced care (not stroke related) ☐ Not documented					
Where patient first received care at your hospital	☐ Emergency Department / Urgent Care	☐ Direct Admit, not through ED	☐ Imaging suite	☐ ND or Cannot be determined		
Advanced Notification by EMS or MSU?	O Yes	O No/ND				
Initial Admitting Service	O Neurology O Neurosurgery O Neurocritical Care	O Medicine O Surgery O Other:				
In which settings were care delivered? Select all that apply.	☐ Neuro/ Neurosurgery ICU ☐ Other ICU ☐ Stroke Unit (Non-ICU)	☐ General Care Floor ☐ Observation ☐ Other:				
If the patient was not cared for in a dedicated stroke unit, was a formal inpatient consultation from a stroke expert obtained?	O Yes	O No	O ND			
Physician / Provider NPI:						
MEDICAL HISTORY						
Previously known medical hx of:	☐ None ☐ Atrial Fib/Flutter ☐ Current Pregnancy (up to 6 weeks post-partum) ☐ Diabetes Mellitus ☐ Type I ☐ Type II ☐ ND Duration: O < 5 years O 5 - < 10 years O 10 - < 20 years O >= 20 years O Unknown ☐ E-Cigarette Use (Vaping) ☐ HF ☐ Hypertension	☐ CAD/ Prior MI ☐ DVT/ PE ☐ Drugs/ Alcohol Abuse ☐ Familial Hypercholesterolemia ☐ HRT ☐ Migraine ☐ Previous TIA ☐ Renal Insufficiency – Chronic ☐ Smoker	☐ Carotid Stenosis ☐ Dementia ☐ Depression ☐ Dyslipidemia ☐ Family History of Stroke ☐ Hx of Emerging Infectious Disease ☐ MERS ☐ SARS-COV-1 ☐ SARS-COV-2 (COVID-19) ☐ Other Infectious Respiratory Pathogen ☐ Obesity Overweight ☐ Prosthetic Heart Valve ☐ Sickle Cell			

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	☐ Previous Stroke ☐ Ischemic Stroke ☐ ICH ☐ SAH ☐ Not Specified ☐ PVD ☐ Sleep Apnea
Ambulatory status prior to current event	O Able to ambulate independently (no help from another person) w/ or w/o device O With assistance (from person) O Unable to ambulate O ND
Pre-stroke Modified Rankin Score	O 1 – A pre-stroke mRS of 0, 1, or 2 was documented in the medical record, OR physician/ APN/PA documentation that the patient was able to look after self without daily help prior to this acute stroke episode. O 2- A pre-stroke mRS of 3, 4, or 5 was documented in the medical record, OR physician/ APN/ PA documentation that the present could NOT look after self without daily help prior to this acute stroke episode. O 3 – A pre-stroke mRS was not documented, OR unable to determine (UTD) from the medical record documentation

DIAGNOSIS & EVALUATION

Symptom Duration if diagnosis of Transient Ischemic Attack (less than 24 hours)	O Less than 10 minutes O 10 – 59 minutes O > = 60 minutes O ND
Had stroke symptoms resolved at time of presentation?	O Yes O No O ND
Initial NIH Stroke Scale	O Yes O No/ND
If yes:	O Actual O Estimate from record O ND
Total Score:	_____ (refer to web program for questions)
NIHSS score obtained from transferring facility:	_____ O ND
Initial exam findings (Select all that apply)	☐ Weakness/Paresis ☐ Altered Level of Consciousness ☐ Aphasia/Language Disturbance ☐ Other neurological signs/symptoms ☐ No neurological signs/symptoms ☐ND
Ambulatory status on admission	O Able to ambulate independently (no help from another person) w/ or w/o device O With assistance (from person) O Unable to ambulate O ND

MEDICATION PRIOR TO ADMISSION

No medications prior to admission	☐
Antiplatelet or Anticoagulant Medication(s):	☐ Yes ☐ No/ND

☐ **Antiplatelet Medication** o aspirin o aspirin/dipyridamole (Aggrenox) o clopidogrel (Plavix) o prasugrel (Effient) o ticagrelor (Brilinta) o ticlopidine (Ticlid) o Other Antiplatelet	☐ **Anticoagulant Medication** O apixaban (Eliquis) O argatroban O dabigatran (Pradaxa) O desirudin (Iprivask) O endoxaban (Savaysa) O fondaparinux (Arixtra) O full dose LMW heparin O lepirudin (Refludan) O rivaroxaban (Xarelto) O unfractionated heparin IV O warfarin (Coumadin) O other Anticoagulant

Antihypertensive	O Yes O No/ND
Cholesterol-Reducer	O Yes O No/ND
Anti-hyperglycemic medications:	O Yes O No/ND

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If yes, select medications (select all that apply)	☐ DPP-4 Inhibitors ☐ SGLT2 inhibitor ☐ Other injectable/ subcutaneous agent ☐ GLP-1 receptor agonist ☐ Sulfonylurea ☐ Insulin ☐ Thiazolidinedione ☐ Metformin ☐ Other oral agent
Antidepressant medication	O Yes O No/ND

VACCINATIONS & TESTING

COVID-19 Vaccination:	o COVID-19 vaccine was given during this hospitalization o COVID-19 vaccine was received prior to admission, not during this hospitalization o Documentation of patient's refusal of COVID-19 vaccine o Allergy/sensitivity to COVID-19 vaccine or if medically contraindicated o Vaccine not available o None of the above/Not documented/UTD
COVID-19 Vaccination date:	____/____/_____ o Not Documented
Is there documentation that this patient was included in a COVID-19 vaccine trial?	o Yes o No/ND
Influenza Vaccination:	o Influenza vaccine was given during this hospitalization during the current flu season o Influenza vaccine was received prior to admission during the current flu season, not during this hospitalization o Documentation of patient's refusal of influenza vaccine o Allergy/sensitivity to influenza vaccine or if medically contraindicated o Vaccine not available o None of the above/Not documented/UTD

SYMPTOM TIMELINE *Hospitalization Tab*

Date/Time Patient last known to be well?	☐ Time of Discovery same as Last Known well	Date/Time of discovery of stroke symptoms?
____/____/_____:____ ☐ MM/DD/YYYY only ☐ Unknown		____/____/_____:____ ☐ MM/DD/YYYY only ☐ Unknown
Comments:		

BRAIN IMAGING

Brain imaging completed at your hospital for this episode of care?	O Yes ☐ CT ☐ MRI O No/ND O NC	**Date/Time Brain Imaging First Initiated at your hospital:**	____/____/_____:____ ☐ MM/DD/YYYY only ☐ Unknown
Interpretation of first brain image after symptom onset, done at any facility:	O Acute Hemorrhage	O No Acute Hemorrhage	O Not Available
Was acute Vascular or perfusion imaging (e.g. CTA, MRA, DSA) performed at your hospital?	O Yes O No	Date/Time 1st vessel or perfusion imaging initiated at your hospital: ___/____/_____:____	☐ MM/DD/YYYY only ☐ Unknown
If yes, type of vascular imaging (select all that apply)	☐ CTA ☐ CT Perfusion ☐ MRA	☐ MR Perfusion ☐ DSA (catheter angiography) ☐ Image type not documented	
Was a target lesion (large vessel occlusion) visualized?	O Yes O No/ND		
If yes, select site of large vessel occlusion (select al that apply):	☐ ICA ☐ Intracranial ICA ☐ Cervical ICA ☐ Other/UTD	☐ MCA ☐ M1 ☐ M2 ☐ Other/UTD	☐ Basilar ☐ Other cerebral artery branch ☐ Vertebral Artery

ADDITIONAL TIME TRACKER

Date/Time Stroke Team Activated: ____/____/_____ ____:____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown O N/A	Date/Time Stroke Team Arrived: ____/____/_____ ____:____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown

