EMPOWERING LOCAL EMERGENCY MEDICAL SERVICES: STATE POLICY IMPACTS ON YOUR PRE-HOSPITAL CARE

A Thesis

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Jonathan Ready Powell
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I dedicate this thesis and research project to my mother, Barbara Ready Powell. Everything I have been able to accomplish has directly resulted from her commitment to loving her daughter and son regardless of the cost.

ACKNOWLEDGEMENTS

Saying “thank you” is never enough, but I’ll make the attempt anyway. Stacy Powell has been the driving force behind me during this process and I appreciate her support more than I can put into words. I’m fortunate that she shares her life and love with me each day. Dr. Jaclyn Bunch has been an incredible professor and mentor, without whom this idea and the resulting research would never have materialized. I’m thankful to my thesis committee: Dr. Jaclyn Bunch, Dr. Thomas Shaw, Dr. Scott Liebertz, Dr. Susan Gordon-Hickey, and Dr. Charles Erwin. Their dedication to responsible research and student success is much appreciated. I’m thankful for the Department of EMS Education and the Pat Capps Covey College of Allied Health at the University of South Alabama for providing a collegial work environment that encourages professional scholarship among its faculty. I’m also thankful for Latosha Armstead, who took an interest in this research and believed in its development from the early days of conception. Lastly, I’d like to acknowledge my family, friends, coworkers, and previous students. I count myself fortunate to be associated with you all and am thankful for our relationships.

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LIST OF ABBREVIATIONS

EMS	=	Emergency Medical Services
EMSPs	=	Emergency Medical Services Providers
ALS	=	Advanced Life Support
BLS	=	Basic Life Support
NEMSIS	=	National Emergency Medical Services Information System
PCR	=	Patient Care Report
HRSA	=	Health Resources and Services Administration
CDC	=	Center for Disease Control
SBP	=	Systolic Blood Pressure
HR	=	Heart Rate
SPO2	=	Pulse Oximetry
RR	=	Respiratory Rate
ETCO2	=	End-Tidal Carbon Dioxide
BGL	=	Blood Glucose Level
GCS	=	Glasgow Coma Score
LOC	=	Level of Consciousness

ABSTRACT

Powell, Jonathan, Ready, M.P.A., University of South Alabama, August 2020. Empowering Local Emergency Medical Services: State Policy Impacts on your Pre-Hospital Care. Chair of Committee: Jaclyn, Bunch, Ph.D.

This thesis analyzes the impact of state policy decisions regarding emergency medical services (EMS) on the delivery of an individual's pre-hospital care. Specifically, I will examine what the decision to decentralize EMS system administration has on the number of medications administered and procedures performed per each EMS activation.

I find that as autonomy is given to localities, the number of medications administered and procedures performed decreases in advanced life support providers. This newly established relationship offers important evidence of the impact of state level policy decisions on your individualized pre-hospital care.

INTRODUCTION AND TOPIC OF STUDY

Decisions made on how to save lives in the pre-hospital emergency environment are thought to be determined by you and your emergency provider. However, in reality, the role of state policy decisions is greater than one may realize. The impact of state policy decisions on the field of Emergency Medical Services (EMS) should be explored to understand how these decisions affect the delivery of pre-hospital care and patient outcomes. Research in a myriad of disciplines has shown that the decision to centralize or decentralize the administration of public goods and services has a direct impact on the implementation of these services (Cho et al. 2005, Enikolopov & Zhuravskaya 2007, Galway & Weins 2013, Treisman 2002). This thesis will look to establish that the degree of state decentralization for EMS systems has an impact on the type of care that is delivered. The ultimate goal of this research is to define the relationship between state EMS system degrees of decentralization and associated health outcomes. Specifically, this thesis will establish the impact of decentralization on the number of procedures performed and on the number of medications administered during EMS activations. Establishing the connection between an administrative decision, such as the degree of decentralization, on the number of procedures performed or medications administered will provide insight into the relationship between those decisions and day to day patient care delivery. Indications such as this will provide fodder for further exploration of this newly defined and understudied relationship.

Exploring Centralization and Decentralization

Centralization can be defined as a method of governing that retains power in the hands of the principal government (Melumad & Reichelstein, 1987). In the American system of federalism it largely is manifested in the federal government retaining decision making authority. This can be viewed differently depending on your orientation in government. A local administrator might see the state government as the decision making authority while that same state government recognizes that its overarching authority may come from the federal government. Conversely, decentralization is a method of governing that transfers its responsibilities to a subordinate government (Kincaid, 1998). Decentralization has continued to flow from local governments to non-governmental agencies, in what Kettl described as the fourth face of federalism (1981). This presents a total of 4 major actors in the American federalist system: the federal government, state governments, local governments, and non-governmental agencies. While this system is hierarchical and vertical in nature, intergovernmental relations consists of interconnected layers that can also be interwoven to solve complex problems using horizontal delegation (Weissert, 2011).

The choice to centralize, decentralize, or find some common ground for governmental administration has been a decision faced by administrators for decades – and has been an increasingly salient issue since the uptick of devolution with the advent of new federalism following the devolution revolution of the 1990's (Kousser, 2014). In the field of emergency response, hard lessons were learned after the terrorist attacks of September 11, 2001 and the natural disaster of Hurricane Katrina on August 29, 2005. These lessons led to a discussion about the best way to structure future responses (Wise, 2006). When considering emergency management in the United States, there are largely two models to choose from, the hierarchical or the network model (Wise, 2006). The hierarchical model is a top down, centralization of power approach that seeks to bring stability to what typically presented as a complex problem. Identified stumbling blocks to this model were the potential for inefficiency when presented with the need for innovation or tasks that were not easily completed without specialization (Wise, 2006). The hierarchical model follows a centralized approach, with authority, power, and funds being solidified with the central government. In the case of EMS policy, this represents state governments. This centralized approach sheds some of the responsibility from those lower level governments, a phenomena seen after the attacks of 9/11 and the race for states and localities to get direction from the federal government (Eisinger, 2006). Defining a problem as complex has different connotations for each reader, so we turn to Rittel and Webber's guidance regarding a similar notion, wicked problems. They define a wicked problem first by noting that there is no actual definition of a wicked problem because it is in fact, complex (Rittel & Webber, 1973). A wicked problem, with its meaning shifting depending on its application, is a problem that is difficult to solve because the only way to understand the problem is to already have ideas to fix it (Rittel & Webber, 1973). In this case, a wicked problem is best described as a problem that currently has no solution but requires hands on understanding and innovation to solve. Weaknesses to the hierarchical model were found when innovation and specialization were needed to solve potentially complex, or wicked problems (Wise, 2006).

Wise's network model is a bottom up, shared power approach that viewed public fields as best run by those who have experience on the ground. In this model, a great amount of importance is placed on, as Weatherly and Lipsky would put it, the "street level bureaucrat" (1977). These bureaucrats, in a network model, would work together and be more cognizant of collaboration rather than competition (Wise, 2006). In a decentralized system, the problems seen when organizing homeland security in a centralized manner would not be as prevalent (May et al., 2011). These problems coalesced around the "failure to foster a strong consistency among state and local interest, or among first responders was a missed opportunity" (May et al., 2011). Thus, complex problems often need local solutions, or at least collaboration and coordination between local stakeholders to increase availability of expertise and specialization. Kettl points this out regarding homeland security, stating that this complex problem requires multiple federal agencies and complex partnerships with its subordinate governments (2003). This approach likely is a major factor in the autonomy and decision making ability involved in EMS policy decisions and implementation, with states needing to partner more with localities for better delivery of care.

