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Electronic Warrant Systems: The Effect of Advanced Technologies on Arrest Performance

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Abstract

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by

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MBA, University of Central Oklahoma, 2002

BS, Mathematics, Central State University, Edmond, Oklahoma 1979

Dissertation Submitted in Partial Fulfillment

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Abstract

Public safety is negatively affected when arrest warrant information is not available to law enforcement officers, judges, prosecutors, and other criminal justice practitioners. The U.S. Government and the criminal justice community have advocated for electronic warrant systems (e-warrants). Peace officers know that when e-warrant systems deliver warrant information to them immediately from multiple jurisdictions, their safety is increased. However, the factors that cause these e-warrants systems to improve safety are not known. The purpose of this historical data analysis study was to determine if the use of e-warrant systems resulted in shorter clearance times than the use of legacy paper-based systems. Stakeholder theory, open systems theory, and service-oriented architecture theory were used to guide the quantitative research design. This study compared 2 years of historical arrest warrants from 6 sheriffs' departments organized into population matched sets. Two-way ANOVA tests and nonparametric tests were conducted to analyze the impact of the independent variables warrant system type and case type on the dependent variables mean service days and percent warrants served. The study showed that operating e-warrant systems in similar size sample agencies did not ensure shorter mean service days and higher percent warrants served over legacy systems, and it confirmed that more research is needed to determine other factors that will lead to an improvement in these variables. The findings of this study may assist agency executives and justice practitioners to identify other variables that may increase effectiveness of e-warrant systems, thereby improving public and officer safety, both important social benefits.

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Dedication

I dedicate this dissertation to my dear departed mother, Carolyn Sue Ward, who was very ill through much of my time in this program. She was proud of me for attempting a difficult degree while raising a family and keeping a job. She passed away before I completed my work, but she never gave up on me. No matter how difficult and distant the goal seemed to be, her confidence was my inspiration to press on. I know that she looks down on me today with great pride. With eternal gratitude—I love you, Mom.

Acknowledgments

"Man's flight through life is sustained by the power of his knowledge."

-- Austin 'Dusty' Miller,
from the Eagle & Fledgling statue at the
U.S. Air Force Academy

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I have many others to thank, starting with my beloved wife, Rita, who stuck with me and paid the price through the long grind all the way to the end. Her sacrifices cannot be measured in time or money, but I am eternally grateful to her for her support on this long journey. For my father--Dad, I finally did it! Thank you for encouraging me to finish at every opportunity. I know how proud you are of this accomplishment. To my two adult children Darren and Andrea, thank you for your sacrifices and support. I will make good on my promise to use this degree to accomplish great things.

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Chapter 1: Introduction to the Study

Introduction

Information on active (servable) arrest warrants is often out of the immediate reach of the peace officer on the street, despite widespread use of sophisticated electronic information systems designed to make the officer's job easier and to improve public safety. The purpose of this study was to examine electronic arrest warrants (e-warrants) used by law enforcement agencies and to better understand how they affect service times and percent warrants served. Open systems theory, stakeholder theory, and IT service-oriented architecture (SOA) provided a theoretical basis for this research. Investment in warrant data sharing technology between courts, law enforcement agencies, and other government entities is grounded in these theories, and it is supported by the U.S. Department of Justice through grants, information, and technical support (Bureau of Justice Statistics, 2011b, p. 3). This study was an investigation of the actual effect of advanced electronic warrant systems on agency effectiveness in clearing warrants.

This chapter contains a historical background explicating the social need for improvements, a problem statement, research questions and hypotheses, a descriptive nature of the study, operational definitions, assumptions, scope and delimitations, limitations, and a concise section outlining the significance of the study.

Background of the Study

Little research is available on the topic of electronic warrants, and most extant literature is connected to the U.S. federal government directly or indirectly through funding of industry and academic programs. Researchers aggregate warrants with other

criminal justice documents, such as arrest records and jail booking records, when researching information exchanges (Geerkin, 2008). I found no evidence of agency warrant service improvements in the literature. The remainder of this section contains a sampling of compelling past criminal cases and other information which established the need for improvements in how arrest warrants are recorded, tracked, shared, and cleared.

Two months before the September 11, 2001, terrorist attacks against the United States, attack mastermind Mohammed Atta was pulled over in Delray Beach, Florida for speeding. The officer was unaware that Atta had an arrest warrant for failure to appear for driving without a license in adjacent Broward County, and no arrest was made (Reynolds, Griset, & Scott, 2006). On September 11, 2001 Atta took control of American Airlines Flight 11 and crashed the Boeing 767 into the North Tower of the World Trade Center, killing all on board and an unknown number of people in the tower (National Commission on Terrorist Attacks Upon the United States, 2004). Had the officer been informed of Atta's active warrant, he would likely have detained or arrested Atta, and the authorities might have been tipped off to the larger terrorist plot by something in his possession or by his behavior. It is plausible that the 9/11 terrorist attack might have been thwarted if Atta's active warrant information had been shared across a single county line.

There are many less reported examples like Atta's. A woman was fatally shot by her ex-husband in Minneapolis in 1997 while he was out on bond awaiting conviction for killing his ex-wife's new boyfriend (Harrison, 2002). The killer had previously been arrested in a neighboring county for threatening to kill his ex-wife with a gun, and the judge did not know of the previous arrest when he ordered the release (Harrison, 2002).

In 2008, Judge Michael Marcus, in testimony before the Oregon Ways and Means Committee, explained how he had released an arrestee who, within 48 hours of his release, brutalized a family. Judge Marcus read about the crime that he had enabled in a newspaper the next day, and later he cited the lack of reliable information about individuals, including warrants, as a primary cause of this tragedy and stated that system improvements were needed to prevent future similar incidents (Marcus, 2008).

These examples are not isolated incidents. Geerkin (2002) identified improper release or failure to hold as a common problem type in a taxonomy of integration-related criminal justice system problems, citing unknown warrant or detainer as a key subtype. The same report contains accounts from 21 incidents, many resulting in loss of life, that could have been prevented with better information sharing between systems (Geerkin, 2002, pp. 9, 18-33). Historical accounts such as these support the assertion that improved information sharing improves public safety.

Many states operate an electronic warrant repository and share information with the FBI. According to a 2011 survey of states, 67% of states with a warrant repository send felony warrants to the FBI National Crime Information Center (NCIC); however, the completeness, accuracy, and timeliness of warrant information vary (National Center for State Courts & SEARCH, 2011, p. 18). Thirty one of the 45 respondents that have state warrant repositories agree or strongly agree that they are able to "share information as necessary to ensure records are updated" (National Center for State Courts & SEARCH, 2011, p. 16). The completeness and quality of shared warrant information needs improvement to increase reliability and user confidence.

Lawmakers and criminal justice associations have funded justice information sharing projects through federal programs. The Crime and Identification Technology Act (CITA) became federal law in 1999 and authorized $250 million per year for 5 years in state grants to "promote the integration of justice systems information and identification technology" (D. J. Roberts, 2004, p. 1). Government and industry organizations, including the U.S. Department of Justice Bureau of Justice Statistics; the Federal Bureau of Investigation; the Global Justice Information Sharing Initiative Advisory Committee (known as GLOBAL); the IJIS Institute; the National Center for State Courts; and SEARCH, the National Consortium for Justice Information and Statistics, advocate the use of e-warrant systems (Melnick et al., 2005; D. J. Roberts, 2004; Walbolt Wagner, 2006; Wormeli, 2009). Taxpayer-funded federal grants are available to agencies for implementing new systems (Bureau of Justice Statistics, 2011b); yet, the outcome of these systems has not been adequately scientifically measured after implementation.

Judges, attorneys, law enforcement officers, and other government officials across the United States make life changing decisions every day that directly impact the safety, freedom, and well-being of the public. Principle decision makers in the U.S. criminal justice system frequently must make decisions (e.g., setting bonds, sentencing, parole, release, licensing) with incomplete or inaccurate information (Geerkin, 2002; Marcus, 2008). If a judge sets a low bail for a defendant and the defendant has a violent criminal history in the same or another jurisdiction, the result could be more crimes committed as in the Minnesota and Oregon cases mentioned previously.

Problem Statement

The general problem that is the focus of this study is that public safety is negatively affected when arrest warrant information is not available to law enforcement officers, judges, prosecutors, and other criminal justice practitioners. Law enforcement officers know that they are safer when e-warrant systems deliver warrant information to them immediately from multiple jurisdictions. Federal government officials and industry group leaders promote standards and best practices for electronic warrant systems (Bettelli, 2005; Marz & Scott III, 2010; Melnick et al., 2005; D. J. Roberts, 2004; Walbolt Wagner, 2006). The specific problem is that the e-warrant factors that enhance safety are not known (Ward, 2010). A lack of empirical studies exists in the literature to support that agencies using electronic warrant systems are more effective for bringing wanted persons to justice than agencies using predominantly paper-based warrant systems (Zaworski, 2004). When measured in aggregate for an agency, effectiveness is measured by the average time required to serve a warrant and by the percent of all warrants that have been served. Greater efficiency is indicated by shorter warrant service times and higher percentages served.

The background section contains the practical social problem of imperfect warrant information as well as anecdotal evidence of justice information system failures (Geerkin, 2002). The potential societal impacts of more advanced methods of creating, distributing, and managing arrest warrants include improved public safety, timely justice, and government efficacy and efficiency. Systems improvements are needed, but little scientific research is available to support the idea that advanced information systems lead

to improved law enforcement performance (Zaworski, 2004, pp. 1-2). Without sufficient and compelling evidence in the literature and from practice, the impact of these programs may not be known.

Purpose of the Study

The purpose of this quantitative study was to validate or refute assertions of government and industry associations that more advanced e-warrant systems produce improved arrest results as measured by the dependent variables mean service days and percent warrants served. Independent variables were warrant system type and case type.

If officer safety can be improved, fugitives can be apprehended, false arrests and other errors can be reduced, operational efficiencies can be gained, and criminal and terrorist acts can be prevented by deploying higher maturity level warrant systems, then state and local agency executives and managers need to review the evidence to better inform their resource and budget decisions. This study was designed to obtain and reveal this evidence.

Research Questions and Hypotheses

Research Questions

An important measure of law enforcement performance is how quickly warrants are served after being ordered by the court. This leads to the four research questions of this study:

1A. To what extent does the use of electronic warrant systems result in shorter mean service days than the use of legacy paper-based warrant systems?

1B. To what extent does the use of electronic warrant systems result in greater percent warrants served than the use of legacy paper-based warrant systems?

2A. How does the mean service days compare between the two systems for each case type?

2B. How does the percent warrants served compare between the two systems for each case type?

I designed the first pair of questions (1A and 1B) to determine if electronic warrant systems change the mean service days or percent warrants served for all warrants. The second pair of questions was designed to compare mean service days and percent warrants served in the two systems by case type. Courts issue warrants for a variety of different causes (case types) such as felony charges, misdemeanor charges, bench warrants, traffic violations, and so on.

Hypotheses

If electronic warrant systems produce faster arrest times, then historical data should support this assertion. I compared historical warrant data over a 2-year period from six different county sheriff's departments in pairs. Each county pair included a county that used a traditional predominantly paper-based warrant system and one that used an electronic warrant system. I evaluated the dependent variables mean service days and percent warrants served over the study period for each agency. The independent variable warrant system type indicated which agency's system warrant data was being

analyzed. The other independent variable case type was examined as a possible influence on service times. I posited the following null hypotheses, one for each research question:

H_{01A}**:** Mean service days will be equal for both values of warrant system type. Restated, the mean service days for warrants during the multiyear period will be equal in the two sheriff's agencies.

H_{a1A}: Mean service days will not be equal for both values of warrant system type.

H_{01B}: Percent warrants served will be equal for both values of warrant system type. Restated, the percent warrants served for warrants during the multiyear period will be equal in the two sheriff's agencies.

H_{a1B}: Percent warrants served will not be equal for both values of warrant system type.

H_{02A}: Mean service days will be equal in both systems for all values of case type. Mean service days for similar case types (felony, misdemeanor, traffic, etc.) will be equal between the two compared systems.

H_{a2A}: Mean service days will not be equal for both systems for all values of case type.

H_{02B}: Percent warrants served will be equal in both systems for all values of case type. In other words, percent warrants served for similar case types (felony, misdemeanor, traffic, etc.) will be equal between the two compared systems.

H_{a2B}: Percent warrants served will not be equal in both systems for all values of case type.

I used, as the primary method of analysis, a two-factor analysis of variance (ANOVA) statistical test with mean service days as the dependent variable and warrant system type and case type as the independent variables. A second set of ANOVA statistical tests were run with percent warrants served as the dependent variable and the other variables remaining the same.

Theoretical Framework for this Study

The notion that an arrest warrant is likely to be served more quickly when it is electronically distributed within an agency and across multiple agencies is part of a national trend towards integrated justice information systems (IJIS). The idea that sharing information among stakeholders in external organizations benefits the information owner (law enforcement agency) and the task environment (criminal justice system) is not a new concept. This study was inspired by, and its research design was based upon, three theoretical foundations: stakeholder theory, open systems theory, and service-oriented architecture (SOA) theory. An in-depth examination of these theories, as they apply to this study, is presented in Chapter 2.

Nature of the Study

This section contains the general research approach and rationale for a quantitative study on the efficacy of electronic warrant information systems. This study was conducted using a quantitative research design with an historical analysis approach, as defined by Singleton and Straits (2010, p. 393), using available electronic warrant data collected from different types of warrant systems in different counties. This was a quasi-experimental quantitative design because samples were not randomly assigned to study

groups (Trochim, 2001, p. 294). Specifically, this design was a posttest-only contrasted groups design as described by Frankfort-Nachmias and Nachmias (1996, p. 132). I used the data files of extracted warrant records from sheriffs' office computer information system databases as the unit of data analysis. I conducted ANOVA and non-parametric statistical analysis using SPSS software. I selected a quantitative historical analysis design for this investigation because complete sets of detailed warrant records were available for long periods of time in both relatively simple systems and more advanced systems.

I analyzed and compared warrant file extracts from six different sheriffs' offices grouped in pairs for the same 2-year period. I selected counties for their warrant systems in use based on the electronic warrant maturity model (EWM^2) presented in Chapter 3. The proposal for this study called for comparing a single pair of counties' warrant records. This was expanded to three county pairs after an examination of available historical data. One system in each pair was a relatively immature paper-based process using a simple electronic file warrant tracking system, and the other was a more advanced e-warrant database system. I collected data by obtaining written permission from the governing agency to conduct a study using their data. I first analyzed the nature of the available data, including table structures, data definitions, data values, and metadata and then requested a specific query to extract a final data set. To maintain the integrity of the study, and to avoid any perception of researcher misuse of data, I excluded from the database extracts all personal identifiers for human warrant subjects (e.g., name, social

security number, address, date of birth, contact information, etc.). County and state names also remained confidential to avoid other possible concerns of the subject agencies.

Operational Definitions

Variables

Bond amount: Is a dollar amount for bail, and it is commonly assigned by a judge when a warrant is issued. Generally speaking, high bond amounts are set for more serious crimes. Some warrants for serious crimes or for high flight risk individuals may be set to no bond, meaning that the accused cannot post bond to get out of jail until his or her court appearance. A bail bond is a financial guarantee that the defendant will appear in court at a designated date and time or forfeit the bond amount. Bond amount is defined for understanding; however, it was removed as a research variable at data collection time as explained in Chapter 2 and Chapter 3.

Mean service days: A calculated arithmetic mean of time measured in days from warrant issue date to the date a warrant is served as measured in days. Mean service days did not include active (open) warrants or warrants that were administratively recalled or vacated. Mean service days was a measure of warrant service effectiveness and was a dependent variable in this study.

Percent warrants served: The percentage of all warrants over a selected period that have been served by arrest (#warrants served divided by #total active and served warrants). This statistic did not count warrants that were administratively recalled or vacated. Like mean service days, percent warrants served was a measure of warrant service effectiveness and was a dependent variable in this study. Note: This term is

generally synonymous with the industry term clearance rate; however, because clearance rate is most often used to describe the status of criminal cases, not just warrants, I have chosen to use the precise mathematical term in this research.

Warrant system type: A Boolean variable used to indicate the warrant system source of data. I used this independent variable to distinguish the more advanced electronic warrant system from the less mature system in each county pair.

Case type: A designation of the type of offense charged to a defendant such as felony, misdemeanor, traffic, and so on. Case type was an independent variable in this study. Warrant systems typically store this as an attribute of a warrant.

Other Terms Used in This Study

Clearance time: Time period from warrant issue date to the date a warrant is served or vacated; synonymous with service time.

E-government: "E-government provides governmental services electronically, usually over the Web, to reduce the physical character of customer transactions by recreating them virtually" (Calista & Melitski, 2007, p. 101).

E-governance: "Employing the Web and Internet to overhaul how the state conducts its democratic dealings by using networked interactions with citizens to foster transparency and participation" (Calista & Melitski, 2007, p. 102).

E-warrant: An arrest warrant is a court order to law enforcement officers to arrest the named individual and bring him or her to appear before the court to face criminal charges. The term e-warrant is becoming more widely used in government documents and literature with a range of different meanings. As a practical matter for information

technology (IT) professionals and scholars, a rigorous definition of e-warrant is required. Due to the lack of a standard formal definition for e-warrant and e-warrant system, I offered the following definitions: (a) an e-warrant is an authoritative legal electronic record of an arrest warrant and (b) an e-warrant system is a computer information system that supports requesting, filing, dissemination, service, and vacating of arrest warrant records. A rigorous electronic warrant maturity model for e-warrant systems is described in Chapter 3.

Extensible markup language (XML): "A text-based scripting language used to describe data structures hierarchically, using HTML-like tags" (Hoffer, Ramesh, & Topi, 2013, p. 360).

Global reference architecture (GRA): Formerly Justice Reference Architecture, an information sharing reference architecture for identifying, defining, implementing, and governing services developed by the U.S. Department of Justice, Office of Justice Programs (Department of Justice, n.d.).

Integrated Justice: A method of electronic criminal justice information sharing that benefits participating agencies and enables better informed decision making (Hargreaves, 1998). Integrated justice information systems (IJIS) are based on technical standards and common business definitions (Hargreaves, 1998, p. 288).

National Criminal History Improvement Program (NCHIP): A program of the Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice to provide "direct awards and technical assistance to states to improve the quality,

timeliness, and immediate accessibility of criminal history records and related information" (Bureau of Justice Statistics, 2012, para. 1).

National Crime Information Center (NCIC): "An automated database of criminal justice and justice-related records maintained by the FBI. The database includes the 'hot files' of wanted and missing persons, stolen vehicles and identifiable stolen property, including firearms" (Bureau of Justice Statistics, 2011a, p. 1).

National Information Exchange Model (NIEM): "A community-driven, government-wide, standards-based approach to exchanging information" (National Information Exchange Model, 2011, para. 1).

Service-oriented architecture (SOA): "A collection of services that communicate with each other in some manner, usually by passing data or coordinating a business activity. While these services do not have to be Web services, Web services are the predominant mechanism used" (Hoffer et al., 2013, p. 368).

Service time: The duration from the time an arrest warrant is issued to the time the warrant is served; synonymous with clearance time.

Assumptions, Scope, Delimitations, and Limitations

Assumptions

The research design was based upon assumptions about the nature of people, organizations, and society. The primary assumptions of this study were

1. Arrest warrants issued by courts and served by law enforcement are an essential element in the U.S. criminal justice system and benefit public safety with their proper application. This assumption was essential to this

study because without it, any demonstrated value of e-warrant systems would be of no value to society.

2. Courts, law enforcement, and other government agencies seek efficient and effective warrant processes. As with assumption #1, this assumption espouses the moral duty of public servants. Without this, this study would have no practical value to government and society because government actors would not value more efficient systems, and likely would not invest limited resources to implement them.
3. The more effort required of an officer to check a subject for warrants, the more likely it will not be done (i.e., passive warrant check systems are better than action-required systems). This assumption was important because I attempted to show that making warrant information accessible to officers in the field may be a factor in improving arrest rates.

Statistical Assumptions

Rutherford (2012) instructed that four assumptions are necessary for a statistically strong ANOVA test:

1. Each condition contains a random sample of the population of such scores
2. The scores in each condition are distributed normally
3. The scores in each condition are independent of each other
4. The variances of the scores in each experimental condition are homogeneous (Rutherford, 2012, pp. 236-237).

I examined each assumption for validity in the test results and reported any failures or partial failures and the potential impact on internal validity in Chapter 4.

Scope and Delimitations

The scope of this study was delimited to warrant history records collected from four pairs of similar-size county sheriff's departments in the United States. Each pair had one county with a relatively less sophisticated warrant tracking system and another that employed an advanced more interoperable and accessible e-warrant system. A system for rating the relative degree of sophistication in warrant systems and what constitutes an e-warrant system is proposed in Chapter 2. Search warrants were not the object of study. Search warrants serve a different purpose in law enforcement. I received a data extract for the same 2-year period from January,1 2012 to December 31, 2013. I selected this date range to obtain a large amount of recent data covering a sufficiently long period based on availability. This study is similar to a multicase qualitative study, but the data were predominantly quantitative, and I used hypothesis testing to investigate the research questions.

Internal validity is defined as establishing the cause-and-effect relationship in the traditional sense because the treatment is not an action of an experiment; rather, it is the selection of different systems and data to study. The treatment is implicit in the type of warrant systems selected and the quality of the data. The less sophisticated system could be considered the untreated sample or control and the more advanced system the treated system.

Generalizability to other jurisdictions (external validity) is limited; however, this research is a first-of-its-kind study, and it is a basis for future studies using data from more agencies, different maturity level systems, and diverse geographic areas. Chapter 3 contains a proposed e-warrant system maturity model with defined levels of sophistication and interoperability. I applied this framework to the subject county warrant systems to define their scalar position and relative range to each other.