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Date/Time of ED Physician Assessment: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown O N/A	Date/Time Neurosurgical services consult: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown
Date/Time Brain Imaging Ordered: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown O N/A	Date/Time Brain Imaging Interpreted: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown
Date/Time IV alteplase Ordered: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown O N/A		
Date/Time Lab Tests Ordered: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown N/A	Date/Time lab Tests Completed: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown
Date/Time ECG Ordered: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown O N/A	Date/Time ECG Completed: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown
Date/Time Chest X-ray Ordered: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown O N/A	Date/Time Chest X-ray Completed: ____/____/_____ ____:_____	Select one option O MM/DD/YYYY HH:MM O MM/DD/YYYY O Unknown
Additional Comments:			

IV THROMBOLYTIC THERAPY

IV thrombolytic initiated at this hospital?	O Yes O No	**Date/Time IV thrombolytic initiated:** ____/____/_____ ____:_____
Thrombolytic used:	O Alteplase (Class 1 evidence) Alteplase, total dose: _____(mg) ☐ Alteplase dose ND	O Tenecteplase (Class 2b evidence) Tenecteplase, total dose: _____(mg) ☐ Tenecteplase dose ND
Reason for selecting tenecteplase instead of alteplase:	O Large Vessel Occlusion (LVO) with potential thrombectomy O Mild Stroke O Other: _____	
If IV thrombolytic administered beyond 4.5-hour, was imaging used to identify eligibility?	O Yes, Diffusion-FLAIR mismatch O Yes, Core-Perfusion mismatch O None O Other: _____	
Documented exclusions (Contraindications or Warnings) for not initiating IV thrombolytic in the 0-3hr treatment window?	O Yes O No	
Documented Contraindications or Warnings for not initiating IV thrombolytic in the 3-4.5hr treatment window?	O Yes O No	

SHOW ALL

If yes, documented exclusions for 0 -3-hour treatment window or 3 – 4.5 treatment window, select reason for exclusion.

For discharges on or after 1 April 2016

Exclusion Criteria (contraindications) 0-3 hr treatment window. Select all that apply:

☐ *C1: Elevated blood pressure (systolic > 185 mm Hg or diastolic > 110 mm Hg) despite treatment*

☐ *C2: Recent intracranial or spinal surgery or significant head trauma, or prior stroke in*

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previous 3 months
- ☐ C3: History of previous intracranial hemorrhage, intracranial neoplasm, arteriovenous malformation, or aneurysm
- ☐ C4: Active internal bleeding
- ☐ C5: Acute bleeding diathesis (low platelet count, increased PTT, INR >= 1.7 or use of NOAC)
- ☐ C6: Symptoms suggest subarachnoid hemorrhage
- ☐ C7: CT demonstrates multi-lobar infarction (hypodensity >1/3 cerebral hemisphere)
- ☐ C8: Arterial puncture at non-compressible site in previous 7 days
- ☐ C9: Blood glucose concentration <50 mg/dL (2.7 mmol/L)

Relative Exclusion Criteria (Warnings) 0-3 hr treatment window. Select all that apply:
- ☐ W1: Care-team unable to determine eligibility
- ☐ W2: IV or IA thrombolysis/thrombectomy at an outside hospital prior to arrival
- ☐ W3: Life expectancy < 1 year or severe co-morbid illness or CMO on admission
- ☐ W4: Pregnancy
- ☐ W5: Patient/family refusal
- ☐ W7: Stroke severity too mild (non-disabling)
- ☐ W8: Recent acute myocardial infarction (within previous 3 months)
- ☐ W9: Seizure at onset with postictal residual neurological impairments
- ☐ W10: Major surgery or serious trauma within previous 14 days
- ☐ W11: Recent gastrointestinal or urinary tract hemorrhage (within previous 21 days)

Exclusion Criteria (contraindications) 3-4.5 hr treatment window. Select all that apply:
- ☐ C1: Elevated blood pressure (systolic > 185 mm Hg or diastolic > 110 mm Hg) despite treatment
- ☐ C2: Recent intracranial or spinal surgery or significant head trauma, or prior stroke in previous 3 months
- ☐ C3: History of previous intracranial hemorrhage, intracranial neoplasm, arteriovenous malformation, or aneurysm
- ☐ C4: Active internal bleeding
- ☐ C5: Acute bleeding diathesis (low platelet count, increased PTT, INR ≥ 1.7 or use of NOAC)
- ☐ C6: Symptoms suggest subarachnoid hemorrhage
- ☐ C7: CT demonstrates multi-lobar infarction (hypodensity >1/3 cerebral hemisphere)
- ☐ C8: Arterial puncture at non-compressible site in previous 7 days
- ☐ C9: Blood glucose concentration <50 mg/dL (2.7 mmol/L

Relative Exclusion Criteria (Warnings) 3-4.5 hr treatment window. Select all that apply:
- ☐ W1: Care-team unable to determine eligibility
- ☐ W2: IV or IA thrombolysis/thrombectomy at an outside hospital prior to arrival
- ☐ W3: Life expectancy < 1 year or severe co-morbid illness or CMO on admission
- ☐ W4: Pregnancy
- ☐ W5: Patient/family refusal
- ☐ W7: Stroke severity too mild (non-disabling)
- ☐ W8: Recent acute myocardial infarction (within previous 3 months)
- ☐ W9: Seizure at onset with postictal residual neurological impairments
- ☐ W10: Major surgery or serious trauma within previous 14 days
- ☐ W11: Recent gastrointestinal or urinary tract hemorrhage (within previous 21 days)

Additional Relative Exclusion Criteria 3-4.5 hr treatment window. Select all that apply:
- ☐ AW1: Age > 80
- ☐ AW2: History of both diabetes and prior ischemic stroke
- ☐ AW3: Taking an oral anticoagulant regardless of INR
- ☐ AW4: Severe Stroke (NIHSS > 25)

Other Reasons (Hospital-related or other factors) 0-3-hour treatment window.
- ☐ Delay in Patient Arrival
- ☐ In-hospital Time Delay
- ☐ Delay in Stroke diagnosis
- ☐ No IV access
- ☐ **Rapid or Early Improvement**
- ☐ Advanced Age

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	☐ *Stroke too severe* ☐ *Other – requires specific reason to be entered in the PMT when this option is selected.*
Other Reasons (Hospital-related or other factors) 3-4.5-hour treatment window.	☐ *Delay in Patient Arrival* ☐ *In-hospital Time Delay* ☐ *Delay in Stroke diagnosis* ☐ *No IV access* ☐ ***Rapid or Early Improvement*** ☐ *Other – requires specific reason to be entered in the PMT when this option is selected*
If IV thrombolytic was initiated greater than 60 minutes after hospital arrival, were Eligibility or Medical reason(s) documented as the cause for delay:	O Yes O No
If IV thrombolytic was initiated greater than 45 minutes after hospital arrival, were Eligibility or Medical reason(s) documented as the cause for delay:	O Yes O No
If IV thrombolytic was initiated greater than 30 minutes after hospital arrival, were Eligibility or Medical reason(s) documented as the cause for delay:	O Yes O No
Eligibility Reason(s):	☐ Social/Religious ☐ Initial refusal ☐ Care-team unable to determine eligibility ☐ Specify eligibility reason:_____
Medical Reason(s):	☐ Hypertension requiring aggressive control with IV medications ☐ Further diagnostic evaluation to confirm stroke for patients with hypoglycemia (blood glucose < 50), seizures, or major metabolic disorders ☐ Management of concomitant emergent/acute conditions such as cardiopulmonary arrest, respiratory failure (requiring intubation) ☐ Investigational or experimental protocol for thrombolysis ☐ Need for additional PPE for suspected/ confirmed infectious disease ☐ Specify medical reason:_____
Hospital Related or Other Reason(s):	☐ Need for additional imaging ☐ Delay in stroke diagnosis ☐ In-hospital time delay ☐ Equipment-related delay ☐ Other_____
IV thrombolytic at an outside hospital or Mobile Stroke Unit?	O Yes O No
If yes, select thrombolytic administered at outside hospital or Mobile Stroke Unit	O Alteplase O Tenecteplase
Investigational or experimental protocol for thrombolysis?	O Yes O No If yes, specify_____
Additional Comments Related to Thrombolytics:	

ENDOVASCULAR THERAPY

Catheter-based stroke treatment at this hospital?	O Yes O No	
IA alteplase or MER Initiation Date/Time	____/____/_____ ____:____	O MM/DD/YYYY only O Unknown
Catheter-based stroke treatment at outside hospital?	O Yes O No	

Note, if your hospital is collecting data for the Comprehensive Stroke Center and/or Mechanical Endovascular Reperfusion measure set, please ensure you complete additional data entry on the Advanced Stroke Care.