Decentralization also allows for extensive loose coupling arrangements between state and local decision makers. Coupling describes the relationship between governments, to include decision making power independent of direct superior governmental control. Loose coupling empowers localities and permits decentralization, whereas tight coupling contains the power in the top down model and retains power in the superior government.

This nested governmental coupling can lead to positive policy implementation outcomes when subordinate governments are involved in decisions that involve them. Policymakers empower local representatives, acting as a supervising overarching authority, to achieve their shared goals. Local street level bureaucrats can then take that power and use it to adapt to uncertainty in ways that the overarching authority cannot (Carter et al., 2014). Due to our unique system of federalism some governments will be more tightly coupled than others (Chenoweth & Clarke, 2010). Alabama, for instance, likely has different needs in the southern port city of Mobile than its largest northern city of Huntsville due to vastly different economies and demographics. The same can be said for the massive urban center of New York City compared too much of the rest of the state. States that have more homogenous populations may solve their local problems differently than those that do not, a reality that is possible due to our system of federalism. Empowering these homogenous and non-homogenous states to devolve authority may increase policy innovation due to multiple policies being made and tested concurrently for greatest positive impact (Strumpf, 2002).

The decision to solve problems with centralization or decentralization continues to be explored across a variety of fields. This application allows for the inference of when commonly confirmed theories on devolution are appropriate or not. Expanding the study of that decision can either lend weight to previously posited theories or lead to a better understanding of why it is not applicable to EMS systems.

Decentralization in EMS Systems

Emergency Medical Services in the United States operate under vastly different patient care guidelines that depend on each individual state's requirements. These guidelines, or protocols, are instituted either at the state, regional, or individual service level. The protocols used by Emergency Medical Services Providers (EMSPs) are created by Medical Directors, usually in consultation with some combination of EMSPs, state officials, and other relevant parties (Kupas et al., 2015). These Medical Directors are physicians who are officers of the state/local government or employed by individual services themselves.

The presence of differing centralization and decentralization degrees between state's protocol implementation has been previously explored and defined. Kupas, Schenk, Sholl, and Kamin developed pre-established protocol categories that can be used to establish a centralization index (2015). Each centralization category is split into 6 separate fields. They include:

- Mandatory A – a state has statewide protocols that must be used by all EMS providers within the state
- Mandatory B – a state has statewide protocols that must be used by all EMSPs within the state, but there is a process for services to petition the state to alter some of the protocols
- Mandatory C – a state has statewide protocols that must be used by all EMSPs within the state, but there is a process for services to petition the state to develop and use their own protocols

- Model – a state has model statewide protocols for providers, but each service or region may choose to use these protocols or may develop their own protocols
- Regional – a state has regional protocols that must be followed by all services in that region and cover a geographical area that includes multiple services
- Local – a state in which each EMS service or agency develops its own protocols (Kupas et al., 2015)

As a state's protocols trend toward Mandatory A they are considered to be more centralized because it requires conformity to a state's decision for all of its EMSPs. As a state's protocols trend toward Local they are considered to be more decentralized because the decision for that locality or service's care is left up to those local actors. Furthering the divide of each individual state's decision to centralize or decentralize, some states also choose to have different levels of centralization based on the service level of the EMSP. These levels are described as advanced life support (ALS) and basic life support (BLS). ALS is defined as prehospital care that uses invasive methods of assessment and treatment while BLS is defined as care that ensures patient vital function until they gain access to appropriate medical care (Ryynanen et al., 2010). Ryynanen et al. continue to describe what impacts the type of care that is delivered in individual systems, to include amount of population, geographical variables, location and level of hospitals, quality of emergency units, and education of the personnel (2010).

Clinical Decision Making: Medications and Procedures

The type of care delivered, to include medications administered and procedures performed, is typically influenced by individual patient level factors. This includes a thorough assessment of each patient and application of that patient's condition to statewide required or delegated protocols. These fundamentals of patient care can be reduced to performing the following for each patient: identify problems, set patient care priorities, develop a treatment plan, and execute that plan (AAOS, 2018). EMSPs use clinical decision making to interpret gathered patient data, apply their protocols to the data collected, and perform interventions such as administering medications or performing procedures to treat each patient's presenting condition. The data collected that influences these decisions are found in an effective primary survey, history taking, and gathering vital signs. These can be gathered with patient observation, patient interviews, and a physical assessment. Appropriate vital signs to record include assessment of the heart rate, respiratory rate, blood pressure, temperature, and pulse oximetry. For complex patient presentations it is recommended to get multiple sets of vital signs to follow patient trending and evaluate effectiveness of interventions (AAOS, 2018). Both medications administered and procedures performed occur as a direct result of the findings of the patient assessment and the need for patient stabilization.

Data found does show that medication administration can be impacted by factors that aren't directly related to patient care. These factors include age and race, specifically when applied to the administration of pre-hospital pain medication (Hewes et al., 2018). Understanding what determines when a medication is administered or a procedure is performed is necessary when exploring a previously unexplained factor that may impact those decisions. While an EMSP does not likely think about their state's decision regarding protocol decentralization when delivering care, the protocols establish what care is or is not permitted in that area. Thus, the degree of centralization absolutely could impact that decision in yet unknown ways.

DESCRIPTION OF STUDY

Defining the relationship between degree of centralization and health outputs is the goal of this study. Given the nature of medical care and data collection in the United States, assessing the ultimate health outcomes of a given patient is untenable. However, researchers can assess the outputs, such as the time taken to transport a patient, the vitals recorded, or in the case of our study the number of procedures performed, and medications given. Data is available that allows the analysis of outputs and degrees of decentralization, and using this I look to establish the impact of decentralization on the number of procedures performed or medications administered. Using 2018 Public Release National Emergency Medical Services Information System (NEMSIS) data, all 22,532,890 EMS activations reported in the year of 2018 will be analyzed for procedures performed and medications administered with an associated decentralization score assigned.

Theory and Hypothesis

Due to the previously documented impact of state policy decisions on the implementation of public goods and services (Cho et al., 2005), I predict that the state policy decision to centralize or decentralize EMS systems also have an impact on pre-hospital care delivery. While a direction of this relationship is put forward, it is worth noting that a finding of significance without relation to direction is in of itself significant.

Defining and describing EMS systems in the United States is difficult due to its varied heterogeneity and fragmented framework (Pozner et al., 2004). A varied heterogeneity and fragmented framework coalesces into a complex system that presents complex problems. Kettl posited that complex problems are sometimes better dealt with using devolved, or decentralized systems (2000). Due to this variance among EMS systems, differences between localities within states across the United States, and importance of innovation and collaboration between EMSPs as street level bureaucrats, the following two hypothesis are presented in conjunction with Wise's network model (2006).

Hypothesis 1: Medications administered will increase in number when administered in a state with a higher degree of decentralization than those performed in a state with a lower degree of decentralization.

I expect this because empowering localities and non-governmental agencies with more autonomy, who are experiencing daily EMS activations and responding to events in real time, give them increased expertise and ability to respond to the needs of their local environment. Increasing local agency provides EMSPs to be more flexible in their application of protocols and potentially allow for more aggressive delivery of life saving procedures. For example, should a locality recognize an increase in haloperidol administration related heart arrhythmias then a decentralized system can allow that Medical Director to more quickly change policy and procedure regarding the use of that medication requiring a cardiac monitor. In a more centralized system, this could take much longer and increased morbidity and mortality could result.