Limitations

The limitations to this study centered on the data sets used and their system contexts. I analyzed the historical arrest warrant data used in this study as-is without questioning its accuracy or completeness. As with all computer systems and user-created information, there were data quality questions. System users may be inconsistent entering and updating warrant information. Policies and instructions governing how to use the system can change over time, and periodic system improvements and personnel changes may affect data quality and completeness. Information systems architecture can affect data quality and completeness. Despite expected common data quality problems, the data received from the state court administrator were used as-is, and no effort was made to correct possible mistakes.

I informally interviewed the state court IT personnel to collect general information about how the systems are used, what changes occurred over the 10-year period, and any known problems with data quality, and this information is included in the final report.

As discussed in the previous section, external validity of this study is limited to similar agencies and systems, but this study may enable future, more diverse studies. Sampling (systemic) bias was not a factor because the data samples were complete warrant records for the selected counties, and the counties were selected based on factors not previously known. The two basis non-e-warrant counties chosen were the only two counties in the study state that did not use an e-warrant system. Other common types of bias such as interviewing bias, response bias, and survey bias were not factors because the data did not originate from interviews or surveys.

Significance of the Study

This study was designed to measure any realized benefits of deploying electronic warrants in law enforcement agencies. As such, the findings of this study may directly inform leaders in the U.S. criminal justice system how to improve arrest results using information technologies for an increased societal benefit.

The potential benefits to society fall into three general categories: (a) public safety, (b) justice served, and (c) government effectiveness and efficiency. If e-warrants are shown to improve arrest performance, the safety of the general public and peace officers in the field may improve, crimes may be prevented, and communities may benefit. When a fugitive is arrested and brought before the courts, the administration of justice is facilitated; defendants may be punished, exonerated, or rehabilitated; and victims may be paid restitution. The last category of potential benefits is improvement of government-to-citizen (G2C) services by effective use of e-government technologies and

e-governance policies as defined earlier. The potential e-warrant benefits in the G2C category include:

1. Leveraging technology investments for interoperability and improved vertical and horizontal communications among criminal justice system agencies. This concept is described in detail in Chapter 2 using a Justice Information Systems Distribution Matrix (JISDM). Example benefits include avoiding redundant data entry, automated person matching algorithms, federated searches, etc.
2. Replacing manual processes and legacy technologies (fax, phone, paper documents, etc.) with automation for transmission, searching, alerting, and so on, which provides faster and more accurate information when and where it is most needed
3. Aggregation and deduplication of criminal records
4. Stewardship of taxpayer treasure, including prioritizing objectives for federal grants to states for criminal justice information system (CJIS) programs.

Summary

This chapter contained an introduction to e-warrant systems and their potential social value, the need for research to validate the purported benefits of e-warrant systems, a theoretical research paradigm, and a high-level design for a quantitative study. A review of past criminal cases where more complete and accessible warrant information could have resulted in the prevention of serious crimes and human suffering is a

compelling case for social change. The suggested benefits of advanced e-warrant systems are public safety benefits, timely justice benefits, and improved government processes. Stakeholder theory; open systems theory, and service-oriented architecture provided the theoretical lens for analysis and research design.

Chapter 2 contains a comprehensive literature review of e-warrants in the integrated justice context which demonstrates a gap in the literature and a need for research to validate the social benefits of e-warrants.

Chapter 2: Literature Review

Introduction

A current review of related literature is required to (a) confirm the research problem that how e-warrant systems improve safety is not known, (b) to confirm that current research on e-warrants systems is insufficient, and (c) to identify any prior scholarly research related to the purpose of this research. Hence, this is a literature review of the extant research surrounding electronic warrant systems. During the quest for relevant prior research on electronic warrants, I discovered two phenomena that had significant effects on the finished product.

First, electronic warrants are one of many criminal justice information exchange documents that are routinely considered with other criminal justice documents in research projects and in actual information system programs; hence, little research exists on electronic warrant systems alone. The extant research on e-warrants is summarized in this chapter and consists primarily of case studies of crimes that might have been prevented by the use of an e-warrants system. An accounting and characterization of references reviewed in this literature review is contained in the section titled Analysis of Literature Related to Key Concepts later in this chapter.

Second, the majority of research on the subject occurred in the few years following 9-11, and it is connected to federal programs of the U.S. Department of Justice either by direct government report or conference proceeding or by a federal grant-sponsored university or industry association study. Because criminal justice is primarily the domain of public sector governance, most of the research in the field is driven by

government entities. The Bureau of Justice Assistance Center for Program Evaluation encourages more research on justice information sharing outcomes, and they attribute "newness of work in this area" to the lack of scholarly research (Reynolds et al., 2006, p. 4). This study was needed because of the scarcity of research on justice information sharing, especially electronic warrant systems.

It is important to draw a contrast between this dissertation and the academic research in criminology and sociology fields which seeks to explain the underlying causes of criminal behaviors or to improve methods of punishment and criminal rehabilitation. My research was aimed not at explaining criminal behaviors, but at seeking to understand how technology can be used to protect the general public and improve government efficiency at the local, state, tribal, and federal levels. As an IT practitioner for over 30 years, a consultant in government justice information systems, and a reserve peace officer, I am motivated to seek improvements in the ways information can be used to fight crime and serve the cause of public safety.

This literature review is organized into six major sections: (a) Literature Search Strategy, (b) Arrest Warrants: A Key Justice Information Exchange, (c) Theoretical Framework for E-warrants and IJIS, (d) State of Integration of Justice Information Systems in the U.S., (e) Findings/Recommendations, and (f) Summary and Conclusion.

Literature Search Strategy

The references found for this review came from a variety of sources including the Walden University Library databases, Google Scholar, the Association for Computing Machinery (ACM) Digital Library, printed books and reports, and U.S. Government and

industry web sites. Search keywords used included *ARJIS, CJIS, e-court, e-warrant, e-government, electronic warrant, GJXDM, IJIS, information sharing, integrated justice, JIEM, JNET, NCIC, NIEM, SOA,* and *XML*. This literature review represents over 2 1/2 years of searching for relevant materials. Due to the limited quantity of available research on electronic warrants, I supplemented the search with several personal and e-mail contacts with academic, government, and industry association professionals, some of whom authored literature cited in this review. In addition, I invited Dr. Robert Roper, former chief information officer for Colorado courts, to participate as an external member of my dissertation supervisory committee. Dr. Roper has first-hand experience implementing electronic warrant systems. Because little research on electronic warrants was found to exist, I conducted a general literature search on justice information exchanges. I define arrest warrants in the context of justice information exchanges in the next section.

I have supplemented this literature with my own past course work at Walden University on the topic of IJIS and electronic warrants in the IJIS context. I have developed two reference models to guide the analysis of the literature and compare and contrast electronic warrant systems in the United States; thus, where appropriate, I have cited my previous work in this chapter and the next.

Arrest Warrants: A Key Justice Information Exchange

In this chapter, I focused on one IJIS information exchange, the arrest warrant in the geopolitical context of a county in a U.S. state, and the potential to improve public safety and government effectiveness through better warrant systems. An arrest warrant is

a court order to law enforcement officers to arrest an individual and bring him or her before a court for adjudication on criminal charges. Police record management systems (RMS) automate the core business of law enforcement agencies to include incident and arrest reports, personnel records, criminal records, and crime analysis data, but many RMS systems lack the connectivity with other local, state, and federal information systems needed to search for active arrest warrants (Dunworth, 2005). Snavely, Taxman, and Gordon (2005, p. 196) categorized criminal justice information systems as closed systems, open systems, or consent-driven systems (p. 196). Closed systems do not interoperate well with external systems (Snavely et al., 2005, p. 197).

When an officer makes a routine contact with a wanted person, such as during a traffic stop, the officer can be exposed to personal danger, and the subject may not be arrested because active warrant information is not known. The traffic offender may be issued a citation, given a written or verbal warning, and then released (e.g., Mohamed Atta). This scenario brings to the fore two procedural barriers to obtaining warrant information.

First, most officers do not routinely request a warrant check on every traffic stop because the check takes more time while stopped and exposed on the side of the road. With a closed system RMS design, an automatic warrant check is not triggered. A warrant check is routinely reserved for situations where the officer suspects that the subject may be involved in other criminal activity. Without an automated instant lookup capability found in some e-warrant systems, warrants are not routinely and automatically checked when officers contact individuals. Hager (2005) stated, “Instant lookup at traffic

stops and other encounters helps law enforcement determine the level of caution needed to ensure the safety of officers and the public, and can ensure that all outstanding warrants are served, especially from other jurisdictions" (p. vii). For the above stated reasons, warrants are not always checked when police contact citizens.

The second barrier is that complete and accurate warrant information may not be available to the dispatcher or the field officer (or other justice system worker). Criminals do not respect jurisdictional boundaries, but many closed system law enforcement systems do (Harrison, 2002, p. 1; Zaworski, 2004, p. 17). A felony warrant issued in a neighboring county or state is not always available to the patrol officer, judge, investigator, probation officer, or social worker due to the silo effect of independently maintained and isolated information systems (MacLellan, 2004, p. 2). Both of the above information barriers can be addressed with improved information system technology (Stoltzfus, 2009, p. 89).

Active arrest warrants and criminal history records are vital to many decision makers in the criminal justice system besides the patrol officer. Prosecutor charging decisions often hinge on prior arrests and convictions. Judges determine an individual's eligibility for foster parenting, guardianships, and permanent home placements for some of the United States' most vulnerable citizens—deprived children. Judges need information about individuals from all types of cases and information systems to inform their decisions about releases, bond amounts, custody of minor children, sentences, and many other matters. Sharing warrant information between the courts, prosecutors, and

law enforcement in an accurate and timely manner is paramount in an effective and efficient justice system.

Warrant Information Systems in the United States

FBI NCIC warrant system. The FBI's NCIC system is used by local, state, tribal, and federal agencies as a central repository for arrest warrants. The NCIC system contained 1,937,308 active wanted person records (warrants) as of November 2011 (J. Arnold personal communication, December 23, 2011). NCIC is the nation's central warrant repository, but it is incomplete, sometimes inaccurate, and not always available to officers in a timely manner (National Center for State Courts & SEARCH, 2011, pp. 13-17).

The FBI's NCIC warrant system is a hierarchical centralized distribution model that depends on a chain of vertically integrated information flows from the local court or agency to the state repository to the federal repository then back down to the local agency that needs the information in real-time to protect officers and citizens. MacLellan (2004) stated:

> Twelve million index crimes (e.g., murder, rape, robbery, burglary, etc.) were committed in 2001, and most of the information gathered in response to these crimes was generated by local law enforcement, local courts, and local jails. To enable federal, state, and local law enforcement to work effectively, this information must be integrated upward into state and federal systems (p. 1).

An e-warrant system designed to serve state and local agencies would operate on a network model where warrant information is distributed directly to local officers within

the agency and to other nearby local agencies (horizontal integration) without requiring a hierarchical upload/download process. In this manner, warrants on locally wanted persons are distributed directly to the agencies most likely to encounter the warrant subject. Central data collection is not a requisite for e-warrant systems. Warrant data can reside where it is owned, but subscribed to by agencies most likely to need it. This more tactical approach is aimed at maximum local utility; whereas, NCIC uses the central repository approach, which is data collection focused with less emphasis on local expediency (National Center for State Courts & SEARCH, 2011; Stoltzfus, 2009, p. 89).

The NCIC system operates by requiring state and local agencies to enter new warrants and clear them when they are served— a burden to agencies facing resource and budget pressures (National Center for State Courts & SEARCH, 2011, pp. 11-13). Typically, the NCIC system is accessed by local agencies through a proprietary system operated by a designated agency in each state. A lack of integration with local law enforcement systems may be a factor contributing to low usage. The FBI imposes training and operational requirements on NCIC data entry operators. Consequently, not all serious criminal warrants are entered into NCIC. When local courts and agencies fail to enter warrants into NCIC, the centralized warrant system model is compromised. NCIC, like most federal systems, relies on a centralized collection and control information model (Pardo, Gil-Garcia, & Burke, 2008, p. 2).This national warrant repository model is functional, but limited in effectiveness at the state and local levels. Geerkin (2008) referred to NCIC as a “bulletin board”-type system that has limited usefulness because it requires manual effort to remember to check for warrants at crucial

times such as when an inmate is about to be released. Perbix (2001) noted that substantial delays between court actions to issue or recall a warrant creates an officer safety issue (2001, p. 1).

A passive warrant system architecture would include an automatic check during critical points in the criminal justice process, such as when an inmate is being released. If the releasing agency does not check NCIC for new or old warrants before release, a warrant can be missed and the subject can be released with an active arrest warrant. Ironically, federal law enforcement agencies make far fewer fugitive contacts (warrant arrest opportunities) than do municipal police, county sheriffs, and state law enforcement, but the federal NCIC system has limited value to state and local authorities (Stoltzfus, 2009, p. 89).

Many local agencies do not consistently submit warrants to the federal system due to manpower shortages and other local priorities. The National Center for State Courts and SEARCH (2011) on state warrant systems found that in 45 responding states, the top two warrant reporting challenges were staffing (87% respondents) and budget (80% respondents), and technology constraints rated a distant third with 58% respondents (2011, p. 21). This creates a situation where NCIC has incomplete warrant information, thus decreasing its utility to local law enforcement. It is local police officers, deputy sheriffs, and state troopers who have the most frequent citizen contact and, therefore, stand to make the greatest positive impact to public safety.

State warrant repositories. Most states operate some form of a warrant repository to support law enforcement agencies; however, integration with courts, local

law enforcement, and NCIC varies; thus, the repositories have completeness, accuracy, and timeliness anomalies that reduce their reliability (National Center for State Courts & SEARCH, 2011, pp. 13-17). The term repository refers only to the distribution model and not the level of integration with state and local agencies, although the U.S. Department of Justice advocates for states to maintain a state central warrant records repository (National Center for State Courts & SEARCH, 2011). The NCSC and SEARCH (2011) revealed that of 45 state respondents, the following have automatic warrant transmission capabilities:

- 27 (60%) law enforcement to the state's central warrant repository
- 26 (58%) law enforcement directly to NCIC
- 18 (40%) courts to the state's central warrant repository
- 12 (27%) courts to local law enforcement
- 9 (20%) courts directly to NCIC
- 21 (47%) state's central warrant repository to NCIC
- Only 3 states reported having all six forms of electronic warrant transmission capability (National Center for State Courts & SEARCH, 2011, p. 17)

Cross-jurisdictional warrant system integration. The survey instrument used in the NCSC report contained only yes or no questions about electronic transfers; thus, a yes response indicates the existence of one or more such interfaces. Using the court-to-state repository interface as an example, if one court (county) system in a state transmits to the state repository, it would appear that all courts also report. Thus, the actual degree of

warrant system interconnectedness varies from location to location within the state, and the overall percentage of total warrants reported may be small.

To illustrate why cross-jurisdictional system integration is important, consider a hypothetical example: an arrest warrant for John Doe is issued in a county court for a felony crime. The new arrest warrant is entered into the district court system, and it may or may not be electronically transmitted to a local law enforcement system or the state warrant repository. If the same individual is stopped for a minor traffic violation in a nearby county the next day, the contacting officer and the dispatcher may not see the active felony warrant unless their municipal or county systems are integrated. Many law enforcement agencies keep paper copies of warrants and re-enter the warrant information into their local system after a paperwork delay. The typical outcome of this example scenario is that the driver is issued a warning or citation for a traffic violation and released, and justice is not served.

Information sharing standards. The federal government has been working with state and local agencies and the private sector software and services industries to establish a GRA of best practices and technical standards for information sharing horizontally and vertically in the criminal justice space. The advent of XML technology simplifies data and document sharing between disparate systems. A central clearinghouse for electronic justice document formats based on the National Information Exchange Model (NIEM) is now in operation and free to practitioners (Marz & Scott III, 2010). NIEM is a federal government "partnership of the U.S. Department of Justice, the U.S. Department of Homeland Security, and the U.S. Department of Health and Human

services" (National Information Exchange Model, 2011, p. 1). NIEM operates a National Information Sharing Standards Help Desk for government IT practitioners (National Information Exchange Model, 2011). Agencies submit commonly used information exchanges to the information exchange package documentation (IEPD) clearinghouse for others to reuse. Currently there are more than 70 IEPDs in the IEPD Clearinghouse (Department of Justice, 2011).

Federal funding for justice information sharing programs. The U.S. Department of Justice has been offering financial grants to the states for many years to advance information sharing and criminal history reporting. However, the National Criminal History Improvement (NCHIP) program awards grants for the collection of justice information at the federal level with less focus on horizontal sharing across the justice levels where most information about people and crimes is collected and consumed. NCHIP funding is limited and administered by elected officials and bureaucrats. Agency executives are often faced with strategic questions whether to hire new officers, build a new jail facility, purchase vehicles and equipment; or to invest limited public funds in new interoperable computer systems. Central data collection is a secondary purpose for e-warrants systems. State and local law enforcement agencies require a more tactical approach aimed at maximum local utility; whereas NCIC utilizes the central repository approach, which is data collection with less emphasis on local expediency.

Theoretical Framework for E-Warrants and IJIS

In this section IJIS is examined through the conceptual lenses of stakeholder theory, open systems theory, and service-oriented architecture (SOA) theory.

Stakeholder Theory: A Framework for E-Warrants

According to Zakhem, Palmer, and Stoll (2008), stakeholder theory was first presented as a comprehensive and formal management theory by R. Edward Freeman in his seminal work *Strategic Management: A Stakeholder Approach* in 1984 (p. 16). Freeman himself traces the word stakeholder back to the Stanford Research Institute in 1963 when it was used in an internal memorandum (Freeman, 1984). Stakeholder theory is an ethics-based management theory that holds that organizations should make decisions on behalf of all their stakeholders, not just their owners (or stockholders). Consequently, stakeholder management ultimately benefits the organization by sustaining critical partnerships, forming operational networks, and serving society with efficiency, fairness, respect, and integrity, while creating value for all stakeholders (Freeman, 2008, pp. 83-86). As with most management theories, stakeholder theory is stated in the language of business organizations. Recently, scholars have entered stakeholder theory in to the dialog of public sector management. Fedorowicz, Gogan, and Culman (2010) suggested that "when stakeholder concerns are identified and acted upon, a public-sector organization can increase its effectiveness" (p. 327). It is logical to apply the central theoretical tenets of stakeholder theory to the public sector, the criminal justice system and electronic warrants. Flak and Rose (2005) posited that the growing forces of e-government increases the need for public agencies to apply stakeholder theory to policy

decision making, and they advance a research framework that includes the proposition "Respecting stakeholders' interests can lead to improved e-government projects. Moreover, an ethical response to stakeholder e-government interests makes an agency reliable and trustworthy, thereby increasing its political credibility" (Flak & Rose, 2005, pp. 656-657). The various government agencies, including the courts, law enforcement, and corrections are in a partnership network in the public trust. Citizen taxpayers expect government agencies to collaborate for public safety and economies of investment. This sentiment has grown in the aftermath of the 9/11 Terrorist Attacks on America. The 9/11 Commission report states:

> The culture of agencies feeling they own the information they gathered at taxpayer expense must be replaced by a culture in which the agencies instead feel they have a duty to the information—to repay the taxpayer's investment by making that information available (National Commission on Terrorist Attacks Upon the United States, 2004, p. 417).

Stakeholder theory applied in the government context extends beyond the profit motive into the moral imperative of public service (Stoltzfus, 2009, p. 91). Thus individual nodes of the network (i.e., law enforcement agencies) should act collaboratively to serve the societal cause of justice, and information sharing between agencies should be the norm.

Figure 1 is a stakeholder network model that depicts a central law enforcement agency (LEA) with an electronic warrant information system. Warrant data are sent to

and received from partner agencies and courts which may result in improved public safety.

Figure 1. Stakeholder network model.

Fedorowicz et al. (2010) applied a typology of stakeholders in collaborative data sharing, wherein participants are typed by their role in the data exchange: data controller, data subject, data provider, and secondary stakeholders (pp. 319-320). With regards to e-warrants, the data controller is normally the law enforcement executive (police chief or sheriff); the subject is the criminal suspect named in the warrant; the data providers include courts (judges) and law enforcement agencies; and secondary stakeholders include citizens, government agencies, and businesses.

Stakeholder theory comports with integrated justice information systems (IJIS) programs and electronic warrants in both government and business in the United States. Appropriate and timely sharing of electronic warrants between criminal justice system agencies, the courts, and other government entities adds value to each participant and the public at large. According to Fedorowicz, Grogan, and Culnan (Fedorowicz et al., 2010), the managerial or instrumental aspect of stakeholder theory asserts that organizational performance and/or organizational survival would be achieved. Thus, the benefits of e-warrants should be demonstrable. For these reasons, stakeholder theory was chosen for this research to support the general research question: do advanced electronic warrant systems with enhanced interoperability improve warrant service effectiveness?

Open Systems Theory and E-Warrants

According to Thompson (2003), complex organizations act according to both the rational (closed system) model and the natural (open system) model of organizational behavior. Thus, law enforcement agencies seek maximum internal efficiency and competitiveness. This suggests that government officials and peace officers would require access to all arrest warrants and criminal histories and to have this information where and when it is needed to make critical decisions. Perfect information sharing between agencies at all levels would likely improve effectiveness on both ends of the exchange. Imperfect and incomplete information, due in part to poor systems interoperability (closed systems), is a contributing factor to operational mistakes in the Unites States' justice system (Geerkin, 2002, pp. 9-12). Every day in the United States law enforcement officers fail to arrest wanted persons. Judges, investigators, prosecutors,

social workers, and other government officials decide on criminal charges, bail amounts, deprived child placements, even jail releases without complete and accurate criminal history information. Open systems theory suggests that a greater connectivity (dependence) with external organizations can improve internal processes (Katz & Kahn, 1978, pp. 16-17).