COMPLICATIONS

Complications of Reperfusion Therapy (Thrombolytic or MER)	☐ Symptomatic Intracranial hemorrhage <36 hours ☐ Life threatening, serious systemic hemorrhage <36 hours ☐ UTD	☐ Other serious complications ☐ No serious complications
If bleeding complications occur in patient after IV alteplase:	O Symptomatic hemorrhage detected prior to patient transfer O Symptomatic hemorrhage detected only after patient transfer	O Unable to determine O N/A

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OTHER IN-HOSPITAL TREATMENT AND SCREENING					
Dysphagia Screening					
Patient NPO throughout the entire hospital stay?	O Yes	O No/ND			
Was patient screened for dysphagia prior to any oral intake including water or medications?	O Yes	O No/ND	O NC		
If yes, Dysphagia screening results:	O Pass	O Fail	O ND		
Treatment for Hospital-Acquired Pneumonia	O Yes	O No	O NC		
VTE Interventions	☐ 1- Low dose unfractionated heparin (LDUH) ☐ 2- Low molecular weight heparin (LMWH) ☐ 3- Intermittent pneumatic compression devices (IPC) ☐ 4- Graduated compression stockings (GCS) ☐ 5- Factor Xa Inhibitor ☐ 6- Warfarin		☐ 7- Venous foot pumps (VFP) ☐ 8-Oral Factor Xa Inhibitor ☐ 9- Aspirin ☐ A- None of the above or ND		
What date was the initial VTE prophylaxis administered after hospital admission?	_____/_____/_____	☐ Unknown			
Is there physician/APN/PA or pharmacist documentation why VTE prophylaxis was not administered at hospital admission?	O Yes	O No			
For discharges on or after 01/01/2013: Is there physician/APN/PA documentation why Oral Factor Xa Inhibitor was administered for VTE prophylaxis?	O Yes	O No			
Other Therapeutic Anticoagulation	☐ apixaban (Eliquis) ☐ argatroba ☐ dabigatran (Pradaxa)	☐ desirrudin (Iprivask) ☐ endoxaban (Savaysa) ☐ lepirudin (Refludan)	☐ rivaroxaban (Xaralto) ☐ unfractionated heparin IV ☐ other anticoagulant		
Was DVT or PE documented?	O Yes	O No/ND			
Was antithrombotic therapy administered by the end of hospital day 2?	O Yes	O No/ND	O NC		
If yes, select all that apply	☐ Antiplatelet	☐ Anticoagulant			
Active bacterial or viral infection at admission or during hospitalization:	☐ None ☐ Bacterial Infection ☐ Emerging Infectious Disease ☐ SARS-COV-1 ☐ SARS-COV-2 (COVID-19) ☐ MERS ☐ Other Emerging Infectious Disease ☐ Influenza ☐ Seasonal Cold ☐ Other Viral Infection				
MEASUREMENTS (first measurement upon presentation to your hospital)					
Total Chol: _____ mg/dl	Triglycerides: _____ mg/dl	HDL: _____ mg/dl	**LDL:** _____ **mg/dl**	☐ Lipids: NC ☐ Lipids: ND	
A_1C: _____ % A_1C ☐ ND	Blood Glucose (required if patient received IV alteplase): _____ mg/dl	☐ ND ☐ Too Low ☐ Too High			
Serum Creatine: _____	☐ ND				
INR: _____	☐ ND	☐ NC			

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Vital Signs:	Heart Rate (beats per minute): _____ bpm ^What is the first blood pressure obtained prior to or after hospital arrival? (required if patient received IV alteplase) _____/_____ ☐ Vital signs UTD			
Height: _____	Oin	Ocm	OND	
Weight: _____	Olbs	Okg	OND	
Waist Circumference: _____	Oin	Ocm	OND	
BMI: _____	☐ ND			

DISCHARGE INFORMATION	*Discharge Tab*
GWTG Ischemic Stroke-Only Estimated Mortality Rate	[Calculated in the PMT]
GWTG Global Stroke Estimated Mortality Rate (Ischemic Stroke, SAH, ICH, Stroke NOS)	[Calculated in the PMT]

Modified Rankin Scale at Discharge	OYes	ONo/ND	
If Yes:	OActual	OEstimated from record	OND
Total Score:	_____		
Ambulatory status at discharge	O Able to ambulate independently (no help from another person) w/ or w/o device O With assistance (from person) O Unable to ambulate O ND		
Discharge Blood Pressure (Measurement closest to discharge)	_____/_____ mmHg (Systolic/Diastolic) ☐ND		

DISCHARGE TREATMENTS

Antithrombotic Therapy approved in stroke	Prescribed? OYes ONo/ND ONC			
	If yes,			
	☐ Antiplatelet		☐ Anticoagulant	
	O aspirin O aspirin/dipyridamole (Aggrenox) O clopidogrel (Plavix) O ticlopidine (Ticlid)		O apixaban (Eliquis) O argatroban O dabigatran (Pradaxa) O endoxaban (Savaysa) O fondaparinux (Arixtra)	O full dose LMW heparin O lepirudin (Refludan) O rivaroxaban (Xarelto) O Unfractionated heparin IV O warfarin (Coumadin)
	Dosage 1. _____ 2. _____ 3. _____ 4. _____	Frequency 1. _____ 2. _____ 3. _____ 4. _____	Dosage 1. _____ 2. _____ 3. _____ 4. _____	Frequency 1. _____ 2. _____ 3. _____ 4. _____
	If NC, documented contraindications	☐Allergy to or complications r/t antithrombotic ☐Patient/Family refused ☐Risk for bleeding or discontinued due to bleeding		☐Serious side effect to medication ☐Terminal illness/Comfort Measures Only ☐Other
Other Antithrombotic(s)	Prescribed? OYes ONo			
	If yes,			
	Medication: ☐Desirudin (Iprivask) ☐Ticagrelor (Brilinta) ☐Prasugrel (Effient) *contraindicated in stroke and TIA ☐Other		Dosage 1. _____ 2. _____ 3. _____ 4. _____	Frequency 1. _____ 2. _____ 3. _____ 4. _____
Persistent or Paroxysmal Atrial Fibrillation/Flutter	O Yes O No			

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If atrial fib/flutter or history of PAF documented, was patient discharged on anticoagulation?			○Yes ○No/ND ○NC
If NC, documented reasons for no anticoagulation	☐ Allergy to or complication r/t warfarin or heparins ☐ Mental status ☐ Patient refused ☐ Risk for bleeding or discontinued due to bleeding		☐ Risk for falls ☐ Serious side effect to medication ☐ Terminal illness/Comfort Measures Only
Anti-hypertensive Tx (Select all that apply)	☐ None prescribed/ND ☐ Other anti-hypertensive med ☐ Ace Inhibitors ☐ Beta Blockers	☐ None - Contraindicated ☐ Diuretics ☐ ARB ☐ CA++ Channel Blockers	
Cholesterol-Reducing Tx (Select all that apply)	☐ None prescribed/ND ☐ None – contraindicated ☐ Statin ☐ Fibrate	☐ Niacin ☐ Absorption Inhibitor ☐ PCSK 9 inhibitor ☐ Other med	
Statin Medication:	☐ Amlodipine + Atorvastatin (Caduet) ☐ Atorvastatin (Lipitor) ☐ Ezetimibe + Simvastatin (Vytorin) ☐ Fluvastatin (Lescol) ☐ Fluvastatin XL (Lescol XL) ☐ Lovastatin (Altoprev) ☐ Lovastatin (Mevacor) ☐ Lovastatin + Niacin (Advicor) ☐ Pitavastatin (Livalo) ☐ Pravastatin (Pravachol) ☐ Rosuvastatin (Crestor) ☐ Simvastatin (Zocor) ☐ Simvastatin + Niacin (Simcor)	**Statin Total Daily Dose:**	_____
Documented Reason for Not Prescribing Guideline Recommended Dose?	☐ Intolerant to moderate (>75yr) or high (<=75yr) intensity statin ☐ No evidence of atherosclerosis (cerebral, coronary, or peripheral vascular disease)	☐ Other documented reason ☐ Unknown/ND	
Documented reason for not prescribing a statin medication at discharge?	○ Yes ○ No		
New Diagnosis of Diabetes?	○ Yes ○ No ○ ND		
Basis for Diagnosis (Select all that apply)	☐ HbA1c ☐ Oral Glucose Tolerance	☐ Fasting Blood Sugar ☐ Test Other	