Hypothesis 2: Procedures performed will increase in number when performed in a state with a higher degree of decentralization than those procedures performed in a state with a lower degree of decentralization.

For the same reason listed for Hypothesis 1, I expect a similar relationship between decentralization and the number of procedures performed. While indications for both medication administration and procedure performance are based off of objective patient assessments, the range and autonomy to act on those indications are controlled by these decisions regarding EMS system decentralization. For example, should a local system recognize that ondansetron is effective at reducing opiate medication related nausea then a decentralized system can allow that Medical Director to more quickly change protocols regarding using opiate medications in conjunction with anti-nausea medications.

While I expect the number of medications given and procedures performed to increase in number due to increased local autonomy, it's important to note that significance of a relationship could be established in an opposite direction due to localities choosing to limit their EMSPs use of interventions in some situations. For example, should a locality recognize an increase of long spine board complications in the elderly population then a decentralized system can allow that Medical director to more quickly change protocols regarding using that procedure in such a potentially vulnerable population.

Methodology

The research of this thesis uses multiple statistical approaches to analyze data that contain vastly different types of variables. In the following models there are categorical and continuous variables, necessitating the use of multiple models to determine appropriate fit to match the requirements of the data. The presence of more than two variables, our search for statistical significance of our key independent variables, and our search for the direction of that potential significance requires the use of multivariate regression. This type of analysis will allow for the above to be found, as well as the relative impact of each included control variables.

In addition to multivariate regression, the distribution of our key dependent variables requires further analysis. As described below, the leftward skewness of the dependent variable distribution violates the assumption of a normal distribution. Without a normal distribution a multivariate regression will be unable to deliver accurate significance. To accurately describe the significance of our findings a negative binomial regression will be used. A negative binomial regression allows for transformation of regression analysis to correctly interpret the skewed data. Due to the change in modeling and its lack of a normal distribution, our coefficient presented will be a log of the expected change in the dependent variable. To better understand the proposed relationship between decentralization and delivery of care, predictive probabilities will also be simulated. The predicted probability models used here will hold all other variables at their average while predicting a number change in the dependent variable based on the preselected decentralization score. This will allow the interpretation of the degree of relationship between decentralization and delivery of care in relative numbers.

Data

Data was collected from the 2018 public-release NEMSIS dataset. The data set includes all EMS activations that resulted in a Patient Care Report (PCR) being completed and submitted in 2018 by reporting states and agencies. Each PCR contains objective patient assessment information, objective call context, and appropriate patient demographics. The NEMSIS database was organized in 2005 as a collaboration between the Health Resources and Services Administration (HRSA), the Center for Disease Control and Prevention (CDC), and the University Of Utah School Of Medicine. It was designed to bridge the gap between EMS as it was and EMS that could be, driven by data and evidence based practice (Dawson, 2006). This system was instituted, in part, after recommendations that the country needed a modern EMS system that has the ability to accurately describe the demographics of local, state, and federal systems (Mears et al., 2010).

The 2018 public-release dataset contains 22,532,890 EMS activations from 9,599 EMS agencies and 43 states/territories. The missing states are Delaware, Hawaii, Idaho, Massachusetts, Mississippi, Missouri, North Carolina, Ohio, Tennessee, and West Virginia. It is not the entire population of EMS activations in the United States for 2018, as reporting standards are in place to ensure cleanliness of data. It is likely that this dataset contains submissions from states and agencies that have sufficient resources to adopt NEMSIS standards (NEMSIS Technical Assistance Center, 2019). This means that this dataset is a sample of convenience rather than a population sample for the year of 2018. As such, this data set is subject to selection and information bias. Even with these limitations, the NEMSIS database is the most accurate national repository of EMS activations across the majority of the United States (Hewes et al., 2018).

It is important to note that multiple PCRs can be completed on the same patient, representing continuity across pre-hospital care delivery. For instance, a first responder or EMSP might establish care on a patient that requires eventual transfer of that patient to another provider. In this instance both the first responder/EMSP and the receiving unit would complete a PCR on the care that was given. The analysis being completed utilizes the 2018 NEMSIS Data User Manual, NEMSIS Data Dictionary v3.4.0, and Extended Data Definitions v3.4.0.

Measuring the Dependent Variables

The dependent variables studied here allow us to measure the impact of decentralization on the actual delivery of pre-hospital care. The potential relationship of a particular state's level of decentralization and actual performance of skills can be measured in both medications administered and procedures performed per call. The production of an actual number change in medications administered and procedures performed will allow for EMS practitioners to understand the direct impact of decentralization on their everyday practice. These dependent variables are also uniquely situated to evaluate the impact of decentralization, in that a state's decision to decentralize could lead to either variable being performed without calling a physician or require that EMSP to contact a physician first.

The first dependent variable being measured is the number of medications administered per EMS activation. This variable was not available in the 2018 public release dataset and required manipulation of the provided data. Each PCR is provided with a unique identifier for each medication that is given, so the number of these identifiers was collapsed to make a numeric variable ranging in 0 to 29. The number 0 represents 0 medications given during that EMS activation. The numbers 1 through 28 represent the number of medications given during that EMS activation. The number 29 represents 29 or more medications given during that EMS activation. This number was also the upper limit of the allowed number of medications administered in the NEMSIS system (NEMSIS Technical Assistance Center, 2019). This variable was made using pre-existing variables and is confirmable when comparing to the master NEMSIS data set. Of note, the medications administered presents with significant positive truncation. The majority of medications administered was 5 or less in 99.55% of EMS activations, leaving the remaining 0.45% in the 6 to 29 range. This truncation can be easily viewed in the following figure:

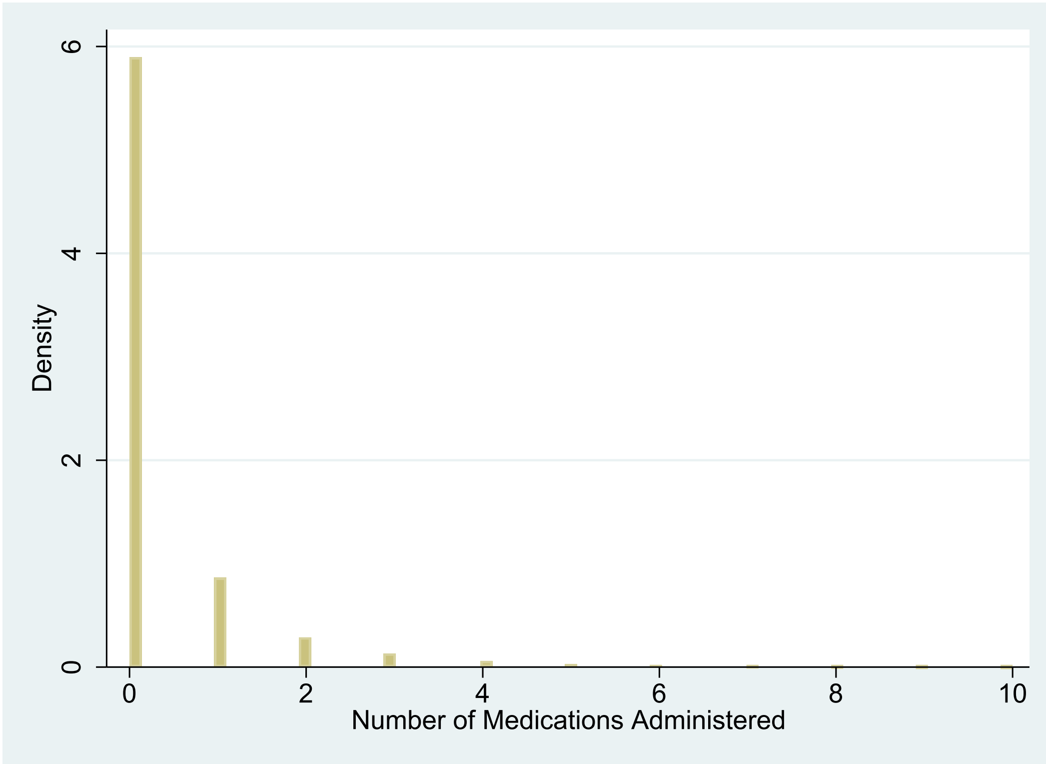

Figure 1. Number of Medications Administered per EMS Activation.

The second dependent variable being measured is the number of procedures performed per EMS activation. This variable was not available in the 2018 public release dataset and required manipulation of the provided data. Each PCR is provided with a unique identifier for each procedure that is performed, so the number of these identifiers was collapsed to make a numeric variable ranging in 0 to 29. The number 0 represents 0 procedures performed during that EMS activation. The numbers 1 through 28 represent the number of procedures performed during that EMS activation. The number 29 represents 29 or more procedures performed during that EMS activation. This number was also the upper limit of the allowed number of procedures performed in the NEMSIS system (NEMSIS Technical Assistance Center, 2019). This variable was made using pre-existing variables and is confirmable when comparing to the master NEMSIS data set. Of note, the procedures performed presents with significant positive truncation, but not to the same degree found in medications administered. The majority of procedures performed was 5 or less in 98.09% of EMS activations, leaving the remaining 1.91% in the 6 to 29 range. This truncation can be easily viewed in the following figure:

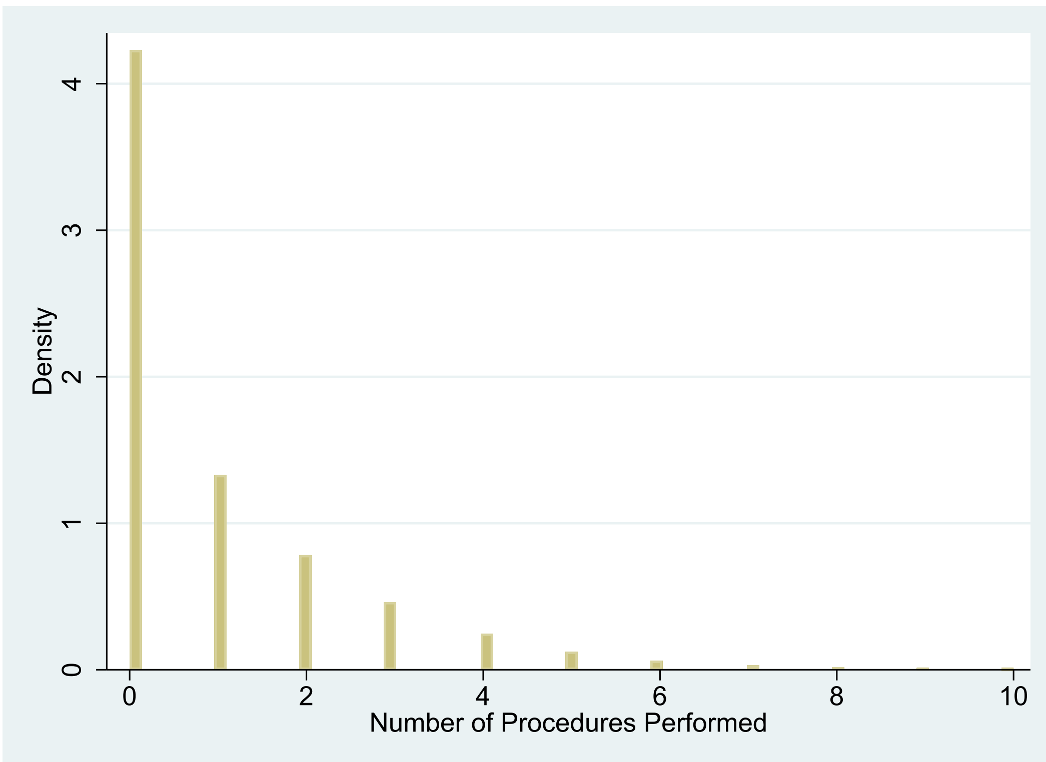

Figure 2. Number of Procedures Performed per EMS Activation.

Measuring the Independent Variables

The key independent variables being studied is each activation's protocol centralization index for both ALS and BLS providers. This ordinal variable index was created using the previously referenced 6 categories denoting each state's level of centralization for both ALS and BLS providers (Kupas et al., 2015). This variable's scale is 1 to 6, with each level denoting a differing and reduced level of centralization. For instance, an assignment of 1 would denote significant state centralization in EMS policy decisions that matches the Mandatory A description, "a state has statewide protocols that must be used by all EMS providers within the state." An assignment of 3 to 4 would denote a measure of both centralization and decentralization that matches the Mandatory C description, "a state has statewide protocols that must be used by all EMS providers within the state, but there is a process for services to petition the state to develop and use their own protocols," and the Regional description, "a state has model statewide protocols for providers, but each service or region may choose to use these protocols or may develop their own protocols." An assignment of 6 would denote significant decentralization that matches the Local description, "a state in which each EMS service or agency develops its own protocols" (Kupas et al., 2015).

The index is based on each activation's state of origin. The 2018 public-release dataset does not describe each activation's state of origin, so additional assistance was obtained from Dr. Clay Mann, the NEMSIS principal investigator. Dr. Mann created the independent interval variables of ALS and BLS centralization by replacing each state's identity with their associated centralization number. This allows for the state of origin to be masked but still effectively study the impact of centralization on each activation. There are no observations in this data set for BLS centralization index variable 5. This is due to one state representing this variable and the identification of this variable effectively removes the masking requirement for data use. The distribution of states in the two independent variables can be viewed in Tables 1 and 2. Of note, northeastern states tend to be categorized closer to centralized protocols whereas the greater number of total states are categorized closer to decentralized protocols. The following figures show the number distribution of EMS activations for both the ALS centralization index and the BLS centralization index.