Open systems theory is commonly applied to information systems architecture and called simply open systems. An open system is an information system that shares internal programming, system design, and architecture, with people and organizations who wish to extend the technology or share in it its benefits, while adhering to one or more universal technology standards. The National Association of State Chief Information Officers supports open systems for "…the elimination of redundant data entry, manpower savings in the retrieval and compilation of information, and technology savings from open systems and common standards" (Geerkin, 2002, p. 1). Morton (2001, p. 2) noted that cost savings is not an expected result of integrating justice systems, but it should improve efficiencies and quality of operations. Roberts (2004) identified the development of open system standards as a responsibility of government regarding systems integration (p. 11). Regarding court information systems, Doty and Erdelez (2002, p. 380) posited that successful implementation of court systems requires a contextual understanding of the courts' local environments and actors—a key tenet of open systems theory. Thus, open systems theory was chosen as a second theoretical basis for this research on electronic warrants.

Service-Oriented Architecture

The emergence of e-government has given new priority to integrated justice information system (IJIS) programs in the United States. Service-oriented architecture (SOA) and extensible markup language (XML) technologies are at the center of an information-sharing revolution. Law enforcement and other government agencies use these methods and technologies to make it easier and less costly to share criminal justice information. Natis and Schulte of Gartner, Inc., the world's largest IT research organization, offer this definition of SOA:

> Service-oriented architecture (SOA) is a client/server software design approach in which an application consists of *software services* and *software service consumers* (also known as clients or service requesters). SOA differs from the more general client/server model in its definitive emphasis on loose coupling between software components, and in its use of separately standing interfaces. (Natis & Schulte, 2003, p. 2)

Legacy systems in the criminal justice and public safety arenas have long included proprietary point-to-point interfaces. If information was needed from a justice partner, a proprietary software interface would be developed under an information sharing agreement. However, if either of the sharing entities changed database structure, network, or development programming language, the interface would have to be changed. Today, Internet technologies, especially web services, have driven the development of SOA, a new way to share information that is independent of the technology at each network node. Service-Oriented Architecture is a concept for information sharing that

focuses on the message, not the source(s) or the endpoint technologies. Extensible Markup Language (XML) and programmed web services are at the core of developing standards in the justice domain. Correll (2005) identified six tenets of SOA in law enforcement. In this tenet he describes the loose coupling and technology independence concepts:

> Law enforcement information sharing must occur across agencies that represent divergent disciplines, branches of government, and operating assumptions. The decentralized, loosely coupled characteristics of an SOA approach means that law enforcement, prosecutors, defense counsel, courts, corrections, probation, and parole can share information without sharing a common set of objectives or funding sources. (Correll, 2005, p. 1)

Correll (2005) highlights the need to agree on the message content, not the software or databases on either end of the exchange. This decentralized SOA approach enables sharing of data beyond the local agencies while the information owner retains control over who sees their information (Correll, 2005, p. 1).

Lengerich (2004) advanced a typology of five integration patterns:

1. Virtual query or portal
2. Data warehouse
3. Centralized index (lookup table)
4. Justice application suite
5. Enterprise application integration (EAI) (Lengerich, 2004, p. 5).

EAI is the preferred architecture for integration where data ownership remains at the source and systems do not require updating of partner systems (loosely coupled systems). SOA is a combination of EAI as the data architecture for integration, XML, and web services (Lengerich, 2004, p. 16).

Expectations of the public for e-government services have grown as SOA architectures have become more commonplace in online services (e.g. shopping, travel services, social networking, etc.) and the underlying technologies including XML, web, services, and ad hoc wireless networks are now commonplace (Meneklis & Douligeris, 2007). The widely touted San Diego, California Automated Regional Justice Information System (ARJIS) is successful in part due to the board of director's decision to not replace the many different legacy systems that contribute information, a tenet of SOA. Instead they link to them and other systems to combine information into a single integrated regional law enforcement application (Sawyer & Tyworth, 2005, 2006). I selected SOA as a third theoretical lens for electronic warrants in this study because it is widely applied in the e-government domain and IJIS.

State of Integration of Justice Information Systems in the U.S.

Intuitively, government agencies should work together to serve the citizenry, especially where public safety is affected. The decision-making behaviors exhibited by agencies with limited budgets and inadequate IT staff, however, do not always reflect external thinking (Davis & Jackson, 2005, p. 36). A federal, state, or local justice agency is, by definition, a bureaucracy. Bureaucracies operate primarily as closed systems, organized to optimize internal tasks and insulate the internal task environment from

external forces (Barnard, 1968). For example, a local police chief may choose to purchase or build a new incident reporting system for the department's officers based on features like ease with which: (a) officers can create incident reports; (b) search for a case; or (c) generate printed reports. Concerns for transferring police reports to the district attorney electronically or importing call for service (911) data from the locally-operated computer-aided dispatch (CAD) system, or even automatic external searches for active arrest warrants on subject contacts may not even enter into the decision. Interfaces may be seen as less important when budget pressures prevail, even if the agency executives have the foresight to include interfaces in the system specifications. Interoperational matters may be passively ignored because the focus is on meeting specific internal and organizational needs. Decision making in agencies with political appointees or elected officials may be influenced by political forces not directly aligned with the public interest (Stoltzfus, 2009, p. 92). In larger organizations departmental thinking prevails, adding barriers to information sharing within an agency. This problem is exacerbated when key information transfer points cross multiple departmental boundaries, government branch divisions, or vertical domains (local, state, tribal, and federal).

The result is a continued dependence on legacy technologies to get the job done. Agencies may continue to make large investments in fax equipment, printers, paper, and manual labor in lieu of electronic interfaces. The natural tendency of decision makers to take care of core agency needs first creates a passive and unintended resistance to electronic information sharing. These behaviors are aligned with a closed system organizational management model, Frederick Taylor's scientific management theory, and

Chester Barnard's motivational theories. The indirect rewards of a partner-stakeholder approach to management of organizational information may be difficult to realize in government bureaucracies.

The adoption rate for electronic warrant systems in the United States was largely unknown before the 2011 National Center for State Courts (NCSC) and SEARCH study of warrant and disposition management. The following results are from the NCSC/SEARCH final report:

1. 23 out of 34 (67.6%) state respondents agree or strongly agree that the warrant information in their state repository is complete
2. 25 of 34 (73.5%) state respondents agree or strongly agree that the warrant information in their state repository is accurate
3. 26 of 34 (76.5 %) state respondents agree or strongly agree that the warrant information in their state repository is timely (National Center for State Courts & SEARCH, 2011)

The NCSC/SEARCH study is significant with respect to warrant management, especially automatic warrant transmission:

1. 27 of 45 respondents reported automatic warrant transmission/electronic delivery from law enforcement to the state's central warrant repository
2. 26 of 45 respondents reported automatic warrant transmission/electronic delivery from law enforcement directly to NCIC
3. 18 of 45 respondents reported automatic warrant transmission/electronic delivery from courts to the state's central warrant repository

4. 12 of 45 respondents reported automatic warrant transmission/electronic delivery from the courts to local law enforcement
5. 9 of 45 respondents reported automatic warrant transmission/electronic delivery from courts to NCIC
6. 21 of 45 respondents reported automatic warrant transmission/electronic delivery from the state's central warrant repository to NCIC (National Center for State Courts & SEARCH, 2011, p. 17)

As positive as the above numbers may seem, the survey instrument used does not account for partial coverage (National Center for State Courts & SEARCH, 2011). For example, if a state reported that the courts automatically submit warrants to NCIC, it is not known if one, several, or all counties and court jurisdictions participate.

Morton (2001) examined three state criminal justice information sharing projects in Colorado, Kansas, and Minnesota and found they each had different impetus, governance, and funding sources; but all three are considered successful programs. Pardo, Gil-Garcia, and Burke (2008) examined four state and local government criminal justice initiatives in search of determinants of governance structure and concluded with six propositions of cause: (1) knowledge of information; (2) knowledge of environment; (3) willingness to accommodate diversity of organizational goals; (4) knowledge about participating organizations; (5) legislation; and (6) executive involvement (pp. 6-8).

In a survey conducted by the Justice Research and Statistics Association, 266 criminal justice information sharing systems were identified in 35 states and Canada, most of which were state wide designs. The study had 56 respondents from 712 contacts.

The distribution of the identified information sharing systems were national (10%), regional across states (11%), region in state (9%), statewide (50%), and countywide (20%). Walbolt and Wagner did not identify whether electronic warrants were included in each subject system (Walbolt Wagner, 2006).

In 2004 the Department of Justice Bureau of Justice Statistics (BJS) reported there were approximately 105,000 federal law enforcement officers in 65 agencies (Reaves, 2004b). By contrast from the same year there were 732,000 commissioned officers employed in 17,876 state and local law enforcement agencies (Reaves, 2004a). That represents a 6.97 to 1 state and local to federal officer ratio and a 275 to 1 agency ratio. The officer ratio is more significant than the agency ratio, because single large federal agencies have multiple jurisdictional subdivisions.

In the latest four-year BJS survey taken in 2008 there are 17,985 state and local law enforcement agencies; which includes state agencies, local police, sheriff's offices, tribal police, special jurisdictions, and constable/marshal offices; employ 765,246 sworn personnel (Reaves, 2008a). By contrast, federal law enforcement agencies numbered 73 and employed 120,348 full-time sworn personnel (Reaves, 2008b). This represents a 6.35 to 1 numerical superiority of state and local officers to federal officers, and a 246 to 1 agency superiority over federal agencies. Noteworthy is the fact that although the federal law enforcement agencies are outnumbered considerably, federal law enforcement gained on state and local agencies in the four years between the studies.

The BJS reports are significant in the study of information systems for two reasons. First, they punctuate the higher number of state and local officers, and hence

more citizen contacts, investigations, and arrests are the norm. Second, the agency ratio indicates that there are many more police records management systems (RMS) at the state and local level than at the federal level. Information sharing is likely to have a greater impact at the state and local level due to the greater number of officers, contacts and information systems. Warrant information needs to be available to local officers, because they are the main workforce of law enforcement in the United States. However, it is within the smaller organizations where we find the more difficult barriers to information sharing. Thus, we have the American criminal justice contradiction: The greatest need for information sharing is at the local level where the funding is scarcest. A topology of criminal justice information systems as a layered matrix of agency operated systems is discussed in the next section.

Justice Information Systems Distribution Matrix (JISDM)

Figure 2 depicts the Justice Information Systems Distribution Matrix, a proposed macro-organizational model of criminal justice systems. The vertical axis contains the hierarchy of justice jurisdictions ranging from municipal to federal and international. The horizontal axis contains a timeline of the criminal justice lifecycle beginning with emergency dispatch and ending with post-conviction corrections and probation. Criminal justice information systems generally operate within single segments of the criminal justice life cycle including computer-aided dispatch (9-1-1) systems, law enforcement records management systems (RMS), jail management systems (JMS), court case management systems (CCMS), offender management systems (OMS), and community service and probation programs. The Justice Information Systems Distribution Matrix

illustrates the fragmented nature of justice information systems. Each of the horizontal slices is duplicated hierarchically in layered jurisdictional stacks ranging from municipal to federal and international domains. Information systems typically exist within each agency lifecycle node (e.g. dispatch, law enforcement, etc.) and at every agency within a horizontal level and up and down vertical levels. I developed the JISDM model in an earlier research paper Electronic Warrants: Combining Technology and Policy for Public Safety (Ward, 2011).

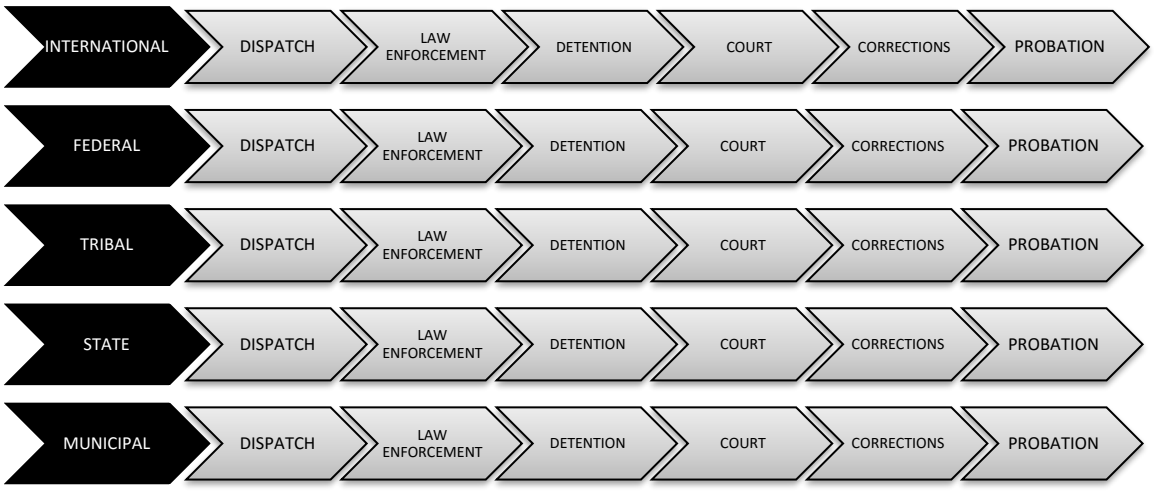


Figure 2. Justice information systems distribution matrix (JISDM) (Ward, 2011).

The JISDM illustrates the two-dimensional nature of independent information systems. Integration across agencies and application types (dispatch, RMS, court, etc.) within the same level represent horizontal integration, whereas information sharing between hierarchical levels up and down the matrix represent vertical integration (D. J. Roberts, 2004, p. 2).

In a post 9/11 terrorist attack analysis of federal justice and national security information systems, the 9/11 Commission Report calls for unity of effort in sharing information and proposed "that information be shared horizontally across new networks that transcend agencies." The 9/11 Commission advocated for the abolishment of the old hub-and-spoke concept for a new decentralized model-- a trusted information network (National Commission on Terrorist Attacks Upon the United States, 2004, p. 418).

Another important aspect of the justice domain that is not apparent in the JISDM is the numerical superiority of agencies, personnel, and systems at the state and local (lower) levels of the matrix, as described in the previous section. Thus the greatest number of information systems and potential sources of warrant information exist at the lower levels.

Pardo and Jiang (2007) characterized the challenges of criminal justice information system integration:

> "Moreover, the difficulty that government agencies face appears to increase proportionally with the increases in the number of boundaries to be crossed, the number and type of information resources to be shared, and the number of technical and organizational processes to be changed or integrated" (Pardo & Jiang, 2007, p. 101).

This proposition becomes more important to the researcher when information sharing efficiencies are sought. Officers in agencies positioned at the bottom of the matrix have more opportunities to encounter warrant subjects, yet information sharing is most challenging at this level due to the many agencies and systems involved. The

distribution of today's justice systems is heavily weighted in the state and local arena. So-called low-level data sharing systems promise the greatest benefits because state and local law enforcement make more contacts, investigate more crimes, and make more arrests than agencies at the federal level. The greatest number of boundaries, information resources, and organizations exist at the local and state levels; thus, both the need and the difficulties of integration are greatest at these levels of government.

Federal Government Role and E-Warrants

The U.S. Federal Government is a major player in U.S. criminal justice systems. A post-9/11 attack General Accounting Report from 2002 identified the challenges of vertical and horizontal integration and refers to agency "stovepipes" of information and cites "information failures within the FBI and CIA highlight some of the primary barriers we face: stove-piped organizations structures, inadequate database sharing, and simple 'turf' issues" (Government Accountability Office, 2002, p. 8). The federal government has for decades established centralized criminal history repositories for use by law enforcement agencies. The FBI's NCIC database of fugitives, missing persons, and stolen property is shared with law enforcement agencies at all levels. The system was first launched in 1967 and as of 2011 contained 11.7 million active records (Federal Bureau of Investigation, 2011).

The FBI NCIC system is a central collection site (repository) and a hierarchical distribution model, which depends on a long chain of information flow from the local court or agency to the state repository to the federal repository then back down to the local agency which needs the information in real-time to protect officers and citizens. An

advanced e-warrant system operates on a network model where warrant information is distributed directly to local officers within an agency and to other local agencies that request it without requiring a long hierarchical upload/retrieval route.

E-Warrant Systems in State Government

The U.S. Department of Justice encourages state-based electronic warrant projects, which are referred to in the federal literature as warrant repositories. These federal programs have specific goals which are closely aligned with the purpose of this study. The following Department of Justice program goals for state warrant repository projects comes from a 2008 Bureau of Justice Assistance (BJA) sponsored report from Texas State University titled *Performance Measurement of Justice Information System Projects* (Geerkin, 2008):

1. Enhance the safety of law enforcement officers by increasing information available to patrol officers and dispatchers
2. Improve identification and apprehension of wanted individuals by providing more accurate and complete information to justice users
3. Reduce errors in justice process operations through improved information sharing and management
4. Improve the time, personnel, and cost efficiency of the justice process by automation of tasks and information sharing
5. Prevent acts of terrorism by improving information sharing and coordination among justice agencies (Geerkin, 2008, p. 73).

Most states have some form of a warrant system for law enforcement use; however, the degree of sophistication of these state systems varies significantly. In the next paragraphs, I briefly describe three examples of advanced state warrant systems in Colorado, Kentucky, and North Carolina.

An electronic warrants system was implemented in Kentucky in 2008, and initial results nearly a year after it was first implemented were encouraging. “More than 62 percent of the new warrants entered into the e-warrants system had been served, compared with less than 10 percent served under the old system….the system was originally funded with a $4.5 million General Fund appropriation” (Blanton & Midkiff, 2008, p. 1). This data was provided to the public in a press release. It is not known to represent the results of a scientific study.

In Colorado warrants issued in court systems were linked to a statewide warrant system for law enforcement (Perbix, 2001, p. 2). The Colorado electronic warrants system is part of the larger Colorado Integrated Criminal Justice Information System (CICJIS) that was started in the late 1990’s and “links together the state’s five principle criminal justice computer systems—those for law enforcement, prosecutors, courts, adult corrections, and juvenile corrections—using a middleware-based data-sharing architecture” (Perbix, 2001, p. 2).

The State of North Carolina’s Warrant Repository (NCAWARE) system collects and stores warrants, orders, citations, and summons from counties across the state and can be accessed through a web-based statewide warrant search (North Carolina Court System, 2010).

These are examples of e-warrant systems implemented by states. Not all e-warrant systems include the same levels of sophistication, interoperability, and availability; thus, a typological framework, or maturity model, is needed to compare various systems. A proposed maturity model for e-warrants is presented in the next section.

Analysis of Literature Related to Key Concepts

More than 100 articles, conference proceedings, and government publications were examined for this literature review. The search for prior research specific to electronic warrant systems was futile, but the literature contains an abundance of research in integrated justice information systems (IJIS), which typically includes sharing of arrest warrants by electronic means. At least 20 articles referenced warrants in context of electronic information sharing; however, none of the peer-reviewed scholarly articles examined contained the word "warrant" in the title or in the abstract. This research on the efficacy of electronic warrant systems is the first of its kind.

Research Approaches Taken

A majority of the available research on IJIS was produced in the years immediately following the 2001 terrorist attacks against the United States and came in the form of case studies conducted by U.S. government organizations (e.g., DoJ, FBI, etc.) and industry and government associations such as the IJIS Institute; SEARCH, the National Consortium for Justice and Statistics; the National Center for State Courts; the National Governors Association; the National Conference of State Legislators; and the National Association of State Chief Information Officers. A few other sources came from university studies, most of which were federally funded by the U.S. Department of

Justice or the National Science Foundation. Two such federally funded research organizations are the Center for Society, Law, and Justice at Texas State University (Geerkin, 2008); and the Center for Technology in Government at the University of Albany, State University of New York (Gil-Garcia, Chengalur-Smith, & Duchessi, 2007).

The predominant research method used by academic and government sources was the qualitative multi-case study that compares and contrasts IJIS programs across the United States. Several research articles included field interviews and surveys or used these methods to supplement case studies.

Table 1 lists some of the most frequently cited case studies in the literature of integrated justice information systems. The repeated use of the same project examples in the literature suggest that few IJIS efforts have achieved significant success and/or few government examples exist to study.

Table 1

Integrated Justice Case Studies

System	Description
ARJIS	San Diego, California area's Automated Regional Justice Information System (Sawyer & Tyworth, 2006; Michael Tyworth & Steve Sawyer, 2006)
CapWIN	Capital Wireless Integrated Network; a collaboration of police, transportation, emergency management, fire, military and homeland security agencies in the greater Washington, D.C. area (Sawyer & Tyworth, 2005)
CJIISP	Hennepin County, Minnesota's Criminal Justice System Information Integration Project began in 1999 and grew into a statewide project that retrieves information real-time from partner systems (Gil-Garcia, Schneider, Pardo, & Cresswell, 2005)
CICJIS	Colorado Integrated Criminal Justice Information System (D. Roberts, 2003)
CJIS	Marin County, California's Criminal Justice Information System took seven years to build starting in 1984 and serves a five county region (Gil-Garcia et al., 2005)
ICJIS	Maricopa County, Arizona Integrated Criminal Justice Information Systems (D. Roberts, 2003)
JIMS	Justice Information Management System; Harris County, Texas, started in 1977 and connects over 250 state and local agencies and 15 federal agencies (Gil-Garcia et al., 2005)
JNET	Commonwealth of Pennsylvania's Justice Network (Michael Tyworth & Steve Sawyer, 2006)

Perhaps the most studied system is the Automated Regional Justice Information System (ARJIS) in San Diego, California. ARJIS has continued to evolve over 25 years and features horizontal and vertical multijurisdictional integration. Horizontal integration is established between local area municipal agency systems, and vertical integrations are

accomplished by links to the San Diego Sheriff's Office (county), the California Highway Patrol (state), and the U.S. Border Patrol (federal). ARJIS serves over 10,000 law enforcement officers in more than ten agencies in the San Diego area (Sawyer & Tyworth, 2006, p. 109).