Anti-hyperglycemic medications:	**Prescribed?**	○Yes ○No ○NC	
	If yes,	Class:	Medication:
		Class:	Medication:
		Class:	Medication:
		Class:	Medication:
	Was there a documented reason for not prescribing a medication with proven CVD benefit?	○Yes ○No/ND	
Follow-up appointment scheduled for diabetes management?	○ Yes ○No/ND ○NC		
Date of scheduled diabetes follow-up appointment:	_____/_____/_____ ○Unknown		

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Anti-Smoking Tx	O Yes	O No/ND	O NC		
Smoking Cessation Therapies Prescribed (select all that apply	☐ Counseling ☐ Over the Counter Nicotine Replacement Therapy ☐ Prescription Medications ☐ Other ☐ Treatment not specified				
Was the patient prescribed any antidepressant class of medication at discharge?	O Yes, SSRI	O Yes, any other antidepressant class	O No/ND		
OTHER LIFESTYLE INTERVENTIONS					
Reducing weight and/or increasing activity recommendations	O Yes	O No/ND	O NC		
TLC Diet or Equivalent	O Yes	O No/ND	O NC		
Antihypertensive Diet	O Yes	O No/ND	O NC		
Was Diabetic Teaching Provided?	O Yes	O No/ND	O NC		
STROKE EDUCATION					
Patient and/or caregiver received education and/or resource materials regarding all the following:					
Check all as Yes: ☐					
Risk Factors for Stroke	O Yes	O No	**Stroke Warning Signs and Symptoms**	O Yes	O No
How to Activate EMS for Stroke	O Yes	O No	**Need for Follow-Up After Discharge**	O Yes	O No
Their Prescribed medications	O Yes	O No			
STROKE REHABILITATION					
Patient assessed for and/or received rehabilitation services during this hospitalization?	O Yes	O No			
Check all rehab services that patient received or was assessed for:	☐ Patient received rehabilitation services during hospitalization ☐ Patient transferred to rehabilitation facility ☐ Patient referred to rehabilitation services following discharge ☐ Patient ineligible to receive rehabilitation services because symptoms resolved ☐ Patient ineligible to receive rehabilitation services due to impairment (i.e. poor prognosis, patient unable to tolerate rehabilitation therapeutic regimen				
HEALTH RELATED SOCIAL NEEDS ASSESSMENT					
During this admission, was a standardized health related social needs form or assessment completed?	O Yes	O No/ND			
If Yes, identify the areas of unmet social need. Select all that apply.	☐ Living Situation/ Housing ☐ Food ☐ Utilities ☐ Personal Safety ☐ Financial Strain	☐ Employment ☐ Education ☐ Mental Health ☐ Substance Use ☐ Transportation Barriers	☐ None		
STROKE DIAGNOSTIC TESTS AND INTERVENTIONS					
Cardiac ultrasound/echocardiography O Performed during this admission or in the 3 months prior O Planned post discharge O Not performed or planned	Extended implantable cardiac rhythm monitoring O Performed during this admission or in the 3 months prior O Planned post discharge O Not performed or planned	Carotid imaging O Performed during this admission or in the 3 months prior O Planned post discharge O Not performed or planned			
Hypercoagulability testing O Performed during this admission or in the 3 months prior O Planned post discharge O Not performed or planned	Carotid revascularization O Performed during this admission or in the 3 months prior O Planned post discharge O Not performed or planned	Extended surface cardiac rhythm monitoring > 7 days O Performed during this admission or in the 3 months prior O Planned post discharge O Not performed or planned			

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Intracranial vascular imaging ○ Performed during this admission or in the 3 months prior ○ Planned post discharge ○ Not performed or planned	Short-term cardiac rhythm monitoring <= 7 days ○ Performed during this admission or in the 3 months prior ○ Planned post discharge ○ Not performed or planned	

OPTIONAL FIELDS – Please do not enter any patient identifiers in this section					*Optional Fields Tab*
Field 1	Field 2	Field 3	Field 4	Field 5	
Field 6	Field 7	Field 8	Field 9	Field10	
Field 11			Field 12		
Field 13	____/____/____ ____:____	☐MM/DD/YYY ☐Unknown	Field 14	____/____/____ ____:____	☐MM/DD/YYY ☐Unknown
Additional Comments:					

Administrative			
PMT used concurrently or retrospectively or combination?	○ Concurrently	○ Retrospectively	○ Combination
Was a stroke admission order set used in this patient?	○ Yes	○ No	
Was a stroke discharge checklist used in this patient?	○ Yes	○ No	
Patient adherence contract/compact used?	○ Yes	○ No	
END OF FORM			

Appendix B: GWTG Data Request Form

AHA Contract ID 176821_09.22.2021

NON-DISCLOSURE AND DATA USE AGREEMENT

This Non-Disclosure and Data Use Agreement ("Agreement") is entered into between the American Heart Association, Inc., a New York not-for-profit corporation, having its principal offices at 7272 Greenville Avenue, Dallas, Texas 75231-4596 ("AHA") and Michael E Brown, Jr., 100 S. Washington Avenue, Minneapolis, MN 55401 ("Investigator").

RECITALS

WHEREAS, AHA is a non-profit health organization with volunteers throughout the United States who are dedicated to being a relentless force for a world of longer, healthy lives through research, advocacy and the development of programs that improve patient access to high-quality health care;

WHEREAS, AHA owns and operates a variety of comprehensive quality improvement and accreditation programs, that include inpatient and outpatient programs for data collection and reporting on standardized, clinical cardiovascular processes, outcomes, procedures, and patient level variables (each a "Program", and collectively referred to as "AHA Quality Improvement Programs");

WHEREAS, each Program includes a registry ("Program Registry") by which hospitals and other healthcare facilities enrolled in one or more Program (referred to as "Program Participant") can submit aggregate and de-identified data, and certain data in the form of a Limited Data Set, as defined under the Health Insurance Portability and Accountability Act of 1996, as amended, ("HIPAA") regulation at 45 C.F.R. 164.514(e);

WHEREAS, the agreement between AHA and the Program Participant enrolled in AHA Quality Improvement Programs permits use and disclosure of aggregate and de-identified data and/or Limited Data Set for the purposes of quality improvement and technical support, and for Research, Public Health or Health Care Operations purposes, as defined under HIPAA;

WHEREAS, Investigator has requested an opportunity to review aggregate and de-identified data, Limited Data Set, and also other confidential, proprietary, and/or copyrighted information (collectively referred to as "Protected Information") housed in one or more Program Registry and subsequently stored on AHA's Precision Medicine Platform ("PMP"), which is AHA's cloud-based technology platform providing data access and analysis solutions for the research community;

WHEREAS, this Protected Information sought by Investigator is maintained in the strictest of confidence and disclosed only pursuant to this Agreement protecting the proprietary nature and rights of the AHA as to the requested information and restricting the use of such information by Investigator.