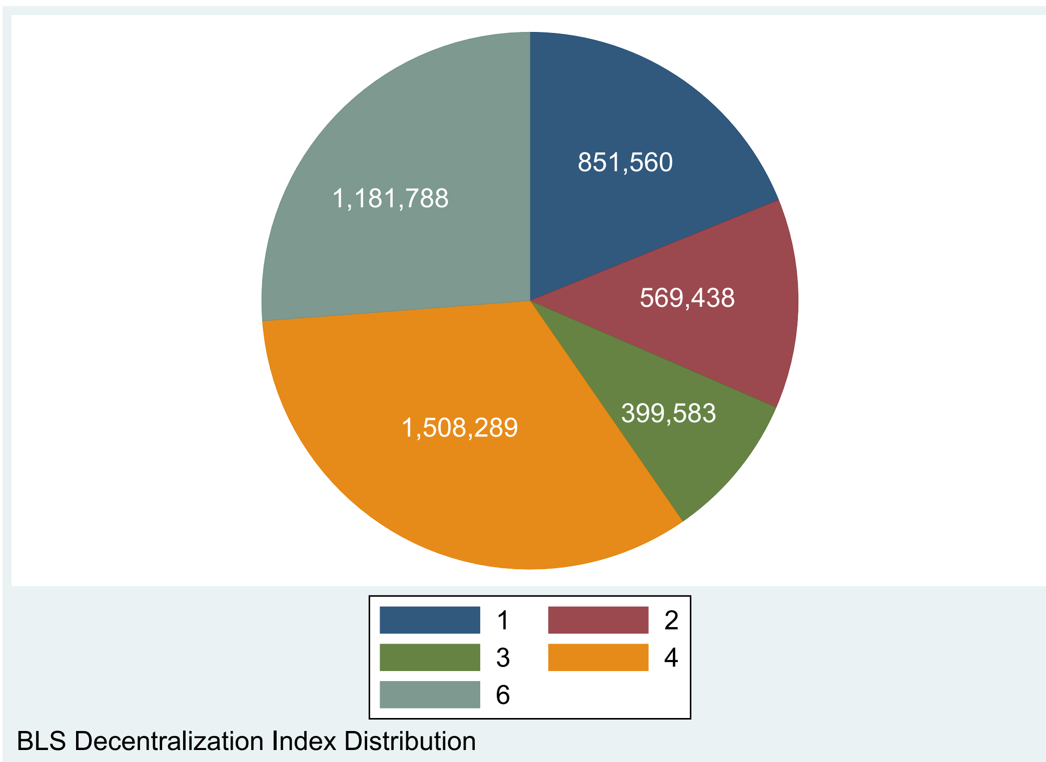

Figure 3. BLS Centralization Index Distribution.

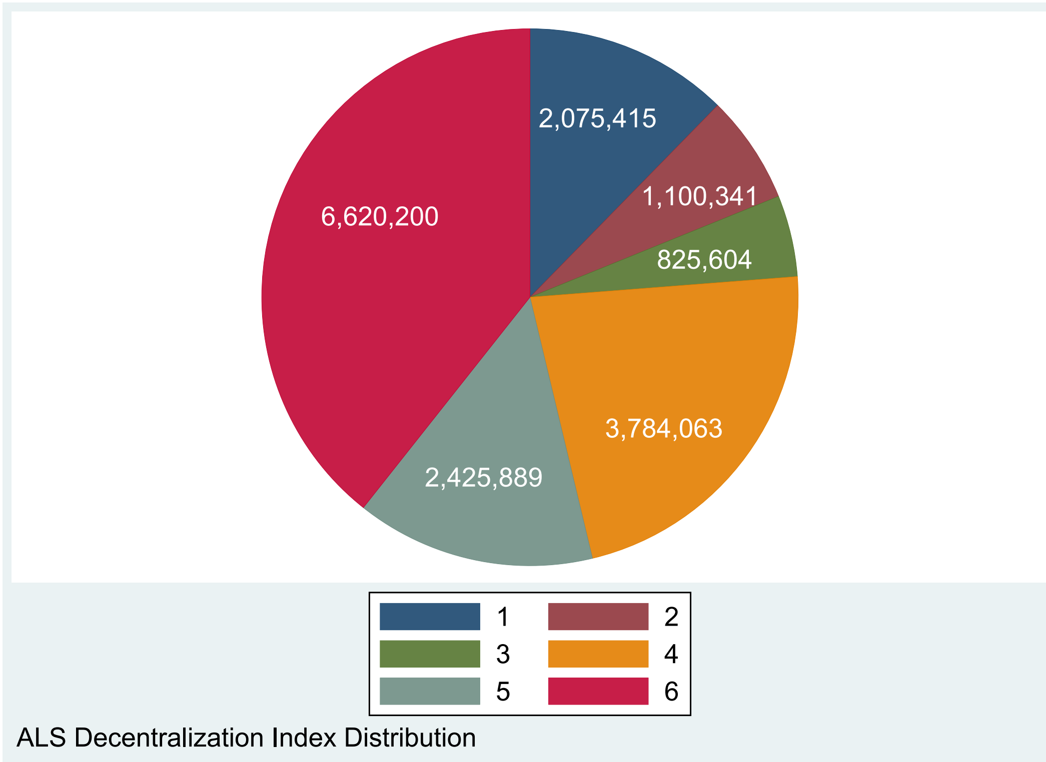

Figure 4. ALS Centralization Index Distribution.

Control Variables

16 additional individual call level factors from each 2018 activation that should affect the dependent variables – number of medications administered or procedures performed, are included in the model:

- Vital signs – We measure the systolic blood pressure (SBP), heart rate (HR), pulse oximetry (SPO2), respiratory rate (RR), end-tidal carbon dioxide (ETCO2), blood glucose level (BGL), Glasgow coma score (GCS), and level of consciousness (LOC) assessment findings for each EMS activation. As we previously established, both medications administered and procedures performed occur as a direct result of the findings of the patient assessment and the need for patient stabilization.

- Patient demographics – We measure the gender, age, and method of payment of each activation. Because demographic information, like age, can impact the type of care received (Owens, 2008), they have an impact on the care itself.
- Call demographics – We measure the total call time, level of care delivered (ALS/BLS), and urbanicity. Total call time gives the amount of time from activation of EMS until termination of the call. Urbanicity is based off of the 2013 urban influence codes and classifies the level of urbanization in the activation's area. This call demographic data paints a clearer picture of the context that each activation occurs in and could reveal unknown biases in prehospital care.

Due to the change in ALS decentralization and BLS decentralization, two separate models will be performed on each key dependent variable with its corresponding independent variable. For medication delivery the models will be as follows:

BLS Medications Given = BLS Decentralization Index + Gender + Age + Call Time + Urbanicity + Systolic Blood Pressure + Heart Rate + Pulse Oximetry + Respiratory Rate + End Tidal Carbon Dioxide + Blood Glucose + Glasgow Coma Score – Eye + Glasgow Coma Score – Verbal + Glasgow Coma Score – Motor

ALS Medications Given = ALS Decentralization Index + Gender + Age + Call Time + Urbanicity + Systolic Blood Pressure + Heart Rate + Pulse Oximetry + Respiratory Rate + End Tidal Carbon Dioxide + Blood Glucose + Glasgow Coma Score – Eye + Glasgow Coma Score – Verbal + Glasgow Coma Score – Motor

For procedure performance the models will be as follows:

BLS Procedures Performed = BLS Decentralization Index + Gender + Age + Call Time + Urbanicity + Systolic Blood Pressure + Heart Rate + Pulse Oximetry + Respiratory Rate + End Tidal Carbon Dioxide + Blood Glucose + Glasgow Coma Score – Eye + Glasgow Coma Score – Verbal + Glasgow Coma Score – Motor

ALS Procedures Performed = ALS Decentralization Index + Gender + Age + Call Time + Urbanicity + Systolic Blood Pressure + Heart Rate + Pulse Oximetry + Respiratory Rate + End Tidal Carbon Dioxide + Blood Glucose + Glasgow Coma Score – Eye + Glasgow Coma Score – Verbal + Glasgow Coma Score – Motor

These models take into account patient demographic data and activation level patient condition data to control for their impact on the number of medications administered and procedures performed. It is important to note that our data and methods are hierarchical in nature, in that we are studying the impact of state level decisions with individual EMS activation inputs. Additional state level data was not added due the structure of the independent variables. Our independent variables are indexes with the state of origin unknown, made by the NEMSIS principal investigator to ensure continued masking. Inputting additional state level variables would have to be done as an index as well, with the observed heterogeneity of the independent variables making those variables inaccurate.