Emerging Themes

An analysis of the IJIS literature revealed five emergent themes that inform government practitioners seeking to maximize information sharing impact:

1. Governance. How to seek an executive sponsor, charter oversight boards, and establish inter-branch/inter-agency agreements.
2. Critical Success Factors/Strategies. Lessons learned from the field--good and bad to apply to future integration programs.
3. Project Management. How effective project management influences the outcome of criminal justice integration programs.
4. Strategic Planning. Practical guidance to projects for establishing a long-term inter-branch/inter-agency plan for integrated justice, followed by project initiatives.
5. Maturity Stages. Evolutionary models for planning and advancing organizational capabilities and increasing degrees of interchange effectiveness and worth (Ward, 2010).

Theme #1: Governance. Frequently cited in the CJIS literature is the need for a formal governance structure with a charter, organization, funding, and power sharing.

Creswell, Pardo, and Hassan (2007) developed a capability assessment tool with 16 dimensions measured by 4 success indicators. The tool was field tested on three integration projects. The survey found a strong agreement among managers for the importance of governance sub-dimensions: (1) formal charter; (2) governance body; (3) clear authority; (4) accepted authority; (5) relevant parties in government; and (6) support (Creswell et al., 2007).

Sawyer, Fedorowicz, Tyworth, Markus, and Williams (2007) advanced a five-level taxonomy of public safety networks (PSN) punctuated by a heterogeneous governance structure of successive maturity levels shown in Table 2.

Table 2

Public Safety Network Maturity Model

Maturity Level	Indicators
Level 0	No collaboration; isolated information silos
Level 1	Discuss shared issues; independent systems
Level 2	Acting collectively to procure independently owned and operated systems
Level 3	Participate in centrally managed activities
Level 4	Collaborating and communicating on a common communication infrastructure
Level 5	Sharing infrastructure and collaborative governance structure

Carter and Carter (2009) stressed the importance of formal partnership agreements such as memorandums of agreement (MOA) and mutual aid pacts (MAP).

Luna-Reyes, Andersen, Pardo, and Cresswell (2007) identified the critical role of the program governance of the New York State Criminal Justice Information Technology Group (CJIT). “CJIT is comprised of seven New York State criminal justice agencies and the New York State Office of Technology” (Luna-Reyes et al., 2007, p. 48). Through a collaboration with the Center for Technology in Government (CTG), the groups formed an Integrated Justice Advisory Board “to develop a shared vision of the problem, alternative solutions, and strategic priorities” (Luna-Reyes et al., 2007, p. 48).

The formal governance structure for boundary-spanning activities was a critical success factor during the Chicago Police Department-led statewide JIS program and an example of successful public private partnership with Oracle Corporation (Rottman, Smith, Long, & Crofts, 2007, p. 440).

Stoltzfus (2009) prescribed the National Information Exchange Model (NIEM) recommendations that IJIS program leaders be department heads from participating agencies, not agency executives (Stoltzfus, p. 89).

Tyworth and Sawyer (2006) studied the critical influences of government institutions on “the development, operation , and governance of integrated criminal justice systems” (Michael Tyworth & Steve Sawyer, p. 107).

Theme #2: Critical success factors/strategies. Cresswell et al. (2007) developed and field tested a capability assessment toolkit which evaluates 16 dimensions by four success indicators. Their model was field tested on one county-level and two state-level programs.

A research study by Doty and Erdelez (2002) recommended four strategies: (1) User-based empirical research; (2) Understand complex relationships between local courts and their environment; (3) focus on internal and external users; and (4) use a strategic approach to information initiatives.

Gil-Garcia, Schneider, Pardo, and Cresswell (2005) examined justice information integration in Harris County, Texas JIMS, Hennepin County, Minnesota CJIISP, and Marin County, California CJIS and elicited seven critical success factors.

Theme #3: Project management. Since the mid 1990's formal project management standards and best practices as prescribed the Project Management Institute have become essential to IT projects (Project Management Institute, 2008). Next, I describe three examples of project management's impact in the IJIS literature.

Poor project management led to the cancellation of the Federal Bureau of Investigation's Virtual Case File program after investing $170 million (Rottman et al., 2007).

Luna-Reyes et al (2007) identified integrated justice project management risk factors to prescribe how to effectively control them.

Lysecki (2005) reported on the failure of the 2002 Canadian Integrated Justice Project to link the provincial justice system due in large part to a failure of project management.

Theme #4: Strategic planning. Creswell, et al (2007)and Gil-Garcia, et al. (2005) and Webster (2004) recognized that strategic planning, not tactical thinking, was vital to long-term IJIS program success.

Stoltzfus (2009, p. 93) proposed a complex model for government information integration with strategic planning as a central element.

Theme #5: Maturity stages. Siau & Long (2009, p. 100) cataloged and contrasted five industry models of e-government stages, and (Sawyer et al., 2007) developed a five-stage taxonomy of public safety networks (PSN) described earlier.

Barriers and Success Strategies

Gil-Garcia's research into several large integrated justice programs (2005) has resulted in a valuable set of information for the criminal justice practitioner. Final analysis of the subject case study systems yielded a list of four common barriers to integration and seven strategies to overcome them. Integration barriers include:

1. Turf and resistance to change;
2. IT and data incompatibility;
3. Organizational diversity and multiple goals; and
4. Environmental and institutional complexity (Gil-Garcia et al., 2005, pp. 3-4).

With awareness of the above barriers, government IT executives should employ Integration Strategies identified by Gil-Garcia (2005) to mitigate these barriers:

1. Retain autonomy of the involved agencies;
2. Establish and exercise a governance structure;
3. Secure strategic partnerships;
4. Build on long-range and comprehensive planning;

5. Build understanding of the business process;
6. Secure adequate financial resources; and
7. Obtain and nurture executive leadership and legislative support (Gil-Garcia et al., 2005, p. 8).

Summary and Conclusion

This dissertation is the first known research designed to test the efficacy of e-warrant systems. An abundance of literature was found that concerns criminal justice information sharing. Federal agencies have advocated for the societal benefits of e-warrants and justice data sharing for decades with little scholarly evidence of the factors that improve warrant service times and percent warrants served.

The research field of integrated criminal justice information systems is dominated by U.S. Government projects and federally funded academic and industry programs; however, no research was found that specifically investigated the societal impact and value of electronic warrant systems. Case studies of crimes that might have been prevented by sharing criminal justice data, especially arrest warrants, provide anecdotal evidence that more of these systems are needed in the United States today.

Stakeholder theory, open systems theory, and service-oriented architecture provide a theoretical foundation for the technologies used in advanced criminal justice information systems. Extant technologies that facilitate justice information system interoperability include NIEM, XML, and service-oriented architecture (SOA).

The body of IJIS literature consists of predominantly qualitative case studies of a few high-visibility IJIS programs including ARJIS (San Diego, California), CapWIN (Washington, D.C.), CJIISP (Hennepin County, Minnesota), CICJIS (Colorado), CJIS (Marin Co., California), ICJIS (Maricopa Co. Arizona), JIMS (Harris County, Texas), and JNET (Pennsylvania). Five themes were identified in the literature to improve IJIS project success: (1) governance; (2) critical success factors; (3) project management; (4) strategic planning; and (5) evolutionary maturity stages. Common sense would suggest that there are benefits to these programs, but the case studies do not contain empirical evidence of the factors that result in improving warrant service times.

Despite the widespread promotion by the U.S. Department of Justice, other federal agencies and industry organizations, and numerous IJIS case studies, scientific studies are needed to justify the investment of U.S. taxpayer treasure in electronic warrant systems. Chapter 3 contains the quantitative research design that I used to investigate the public value proposition of e-warrant systems and to begin to fill the gap in the literature.

Chapter 3: Research Method

Introduction

The purpose of this quantitative study was to validate or refute assertions of government and industry associations that more advanced e-warrant systems produce improved arrest results as measured by the dependent variables mean service days and percent warrants served.

This chapter contains detailed descriptions of the research method that was used in this quantitative study of historical warrant data. The sections that follow include discussions on study design and rationale, methodology, threats to validity, ethical issues, and a summary.

Research Design and Rationale

Research Questions and Hypotheses

The study research questions and corresponding hypotheses from Chapter 1 are repeated here for reader convenience and to comply with Walden University requirements.

1A. To what extent does the use of electronic warrant systems result in shorter mean service days than the use of legacy paper-based warrant systems?

1B. To what extent does the use of electronic warrant systems result in greater percent warrants served than the use of legacy paper-based warrant systems?

2A. How does the mean service days compare between the two systems for each case type?

2B. How does the percent warrants served compare between the two systems for each case type?

H_{01A}: Mean service days will be equal for both values of warrant system type. Restated, the mean service days for warrants during the multiyear period will be equal in the two sheriff's agencies.

H_{a1A}: Mean service days will not be equal for both values of warrant system type.

H_{01B}: Percent warrants served will be equal for both values of warrant system type. Restated, the percent warrants served for warrants during the multiyear period will be equal in the two sheriff's agencies.

H_{a1B}: Percent warrants served will not be equal for both values of warrant system type.

H_{02A}: Mean service days will be equal in both systems for all values of case type. Mean service days for similar case types (felony, misdemeanor, traffic, etc.) will be equal between the two compared systems.

H_{a2A}: Mean service days will not be equal for both systems for all values of case type.

H_{02B}: Percent warrants served will be equal in both systems for all values of case type. In other words, percent warrants served for similar case types (felony, misdemeanor, traffic, etc.) will be equal between the two compared systems.

H_{a2B}: Percent warrants served will not be equal in both systems for all values of case type.

Research Variables

The dependent variables from the study purpose were mean service days (MSD) and percent warrants served (PWS). MSD was a calculated difference between warrant issued date (WID) and warrant served date (WSD) for warrant record spanning the historical period of study. Subscripts 1 and 2 denote each agency's data.

Thus,

$$MSD_1 = \frac{\sum_1^n (WSD_{1,n} - WID_{1,n})}{n}$$

and

$$MSD_2 = \frac{\sum_1^n (WSD_{2,n} - WID_{2,n})}{n}$$

where *n* is the number of served warrant records in the sample. WSD and WID represent date fields in warrant records and are not independent variables.

The second dependent variable, PWS, was computed by dividing total warrants served (TWS) by total warrants served (TWS) plus total active warrants (TAW); therefore, recalled, held, and returned unserved warrants were not counted.

Thus,

$$PWS_1 = \frac{TWS_1}{TWS_1 + TAW_1} \times 100$$

And

$$PWS_2 = \frac{TWS_2}{TWS_2 + TAW_2} \times 100$$

Selecting independent variables for this study presented a challenge. Without looking at the database schemas (structures) of the selected warrant systems, it was impossible to ensure that determinant data fields existed in all systems and that they were populated. This risk was identified in the research proposal. Walden University's research policy prohibits researchers from first examining the data schema before the proposal is approved (Walden IRB Application, 2010). After proposal acceptance, I received warrant data extracts from the donor state court administration office. Upon examination of the data, a design change became necessary; therefore, I used two separate sections to describe the research design, first as approved in the proposal, then as modified after data collection.

Initial research variable design. The independent variables initially selected for this study were:

1. Warrant system type
2. Case type
3. Bond Amount (covariate)

Figure 3 depicts the study variables selected in the proposal design. Warrant system type was a binary nominal independent variable and had a domain of two possible values: 1 for system type (county) #1 and 2 for system type (county) #2.

Case type indicated the legal category of the arrest warrant, which may vary from court to court and system to system, but generally there are felony warrants, misdemeanor warrants, traffic warrants, failure to appear warrants, and failure to pay warrants. Thus, case type was a categorical or nominal independent variable with a fixed

discrete set of values. The actual case types used by the subject counties are described in the final research variable section.

Bond amount is a common attribute of warrant records and indicates the amount that must be paid to the court to guarantee the subject's court appearance. In many courts, judges assign a bond amount to a warrant reflecting the severity of the alleged crime and the perceived flight risk. Generally speaking, the more severe the crime, the higher the bond will be. Bond amount was expected to be an inverse covariate on the dependent variables MSD and PWS. As such, the influence of bond amount on the dependent variables might be cancelled out using an analysis of covariance (ANCOVA) statistical test to reveal the effects of the other two independent variables on the dependent variables. For very serious charges, a judge may stipulate a no bond warrant, indicating that the accused cannot bond out of jail and must remain in custody until a court appearance or other court order. The plan for this independent variable was to use the actual numeric dollar amount of the bond, substituting a large number such as $1,000,000 for no bond warrants. I proposed to conduct a sensitivity analysis using multiple large numbers to determine the effect.

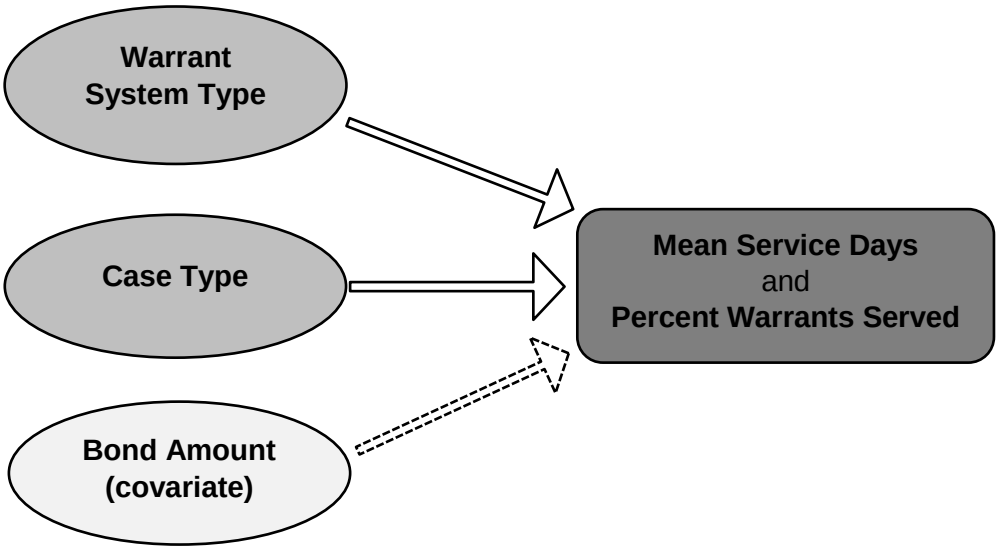


Figure 3. Initial proposed variable model. Dependent variables MSD and PWS are shown with independent variables warrant system type, case type, and covariate bond amount.

Final research variables. This section contains a description of the modified variable design that was executed in the data analysis phase of this research. When sample data were first received, bond amount was not included with the warrant records. Upon further inquiry, I was advised that bond amount was not a part of the warrant records due to an established court process in that state whereby bond amounts are assigned in a separate court hearing not associated with warrant issuance. After consideration and consultation with my dissertation committee chair, I decided to exclude the covariant bond amount and change from an ANCOVA statistical test to an ANOVA

test. Thus, two independent variables were used in this study: (a) warrant system type and (b) case type.

Figure 4 depicts the variables used in this study. The definitions of warrant system type and case type remain the same as previously described.

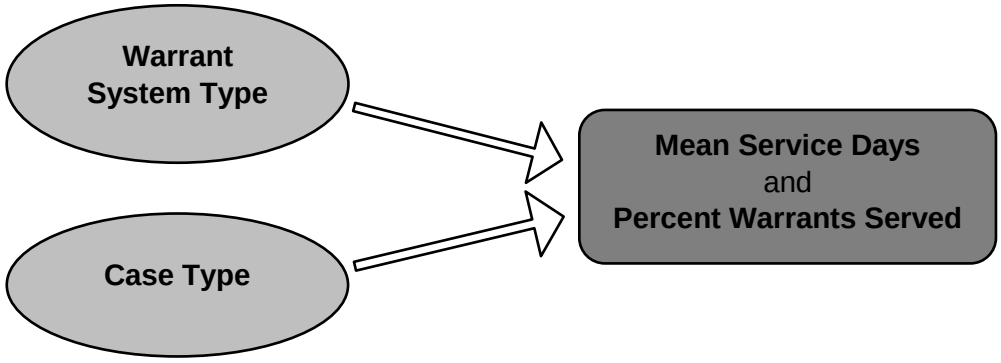


Figure 4. Final variable model. Dependent variables MSD and PWS are shown with independent variables warrant system type and case type.

Special Data Considerations

Two warrant types in the collected data samples required special consideration. First, recently issued warrants posed a challenge due to the unwanted effect of new warrants in process. It is reasonable to expect that a high percentage of warrants will be served within days and weeks of issuance, but if recently issued warrants were included, many warrants that are about to be served will be counted as not served, thus skewing the

results. To avoid this, warrants issued less than 1 year prior to the date of data extract were excluded from data analysis.

The second warrant category requiring special consideration was inactive or closed warrants that were never served. Courts use a variety of terms to describe these warrants that are no longer active: recalled, vacated, quashed, administratively closed, held, or suspended. The warrant records used in this study were marked with one of five warrant status values:

1. Active
2. Hold
3. Recalled
4. Retuned Served
5. Returned Unserved

To ensure that MSD and PWS were accurately calculated, only returned served warrant records were counted in this study. When calculating PWS, only active and served warrants were included in the denominator.

State and local laws determine what case types are used in courts. During proposal design prior to final data selection, there was concern that case types might be mismatched and have to be mapped. This concern was allayed when the decision was made to collect county warrant data from a state-wide warrant system where uniform case types were in use.

One common type of warrant that is sometimes considered less severe than others is the bench warrant. Bench warrants are so named because the judge issues them from

the bench usually for violation of instructions to appear in court or to pay fines and costs or possibly for in-court misconduct. A bench warrant is normally issued as an adjunct to an existing case for subsequent court violations. A common example is when an alleged traffic offender agrees to appear in court to contest a traffic citation then fails to appear at the agreed time and place; the judge may issue a bench warrant for the offender's arrest. Before seeing the warrant data, I had proposed to treat bench warrants as a warrant type; however, when the data were made available, bench warrant was a data attribute separate from case type. Hence, to stay true to the proposed variable design, I decided not to break out bench warrants as a separate category for analysis. The data used in this study included bench warrants and other types of warrants.

Research Design

The conventional wisdom of the justice industry and government is that more advanced warrant systems should result in faster arrest times and decreased warrant backlogs. The four research questions framed a scientific inquiry of this notion. To answer these questions, a comparative study between two or more warrant systems of different maturity was needed. Anecdotal testimony of the benefits of advanced e-warrant systems by government bureaucrats, although interesting, does not represent empirical scientific evidence to the claims. A quantitative head-to-head historical study of two or more systems was required to investigate the research questions.

Because this was a study of historical data, timing constraints for data collection were different from a survey collection method; however, timing played a part in internal construct validity. Two time-related elements were critical: (a) historical time period and

(b) equal time periods. The selected systems needed to have a sufficiently long period of parallel operation to increase statistical validity. Ultimately data for the 2-year period from 1 January 2012 to 31 December 2013 was chosen to meet these criteria. An in-depth discussion of timeframe selection is contained in Chapter 4.

Methodology

Population

The target population of this quantitative research was all law enforcement agencies in U.S. counties that are comparable to the agencies selected for warrant data sampling. The goal was to generalize the study results to agencies with similar technical and environmental attributes. A description of the subject county populations and a discussion of other attributes are contained in Chapter 4.

Procedure for Identifying Relevant Historical Data

Identifying warrant systems for comparative analysis required a method for rating system sophistication and a method for case selection. I defined custom procedures for system maturity rating and selection in this section.

E-warrant maturity model. It was necessary to establish a method for categorizing computerized warrant systems for comparison and selection of cases. As an aid to further research in electronic warrants, I proposed a comprehensive five-level maturity model for describing an organization's level of warrant system sophistication and interoperability. Table 3 and the follow-on description section contain a revised version of the E-warrant Maturity Model (EWM^2) first drafted in my earlier paper Electronic warrants: Combining technology and policy for public safety (Ward, 2011).

This model incorporates a cumulative scale of key system functions ranging from simple manual processes to advanced passive automation features. The next subsections contain the criteria and describe the methods of operation for the five levels of EWM^2.

Table 3

E-warrant Maturity Model (EWM^2)

Feature	Level 0: Manual	Level 1: Captured	Level 2: Automated	Level 3: Published	Level 4: Integrated
Electronic warrant record	No	Yes	Yes	Yes	Yes
Searchable field-level data	No	Yes	Yes	Yes	Yes
Automated workflow	No	No	Yes	Yes	Yes
Electronic signature	No	No	Yes	Yes	Yes
NIEM standard schema	No	No	No	Yes	Yes
Publish/subscribe external systems	No	No	No	Yes	Yes
NCIC synch.	No	No	No	No	Yes
Passive search	No	No	No	No	Yes

Level 0: Manual (Paper and Fax). Level 0 represents the unimproved method of warrant management. At this level courts issue warrants on paper that are couriered or faxed to the law enforcement agency, where workers file them in cabinets. To initiate a warrant search, the field officer must make the request, usually via police radio

dispatcher or records clerk, who physically searches the paper files for an active warrant for the subject person. When a warrant is fulfilled by the subject or recalled by a judge, workers rout another paper document to the law enforcement agency (LEA) warrants section to request removal of the paper warrant. Warrant teams carry paper copies of warrants for field identification of subjects. Every step in the level 0 process incurs a time delay and is subject to human error. Because level 0 systems are fully manual paper-based processes, level 0 systems are not considered e-warrant systems for the purposes of this study.

Level 1: Captured. A level 1 e-warrant is an electronic record of a court order of arrest. At this level the basic warrant information such as defendant name, address, descriptors, and criminal charges are entered and stored in fields in a computer information system database. level 1 e-warrants are searchable and contain basic status information such as Requested/Active/Denied/Recalled/Served status along with request date, issue date, action date, judge identifiers, and officer identifiers. Level 1 Warrants are found in most police records management systems (RMS) today. The level 1 e-warrant system does not include an automated workflow process or electronic signatures. Level 1 e-warrants do not replace the signed paper document—they supplement the court paper for searching and status information. A level 1 e-warrant is not a legal court record. Having separate legal hardcopy documents and electronic records introduces the potential for erroneous information due to an imperfect update process. For example, a judge may recall a warrant electronically, leaving paper copies in files. Having duplicate records imposes a tedious manual task on record keepers to recall

paper warrants. This is why many law enforcement records departments must check their warrants database first then verify the warrant status by finding the legal paper warrant in a file cabinet.