NOW THEREFORE, in consideration of the foregoing recital and of the mutual covenants and agreements herein, the parties hereto agree to the following:

1. Definitions.
    a. "Protected Information" refers to aggregate and de-identified data, Limited Data Set, and also other confidential, proprietary, and/or copyrighted information provided by AHA or on behalf of AHA.
    b. Unless otherwise defined in this Agreement, all capitalized terms used in this Agreement will have the same meaning as provided under the HIPAA Regulations.
2. Acknowledgement of Proprietary Rights. All Protected Information provided to Investigator under this Agreement is under the care, custody, and control of the AHA, which is the owner or licensee thereof,

and constitutes confidential and proprietary information. The Investigator does not obtain any right, title, or interest in any of the data furnished by AHA.

3. Authorized Purpose. This Agreement addresses terms and conditions for the following project ("Authorized Purpose") described below:

   Project Module: GWTG Stroke
   Brief Project Description: A Comparative Effectiveness Study for Acute Ischemic Stroke Care between Stroke Belt and Non-Stroke Belt Hospitals Utilizing the Get with the Guidelines-Stroke Program.
   Project #: 21ST011
   The following AHA data set file(s) is/are covered under this agreement.

File(s)	Year(s)
GWTG Stroke PMP Data Set	Jan 2015 to Dec 2019

4. Term. The parties mutually agree that Investigator's authorization to possess and/or use the aforesaid file(s) (and/or any derivative file(s)) including those files that indirectly identify individuals, those that can be used in concert with other information to identify individuals, and all other Protected Information, and access the PMP, shall terminate upon twelve (12) months from the Effective Date of this Agreement or completion of the Authorized Purpose, whichever comes first, unless otherwise agreed in writing by the AHA. AHA may immediately terminate this Agreement by giving written notice of termination to Investigator.

5. Obligations of Investigator. Investigator understands and agrees (I) the Protected Information constitutes confidential and proprietary information; (II) to maintain the Protected Information in strict confidence; (III) not to disclose, duplicate, or otherwise reproduce, directly or indirectly, the Protected Information in whole or in part, or any materials relating thereto; and (IV) not to use or disclose the Protected Information except as it directly relates to the Authorized Purpose and as set forth in Section 5(a), Permitted Uses and Disclosures.

   a. Permitted Uses and Disclosures. The Protected Information shall only be used as provided in the Authorized Purpose of this Agreement, and as set forth in the enclosed AHA approved research proposal subject to the following additional requirements: (i) AHA, the Precision Medicine Platform, and AHA Quality Improvement Program shall be acknowledged in any publication related to the research proposal; (ii) Investigator further agrees and attests that the Protected Information shall not be used for any other purpose or project except as it directly relates to the Authorized Purpose, and that any additional or subsequent use of this Protected Information shall require prior written approval from AHA; (iii) any use of the Protected Information beyond that authorized in this Agreement shall subject Investigator to legal and equitable remedies, including but not limited to, injunctive relief and additional use charges as set by the AHA. In addition to the foregoing, AHA may maintain a public ongoing list of approved research proposals.

   b. Minimum Necessary Information. Investigator represents and warrants that only persons in its employ or control, directly involved in the Authorized Purpose of the Protected Information, and with a need to know shall have access to the Protected Information and that persons having access to the Protected Information shall be subject to and comply with the requirements herein and refrain from any disclosure, duplication, or reproduction of the Protected Information. Investigator agrees to bind in writing and obtain the signature of all persons with access to the Protected Information to this Agreement prior to disclosure, unless such persons are already legally obligated to maintain the confidentiality of AHA's Protected Information pursuant to a prior existing agreement with Investigator, or as otherwise authorized by AHA.

c. Safeguards to Prevent Unauthorized Use or Disclosure. Investigator agrees that it shall use appropriate safeguards to prevent Use or Disclosure of the Protected Information other than as permitted under this Agreement.

d. Reporting of Unauthorized Uses or Disclosures. Investigator shall report promptly to AHA any Use or Disclosure of the Protected Information not permitted by this Agreement of which Investigator becomes aware.

e. Identification of Information. Investigator shall not attempt to identify or contact any specific individual whose record is included in the Protected Information. Absent prior written authorization from AHA, the Investigator shall not attempt to link records included in the file(s) specified in Section 3, provided that this restriction will not be interpreted to prevent Investigator from conducting activities such as they relate directly to the Authorized Purpose under the Agreement.

f. No Commercial Use. Investigator agrees that it shall not attempt to commercially exploit the Protected Information in any manner and that it shall not disassemble, decompile, or otherwise reverse engineer the Protected Information.

6. Miscellaneous.

a. Fees. As consideration for the provision of Protected Information and access to the Precision Medicine Platform, Investigator shall pay to AHA the fees generally set forth on Exhibit A. Upon execution of this Agreement, AHA shall send an invoice to Data Recipient. If the investigator chooses to collaborate with the AHA Data Analysis Team to conduct analysis on the PMP a separate invoice will be generated based on hours and specified rate (See Exhibit A). Payment in full is due within 30 days of receipt of any invoices received. Payments are non-refundable. AHA reserves the right to suspend or terminate this Agreement or PMP access in the event of nonpayment. Investigator will be held responsible for any and all fees incurred up to termination.

b. No Waiver of Rights. AHA's failure to exercise or enforce any right or provision of this Agreement does not constitute a waiver of that right or provision, or of any other right or provision under this Agreement.

c. Governing Law. This Agreement and all adversarial proceedings arising out of this Agreement, shall be governed by the substantive laws of the State of Texas, without reference to its conflict of laws provisions. However, if Investigator is a governmental entity or state institution, this Agreement shall be interpreted and construed under the substantive laws of the state in which the Investigator resides without respect to its conflict of law principles.

d. Entire Agreement. This Agreement contains the entire agreement between the parties with respect to the subject matter of this Agreement, and it supersedes all other prior and contemporary agreements, undertakings, and commitments between the parties with respect to the subject matter of this Agreement.

IN WITNESS WHEREOF, the parties have executed this Agreement to become effective as of the last date below ("Effective Date").

Investigator	American Heart Association
Name: Michael E Brown, Jr., MPH, Paramedic	Name:Christine Rutan
Title: MD/Ph.D (Candidate/Researcher)	Title: VP, RWE & Healthcare IT
Email: [redacted]	Email: Christine.Rutan@heart.org
ıature: E-SIGNED by Michael E. Brown, Jr. on 2021-09-23 12:07:33 GMT	Signature: E-SIGNED by Christine Rutan on 2021-09-29 19:48:52 GMT

APPROVED AS TO FORM
Date: 09-22-2021
By: TPH
AHA LEGAL DEPT

EXHIBIT A

PMP-GWTG PRICING PLAN

☒ Investigator-led Data Analysis on AHA's Precision Medicine Platform (PMP)

	PMP Annual Subscription Fee	GWTG Data Administration Fee Per Proposal	Complimentary Computational Cloud Credits
Early Career*	$500	$250	$50,000/year
Established	$2000	$1000	$50,000/year

- Each workspace owner will name an analytic team on the manuscript proposal, which will be provisioned with the PMP workspace and appropriate dataset.
- Software available for basic statistical analysis include SAS, Python and R. Individuals may also use machine learning and AI tools as well as the many other visualization and software programs within the PMP workspaces.

☐ Collaborate with AHA Data Analysis Team to Conduct Analysis on the PMP**

- The AHA Data Analysis Team will work with the authors to estimate the number of hours per project. The authors will need to be available for questions and discussion as part of the estimation process. This information will also help inform the author of the expected length of time a PMP workspace will be needed, to enable a cost projection.
- The AHA Data Analysis Team includes 2 PhDs with significant study design, epidemiology and computer science capabilities, 2 data scientists with an MS, one with an MPH in Biostats and Epidemiology, and one bioinformaticist.
- Typical analyses will range from 50 – 250 hours depending on the complexity of the analyses.
- Rates are $125 per hour in addition to the monthly PMP usage fees as noted above. Prioritization of manuscripts may depend on workflow
- The investigator will be invoiced directly for analytical hours accrued per month.
- See following page for more detail regarding AHA Data Analysis Team.