ANALYSIS OF STUDY

We test our hypotheses of increased number of medications administered and procedures performed when under decentralized EMS policy decisions using one linear regression model, two negative binomial regression models, and a predictive probability analysis. Results will be reported for medications administered and procedures performed via linear regression and then further tested using the negative binomial regression models.

Linear Regression Results

Using the key dependent variable representing the number of medications administered per call, linear regression is used to show significance to the relationship, the direction of that relationship, and a regression coefficient. Significance is found via a p value that is less than 0.05, with further strength of significance found when p values drop below 0.01 or 0.001. We find the degree of impact of the key independent variable plus control variables, and the direction of the relationship, in the unstandardized regression coefficient. The value found in the unstandardized regression coefficient represents the increase of value in the dependent variable for each one unit increase in the independent variable while controlling for all other variables in the model.

Table 3 presents the output from the 4 linear regression models run. Columns 1 and 2 represent the impact of centralization on both advanced life support and basic life support administration of medications. Centralization is found to be statistically significant in both advanced and basic life support medication administration. Hypothesis 1 is supported in basic life support providers but rejected in advanced life support providers. According to this model, every 1 unit increase towards decentralization causes advanced life support providers to administer 0.037 less medications when basic life support provider administer 0.064 more medications. While decentralization is significant for both advanced and basic life support providers, only basic life support providers confirm the direction of relationship hypothesized.

Columns 3 and 4 from Table 3 represent the impact of centralization on both advanced life support and basic life support performance of procedures. Centralization is found to be statistically significant in both advanced and basic life support procedure performance. Hypothesis 2 is rejected in both advanced and basic life support providers. According to this model, every one unit increase towards decentralization causes advanced life support to perform 0.179 less procedures in advanced life support providers and 0.193 less procedures in basic life support providers. The direction of significance for both advanced and basic life support providers is in the opposite of the hypothesized relationship.

When analyzing the regression results between advanced and basic life support decentralization, differences in the unstandardized regression coefficient are noted. Across the board for decentralization, the size of the basic life support coefficients are much higher than advanced life support. This could be due to the smaller sample size and distribution of data analyzed. Multiple control variables are found to be statistically significant with age, call time, urbanicity, payment, systolic blood pressure, heart rate, end tidal carbon dioxide, blood glucose level, Glasgow coma score – eye, and Glasgow coma score – motor being considered across advanced and basic life support providers. Of note, as time of call increases so does the number of procedures performed across advanced and basic life support providers. This relationship passes the eye test, with conventional reasoning that more time means more opportunity for additional care being confirmed. It is also noted that all variables dealing with level of consciousness (Glasgow comas scale eye/verbal/motor, LOC) are considered significant across advanced life support providers while not across basic life support providers. This could be attributed to tiered dispatch systems that send advanced life support providers to more medically unstable patients.

Due to the significant skewness of our dependent variables, the significance drawn from applying our linear regression models to our data is not accurate enough because of the linear regressions assumption of a normal distribution. The dependent variables in these models are not normally distributed so further specific modeling is needed.

Negative Binomial Regression Results

The medications administered and procedures performed were made using a count variable. Some patients receive neither a medication nor a procedure during their EMS activation, leading to a significant number of values found at zero. This leads to the left sided skewness that was described previously. To correct for this, the negative binomial regression model allows for transformation of regression analysis to correctly interpret the skewed data. Similar metrics are used to evaluate the negative binomial regression outcomes as were used in the linear regression outcomes, with the main difference being the interpretation of the model coefficient. As the negative binomial model transforms the linear regression analysis to correctly analyze our data, the coefficient presented cannot be interpreted as it was previously. The negative binomial coefficient is a log expected value, meaning that for every one unit increase in the independent variable there results a log expected increase of the dependent variable. To get a true number of medications given or procedures performed predictive probabilities are found afterwards.

The negative binomial regression outcomes can be found in Table 4. Columns 1 and 2 represent the impact of decentralization on both advanced and basic life support administration of medications. Decentralization is found to be statistically significant in both advanced and basic life support medication administration. Hypothesis 1 is supported in basic life support providers but rejected in advanced life support providers. According to this model, the log expected medication count would be less 0.03 for advanced life support providers and more 0.125 for basic life support providers with every one unit increase in decentralization. While decentralization is significant for both advanced and basic life support providers, the direction of that relationship is opposite of what is hypothesized for advanced life support providers.

Columns 3 and 4 from Table 4 represent the impact of decentralization on both advanced and basic life support performance of procedures. Decentralization is found to be statistically significant in both advanced and basic life support procedure performance. Hypothesis 2 is rejected in both advanced and basic life support providers. According to this model, the log expected procedure count would be less 0.066 for advanced life support providers and less 0.152 for basic life support providers with every 1 unit increase in decentralization. While decentralization is significant for both advanced and basic life support providers, the direction of that relationship is opposite of what is hypothesized.

The results from table 4 deserve further discussion. As referenced above, we find significance between the degree of centralization and the number of medications administered and procedures performed. What was not expected, according to Hypothesis 1 and 2, was the direction of these relationships. Our results overwhelmingly lean towards decentralized EMS systems leading to fewer medications administered and procedures performed per EMS activation. While we expected a decentralized system to give medical directors and local agencies the autonomy to increase local use of medications and procedures to better provide their communities, we find that medical directors and local agencies use that autonomy to limit the local use of medication and procedure delivery.

Additional factors may influence why our results do not coincide with the majority of the hypotheses. This limiting of medication and procedure delivery in devolved systems could be tied to localities using their autonomy to protect vulnerable populations from procedures and medications that have been shown to be harmful or ineffective. Returning to our earlier example, it has been established that risk for pressure ulcers increases the longer a severely ill or injured patient is secured to a long spine board with a cervical collar (Ham et al., 2014). Localities could see this information and believe that the risk of pressure ulcers is an acceptable trade for spine stability, except that there is evidence that it doesn't provide that (Wampler et al., 2016). This would be an excellent opportunity for a devolved system to move on its own accord to better serve their members and limit use of that procedure, rather than wait for a centralized system to adapt to a changing environment.

It also could be occurring due to potential liability considerations. The estimated cost of the medical liability in 2008 was 55.6 billion dollars, totaling to 2.4 percent of national health care spending in that year (Mello et al., 2010). EMS providers have been linked to adverse events due to the unpredictable field environment that often has very little direct oversight (Wang et al., 2008). This uncontrolled environment and increased link to adverse events could drive devolved local EMS systems to reduce performing complicated procedures and administering medications with potential negative side effects. The lack of direct oversight could also be a contributing factor to not allowing EMS providers to be more aggressive in the field.

Multiple control variables are found to be statistically significant across both the advanced and basic life support providers. Call time continues to be a positive indicator of more log expected medications administered and procedures performed. Level of consciousness (Glasgow comas scale eye/verbal/motor, LOC) variables continue to be found significant for advanced life support providers but not basic life support providers.