Level 2: Automated. At this intermediate level the e-warrant replaces the paper document and wet ink signature with a fully-attributed and well-structured data record. The level 2 e-warrant system utilizes automated workflow processes with electronic signatures. The system also enables printing of a facsimile court document. At this level, e-warrants are expected to show internal benefits to the agency such as shortened arrest times, improved arrest records, more reliable warrant status, and instant availability to the field officer within the issuing jurisdiction. Today many leading commercial off-the-shelf (COTS) police record management system (RMS) vendors include a level 2 e-warrant capability with their application system.

Level 3: Published. The level 3 warrant system adds to the functions of level 2 by extending warrant access to external agencies. Using technologies such as extensible markup language (XML), National Information Exchange Model (NIEM) design, and service-oriented architecture (SOA) the agency or court officials publish their warrants to neighboring counties, municipalities, or states. Outside agencies can opt-in to subscribe their internal information systems to the publishing agency's warrants, thereby extending the reach of the warrant.

Level 4: Integrated. At the top of the e-warrant stack is level 4. The level 4 e-warrant represents the highest degree of system sophistication, including all the features of levels 1 through 3 warrants plus passive system interoperability. This definition

requires that: (a) officers in the field can search and view warrants electronically; (b) warrants are searchable by authorized external agencies; and (c) an automatic "push" method of information sharing is implemented with other criminal justice system(s). Level 4 e-warrant systems utilize fully conformant NIEM data exchanges. Few, if any, electronic warrant systems that are in use today achieve maturity level 4 due to interoperability requirements. A level 4 system promises the greatest potential value for improving public safety. A few highly advanced warrant systems have additional features including: (1) online return of service entry by law enforcement, (2) automatic asynchronous NCIC wanted person lookup; (3) automatic NCIC adds, updates, and clearance; and (4) warrant history on subject (closed warrants).

Case selection methodology. This section contains a case selection methodology that I developed as part of my research proposal prior to receiving data samples and prior to expanding the scope of study from a single pair of counties to four county pairs. The E-warrant Maturity Model (EWM^2) can be employed in a case selection methodology to identify suitable warrant systems for comparison. I first developed this case selection methodology in a prior research paper Knowledge Area Module (KAM) #7 titled The Case Study Research Method (Ward, 2013b). I adopted the Case Selection Variable Map (Figure 5) and the Case Selection Process Flow Chart (Figure 6) from that paper for this dissertation as originally intended.

This method is designed to select two candidate cases with a maximum absolute value of difference (M_2-M_1), where M_n is the maturity level of candidate case *n*. The EWM^2 utilizes a scale from 1 to 4, but for purposes of this paper, level 3 and 4 systems

are considered mature e-warrant systems. As such, I attempted to identify one system with a 3 or 4 level rating and a second system with a significantly lower maturity rating. My goal was to select two cases with significantly different maturity levels (electronic vs. mostly manual), but with similar environmental variables and system history.

Candidate warrant system environmental variables of research interest were:

1. Jurisdiction type (JT)
2. Population served (P)
3. Size of force (SF)
4. Level of cooperation (C)

Candidate warrant system technical variables of research interest were:

1. E-warrant system maturity level (M)
2. Years with current warrant system (SY)
3. Case types (CT)

A definition of the environmental variables is contained in the following paragraphs.

Years with current warrant system (SY). This is the number of years the law enforcement agency has been using the warrant system and was used to select matching warrant record date ranges for case comparison. The goal was to find two or more cases (systems) that contained warrants for the same recent number of years.

Jurisdiction type (JT): federal, state, county, municipal, or tribal. It is essential that both cases selected are the same jurisdiction type. In most states the county sheriffs are responsible for tracking and servicing arrest warrants. When municipal police or other

agencies arrest on a state warrant, the county warrant system is typically updated to indicate the arrest.

Population served (P): Indicates population served by the law enforcement agency which is responsible for administering and serving warrants. To strengthen internal validity of the follow-on data analysis after case selection, the selected cases should have similar populations. In other words, it would not be useful to compare a sheriff's office in a rural county with 50,000 people to a metropolitan county with a population of one million.

Case types (CT): Indicates what types of warrants are tracked in the system. Special public safety interest is given to felony, misdemeanor, and traffic warrants. Failure to appear warrants may also have a public safety component, depending upon the original charges. Consideration was given to congruency of case types between systems. This is discussed in the Special Data Considerations section earlier in this chapter.

Size of force (SF): This is the number of commissioned peace officers in the law enforcement agency which tracks warrants. The size of the force may affect warrant service. A small force may be less capable of servicing warrants than a larger force in a similar sized county. Similar SFs will add to internal validity of the subsequent data analysis.

Level of cooperation (C): This factor reflects the participating organization's ability and willingness to share data for research. A contributing factor to an agency's willingness to share data is resource availability. Law enforcement agencies may have limited funding and personnel to work on these special requests. Often they must rely on

officers with limited technical skills, technical experts in a separate county information technology group, or even vendor personnel to carry out information requests of this nature as time and resources allow.

Figure 5 depicts a case selection variable diagram which depicts independent variables and intermediate variables for environmentally qualified (E) and technically qualified (T) candidate cases which, in turn, determine overall qualification for study inclusion (Q).

Four-step case selection process. Selecting cases for a quantitative comparative study of historical warrant data requires an agile and iterative four-phased process: (1) identify; (2) qualify on environmental variables; (3) qualify on technical variables; and (4) select final test cases. Figure 6 contains a flow chart of the process. A narrative describing the four main steps follows the diagram.

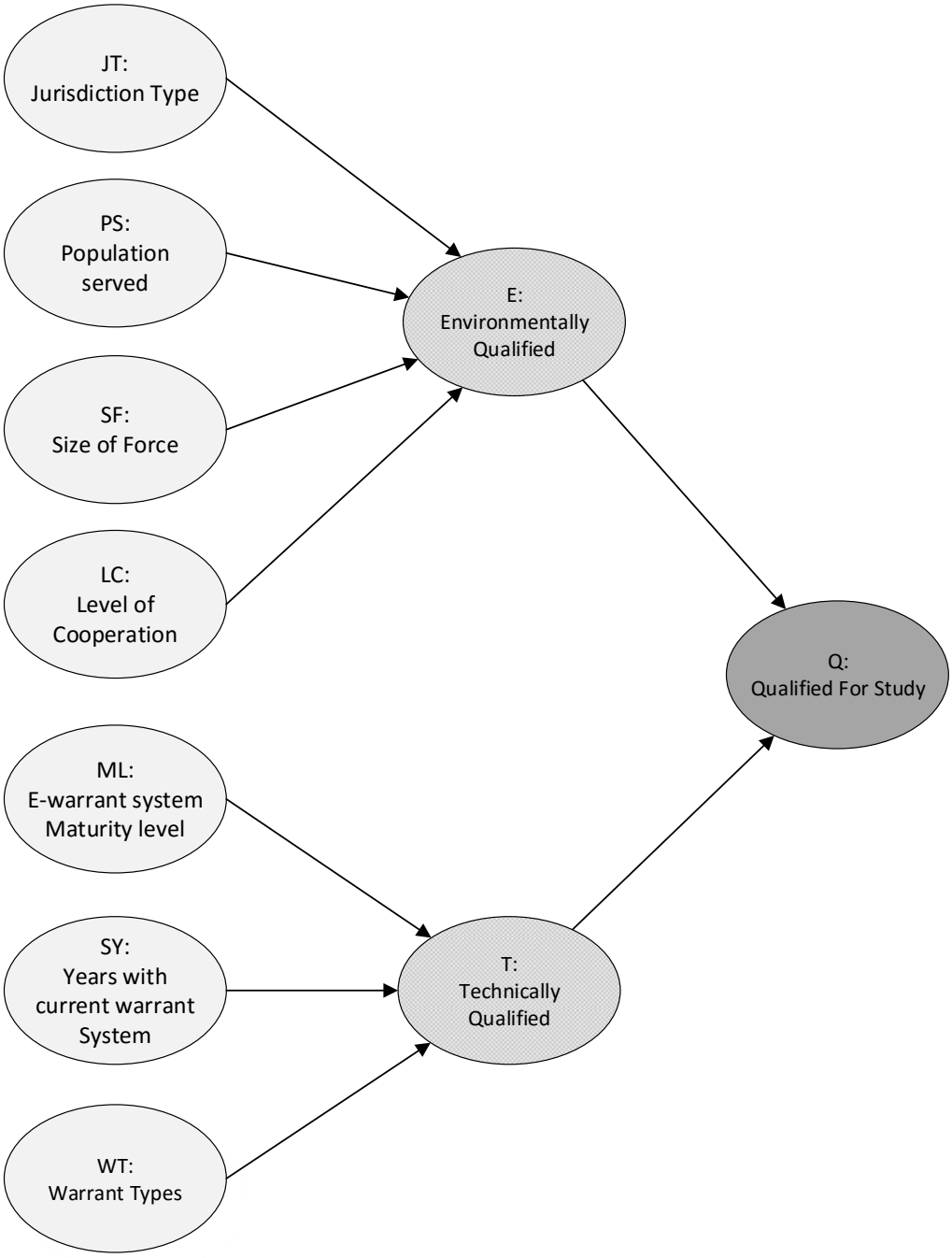


Figure 5. Case selection variable map. Depicts independent, intermediate, and dependent variables and determinants; adapted from Ward (2013).

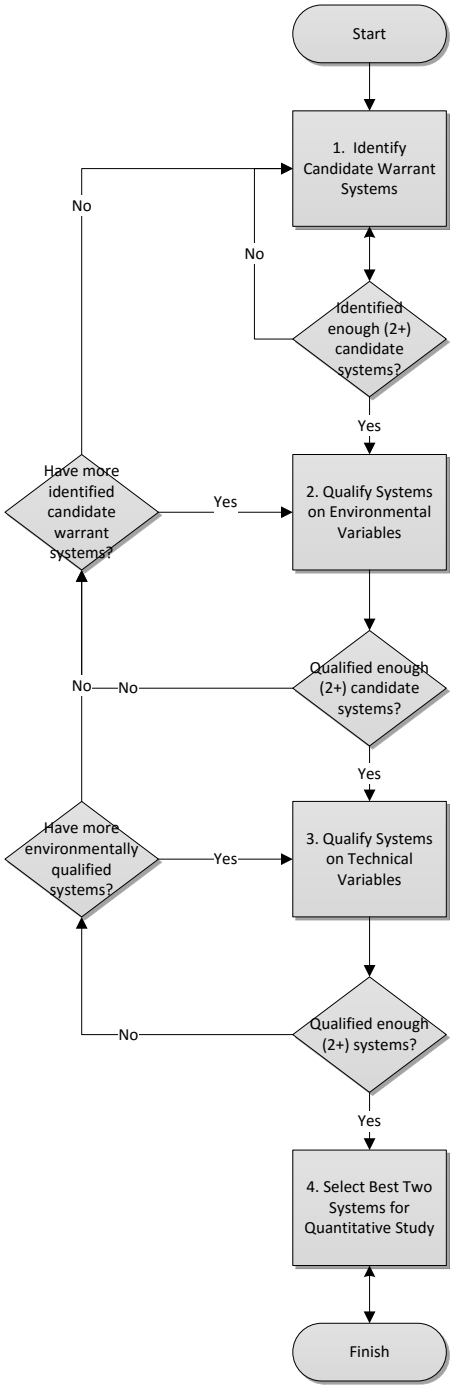


Figure 6. Case selection process flow chart. Depicts sequence and logic used in case selection process (Ward, 2013).

Most states operate some form of an electronic warrant system (National Center for State Courts & SEARCH, 2011, pp. 13-17). They vary widely in age, technology, and functionality. As an information technology professional who has worked in the criminal justice field for many years, I had become aware of several state systems. Initial qualifying included Internet-based research of news, government, and industry web sites and publications; and contacting peers and associates across the country. The goal of this first step was to identify two or more candidate systems that might meet the environmental and technical requirements, not to survey the entire country for candidate systems.

The second step was to qualify candidate cases based on the four environmental variables JT, PS, SF, and LC. This step involves gathering environmental information for each candidate and comparing to other candidates. The step is complete when two or more candidate systems are found to be similar to each other within acceptable margins. Similar values in all environmental variables will strengthen internal validity. At proposal time this process model had an additional variable called state repository. This variable was dropped from the process when it was decided later that all county samples where to come from a single state with a state warrant repository; thus, rendering it a moot factor. This qualifying step was repeated until all known candidate cases have been evaluated on the environmental variables. The process was designed to be continued until two or more environmentally similar cases were found. If all candidates are determined to be incompatible, then step #1 had to be repeated.

The third step in the selection process required an in-depth look at environmentally similar candidate systems that passed step #2. The three system variables (ML, SY, and WT) were examined to determine suitability for use in a quantitative analysis of historical warrant data. To strengthen internal validity, candidate systems must have available data for the same time period of time longer than one year. Ultimately this meant that candidate systems must have substantially different maturity levels and compatible system ratings. Steps 1 through 3 were iterated individually as necessary to yield at least two candidate cases.

The fourth and final step in the process was to choose the best two or more cases from the results of step 3.

This section detailed the method proposed for identifying two or more warrant systems for comparative analysis in this study. Chapter 4 contains a description of the final selection process that resulted in six counties in four matched pairs.

Procedures for Obtaining Permissions to Use Historical Data

A state administrative office of the courts (AOC) owned the warrant data collected from the six selected counties, which simplified the data permission and acquisition process. A formal data use agreement was executed with the state AOC. Following a successful oral defense of my proposal with my dissertation supervisory committee, the Walden University Institutional Review Board (IRB) reviewed and approved my proposed data collection methods and data analysis. Data collection began after IRB approval.

Retrieving Historical Data

Warrant data is maintained by government organizations, generally courts and law enforcement agencies; thus these are the most reliable sources available. Other systems such as NCIC are incomplete and latent secondary sources for warrant data. It is, however, important to evaluate the quality of any data selected by learning how it was collected and how it is maintained. The case selection method described earlier in this chapter details how candidate systems can be qualified on several environmental and technical variables. The six systems are suitably disparate in degrees of sophistication, based on the electronic warrant maturity model (EWM^2), and they are comparable in population and other environmental variables.

Prior to final selection, I had planned to examine the data base schemas and develop structured query language (SQL) to extract the study datasets from each agency's warrant system. To protect the security interests of the donor agencies, I expected to ask the IT organization in each agency to run the SQL queries that I send them via email. Instead, the AOC IT organization was not willing to share the database schema and developed the extract SQL internally. No personal identifiers on the warrant subjects were included in database extracts; thus protecting the security interests of the system owners and the privacy of warrant subject persons. Notably, arrest warrant information is generally public information, but some jurisdictions limit bulk data requests. I received the warrant dataset extracts in Microsoft Excel format via email attachments which I later imported into IBM SPSS for analysis. Chapter 4 contains a detailed description of the data collection and analysis processes used in this study.

Method of Analysis

I conducted two-way analysis of variance (ANOVA) statistical tests on each county set as the primary method of analysis. I used IBM SPSS statistical software on my personal computer to test the independent variables for individual and combined effects on the dependent variables. A p statistic value less than .05 was selected as the statistical significance level for the independent variables. I also ran descriptive statistics; including means, medians, standard deviations, and ranges; on all variables to compare historical datasets and subgroups (e.g., case type).

Contingency Method of Analysis

During the data analysis, tests for two-way ANOVA assumptions were run on the sample data sets. Most assumptions were found to be false; therefore, it was necessary to resort to follow-on non-parametric SPSS tests on both dependent variables. A further explanation of these tests and the results are contained in Chapter 4.

Threats to Validity

Threats to External Validity

One significant threat to external validity was that only six systems were examined in this study. While thousands of records were analyzed for each of the selected systems, the question of generalizability to other systems was dependent largely upon environmental similarities such as population served, size of force, and other variables as shown previously in Figure 5.

Another potential threat to generalization of results is the variability of warrant system maturity as defined previously in the E-warrant Maturity Model (EWM^2). The

results of this study should not be loosely generalized to any two warrant systems of any maturity level. For example, this study compares level 0 or level 1 warrant system to level 3 warrant systems, and the results may not be valid when comparing a level 3 and a level 4 system, for example. Generalizations should be limited to systems with the same maturity levels. Indeed, one possible follow-on study approach would be to analyze several systems of all maturity levels looking for consistent results and a possible impactful threshold. For example, it may be discovered that systems of level 3 or higher roughly equally outperform lower rated systems.

Threats to Internal Validity

Creswell (2009) defines threats to internal validity as "…experiments procedures, treatments, or experiences of the participants that threaten the researcher's ability to draw correct inferences from the data about the population in an experiment" (J. W. Creswell, 2009, p. 162). Eight of the ten types of threats to internal validity pertain only to experiments involving participants or experimental treatments. The two remaining procedural threats are testing and instrumentation (J. W. Creswell, 2009, pp. 162-164). Since participants and testing were not used in this study, this leaves only instrumentation threats to internal validity. Instrumentation normally deals with variations in the instrument used. In this study historical data are used, and the internal threats to validity relate to quality of source data (i.e., instrumentation errors are built in to the historical datasets).

As a practitioner of criminal justice computer information systems and a commissioned law enforcement officer, I am interested in improving arrest rates;

however, I have designed this study using historical data sets, which does not allow for influencing the study with survey bias or participant selection biases.

Threats to data quality come in several forms. Loshin and Russom enumerate eight characteristics of quality data: uniqueness; accuracy; consistency; completeness; timeliness; currency; conformance; and referential integrity (as cited in Hoffer et al., 2013, pp. 438-439). Consistency, accuracy and completeness are the most likely threats to data quality. An in-depth discussion of data quality and limitations is contained in Chapter 5.

To establish consistency between two systems, the same time period of operation must be used, and the time period must be sufficiently long to dampen the effects of external variations such as economy, weather, political influences, and legal mandates. I settled on a two-year time frame for warrant performance comparison of the four county pairs. An explanation of the time frame selection is contained in Chapter 4.

Factors affecting accuracy of data include: method of data capture; data validation rules used; and quality assurance procedures. Data completeness may be a threat if some of the warrant data were not captured uniformly across counties.

Threats to Construct or Statistical Validity

Construct validity is a measure of how effectively the research design addresses the research questions, or as Trochim (2001) stated, “construct validity refers to the degree to which you are measuring what you intended to measure” (Trochim, 2001, p. 105). Given that the independent variables were selected prior to knowing the data

schemas, there was a risk that the variables did not exist in a usable form, but no such problem was found. There are no other known threats to statistical validity.

Ethical Procedures

Protection of Confidential Information

This study of historical data does not include direct participants or a survey instrument. Instead, warrant data records on wanted persons are the source of analysis. In the United States criminal justice system, arrest warrant records are generally considered public information; however, identifying individual warrant subjects is not germane to this study, and therefore I excluded this type of information from sample datasets. Personal identifiers such as name, address, date of birth, social security number, employer, next of kin, phone numbers, etc. were not extracted from the source systems. The file extracts used contained all the detail needed for research, but did not include individual identifiers. All data collected remains on my personal computer equipment and backup systems, including a secure cloud-based backup service (Carbonite) and Google Drive. All applicable Walden Institutional Review Board (IRB) procedures were followed.

Summary

This chapter contains a description of the research method used in this quantitative study of historical arrest warrant records extracted from six law enforcement agencies. I used a custom-designed case selection process to qualify candidate systems with similar technical and environmental attributes but with significantly different e-warrant maturity levels, as determined using a proposed e-warrant maturity model

(EWM^2). Analysis was performed using descriptive statistics, analysis of variance (ANOVA), and non-parametric tests on two dependent variables, MSD and PWS, and two independent variables, warrant system type and case type. Privacy of human warrant subjects was fully protected by excluding all personal identifiers from source data extracts prior to data analysis.

Chapter 4 contains a detailed accounting of the research study outcome, including sections on data collection, study results, and study findings.

Chapter 4: Results

Introduction

The purpose of this study was to examine whether the use of advanced e-warrant systems improves arrest results as measured by the dependent variables MSD and PWS. These advanced e-warrant systems are aimed at improving arrest performance, thus improving public safety. The federal government and the criminal justice community advocate for more advanced electronic warrant systems that share data with other agencies. The independent variables that were examined in this study are WST and case type.

The four research questions of this study were

1A. To what extent does the use of electronic warrant systems result in shorter MSD than the use of legacy paper-based warrant systems?

1B. To what extent does the use of electronic warrant systems result in greater PWS than the use of legacy paper-based warrant systems?

2A. How does the MSD compare between the two systems for each case type?

2B. How does the PWS compare between the two systems for each case type?

Questions 1A and 1B were about the overall effect of the different system types on total arrest performance for the agency. Questions 2A and 2B were designed to drill-down to compare arrest performance by individual case type.

This study was based on four null hypotheses, one for each research question:

H_{01A}: MSD will be equal for both values of WST. Restated, the MSD for warrants during the multiyear period will be equal in the two sheriffs' agencies.

H_{01B}: PWS will be equal for both values of WST. Restated, the PWS for warrants during the multiyear period will be equal in the two sheriffs' agencies.

H_{02A}: MSD will be equal in both systems for all values of case type. In other words, MSD for similar case types (felony, misdemeanor, traffic, etc.) will be equal between the two compared systems.

H_{02B}: PWS will be equal in both systems for all values of case type. In other words, PWS for similar case types (felony, misdemeanor, traffic, etc.) will be equal between the two compared systems.