☒ Ad Hoc Support with AHA Data Analytics

- The AHA Data Science Team are available on an ad hoc basis to provide technical and analytic support for Self Service authors.
- Rates are $175 per hour.

☐ Early Career Investigator Database Research Seed Grant (ECI Grant) Recipient

- ECI Grants are competitively awarded each year for Get With the Guidelines national-level research.
- The following fees are waived for ECI Grant recipients that have been approved for research to be conducted using GWTG data on the PMP:
  - PMP Annual Subscription Fee, up to one year,
  - GWTG Data Administration Fee for one proposal,
  - Collaboration with the AHA Data Analysis team (up to 150 hours).

*Early Career Investigator includes the following:

- Predoctoral fellows pursuing a post-baccalaureate doctoral degree including PhD, MD, DNP, or equivalent clinical health science doctoral degree program
- Postdoctoral fellows including trainees with post-baccalaureate PhD, MD, DNP, or equivalent clinical health science doctoral degree program. This includes MDs who are current residents, fellows in training or have completed training within the last 5 years.
- Research or Clinical faculty/staff up to and including the rank of assistant professor (or equivalent) for which no more than five years have elapsed since the first faculty/staff appointment.

**Collaborate with AHA Data Analysis Team to Conduct Analysis on the PMP

Obligations of AHA Data Analysis Team

AHA Data Analysis team will hold an initial call with the principal investigators (PI), and/or their appropriate research staff to assess and understand the statistical needs of the project. Topics to be discussed during the initial consultation call include but are not limited to: overview of expectations and accountability, description of project, research hypothesis, feasibility, primary and secondary objectives, definitions of exposure variables, end points, and cut off values, discussion of statistical techniques and methodologies, overview of desired and format of output including charts, graphs, tables etc, and estimation of hours and cost.

Within a week of the consultation call, the Data Analysis team will send a Statistical Analysis Plan (SAP) to the PI and their appropriate research staff detailing the planned analysis and agreed upon project deliverables with a time frame. Any changes to the planned analyses should be made prior to formal written approval of the SAP. Suggested changes must be within the scope of the approved proposal. The PI and their appropriate research staff will provide written approval of the Statistical Analysis Plan. Work on the project only will start after the contract has been agreed upon and signed by all necessary parties.

The Data Analysis team will provide the PI and their appropriate research staff with regular status updates and communicate any statistical issues that may arise. A finalized Statistical Analysis Report within the prespecified time frame will be delivered via email to the PI. The Data Analysis team performing the analysis will be co-authors on the publication(s) to acknowledge the intellectual contribution to the work. The Data Analysis team will be given at least 1 week to review any final drafts of an abstract or publication prior to submission or resubmission to ensure study and statistical integrity.

American Heart Association.
Get with the Guidelines.

Research Proposal Form
American Heart Association Quality Improvement Programs Registry

Questions? Or Email this Form – QualityResearch@Heart.org

Date Submitted to AHA: 24 March 2021	Project # (assigned by AHA Staff): 21ST011

Working Title of Research Proposal:
A Comparative Effectiveness Study for Acute Ischemic Stroke Care between Stroke Belt and Non-Stroke Belt Hospitals Utilizing the Get with the Guidelines-Stroke Program.

National Level Program Primary Database – Please select one:
Click here for Program Descriptions and Click here for details on AHA GWTG Research Program

☐GWTG AFib	☐GWTG Resuscitation Adult
☐GWTG Heart Failure (HF)	☐GWTG Resuscitation Pediatric/Neonatal
☒GWTG Stroke	☐GWTG Coronary Artery Disease (CAD)
	☐Mission: Lifeline

Are you an Early Career Investigator? ☐Yes ☒ No

Are you applying for AHA Young Investigator Database Seed Grant? ☐Yes ☒ No

Principal Investigator / Lead Author Information:
Name and Credentials: Michael E Brown Jr, Ph.D (ABD), M.D (Candidate), MPH, Paramedic
Title/Position: MD/Ph.D (Candidate/Researcher)
Institution/Company: Walden University
Mailing Address, City, State, Zip: [redacted]
Email: [redacted]
Phone Number: [redacted]
AHA Professional Membership – status or number:

Diversity & Inclusion:
"Strengthening all of us as individuals, as an organization and as one world"
By marking the box below, please confirm that you will make every effort as the Project Lead to strive for AHA's commitment to diversity and inclusion in the Scientific and Healthcare Quality Community. This will include building a collaborative project team that is inclusive of individuals who are diverse across gender, race/ethnicity, career stage, and institution. If you are unable to find a collaborator for each of these groups, please contact the AHA team and we will help to build your project network.
☒

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Senior Author and/or GWTG Mentor (if applicable):
Name: Michael E Brown Jr
Institution: Walden University
Email Address: [redacted]

Co-Investigator(s)/Author(s) – Name, Institution, Email address:

Name: Howell Sasser, Ph.D
Institution: Walden University
Email: [redacted]

Name: David Segal, Ph.D
Institution: Walden University, University of Miami
Email: [redacted]

Name:
Institution:
Email:

Funding – Select only one:

☐AHA Funding – Competitive Approval based on Scientific Merit, Feasibility, Novel Contribution
Click here for more information

☐AHA Young Investigator Database Seed Grant – annual submission close Oct 15
Click here for more Young Investigator Award Information

☒External Funding – Accepted on Limited Basis – Specify Source of Funding:

- ☐Federal Grant: _____
- ☐Non-Federal Grant or Foundation: _____
- ☐Academic Source: _____
- ☒Self-Funded: Personal Funds _____
- ☐Other: _____

If Project is Grant or Foundation Funded:

- ❑ What is Project Duration: _____
- ❑ Total Funding budgeted for AHA GWTG Statistical Support: _____

Linkage of Data Set:
Are you proposing to link to another data set?

☐Yes, what data set? _____

☒No, this project will be completed exclusively with data collected in the GWTG programs

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Date Range for Project:
Date Range: From: Jan 1, 2015 To: Dec 31, 2019
Or
Number of Years of Data: _____

Target:
- ❑ Scientific Conference: American Public Health Association (APHA), American Heart Association (AHA)
- ❑ Journal: *Stroke*
- ❑ Other: Please specify: Dissertation Defense

Project Originality:

Check Here ☒ that you have reviewed existing publications to ensure no overlap with your proposal. see GWTG Online Library of Publications

How is this project novel and significant?

The specific focus on the Stroke Belt, in comparison with nationwide trends, will fill a significant gap in the current understanding of stroke treatment. By focusing on treatment interventions (i.e., r-tPA) and mortality rates in a single geographical treatment facility type (i.e., Stroke Belt Hospitals (SBH) vs. Non-Stroke Belt Hospitals (NSBH)), researchers and physicians will better understand stroke treatment programs in the region most severely affected by this health crisis. The AHA/ASA has conducted several studies on its GWTG-Stroke Program; most have demonstrated that the GWTG-Stroke Program has improved stroke care and critical process measures. However, the impact on Stroke Belt Hospital treatment and mortality remains limited. Past research studies have focused on the systemic stroke quality initiatives such as GWTG-Stroke based on nationwide trends, but there has not been an equivalence study that focuses on GWTG-Stroke utilization in SBHs (Crumbler et al., 2018; Howard et al., 2018; Ormseth, Sheth, Saver, Fonarow & Schwamm, 2017; Romano et al., 2018). These previous studies compared JCAHO-certified stroke centers and non-certified hospitals participating in the GWTG-Stroke national database; in particular, they examined the efficacy of IV-r-tPA and administration rates of the intervention. Nevertheless, little research has compared the regional differences in the efficacy of the GWTG-Stroke Program on stroke mortality and r-tPA administration in hospitals within and outside Stroke Belt (i.e., SBHs vs. NSBHs). By analyzing the management and treatment of acute ischemic stroke, researchers and physicians in Stroke Belt states may learn ways to improve the quality and continuity of stroke care: identifying more efficacious ways to manage AIS patients while reducing stroke mortality rates and long-term disability. The results of this research study will translate into a public health benefit and positive social change by reducing mortality and improving survivability among stroke victims in Stroke Belt states. By comparing the efficacy of the GTWG-Stroke program within and outside of Stroke Belt states, this research study will test the notion that the elevated rates of stroke-related mortality in that region are reducible to stroke associated risk factors alone, rather than a deficiency in proper stroke treatment. Within hospitals that have implemented the GWTG-Stroke Program, research has noted a reduction in stroke mortality rates, along with an increase in intervention usage (i.e., r-tPA). The point where primary preventative methods will be effective at drastically reducing mortality in the Stroke Belt has passed. Tertiary prevention, along with utilization and implementation of GWTG-Stroke, may be effective at reducing stroke mortality and increasing intervention usage within the Stroke Belt region.