The binomial regression models are more appropriate for analysis than linear regression models, but here they confirm similar findings. In all hypotheses, the independent variable of centralization was found to be statistically significant, but only in one of the four directions posited. To better describe the impact of decentralization on the number of medications administered and procedures performed we performed predictive probability analysis of the advanced life support models. The basic life support model is not used due to low sample size and attributed missingness. The predicted probability models hold all other variables constant while predicting a number of medications administered and procedures performed under a pre-selected decentralization score. We use this to give us an actual number prediction because the negative binomial model outputs log expected counts.

Table 5 presents the predicted probabilities of medications administered by advanced life support providers with a pre-selected decentralization score. The predicted probabilities are consistent with the direction of the relationship found in the original negative binomial model. At our most centralized we find that 1.672 medications are administered per EMS activation. At our most decentralized we find that 1.291 medications are administered per EMS activation. While the direction between most centralized to least centralized does indeed go down, our two middle values of decentralization do not present with this direction and the relationship is inverted. The difference between the two is 0.072 medications administered per EMS activation.

Table 6 presents the predicted probabilities of procedures performed by advanced life support providers with a pre-selected decentralization score. The predicted probabilities are consistent with the direction of the relationship found in the original negative binomial model. At our most centralized we find that 3.730 procedures are performed per EMS activation. At our most decentralized we find that 2.471 procedures are performed per EMS activation. While the direction between most centralized to least centralized does indeed go down, our two middle values of decentralization do not present with this direction and the relationship is inverted. The difference between the two is even smaller for procedures performed, coming in at 0.003 per EMS activation.

A concerning development in our negative binomial model was the low sample size. With the BLS data set compiling over 5 million observations and the ALS data set compiling over 17 million observations, sample sizes of 1,351 and 34,699 respectively may not show that we are accurately reporting on the data set that we are using. This discrepancy is found because the statistical software used (STATA) only runs the model on EMS activations that contain each of the variables listed. Thus, the model choices utilize listwise deletion to account for missingnness. The missingness is expected and natural to our data as not every patient will have every diagnostic test conducted. To support our previous model we run a second negative binomial model with ALS data that has significant missing values removed, specifically removing variables that are unlikely to be performed on a routine emergency service call. After removing end tidal carbon dioxide, blood glucose level, Glasgow coma score – eye, Glasgow coma score – verbal, and Glasgow coma score – motor we find our sample size has grown from 34,699 observations to 2,925,218 observations. The results of this model can be found in Table 7. We find that all variables are significant and that the direction of relationship remains consistent with the original negative binomial model in procedures performed but not medications administered, thus establishing some degree of robustness.

Focusing on the more appropriate regression model for this data, the negative binomial model and its predictive probabilities are used for analysis. This model presents that there is a relationship between both medications administered and procedures performed with the type of decentralization score that care is performed under. This relationship is negative, in that as you become more decentralized you typically also see less medications administered and procedures performed. This is somewhat more clouded when looking at decentralization scores in the middle, but is more pronounced when comparing most and least decentralized.

The narrower negative binomial model that has additional observations casts doubt on the medications administered by flipping its expected relationship. Both models show significance of opposing directions, warranting further study.

CONCLUSION

Prior to this thesis, no attempt has been made to link state policy decisions about decentralization to the care received by individuals from the pre-hospital EMS systems that they reside in. That link has been unearthed and given an initial direction with the conclusion of this thesis. The decision for state governments to centralize or decentralize the administration of EMS systems has a significant impact on how those systems operate. With the natural policy disputes that occur every day between Americans towards government involvement in public goods and services, understanding how that relationship works is necessary to ensure equitable delivery of these goods and services.

Decentralization's impact on the actual care delivered, to include medications administered and procedures performed per EMS activation, has been established and given direction. Procedure delivery, across both ALS and BLS provider levels, decreases as decentralization increases. This means that in a completely decentralized state you will have less medications administered to you than if you received that same care in a centralized state. Our modeling predicts that, per EMS activation for ALS providers, you receive approximately 3.7 procedures performed in the most centralized state whereas you will receive approximately 2.5 procedures performed in the most decentralized state.

Medication delivery across ALS provider levels follows this trend, with fewer medications administered in a more decentralized state than in a more centralized state. Our modeling predicts that, per EMS activation for ALS providers, you receive approximately 1.6 medications administered in the most centralized state whereas you will receive approximately 1.3 medications administered in the most decentralized state. An important deviation from this is that across BLS provider levels we have an increase in medications administered in decentralized states.

These relationships, both for medications administered and procedures performed, are further examined and found to be less significant when at middling degrees of centralization while being more significant when comparing each end of the decentralization spectrum. Further exploration of what else impacts medication administration, procedure delivery, and the role of local autonomy in EMS systems should be considered.

These results have meaning and matter because of what they represent. While each activation represents a statistically small amount of data when observing a year's worth of experiences, each activation means much more to those who live it. To think that the type of care received, especially in the revealing and uncomfortable realm of pre-hospital care, is influenced by state governments who may not fully comprehend the impact of their policy decisions is concerning. The important research findings found in this thesis provide a base for further study of how state policy decisions can change the delivery of care in the pre-hospital environment.

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APPENDIX

Appendix A: Variable and Statistical Analysis Tables

Table 1. BLS Decentralization Index State Distribution.

1	2	3	4	5	6
Maine	Alabama	Illinois	Alaska	n/a	Colorado
Maryland	Iowa	Nevada	Arizona		Florida
New Hampshire	Michigan	New York	Arkansas		Indiana
Pennsylvania	Montana	Oklahoma	Connecticut		Kansas
Rhode Island	Vermont		Georgia		Louisiana
	Washington		Kentucky		New Jersey
			Minnesota		Oregon
			Nebraska		Texas
			New Mexico		Virginia
			North Dakota		Wyoming
			South Carolina		
			South Dakota		
			Utah		

Table 2. ALS Decentralization Index State Distribution.

1	2	3	4	5	6
Maine	Alabama	Nevada	Alaska	California	Colorado
Maryland	Iowa	Oklahoma	Arizona	New York	Connecticut
New Hampshire	Michigan		Arkansas	Washington	Florida
New Jersey	Montana		Georgia		Illinois
Pennsylvania	Vermont		Kentucky		Indiana
Rhode Island			Nebraska		Kansas
			New Mexico		Louisiana
			North Dakota		Minnesota
			South Carolina		Oregon
			Utah		South Dakota
			Wisconsin		Texas
					Virginia
					Wyoming

Table 3. Impact of Decentralization on Medications Administered and Procedures Performed (Regression)