This chapter contains the data analysis results organized into sections including Data Collection, Data Quality, and Study Results.

Data Collection

Data collection was a significant and time-consuming effort due to difficulties in data extraction and resource limitations of the donor state court organization. The proposed research design called for data from only two counties with similar populations, court processes, and environmental factors: one basis county that did not use an e-warrant system and another that did. An accounting for the data search, selection, and quality follows in the next sections.

The Search for Historical Warrant Data

My research for the literature review and my personal contact with criminal justice industry consultants led me to the conclusion that the best chance of finding counties with similar environments would be to look at states that had implemented, or were implementing, a state-wide e-warrants system for use by county sheriffs. The search

narrowed to three known state wide e-warrant systems. One state did not respond to my requests for data. A second state had employed a less advanced system with limited county participation. Court officials in the final remaining state pledged to provide data for this study. I received verbal approval from the state court's administrative office of the courts director and the state courts IT director. A data use agreement was soon executed, and then lengthy telephone discussions and e-mail exchanges led to the selection of study counties from that state. The state court system had access to data from all counties in their state, including the two counties that were not connected to the recently implemented e-warrant system. This presented a new opportunity to expand the study from one base (non-e-warrant) county to two base counties.

Selection of Subject Counties and Data Time Frame

County selection was based on population data retrieved from the U.S. Census Bureau 2010 census (United States Census Bureau, 2014). The subject state court IT department provided a schedule showing the date that each county began using the new e-warrant system. With the names of the two counties not using the new e-warrants system, I was able to sort a census bureau data extract by county population. The two closest counties by population to each of the two basis counties were selected for this study. This step yielded six selected counties in two study groups. This study population, therefore, included all counties in the United States with rural populations similar to the sample counties, which are approximately 21,000 and 28,000 people. The exact census numbers are withheld to keep the identities of the subject counties confidential. Because the sample data were provided by the state AOC, not all of the proposed selection factors

were available to qualify each data source. Jurisdiction type was the same for all samples: a county sheriff's office. Population served was matched as described earlier. The size of force and level of cooperation were not available. The number of years with the current warrant system, while not known for the basis counties, was critical in determining the sample data frame used. Warrant types were uniform in all county samples. System maturity was level 3 for the four e-warrant counties, and the basis counties were understood to be mostly manual systems at level 0 or 1, thus yielding a sufficient system maturity difference to use in this study.

Next, the data frame selection was based on e-warrant system go-live dates that were provided by the state. The goal was to select the longest time period of systems usage across all six subject counties. Complete data for calendar years 2012 and 2013 were available; therefore, this became the study data frame. Another factor in time frame selection was that it should be more than a year older than the data extract to reduce the effect of new warrants in the system that had not been served yet simply because they were relatively new. This condition was met because the newest warrant data were from December 2013—more than a year prior to the date that the data was extracted.

This process yielded two basis counties each being paired with two different counties with complete warrant data for 2 full calendar years 2012 and 2013. This resulted in a total of four pairs of counties. Instead of the original single county pair called for in the proposal, the scope was expanded to four pairs, essentially increasing the study's reliability.

Study Population

The study population was all law enforcement agencies in U.S. counties with similar populations to the six subject counties. There are 3,143 counties in the United States (United States Census Bureau, 2015). I downloaded a table of U.S. county populations from the U.S. Census Bureau to Microsoft Excel, and then sorted them by population, and I ran ranking and descriptive statistics in Excel. The mean population for all U.S. counties was 98,233 and the median population was 25,857. Table 4 shows how the six subject counties are grouped into Group A and Group B. The mean and median of the three Group A counties rounded to the nearest 1,000 was 29,000. The population difference between the largest and smallest counties in Group A was less than 400. The mean and median of the three Group B counties rounded to the nearest 1,000 was 21,000. The population difference between the largest and smallest counties in Group B was less than 200. Approximately 53% of all U.S. counties had populations lower than the Group A counties in this study, and 43% of all counties had populations lower than Group B counties. The six counties in this study represent typical, mostly rural, U.S. counties.

At the time of this writing, permission to use actual county names in this dissertation had not been granted by the data owners; therefore, moniker letters were assigned to each of the six subject counties as described in Table 4. To further ensure anonymity, the subject state name and specific county population sizes are not revealed in this study.

Table 4

County Letter Assignments

Group	County Letter Assignment	Description
A	A_0	Group A Non-E-Warrants County
A	A_1	Group A First E-Warrant County
A	A_2	Group A Second E-Warrant County
B	B_0	Group B Non-E-Warrants County
B	B_1	Group B First E-Warrant County
B	B_2	Group B Second E-Warrant County

The data analysis was performed on four county pairs:

1. Pair A_0A_1: County A_0 and County A_1
2. Pair A_0A_2: County A_0 and County A_2
3. Pair B_0B_1: County B_0 and County B_1
4. Pair B_0B_2: County B_0 and County B_2

Each county pair dataset was subjected to the same statistical analysis, yielding four times the results originally set forth in the proposal.

Each pairing of counties in this research design included a basis county that did not use an electronic warrant system (warrant system type 0), and it was designated with a zero subscript. The second county in each pair used an electronic warrant system (warrant system type 1), and it was designated with a subscript of 1 or 2. Thus, the research variable WST corresponds to county, and county was used interchangeably for WST in the remainder of this study for better understanding.

Data Quality and Research Design

The original proposal design called for a third determinant variable, bond amount, which was propositioned to be a possible covariant with the dependent variables. However, as explained in Chapter 3, when the data were first received from the donor state court system, bond amount was not included. As a result, this research design was modified to use the two remaining independent variables and the central statistical test changed from the two-way ANCOVA in the original proposal to a two-way ANOVA.

Sample size for each county in the 2-year time frame from January 2012 to December 2013 ranged from 1,278 warrants to 3,874 warrants. Table 5 contains warrant counts (served and unserved) by county and case type.

Table 5

Warrant Counts by County and Case type (calendar years 2012 and 2013)

County	Circuit Criminal	Felony	Misde-meanor	Traffic	Total
A_0	691	519	1,661	1,551	4,422
A_1	737	419	2,530	3,233	6,919
A_2	456	116	684	709	1,965
B_0	398	210	430	604	1,642
B_1	473	174	559	708	1,914
B_2	533	157	647	932	2,269

The e-warrant counties selected for each group were the two closest in census population based on 2010 Census Bureau figures (United States Census Bureau, 2014). Table 6 contains population difference percentages.

Table 6

Percent Population Difference from Basis County

County	Percent Difference
A_0	0% (basis)
A_1	+0.4%
A_2	+0.4%
B_0	0% (basis)
B_1	+0.5%
B_2	+1.6%

Study Results

This study results section is divided into two subsections, one for each dependent variable, MSD and PWS. Each subsection contains a discussion of two-factor ANOVA assumptions and results, alternative nonparametric tests, hypothesis findings, and research question results.

Study Results: Mean Service Days

Two-factor ANOVA assumption tests: Mean service days. The ANOVA test is based on three fundamental assumptions: (a) independence of errors, (b) normal distribution, and (c) homogeneity of variance (Gamst, Meyers, & Guarino, 2008, pp. 49-60). Independence of errors is assumed to be met because the sample data were created from independent events that occurred in different courts and sheriffs' agencies. It is unlikely that any significant dependencies would exist between warrants or subjects.

Outlier data points can signal a non-normal distribution. An examination of SPSS box plots for service days in every subject county and county*case type combination revealed many apparent outliers. This is explained by the warrant service process; some warrants never get served, and these were intentionally omitted from the analysis. Other warrants take years to be served. This may be due to a variety of reasons including

1. Subjects moving or evading to avoid arrest
2. Agency, court, and legislative public safety priorities
3. Limited law enforcement budgets and/or resources
4. Political will

The six datasets examined for this study all had numerous outliers at the high end. In other words, many warrants in each county were served long after issuance. Warrants that are not served in the first few days after issue can become part of a back log that may get little proactive attention from agency warrant teams as new warrants are ordered for fresh cases. Service on an old warrant is often coincidental with unrelated contacts with law enforcement, such as traffic stops or investigations of different crimes. Appendix A contains box plots of unmodified service days data.

Data outliers can be handled in three basic ways: (a) trim them out of the sample, (b) transform them by mathematical formula, or (c) ignore them (Gamst et al., 2008, p. 57). I selected a mathematical formula called Winsorizing that replaces high-end and low-end outliers with calculated upper limit or lower limit values (Kennedy, Lakonishok, & Shaw, 1992, p. 169). Hoaglin et al. (1986)developed a formula for identifying outliers using statistical sample quartiles (*Q1*, *Q2*, *Q3*, and *Q4*) and a factor *K*=2.2 (Hoaglin & Iglewicz, 1987; Hoaglin et al., 1986):

$$Upper = Q3 + (2.2 * (Q3 - Q1))$$

$$Lower = Q1 - (2.2 * (Q3 - Q1)$$

Winsorizing is the preferred method over trimming or ignoring in this case because the sample size *N* is not reduced, and the outliers are brought back into the expected normal range. Using SPSS, I added a new data column Winsorized service days, copied service days into it, then replaced outliers with the calculated upper limit. Winsorized service days was used in subsequent ANOVA and non-parametric tests. The lower limit was not applicable because there are no lower limit outliers less than 1 day,

because law enforcement cannot serve a warrant before it is issued. I applied the same transformations to each of the six county pair data sets.

Appendix B: Service Days Distribution contains histograms of Winsorized service days for all data sets. The histograms reveal the asymptotic shape of the warrant data with the highest number of warrants served just after issuance then declining steadily over days, weeks, and months. The distributions are extremely positively skewed.

An examination of all four sample's indicators for normal distribution yielded consistent results for all data sets. Table 7 contains skewness indicators, Kurtosis indicators, and Shapiro-Wilk significance indicators for all counties before and after Winsorizing. Every skewness value was well above zero, indicating a left-heavy positively skewed curve. All Kurtosis indicators were also above zero, indicating a higher than normal curve stacking around the mean. A Shapiro-Wilk Significance value above .05 indicates a normal distribution; however, all test data sets failed this normality test with a Shapiro-Wilk significance value of zero. In summary, all data samples were not normally distributed on the dependent variable service days. Histograms for each county are contained in Appendix C.

Table 7

Normal Distribution Indicators

	With Outliers			Winsorized		
County	Skewness	Kurtosis	Shapiro-Wilk Sig.	Skewness	Kurtosis	Shapiro-Wilk Sig.
A_0	2.401	6.996	.000	1.745	2.532	.000
A_1	1.781	2.992	.000	1.524	1.613	.000
A_2	2.401	6.996	.000	1.497	0.969	.000
B_0	2.938	9.739	.000	1.992	3.340	.000
B_1	3.165	12.524	.000	1.903	2.916	.000
B_2	2.260	5.729	.000	1.799	2.718	.000

Finally, I examined the samples for the homogeneity of variance assumption. Gamst, Meyers, and Guarino (2008, pp. 57-58) suggested that floor or ceiling effects, such as exists with warrants that cannot be served in less than a day, may cause large variance in the distribution of residual errors; thus violating the homogeneity of variance assumption. An SPSS Levene test for homogeneity of variance yielded a significance value of .000 for all four county pair data sets. Therefore, all pairs failed the homogeneity of variance assumption. This is attributed to the aforementioned lower floor limit of warrants.

Tables 8 and 9 contain means service days and standard deviations for county and county*case type, respectively.

Table 8

County Mean Service Days and Standard Deviations

County	MSD	Standard Deviation
A_0	106.01	129.20
A_1	138.05	122.54
A_2	50.12	65.93
B_0	66.57	94.50
B_1	62.95	86.79
B_2	104.75	132.69

Table 9

*Mean Service Days and Standard Deviations by County*Case Type*

	Circuit		Felony		Misdemeanor		Traffic	
County	MSD	Std. Dev.	MSD	Std. Dev.	MMSD	Std. Dev.	MSD	Std. Dev.
A_0	28.19	36.04	106.34	121.65	119.66	126.52	137.00	151.15
A_1	99.53	122.54	106.12	140.70	132.43	152.83	159.59	181.33
A_2	37.36	52.51	53.80	67.48	55.22	72.12	54.42	67.44
B_0	23.04	30.91	78.40	99.19	90.80	113.91	83.19	101.50
B_1	27.27	33.35	55.47	73.41	74.96	93.38	85.56	104.99
B_2	46.02	59.24	97.28	118.77	127.00	139.38	135.35	154.68

Standard deviations higher than the means are due to the long right curve tails, and suggest that many long service times remain after Winsorization. Appendix C contains histograms of Winsorized service days for each of the six subject counties. Table 8 highlights that each county had a high MSD and large standard deviation. For example, County A_0 had an MSD of 106.01 and a standard deviation of 129.20. Two standard deviations from the mean is almost a year (364 days) after warrant issue date.

All sample data sets failed assumptions of normal distribution and homogeneity of variance, even after transforming the outliers with Winsorization. Gamst, Meyers, and Guarino (2008) found that "ANOVA is considered to be quite resilient or robust to departures from normality" (Gamst et al., 2008, p. 56). This is especially true with large

sample sizes such as the data sets used in this study. Rutherford stated that “as sample size increases, test power increases and with large enough samples, virtually all tests will have sufficient power to reject the null hypothesis (2012). Therefore, one of the test assumptions is met (independence), another is mitigated by a large sample size (normal distribution), and a third assumption (homogeneity) failed. While this does not require wholesale rejection of ANOVA results, the accuracy of the findings is brought into question. Therefore, I performed additional non-parametric tests on MSD. Before I present non-parametric test results, I summarize the two-way ANOVA findings.

The results of the two-way ANOVA tests on MSD were mixed. A set of profile plots for each of the four county pairs depicting MSD for every case type is contained in Appendix D. The detailed ANOVA results are contained in Appendix F, and the results are summarized in Table 10. To aid in reader understanding, a three color coding convention is used in Table 10 and other similar results tables through the remainder of this study. Green favors the use of e-warrants, yellow does not favor the use of e-warrants, and blue means the results were not conclusive.

Table 10

Summary ANOVA Findings for Mean Service Days by County and Case Type

County Pair	County	County*Case Type			
		Circuit	Felony	Misde-meanor	Traffic
A_0A_1	No	No	NC	No	No
A_0A_2	Yes	NC	Yes	Yes	Yes
B_0B_1	Yes	NC	Yes	Yes	NC
B_0B_2	No	No	NC	No	No

Note. Yes/Green = favors use of e-warrants; No/Yellow = does not favor use of e-warrants; NC/Blue = not conclusive.

On county alone the results were evenly split; two sample pairs favored the use of e-warrants, and two did not. Sixteen tests of county*case type interactions resulted in five favoring e-warrants, six not favoring e-warrants, and five tests were not statistically significant.

Non-parametric tests for mean service days. The evenly mixed results of the two-way ANOVA tests, suggests that other confounding factors may exist in the four agency pairs. As discussed in relation to data outliers earlier in this section, some of the same factors may be in play with MSD:

1. Subjects moving or evading to avoid arrest
2. Agency, court, and legislative public safety priorities
3. Limited law enforcement budgets and/or resources

4. Political will

In an effort to mitigate potential unknown confounding factors, I decided to combine the warrant data from the two e-warrant agencies in each group and compare the merged data with the base (non-e-warrant) agency in the group. This resulted in reducing four groups to two. Group A contained data from counties A_0, A_1, and A_2. Group B contained data from counties B_0, B_1, and B_2. Each new group contains three counties with very similar populations.

To prepare the data for non-parametric testing, I added a data column, E-Warrant Flag, and populated it with "Y" and "N" values, based on the county warrant system type. Tables 11 and 12 contain means and standard deviations for groups and case types, respectively.

Table 11

MSD, Median, and Standard Deviations by Group

Group	E-Warr. Flag	MSD	Median	Std. Dev.
A	N	106.01	59.00	129.203
	Y	114.83	49.00	148.802
B	N	66.57	23.00	94.496
	Y	85.95	34.00	116.209

Note. Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

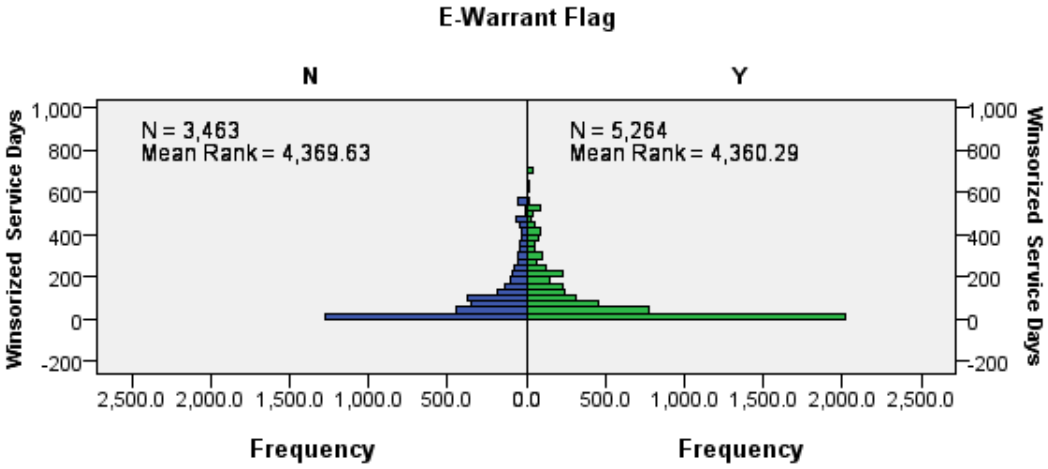
Table 12

*MSD, Median, and Standard Deviation by Group*Case Type*

Group	E-Warr. Flag	MSD	Median	Std. Dev.
		Circuit		
A	N	28.19	12.00	36.04
	Y	72.15	27.00	102.76
B	N	23.04	7.00	30.91
	Y	37.70	14.00	50.30
		Felony		
A	N	106.34	60.00	121.65
	Y	91.82	33.50	127.08
B	N	78.40	28.00	99.19
	Y	74.05	29.00	98.24
		Misdemeanor		
A	N	119.66	76.00	126.52
	Y	114.40	54.00	142.05
B	N	90.80	41.00	113.91
	Y	102.39	49.50	122.56
		Traffic		
A	N	137.00	84.00	151.15
	Y	136.36	62.00	168.89
B	N	83.19	37.00	101.50
	Y	114.87	54.00	138.57

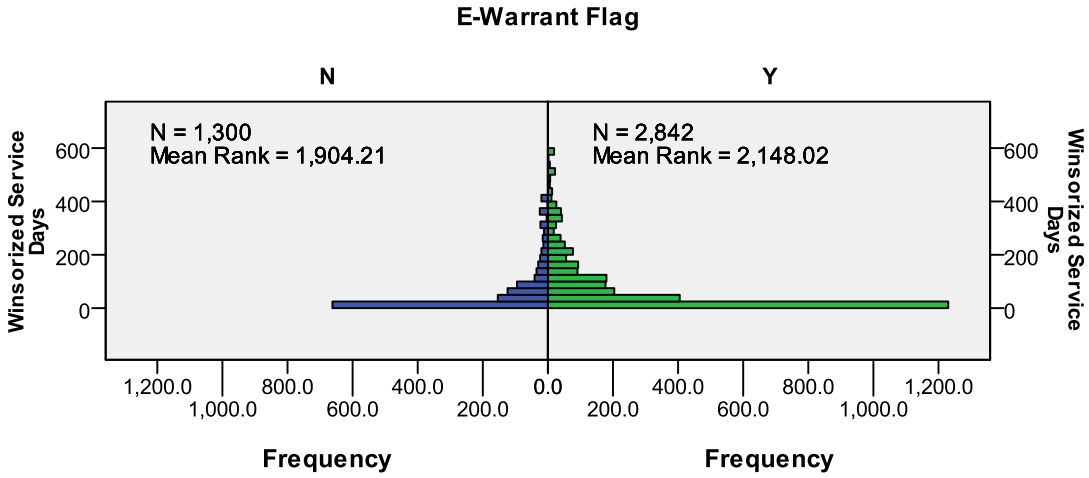
Note. Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

Next, I ran SPSS non-parametric tests for independent data samples. The non-parametric testing is limited to continuous variables; therefore, only Winsorized service days was tested. The categorical variable case type and the interaction of Winsorized service days*case type could not be tested using this method. Based on the sample data set, I executed a Mann-Whitney U Test in SPSS. Group A had N equal to 8,727, and Group B had N equal to 4,142. The Mann-Whitney U Test has only two required assumptions, which are both met in this study: (a) the samples must be random samples from the two populations; and (b) the samples are drawn independently of each other (Aczel & Sounderpandian, 2009, p. 633). The test results for groups A and B are shown in Figure 7 and Figure 8, respectively.



Total N	8,727
Mann-Whitney U	9,095,103.000
Wilcoxon W	22,952,583.000
Test Statistic	9,095,103.000
Standard Error	115,138.088
Standardized Test Statistic	-.169
Asymptotic Sig. (2-sided test)	.865

Figure 7. Group A independent samples Mann-Whitney U Test results.



Total N	4,142
Mann-Whitney U	2,064,772.500
Wilcoxon W	6,104,675.500
Test Statistic	2,064,772.500
Standard Error	35,709.367
Standardized Test Statistic	6.090
Asymptotic Sig. (2-sided test)	.000

Figure 8. Group B independent samples Mann-Whitney U Test results.

Hypotheses Findings and Research Questions Results: Mean Service Days

The two research questions of this study involving the independent variable service days were:

1A. To what extent does the use of electronic warrant systems result in shorter MSD than the use of legacy paper-based warrant systems?

2A. How does the MSD compare between the two systems for each case type?