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- Please understand that the approved proposal is the property of the American Heart Association and will be managed according to the Get With The Guidelines® Publication policies.
- The AHA is providing analyzed data in the form of aggregate data tables as an in-kind contribution for research.
- If a complete manuscript has not been drafted within Time Frame indicated above, then lead author and/or senior authorship will be reassigned.
- Failure to comply with author requirements and publication policies may affect the eligibility of investigators to submit manuscripts for publication and future proposals.

Goals/Objectives/Research Question:

The purpose of this study is to compare the efficacy of the GWTG-Stroke Program in reducing key AIS treatment disparities and stroke-related mortality (i.e., GWTG Ischemic Only Estimated Mortality Rate) in Stroke Belt hospitals as compared to hospitals outside the Stroke Belt. This study shall assess the efficacy of implementing the GWTG-Stroke Program within Stroke Belt hospitals and its association on improving AIS treatment, patient outcomes, and eliminating tertiary treatment disparities in comparison with Non-Stroke Belt Hospitals participating in the GWTG-Stroke Program. Data and results from this study will provide quantitative evidence useful to create and push relevant public health, healthcare policies and evidence-based practice. This study will employ an equivalence study design utilizing a quantitative cross-sectional non-experimental approach.

The primary objective of this study is to compare the efficacy of the GWTG-Stroke Program in reducing ischemic stroke mortality (i.e., GWTG Ischemic Only Estimated Mortality Rate) and fostering improvements in AIS treatment (i.e., DTN, DTI, and r-tPA administration rates) within SBHs and NSBHs. The independent variable will be GWTG-Stroke hospital type geographical location and attendant demographical factors (i.e., SBH, NSBH), whereas patient outcome (i.e., mortality), DTN, DTI, and r-tPA administration will be the dependent variables. The unit of analysis will be GWTG-Stroke QI Program implementation and usage within the hospital stratified by geographical location and attendant demographical factors (i.e., SBH, NSBH).

Research questions for equivalence studies are quantitatively based and should compare interventions amongst comparison groups. The research questions and hypothesis for this study are:

1. RQ1: Is there a difference between the in-hospital r-tPA administration rates for AIS patients meeting criteria between NSBHs and SBHs?
   - $H_0$1: There is a difference in in-hospital r-tPA administration rates for AIS patients meeting criteria between NSBHs and SBHs.
   - H_A1: There is no difference in in-hospital r-tPA administration rates for AIS patients meeting criteria between NSBHs and SBHs.
2. RQ2: Is there a difference in in-hospital DTN time for AIS patients administered r-tPA between NSBH and SBHs?
   - $H_0$2: There is a difference in in-hospital DTN time for AIS patients administered r-tPA between NSBH and SBHs.
   - H_A2: There is no difference in in-hospital DTN time for AIS patients administered r-tPA between NSBH and SBHs.
3. RQ3: Is there a difference in in-hospital time to brain imaging (i.e., computerized tomography [CT] and magnetic resonance imaging [MRI]) between NSBH and SBHs?
   - $H_0$4: There is a difference in in-hospital time to brain imaging (i.e., computerized tomography [CT] and magnetic resonance imaging [MRI]) between NSBH and SBHs.
   - H_A4: There is no difference in in-hospital time to brain imaging (i.e., computerized tomography [CT] and magnetic resonance imaging [MRI]) between NSBHs and SBHs.
4. RQ4: Is there a difference in GWTG ischemic stroke only mortality rates between NSBHs and SBHs?
   - $H_0$4: There is a difference in GWTG ischemic stroke only estimated mortality rates between NSBHs and SBHs.
   - H_A4: There is no difference in GWTG ischemic stroke only estimated mortality rates between NSBHs and SBHs.

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Hypothesis/Rationale:
The hypothesis is that hospitals within the Stroke Belt have adequately implemented the GWTG-Stroke program and thus will have no significant difference in outcomes in comparison to Non-Stroke Belt hospitals utilizing the GWTG-Stroke Program. A lack of significant difference in outcome between the two comparison groups would suggest that the GWTG-Stroke quality intervention is effective at decreasing AIS treatment disparities and mortality.
This study employs an equivalence study design utilizing a quantitative cross-sectional non-experimental approach. This equivalence research study design will be employed to compare the efficacy of the GWTG-Stroke Program in reducing stroke-related mortality (i.e., GWTG Ischemic Only Estimated Mortality Rate) and fostering improvements in AIS treatment (i.e., DTN, DTI, and r-tPA administration rates) within SBHs and NSBHs. This research study will examine the efficacy of the intervention, which is implementation and utilizing of the GWTG-Stroke QI Program by hospital stratified by demographics (i.e., SBH vs. NSBH); a comparison of the means between the two groups will be assessed to identify if the two intervention groups are equivalent in improving core stroke measures related to AIS patient treatment and outcome (i.e., mortality).

Study Population
(specify admission diagnosis of interest, including inclusion and exclusion criteria):
The target population will be patients with suspected stroke that present to a hospital within the United States participating in the GWTG-Stroke Program and registry. The inclusion/exclusionary criteria are as follows: study participants will be inclusive of: --patients treated and diagnosed with an ischemic stroke as evident by an international classification of disease-10 (ICD-10) code at hospitals within the United States that have implemented the GWTG-Stroke Program. Study Participants will be inclusive of participants older than 18 years of age, and patients with various means of hospital presentation or admission (i.e., Pre-hospital/EMS, direct self-admission to ED). Patients with an ICD-10 of Hemorrhagic stroke, and patients with counterindication for tPA will be excluded. The sampling timeframe is inclusive of participants meeting the criteria stated above during the following cross-section: **January 1, 2015- December 31, 2019 (4-years).**

Variables Utilized for Project:
- Independent variable (IV): Hospital type based on geographical location (i.e., SBHs vs NSBHs), hospitals within Stroke Belt States (i.e., Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee) will be grouped and identified as Stroke Belt Hospitals (SBHs). Hospitals not located within one of the aforenoted stated will be grouped and identified as Non-Stroke Belt Hospitals (NSBHs).

- Dependent variable (DV 1): [tPA Administration]
- DV2: [Door to Needle Time]
- DV3: [Door to Imaging Time]
- DV4: [GWTG ischemic stroke only estimated mortality rate]

Primary Outcome/Endpoint: (DVs stratified by IV)
- Dependent variable (DV 1): [tPA Administration]
- DV2: [Door to Needle Time]
- DV3: [Door to Imaging Time]
- DV4: [GWTG ischemic stroke only estimated mortality rate]

Secondary Outcomes/Endpoints:

Brief Description of Proposed Analyses:
In this study, an equivalence study design will be utilized. For the purpose of this study, the predetermined difference or equivalence margin for the difference in proportion is δ= 5 percentage points. The two one-sided test (TOST) procedure will be utilized to test for equivalence. Equivalence will be established at the α-significance level if (1-2α) x 100% confidence interval (CI) for the difference in efficacy between SBHs and NSBHs is contained within the interval (-δ, δ). The equivalence margin has been predetermined as δ= five percentage points; thus, the interval is (-0.05, 0.05) percentage point difference, respectively. A 90% confidence interval is appropriate for the TOST procedure and will yield a significance level for the equivalence test of 0.05. Statistical analysis employing Chi-square (i.e., DV1 Categorical Analysis) and two one-sided t-tests (TOST) will be utilized.