	Medications Administered (ALS)	Medications Administered (BLS)	Procedures Performed (ALS)	Procedures Performed (BLS)
Decentralization	-0.037*** (0.006)	0.064* (0.031)	-0.179*** (0.01)	-0.193** (0.057)
Gender	-0.072*** (0.017)	-0.041 (0.057)	-0.161*** (0.023)	0.002 (0.107)
Age	0.003*** (0.000)	-0.004* (0.002)	0.01*** (0.001)	-0.011** (0.003)
Call Time	0.003*** (0.000)	0.001 (0.001)	0.002*** (0.000)	0.003*** (0.001)
Urbanicity	-0.112*** (0.013)	-0.121*** (0.031)	-0.409*** (0.018)	-0.217*** (0.057)
Payment	-0.016 (0.01)	0.115* (0.047)	0.136*** (0.014)	0.181* (0.088)
Systolic BP	0.001** (0.000)	0.004*** (0.001)	-0.001* (0.000)	0.01*** (0.002)
Heart Rate	0.002*** (0.000)	0.001 (0.001)	0.001** (0.000)	0.005* (0.002)
Oxygen Saturation	-0.030*** (0.001)	-0.007 (0.003)	-0.015*** (0.001)	-0.009 (0.006)
Respiratory Rate	0.01*** (0.09)	0.004* (0.002)	-0.000 (0.000)	0.003 (0.003)
End Tidal Carbon Dioxide	0.01*** (0.001)	0.007*** (0.001)	0.004*** (0.001)	0.018*** (0.002)
Blood Glucose Level	0.000 (0.000)	0.007** (0.000)	0.001*** (0.000)	0.002*** (0.000)
GCS – Eye	-0.175*** (0.022)	-0.044 (0.087)	-0.191*** (0.03)	-0.379* (0.161)
GCS – Verbal	0.212*** (0.012)	-0.03 (0.043)	0.068*** (0.016)	-0.116 (0.08)
GCS – Motor	-0.203*** (0.013)	-0.13* (0.063)	-0.161*** (0.018)	-0.250* (0.118)
Level of Consciousness	0.125*** (0.02)	0.076 (0.088)	0.091** (0.028)	-0.085 (0.163)
_cons	4.329*** (0.152)	1.308* (0.608)	6.67*** (0.206)	4.773*** (1.131)
N	34,699	1,351	34,699	1,351
Adjusted R^2	0.1	0.14	0.09	0.24

Cell entries are linear regression coefficients with standard errors in parentheses.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 4. Impact of Decentralization on Medications Administered and Procedures Performed (Negative Binomial Regression)

	Medications Administered (ALS)	Medications Administered (BLS)	Procedures Performed (ALS)	Procedures Performed (BLS)
Decentralization	-0.03*** (0.004)	0.125* (0.051)	-0.066*** (0.003)	-0.152** (0.053)
Gender	-0.056*** (0.012)	-0.093 (0.099)	-0.058*** (0.008)	0.054 (0.094)
Age	0.003*** (0.000)	-0.006 (0.003)	0.003*** (0.000)	-0.01*** (0.003)
Call Time	0.002*** (0.000)	0.002 (0.001)	0.000*** (0.000)	0.004*** (0.001)
Urbanicity	-0.073*** (0.009)	-0.235*** (0.053)	-0.131*** (0.006)	-0.149** (0.05)
Payment	-0.018* (0.007)	0.151* (0.074)	0.052*** (0.005)	0.092 (0.07)
Systolic BP	0.001*** (0.000)	0.006*** (0.002)	-0.000 (0.000)	0.006*** (0.001)
Heart Rate	0.002*** (0.000)	0.003 (0.002)	0.001*** (0.000)	0.006** (0.002)
Oxygen Saturation	0.016*** (0.001)	-0.011 (0.006)	-0.004*** (0.000)	-0.01 (0.006)
Respiratory Rate	0.007*** (0.000)	0.01** (0.004)	0.000 (0.000)	0.004 (0.004)
End Tidal Carbon Dioxide	0.006*** (0.000)	0.014*** (0.002)	0.001*** (0.000)	0.025*** (0.003)
Blood Glucose Level	-0.000*** (0.000)	0.002*** (0.001)	0.000*** (0.000)	0.004*** (0.001)
GCS – Eye	-0.126*** (0.015)	-0.067 (0.137)	-0.059*** (0.01)	-0.26* (0.129)
GCS – Verbal	0.15*** (0.01)	-0.025 (0.069)	0.019** (0.006)	-0.083 (0.067)
GCS – Motor	-0.012*** (0.01)	-0.138 (0.097)	-0.045*** (.006)	-0.112 (0.092)
Level of Consciousness	0.085*** (0.014)	0.047 (0.122)	0.03** (0.01)	-0.204 (0.137)
_cons	1.605*** (0.104)	-0.177 (0.93)	2.119*** (0.067)	1.80 (0.971)
N	34,699	1,351	34,699	1,351
Pseudo R^2	0.027	0.077	0.022	0.077

Cell entries are negative binomial regression coefficients with standard errors in parentheses.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 5. Predictive Probability of Decentralization on Number of ALS Medications Administered

Decentralization Score	Number of Medications Given	SE	95% Confidence Interval
1 (Most Centralized)	1.672	0.004	1.596 – 1.748
2	1.742	0.005	1.691 – 1.794
3	1.469	0.003	1.456 – 1.482
4	1.541	0.004	1.517 – 1.564
5	1.371	0.003	1.352 – 1.389
6 (Most Decentralized)	1.291	0.003	1.282 – 1.299

Note: The coefficient value is the predicted change in number of medications given with all other variables held constant, across the observable range of data.

Table 6. Predictive Probability of Decentralization on Number of ALS Procedures Performed

Decentralization Score	Number of Procedures Performed	SE	95% Confidence Interval
1 (Most Centralized)	3.730	0.004	3.648 – 3.812
2	3.526	0.004	3.477 – 3.576
3	3.152	0.003	3.138 – 3.166
4	3.155	0.004	3.135 – 3.176
5	2.592	0.002	2.580 – 2.605
6 (Most Decentralized)	2.471	0.003	2.463 – 2.478

Note: The coefficient value is the predicted change in number of procedures performed with all other variables held constant, across the observable range of data.

Table 7. Impact of Decentralization on Medications Administered and Procedures Performed, ALS Models (Negative Binomial Regression with missingness controlled)

	Medications Administered (ALS)	Procedures Performed (ALS)
Decentralization	0.052*** 0.001	-0.098*** 0.000
Gender	-0.064*** 0.002	-0.051*** 0.001
Age	0.006*** 0.000	0.004*** 0.000
Call Time	0.002*** 0.000	0.001*** 0.000
Urbanicity	-0.114*** 0.001	-0.079*** 0.001
Payment	-0.021*** 0.001	0.035*** 0.001
Systolic BP	0.001*** 0.000	0.001*** 0.000
Heart Rate	0.006*** 0.000	0.003*** 0.000
Oxygen Saturation	-0.029*** 0.000	-0.007*** 0.000
Respiratory Rate	0.036*** 0.000	0.006*** 0.000
End Tidal CO2	-	-
Blood Glucose Level	-	-
GCS – Eye	-	-
GCS – Verbal	-	-
GCS – Motor	-	-
Level of Consciousness	0.403*** 0.002	0.224*** 0.001
_cons	-0.036	0.826
N	2,925,218	2,925,218
Pseudo R^2	0.031	0.022

Cell entries are negative binomial regression coefficients with standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

BIOGRAPHICAL SKETCH

BIOGRAPHICAL SKETCH

Jonathan Ready Powell was born in Mobile, Alabama on November 2, 1988. He graduated from the University of South Alabama in Mobile, Alabama in 2012 with a Bachelor of Science in Emergency Medical Services. He is scheduled to graduate from the University of South Alabama in Mobile, Alabama in the summer of 2020 with a Master Degree in Public Administration. He was awarded the Dean's Award for Academic Excellence in 2012, Master in Public Administration Health Policy Scholarship in 2018, and Outstanding Service Award in 2019. He and his wife Stacy will be moving to Columbus, Ohio to continue their journey.