Two-way ANOVA test results using three county pairs. Based on the partially deprecated ANOVA results, the null hypothesis Ho_{1A} is rejected and the alternate hypothesis Ha_{1A} is supported at the 95% confidence level for all four county pairs. Results of research question 1A are mixed. County pairs A_0A_2 and B_0B_1 favor the use of e-warrants to reduce warrant service time; however, pairs A_0A_1 and B_0B_2 had longer service times with e-warrants. Table 10 contains results of the two-way ANOVA for all four county pairs, and complete detailed two-way ANOVA test results are contained in Appendix F.

Mann-Whitney U test results using two groups of three counties. The results of the Mann-Whitney U tests on the two combined three-county groups are split as shown on Figures 7 and 8. Group A results indicate that the null hypothesis should not be rejected (does not support the alternate) with an asymptotic significance of .865. For Group A, the answer to research question 1A is that MSD in the e-warrant county is not significantly different than the non-e-warrant counties.

Group B results suggest that the distributions are different with a significance level of .000. The null hypothesis for group B is rejected, and the alternative hypothesis is

supported. The answer to research question 1A is that the MSD for the e-warrant counties is 19 days longer than the base county with a similar population. Thus e-warrant systems in the Group B test sample are less efficient than less sophisticated systems.

Study Results: Percent Warrants Served

Two-factor ANOVA assumption tests: Percent warrants served. PWS is referred to in criminal justice circles as the "warrant clearance rate", and it is a commonly used measure of law enforcement performance with arrest warrants. PWS is a computed dependent variable that was not directly provided by the state court data source. Thus, I computed PWS for each county and for each case type*county combination prior to evaluating assumptions for the two-way ANOVA. Because these percentages were assigned to each warrant record in the county or case type/county combination, the ANOVA assumptions were not met: (a) the independence of errors is not applicable; (b) the data are not normally distributed; and (c) homogeneity of variance, while 100% homogeneous was not applicable. Since all three assumptions are not met, the ANOVA test results were not defensible; therefore, ANOVA test results are shown only in Appendix G, and it was necessary to resort to alternative non-parametric tests for the difference of the two proportions. I selected two different statistical methods to compare proportions between independent samples: a large sample Z-test for the difference between two population proportions; and a Pearson Chi-Square Test.

Large sample Z-test for the difference between two population proportions: Percent warrants served. The only assumption for this test is that the two independent samples are large. This assumption is met because the smallest population in both groups

A and B is 1,642. I used the same two combined county groups that were assembled in the Mann-Whitney U Tests for MSD, Group A and Group B, as. Group A contained data from counties A_0, A_1, and A_2. Group B contained data from counties B_0, B_1, and B_2. A Microsoft Excel template was used to compute the test statistics shown in Table 13. The Excel template was provided as a companion tool for the textbook *Complete Business Statistics* (Aczel & Sounderpandian, 2009).

Table 13

Results of Large Sample Z-Test for the Difference Between Two Population Proportions

Group		E-Warrant Flag = N	E-Warrant Flag = Y
A	Size	4,422	8,884
	Served	3,463	5,264
	Proportion	0.7831	0.5925
B	Size	1,642	4,183
	Served	1,300	2,842
	Proportion	0.7917	0.6794

Note. Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

Group A had a pooled p-hat of 0.6559 and a test statistic (Z) of 21.7997. Group B had a pooled p-hat of 0.7111 and a test statistic of 8.5077. Both group z-statistics fall to the right of the rejection region for $\alpha = .01$ (2.575) on the Z-distribution curve; therefore,

both null hypotheses are rejected at the 99% confidence level with p-value of 0.0000, which supports the alternate hypotheses that the PWS are not equal in both test groups.

Pearson Chi-square test for equality of proportions: Percent warrants served. The Pearson Chi-square test of homogeneity is used to test for a difference in proportions on two categorical variables in two or more independent samples (Franke, Ho, & Christie, 2012, p. 451). The only assumption for a Chi-square test is that the expected count in every cell is at least 5 (Aczel & Sounderpandian, 2009, p. 665). This assumption is met for all samples in this study. The Chi-square test is suited for comparing e-warrant flag and case type. The same groups A and B that were used in the Mann-Whitney U-Test and the large sample Z-test were used for this test. The results of the Chi-square tests for both groups with all case types combined are displayed in Table 14.

Table 14

Results of Chi-Square Test for All Case Types

Group	E-Warrant Flag		Warrant Served Flag = N	Warrant Served Flag = Y	Total
A	N	Count	959	3463	4422
		Expected Count	1521.7	2900.3	4422.0
		% within E-Warr. Flag	21.7%	78.3%	100%
		% of Total	7.2%	26.0%	33.2%
	Y	Count	3620	5264	8884
		Expected Count	3057.3	5826.7	8884.0
		% within E-Warr. Flag	40.7%	59.3%	100.0%
		% of Total	27.2%	39.6%	66.8%
	Total	Count	4579	8727	13306
		Expected Count	4579.0	8727.0	13306.0
		% within E-Warr. Flag	34.4%	65.6%	100%
		% of Total	34.4%	65.6%	100.0%
B	N	Count	342	1300	1642
		Expected Count	474.4	1167.6	1642.0
		% within E-Warr. Flag	20.8%	79.2%	100.0%
		% of Total	5.9%	22.3%	28.2%
	Y	Count	1341	2842	4183
		Expected Count	1208.6	2974.4	4183.0
		% within E-Warr. Flag	32.1%	67.9%	100.0%
		% of Total	23.0%	48.8%	71.8%
	Total	Count	1683	4142	5825
		Expected Count	1683.0	4142.0	5825.0
		% within E-Warr. Flag	28.9%	71.1%	100.0%
		% of Total	28.9%	71.1%	100.0%

Note. Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

The Group A computed value of the Pearson Chi-Square statistic is 475.229 with one degree of freedom. This value is greater than the rejection value of 6.63490 on the Chi-Square distribution with 1 degree of freedom and an asymptotic significance level of .000. Therefore, the null hypothesis is rejected and conclude that the proportions are not equal.

The Group B computed value of the Pearson Chi-Square statistic is 72.382 with one degree of freedom. This value is greater than the rejection value of 6.63490 on the Chi-Square distribution with 1 degree of freedom and an asymptotic significance level of .000. Therefore, we reject the null hypothesis that the proportions are equal and conclude that the proportions are not equal.

Next I ran Chi-square tests by case type. Tables 15, 16, 17, and 18 contain results of the Chi-square tests by case type within groups.

Table 15

Results of Chi-Square Test by E-Warrant Flag and Case Type = Circuit

Group	Case Type	E-Warrant Flag		Warrant Served Flag = N	Warrant Served Flag = Y	Total
A	Circuit	N	Count	33	658	691
			Expected Count	141.6	549.4	691.0
			% within E-Warr. Flag	4.8%	95.2%	100%
			% of Total	1.8%	34.9%	36.7%
		Y	Count	353	840	1193
			Expected Count	244.4	948.6	1193.0
			% within E-Warr. Flag	29.6%	70.4%	100.0%
			% of Total	18.7%	44.6%	63.3%
		Total	Count	386	1498	1884
			Expected Count	386	1498	1884
			% within E-Warr. Flag	20.50%	79.50%	100.00%
			% of Total	20.50%	79.50%	100.00%
B	Circuit	N	Count	11	387	398
			Expected Count	57.5	340.5	398
			% within E-Warr. Flag	2.80%	97.20%	100.00%
			% of Total	0.80%	27.60%	28.30%
		Y	Count	192	814	1006
			Expected Count	145.5	860.5	1006
			% within E-Warr. Flag	19.10%	80.90%	100.00%
			% of Total	13.70%	58.00%	71.70%
		Total	Count	203	1201	1404
			Expected Count	203	1201	1404
			% within E-Warr. Flag	14.50%	85.50%	100.00%
			% of Total	14.50%	85.50%	100.00%

Note. Degree of freedom = 1; Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

Table 16

Results of Chi-Square Test by E-Warrant Flag and Case Type = Felony

Group	Case Type	E-Warrant Flag		Warrant Served Flag = N	Warrant Served Flag = Y	Total
A	Felony	N	Count	89	430	519
			Expected Count	148.7	370.3	519
			% within E-Warr. Flag	17.10%	82.90%	100.00%
			% of Total	8.40%	40.80%	49.20%
		Y	Count	213	322	535
			Expected Count	153.3	381.7	535
			% within E-Warr. Flag	39.80%	60.20%	100.00%
			% of Total	20.20%	30.60%	50.80%
		Total	Count	302	752	1054
			Expected Count	302	752	1054
			% within E-Warr. Flag	28.70%	71.30%	100.00%
			% of Total	28.70%	71.30%	100.00%
B	Felony	N	Count	39	171	210
			Expected Count	56.3	153.7	210
			% within E-Warr. Flag	18.60%	81.40%	100.00%
			% of Total	7.20%	31.60%	38.80%
		Y	Count	106	225	331
			Expected Count	88.7	242.3	331
			% within E-Warr. Flag	32.00%	68.00%	100.00%
			% of Total	19.60%	41.60%	61.20%
		Total	Count	145	396	541
			Expected Count	145	396	541
			% within E-Warr. Flag	26.80%	73.20%	100.00%
			% of Total	26.80%	73.20%	100.00%

Note. Degree of freedom = 1; Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

Table 17

Results of Chi-Square Test by E-Warrant Flag and Case Type = Misdemeanor

Group	Case Type	E-Warrant Flag		Warrant Served Flag = N	Warrant Served Flag = Y	Total
A	Misdmnr.	N	Count	361	1300	1661
			Expected Count	519.3	1141.7	1661
			% within E-Warr. Flag	21.70%	78.30%	100.00%
			% of Total	7.40%	26.70%	34.10%
		Y	Count	1163	2051	3214
			Expected Count	1004.7	2209.3	3214
			% within E-Warr. Flag	36.20%	63.80%	100.00%
			% of Total	23.90%	42.10%	65.90%
		Total	Count	1524	3351	4875
			Expected Count	1524	3351	4875
			% within E-Warr. Flag	31.30%	68.70%	100.00%
			% of Total	31.30%	68.70%	100.00%
B	Misdmnr.	N	Count	103	327	430
			Expected Count	129.6	300.4	430
			% within E-Warr. Flag	24.00%	76.00%	100.00%
			% of Total	6.30%	20.00%	26.30%
		Y	Count	390	816	1206
			Expected Count	363.4	842.6	1206
			% within E-Warr. Flag	32.30%	67.70%	100.00%
			% of Total	23.80%	49.90%	73.70%
		Total	Count	493	1143	1636
			Expected Count	493	1143	1636
			% within E-Warr. Flag	30.10%	69.90%	100.00%
			% of Total	30.10%	69.90%	100.00%

Note. Degree of freedom = 1; Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

Table 18

Results of Chi-Square Test by E-Warrant Flag and Case Type = Traffic

Group	Case Type	E-Warrant Flag		Warrant Served Flag = N	Warrant Served Flag = Y	Total
A	Traffic	N	Count	476	1075	1551
			Expected Count	668.3	882.7	1551
			% within E-Warr. Flag	30.70%	69.30%	100.00%
			% of Total	8.70%	19.60%	28.20%
		Y	Count	1891	2051	3942
			Expected Count	1698.7	2243.3	3942
			% within E-Warr. Flag	48.00%	52.00%	100.00%
			% of Total	34.40%	37.30%	71.80%
		Total	Count	2367	3126	5493
			Expected Count	2367	3126	5493
			% within E-Warr. Flag	43.10%	56.90%	100.00%
			% of Total	43.10%	56.90%	100.00%
B	Traffic	N	Count	189	415	604
			Expected Count	226.6	377.4	604
			% within E-Warr. Flag	31.30%	68.70%	100.00%
			% of Total	8.40%	18.50%	26.90%
		Y	Count	653	987	1640
			Expected Count	615.4	1024.6	1640
			% within E-Warr. Flag	39.80%	60.20%	100.00%
			% of Total	29.10%	44.00%	73.10%
		Total	Count	842	1402	2244
			Expected Count	842	1402	2244
			% within E-Warr. Flag	37.50%	62.50%	100.00%
			% of Total	37.50%	62.50%	100.00%

Note. Degree of freedom = 1; Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

The results were uniformly consistent with the results of the test with all case types. The computed Chi-square statistics are contained in Table 19. All eight Chi-square statistics are greater than the rejection value of 6.63490 on the Chi-Square distribution with 1 degree of freedom and an asymptotic significance level of .000. Therefore, the null hypothesis is rejected for every case type in both groups.

Table 19

Chi-Square Statistics by Group and Case Type

Group	Case Type	Chi-Square	df	Asymp. Sig. (2-sided)
A	Circuit	165.379	1	.000
	Felony	66.197	1	.000
	Misdmnr.	106.429	1	.000
	Traffic	135.542	1	.000
	Total	475.229	1	.000
B	Circuit	61.424	1	.000
	Felony	11.852	1	.000
	Misdmnr.	10.585	1	.000
	Traffic	13.687	1	.000
	Total	72.382		

Note. Green = favors use of e-warrants; Yellow = does not favor use of e-warrants; Blue = not conclusive.

Hypotheses Findings and Research Questions Results: Percent Warrants Served

The two research questions of this study concerning the independent variable percent warrants served were:

1B. To what extent does the use of electronic warrant systems result in greater PWS than the use of legacy paper-based warrant systems?

2B. How does the PWS compare between the two systems for each case type?

Null hypothesis Ho_{1B} is rejected and the alternate hypothesis is supported at the 99% confidence level for Group A and Group B. Results of research questions 1B and 2B for both county groups indicate that the non-e-warrant county in each pair has a higher (better) PWS than the paired e-warrants county in aggregate and by case type.

Summary

This quantitative study tested two null hypotheses on dependent variable MSD, and it tested two null hypotheses on the dependent variable PWS.

Results of research questions 1A and 2A on the effects of county and county*case type, respectively, on the dependent variable MSD were mixed. The partially deprecated two-way ANOVA test results were evenly split on question 1A, and the results were mixed and inconclusive on question 2A.

Results of the non-parametric Mann-Whitney U Tests on Winsorized service days yielded different results for Group A and Group B. For Group A, the answer to research question 1A is that MSD in the e-warrant county is not significantly different than the non-e-warrant counties. The answer to research question 1A for Group B; however, is that the MSD for the e-warrant counties is 19 days longer than the base county with a similar population. Thus e-warrant systems in the Group B test sample were less efficient than less sophisticated systems. Question 2A regarding case type was not addressed by the Mann-Whitney U test due to a continuous factor requirement.

Results of research questions 1B and 2B on the effects of county and county*case type on the second dependent variable percent warrants served are summarized in Table 20. This set of 20 Z-tests and Chi-square tests uniformly showed better warrant service performance in counties not using e-warrants.

Table 20

Summary Findings for Percent Warrants Served

County Group	County	County*Case Type			
		Circuit	Felony	Misde-meanor	Traffic
A	No	No	No	No	No
B	No	No	No	No	No

Note. Yes/Green = favors use of e-warrants; No/Yellow = does not favor use of e-warrants; NC/Blue = not conclusive.

This chapter provided the results of this research study. The four research questions were answered using two-way ANOVA, non-parametric tests, and descriptive statistics. An interpretation of the findings, a discussion of research limitations, recommendations for further research, and the implications of social change are contained in Chapter 5.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The stakes are high for positive social change when wanted persons are brought to justice quickly before subjects can commit further crimes against the public. I designed this research study to investigate the public safety value of e-warrant systems. The U.S. Government and criminal justice groups have recommended e-warrant systems to law enforcement agencies for many years without supporting empirical evidence. Using dependent variables MSD and PWS, I sought to measure the effects of these advanced warrant systems against more traditional, predominantly paper-based and independent warrant systems. The specific problem was that the factors related to electronic warrant systems improving safety were not understood, and there was a paucity of scholarly evidence in support of e-warrant systems. This study was the first study designed to confirm or disconfirm the effectiveness of e-warrant systems.

The findings of this study are a mixture of expected results, unexpected results, and evidence that warrant service effectiveness may be affected by factors not explored in this study. The results of MSD were split evenly on the four sample data sets. Also, the results of a deeper examination of MSD by county and case type was split with six not favoring e-warrants and five favoring e-warrants. The analysis of PWS favored the non-e-warrant county in both test groups.

Interpretation of Findings

This study of e-warrant efficacy was the first known of its kind in the scientific literature. Test results suggest that the clearance rate the base counties without e-warrants

out-performed the counties with e-warrants for every case type. This was not expected, especially given that law enforcement officers value the safety benefits from immediate and multi-jurisdiction warrant information. Further exploration into this phenomenon is needed to find what other key factors may be at work in the subject counties. One potential factor is the degree of e-warrant system adoption and exploitation. It is not known how the county sheriff's departments, whose warrant data were examined in this study, used the new system. For example, the new system may have fully replaced a legacy system and manual processes or it may have been used primarily for state reporting purposes. It is also possible that prior to adopting the e-warrant system, record keeping was inaccurate or incomplete. The state court organization that provided the historical data for this study did not provide qualitative information about the nature of county warrant processes, other local systems in use, interfaces, and system architectures.

Data quality and completeness are areas of concern. A further investigation is indicated to verify that all warrant records were included in the samples received and that the state reporting process did not filter out certain types of served or unserved warrants that could explain the one-sided and counter-intuitive results on PWS. For example, if some served warrants were excluded from the data extracts, the e-warrant statistics would be negatively impacted. A review of the state's warrant data collection process is needed to aid in understanding the results of this study, which partially favored legacy systems over e-warrant systems, which is counter-intuitive, as e-warrants are known to be more effective in practice.

The original research design involved just two counties, one non-e-warrant basis county and one e-warrant county. Once it became known that the data were available for many counties within a single state, I expanded the design to two basis counties and four e-warrant counties to improve reliability. In the final analysis this design expansion may have highlighted an inconclusive finding in the case of dependent variable MST. If the research had been limited to any of the four single county pairs, for example (see Table 10), the findings would have been much different. Pairs A_0A_1 and B_0B_2 would have not supported e-warrants, while pairs A_0A_2 and B_0B_1 would have supported e-warrants. But, by analyzing four pairs instead of one pair, a more consistent result was expected; however, a strong conclusion in either direction is not supported. This suggests that other factors exist within the agencies that strongly impact MST besides the independent variables WST (county) and case type.

Limitations of the Study

The pair-wise examination of six samples from similar-sized counties, while sound in design and purpose, did not yield conclusive evidence of improved warrant service dependent variables. Even after combining counties into two similar population groups of three counties each, the results were mixed in the case of MSD. The data samples of 2 full years of warrants-- thousands of records should have been more than adequate to expose any major systems impacts on the dependent variables, if all other factors were the same. The results suggest that other factors besides the warrant tracking system in use may have an important effect on an agency's warrant service as shown by clearance rate (PWS) and MST.

The limitations of this study; therefore, are related to the scope of the study design:

1. The study did not examine individual county warrant data before and after transitioning to the new e-warrant system. As a result, it is not known how adoption of e-warrants affected warrant service in each county.
2. This study did not account for unknown organizational warrant process differences between study counties—differences that may have significantly affected warrant service.
3. The quality of sample data sets, especially completeness and accuracy are not well qualified. For example, if the sample data sets did not include all warrants of a certain category or status, the results might be significantly affected.

The next section describes recommendations for future e-warrant research that address the limitations of this study.

Recommendations

This section outlines three recommendations for follow-on research to further explore the research questions while addressing the limitations of this study.

First, the inconclusive evidence on MST and counterintuitive PWS results of this pair-wise county comparison punctuates the need for a time-based study of individual counties before and after e-warrant system adoption. There are many potential environmental and organizational factors that distinguish counties from each other; therefore, a linear time study of individual counties before and after e-warrants may

expose the direct effects of e-warrants and other factors that may improve e-warrant system results. The goal of this type of study would be to eliminate the effects of environmental and procedural differences between agencies not accounted for in this study, and which may have had a significant impact on warrant service results. A follow-on study of the four e-warrant counties A_1, A_2, B_1, and B_2 would be a logical choice, with a time frame of 2 years—1 year before the new system and 1 year after startup of the new system, could demonstrate meaningful warrant service performance transformations.

The second recommendation is a follow-on qualitative investigation of each of this study county's warrant processes, system architecture, and interfaces. Current process models of the six subject counties may reveal significant differences in manual and automated processes. Interviews with key sheriffs' office staff and IT personnel in each county are needed to develop comparative process models. The goal of this research would be to identify potential new independent variables that could be empirically tested as determinants of MSD and PWS. Unfortunately, an in-depth study of the subject warrant systems was not practical within the scope of this research, and the court organization that provided data was not privileged to this information.

The third and final recommendation for further research is an in-depth examination of the data collection process used by the state court system that provided data for this study. The objective of this research would be to identify any potential threats to data quality or completeness. A technical review of system interfaces and an end-to-end examination of warrant record creation through final disposition is needed. If

errors or omissions are discovered that can be corrected, then some or all of the individual tests could be repeated using corrected data.

This study was designed to first compare results of all warrant types across similar-sized counties then drill down by case types. Because the county-wide results were inconclusive on the dependent variable MSD, future research should again seek to identify differences by case type. For example, if clearance rates for serious felonies were shown to improve with e-warrants, the positive impact to public safety would be significant. As the e-warrant body of knowledge advances beyond this research, future studies should focus on warrants for serious crimes because of the greater potential impact to public safety.

The EWM^2 provides a starting foundational framework for assessing the maturity level of warrant systems. A further investigation into the subject counties in this study is needed to collect qualitative information about agency warrant processes, how the new e-warrant system is used, and any ongoing dependencies that may exist on a legacy warrant system, possibly impacting the utility of the new system. This type of research may lead to a revision of the feature list and/or a refinement of the model's maturity levels. A revised EWM^2 would inform the design of follow-up studies on e-warrant efficacy.