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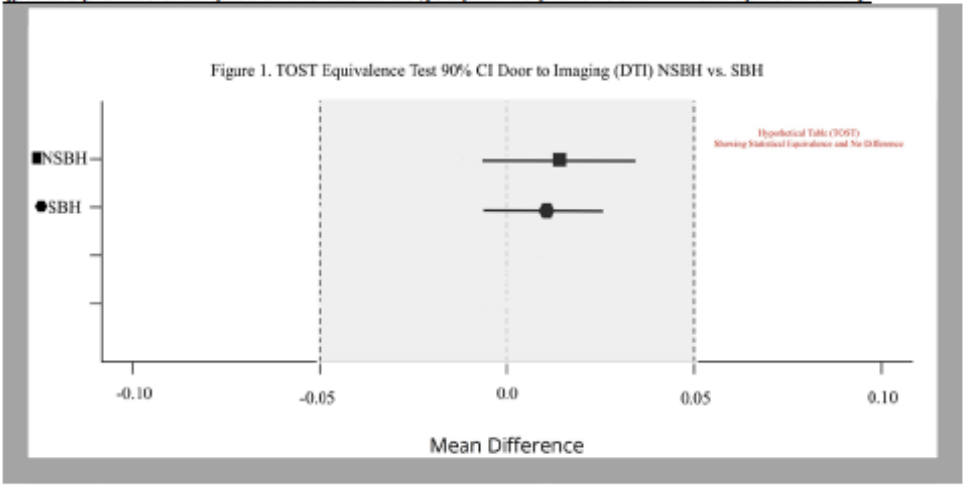
Sample Tables
(please provide examples of the tables as you plan to present them in the space below):



Key References:

Cumbler, E., Wald, H., Bhatt, D., Cox, M., Xian, Y., & Reeves, M.,...Fonarow, G.(2013). Quality of care and outcomes for in-hospital ischemic stroke: Findings from the national Get With The Guidelines-Stroke. *Stroke, 45*(1), 231-238. doi: 10.1161/STROKEAHA .113.003617

Howard, G., Schwamm, L., Howard, V., Rhodes, D., Jasne, A., Smith, E.,...Albright, K. (2018). Abstract 5: Differences in stroke care among patients in the REGARDS study by admission to a hospital participating versus not participating in GWTG-Stroke [Supplemental Material 1]. *Stroke, 49*(A5). doi: 10.1161/str.49.suppl_1.5

Ormseth, C., Sheth, K., Saver, J., Fonarow, G., & Schwamm, L. (2017). The American Heart Association's Get With the Guidelines (GWTG)-Stroke development and impact on stroke care. *Stroke and Vascular Neurology, 3*(2), 94-105. doi: 10.1136/svn-2017-000092

Romano, J., Smith, E., Liang, L., Gardener, H., Camp, S., & Shuey, L.,...Schwamm, L. (2015). Outcomes in mild acute ischemic stroke treated with intravenous thrombolysis: A retrospective analysis of the Get With the Guidelines-Stroke registry. *Journal of the American Medical Association Neurology, 72*(4), 423-431. doi: 10.1001/jamaneurol. 2014.4354.

Appendix C: IRB Approval to Conduct Research

IRB Approval Granted, Conditional upon Partner Approval - Michael Brown

From: **IRB** | irb@mail.waldenu.edu Tuesday, Dec 22, 2020, 4:21 PM

To: **Michael Brown** | michael.brown@waldenu.edu

Cc: **IRB** | irb@mail.waldenu.edu, **Howell C. Sasser** | howell.sasser@mail.waldenu.edu

Dear Michael,

This email is to notify you that the Institutional Review Board (IRB) has approved your application for the study entitled, "A Comparative Effectiveness Study for Acute Ischemic Stroke Care between Stroke Belt and Non-Stroke Belt Hospitals Utilizing the Get with the Guidelines-Stroke Program," conditional upon the approval of the research partner, as documented in the signed data use agreement, which will need to be submitted to the Walden IRB once obtained. You may not commence the analysis of the data until the Walden IRB confirms receipt of that as documented in the signed data use agreement. Our records indicate that the site's IRB agreed to serve as the IRB of record for this data collection. Since this study will serve as a Walden doctoral capstone, the Walden IRB will oversee your capstone data analysis and results reporting. The IRB approval number for this study is 12-22-20-0047087, which expires when your student status ends.

This confirmation is contingent upon your adherence to the exact procedures described in the final version of the documents that have been submitted to IRB@mail.waldenu.edu as of this date. This includes maintaining your current status with the university and the oversight relationship is only valid while you are an actively enrolled student at Walden University. If you need to take a leave of absence or are otherwise unable to remain actively enrolled, this is suspended.

If you need to make any changes to your research staff or procedures, you must obtain IRB approval by submitting the IRB Request for Change in Procedures Form. You will receive confirmation with a status update of the request within 10 business days of submitting the change request form and are not permitted to implement changes prior to receiving approval. Please note that Walden University does not

accept responsibility or liability for research activities conducted without the IRB's approval, and the University will not accept or grant credit for student work that fails to comply with the policies and procedures related to ethical standards in research.

When you submitted your IRB materials, you made a commitment to communicate both discrete adverse events and general problems to the IRB within 1 week of their occurrence/realization. Failure to do so may result in invalidation of data, loss of academic credit, and/or loss of legal protections otherwise available to the researcher.

Both the Adverse Event Reporting form and Request for Change in Procedures form can be obtained on the Tools and Guides page of the Walden website: https://academicguides.waldenu.edu/research-center/research-ethics/tools-guides

Doctoral researchers are required to fulfill all of the Student Handbook's Doctoral Student Responsibilities Regarding Research Data regarding raw data retention and dataset confidentiality, as well as logging of all recruitment, data collection, and data management steps. If, in the future, you require copies of the originally submitted IRB materials, you may request them from Institutional Review Board.

Please note that this letter indicates that the IRB has confirmed your study meets Walden University's ethical standards. You may not begin the doctoral study analysis phase of your doctoral study, however, until you have received the **Notification of Approval to Conduct Research** e-mail. Once you have received this notification by email, you may begin your study's data analysis.

Both students and faculty are invited to provide feedback on this IRB experience at the link below:

http://www.surveymonkey.com/s.aspx?sm=qHBJzkJMUx43pZegKlmdiQ_3d_3d

Sincerely,

Elyse V. Abernathy, MSL, MSM
Research Ethics Support Specialist

Office of Research Ethics and Compliance

Walden University
100 Washington Avenue South, Suite 1210
Minneapolis, MN 55401
Email: irb@mail.waldenu.edu
Phone: (612) 257-6645
Fax: (612) 338-5092
Information about the Walden University Institutional Review Board, including instructions for application, may be found at this link:
http://academicguides.waldenu.edu/researchcenter/orec

Notification of Approval to Conduct Research - Michael Brown

From: **IRB** | irb@mail.waldenu.edu Friday, Sep 24, 2021, 4:52 PM

To: **Michael Brown** | michael.brown@waldenu.edu
Cc: **Howell C. Sasser** | howell.sasser@mail.waldenu.edu

Dear Michael Brown,

This email confirms receipt of the approval notification for the partner organization and also serves as your notification that Walden University has approved BOTH your doctoral study proposal and your application to the Institutional Review Board. As such, you are approved by Walden University to conduct research with this site.

Congratulations!

Libby Munson
Research Ethics Support Specialist
Research Ethics, Compliance, and Partnerships

Leilani Gjellstad
IRB Chair, Walden University

Information about the Walden University Institutional Review Board, including instructions for application, may be found at this link: http://academicguides.waldenu.edu/researchcenter/orec

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