Another aspect of electronic warrants not directly tested in this study is the effect of out-of-county arrests made more likely by electronic warrant information sharing. Interagency sharing is a principle tenet of e-warrants. Sharing warrant information with other law enforcement agencies is a key feature of level 3 in the proposed EWM^2. If

warrants are quickly and passively shared across jurisdictional boundaries (municipalities, counties, states, tribes, federal agencies, etc.), more warrants should be served in shorter time. A study to investigate this factor would require warrant files containing a serving agency identifier or two simple out-of-county service flags, one for local warrant served out of county and one for other agency warrant served in county. When I collected data for this study, I inquired at the state court's IT department if this data were available, but I was informed that it was not available. The suggestion for follow-on examination of the data collection process described earlier in this section might reveal a possible source for jurisdictional service data.

Implications

The primary implication of this study is that counties seeking to improve warrant clearance rates and service times should examine their internal warrant processes and organizational limitations for areas that need improvement, and consider implementing a e-warrant system to seek further performance improvements. This study produced no consistent evidence to suggest that similar-sized counties affected arrest performance by adoption of an e-warrant system. Adopting an e-warrant system without first examining other non-IT factors may not result in better clearance rates or service times. For example, the most sophisticated e-warrant system cannot improve arrest rates if the agency suffers from a lack of personnel dedicated to locating and arresting warrant subjects. A balance of internal process improvements and information system improvements is recommended.

Conclusions

The practical knowledge of improved public safety through intelligent application of electronic warrant information technology remain unproven by scientific study. Although in practice e-warrant systems are more effective than legacy warrant systems, the results of this study indicated that there are some areas that need improvement. More research is needed to identity other variables that impact the outcomes of e-warrant systems. Criminal justice practitioner-leaders in the public sector need to make management decisions based on proven performance. This study opened the door on research that may eventually provide definitive evidence for the advantages of e-warrant systems. However, further study is needed to support or discredit the effects of advanced electronic warrant tracking systems. This first study of this kind did not support or discredit the use of e-warrant systems for effect on MSD, and it revealed an unexpected bias against e-warrants on PWS in both study groups, a result that also requires further investigation to explain or discredit this finding.

This research has shown that other factors besides e-warrant systems and case type determine warrant performance in similar-sized county agencies. For sheriffs and criminal justice practitioners in the United States, a best practice recommendation is to ensure that the everyday manual processes related to serving warrants are operating efficiently before committing to new information systems. Agencies should look for improvements in warrant service policies, staffing levels, and financing to improve warrant clearance rates and times. Further research outlined in this chapter is designed to identify specific nonsystem factors that determine warrant service performance and a

better understanding of transformative information system impacts within a single agency. Although e-warrant systems have resulted in positive social change over paper-based legacy systems, further research is needed to identify the specific performance factors that could improve these systems for greater positive social change.

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Appendix A: Outliers

This appendix contains SPSS output box plot figures of service days for each County. These plots include all outliers prior to Winsorization.

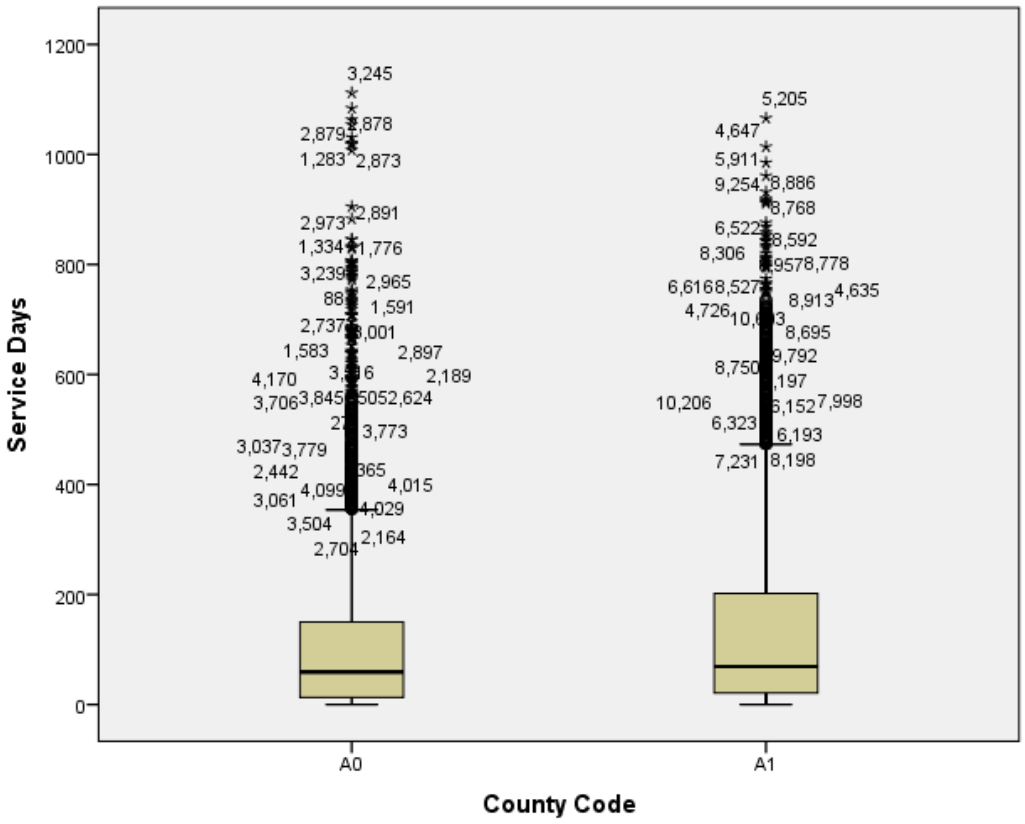

Figure A1. County pair A_0A_1 service days box plots.

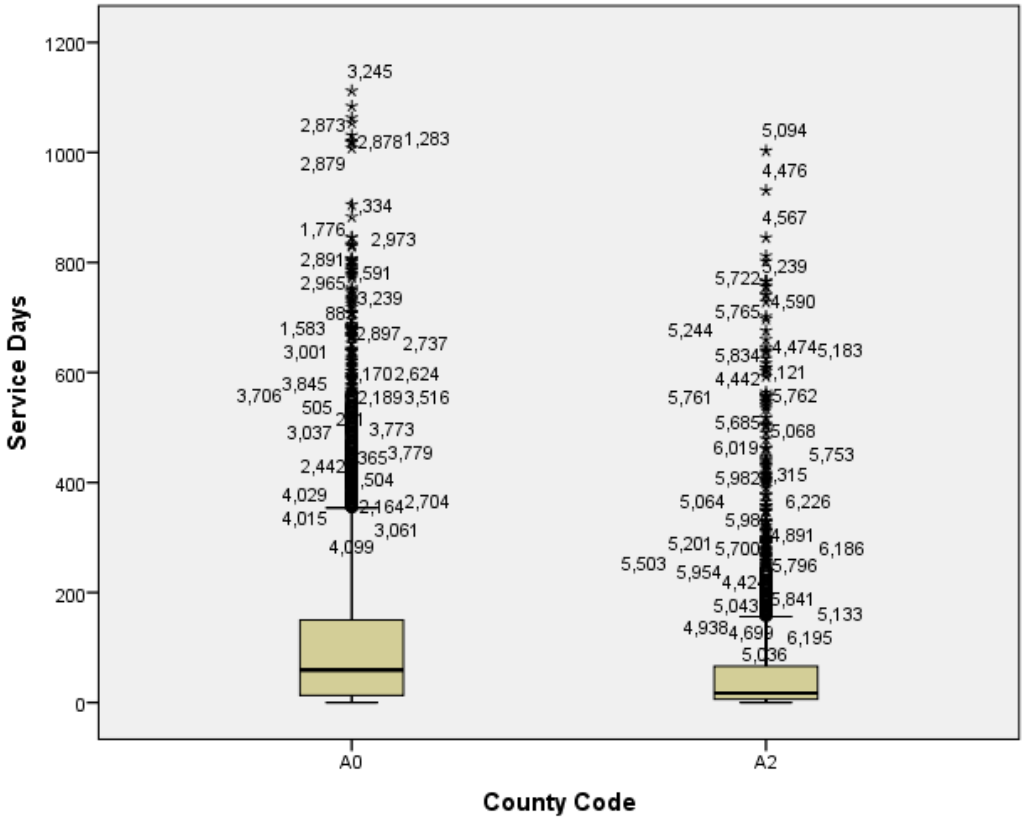

Figure A2. County pair A_0A_2 service days box plots.

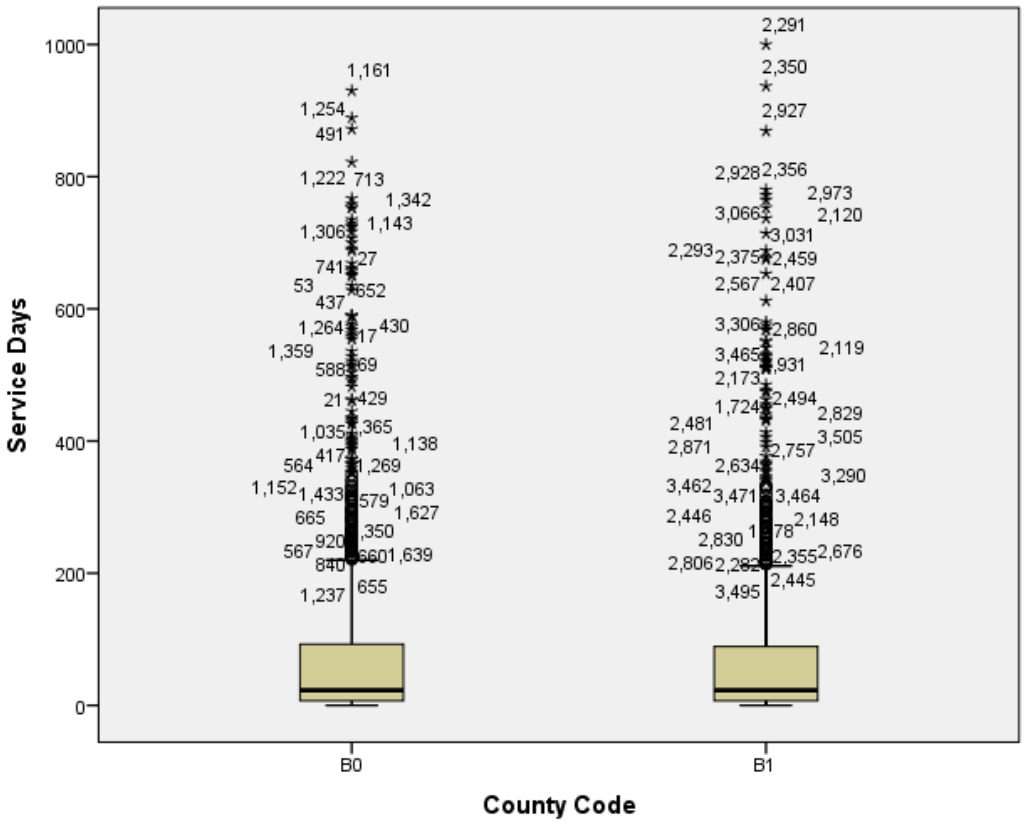

Figure A3. County pair B_0B_1 service days box plots.

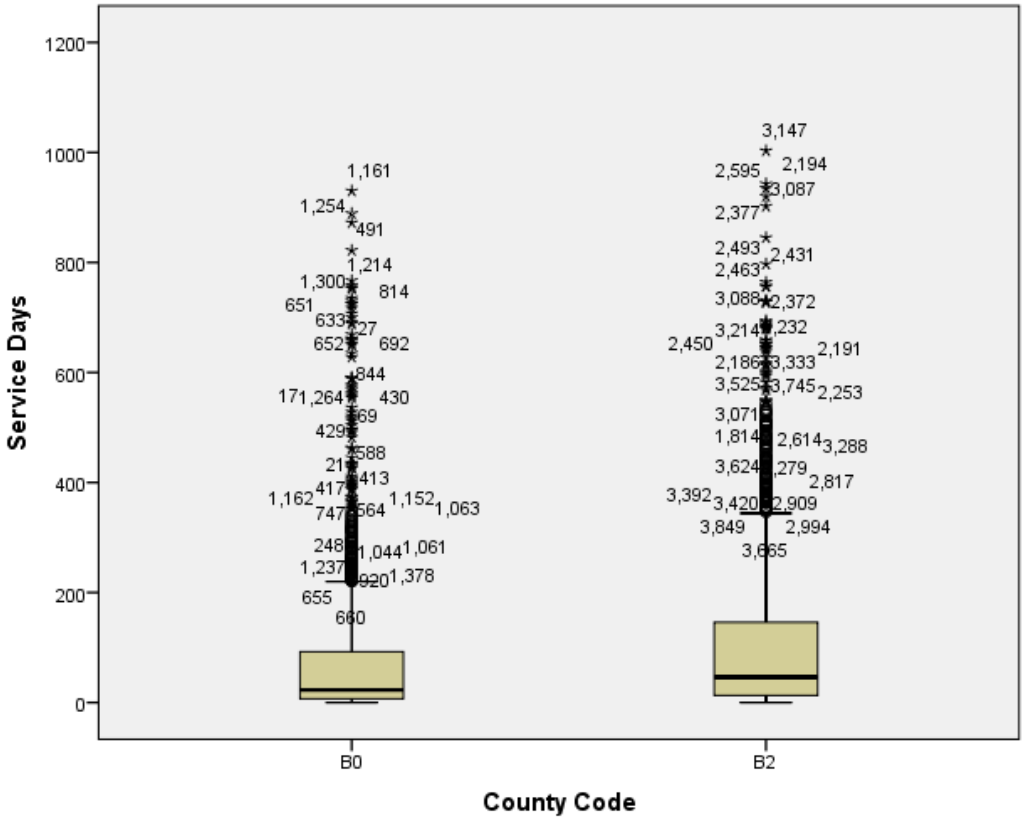

Figure A3. County pair B_0B_2 service days box plots.

Appendix B: Service Days Distribution (Winsorized)

This appendix contains SPSS output Quantile-Quantile plots of service days vs. normal distribution for each county.

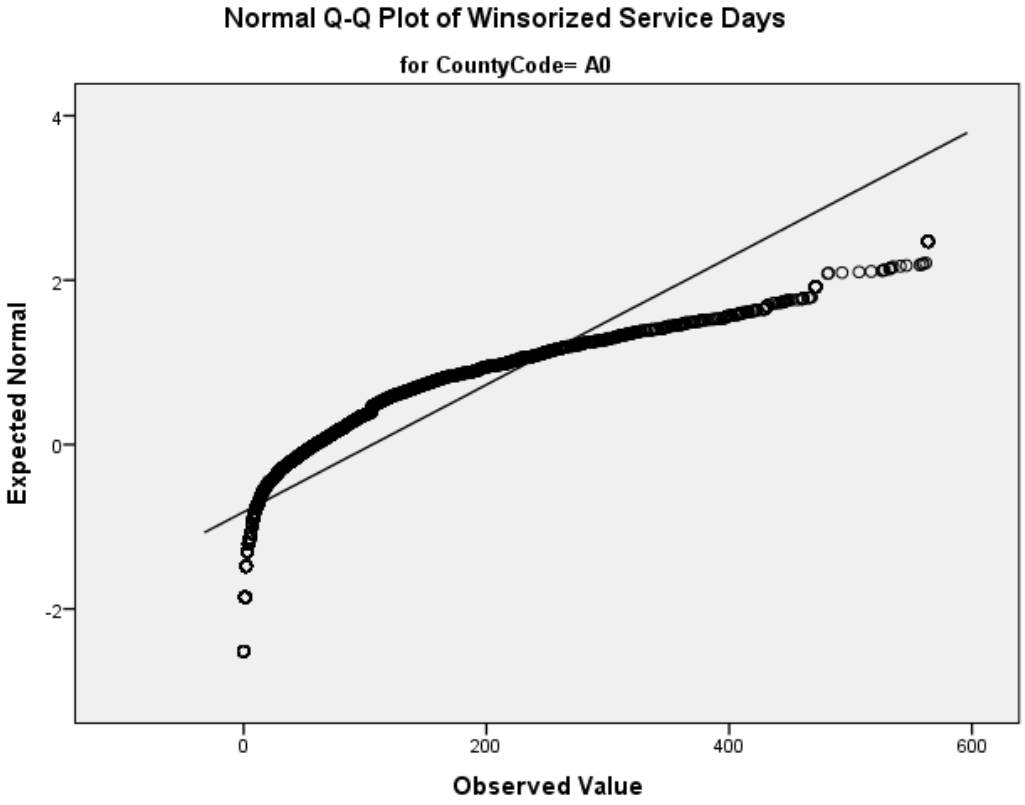

Figure B1. County A_0 service days (Winsorized) vs. normal curve.

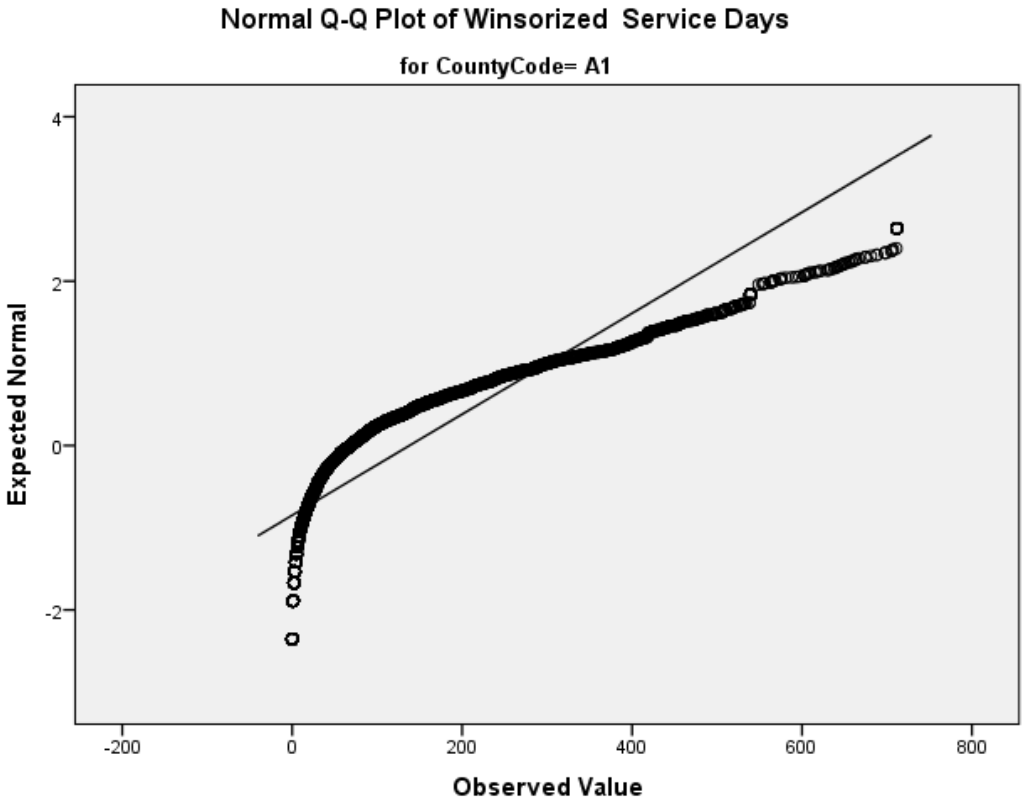

Figure B2. County A_1 service days (Winsorized) vs. normal curve.

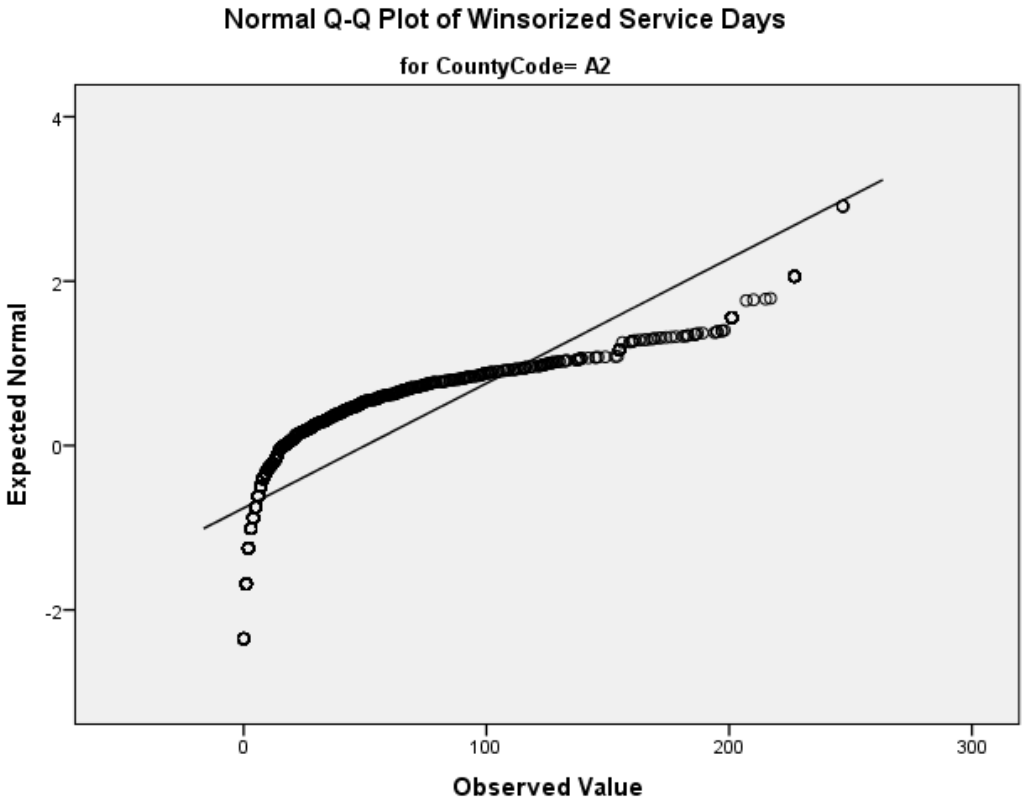

Figure B3. County A_2 service days (Winsorized) vs. normal curve.

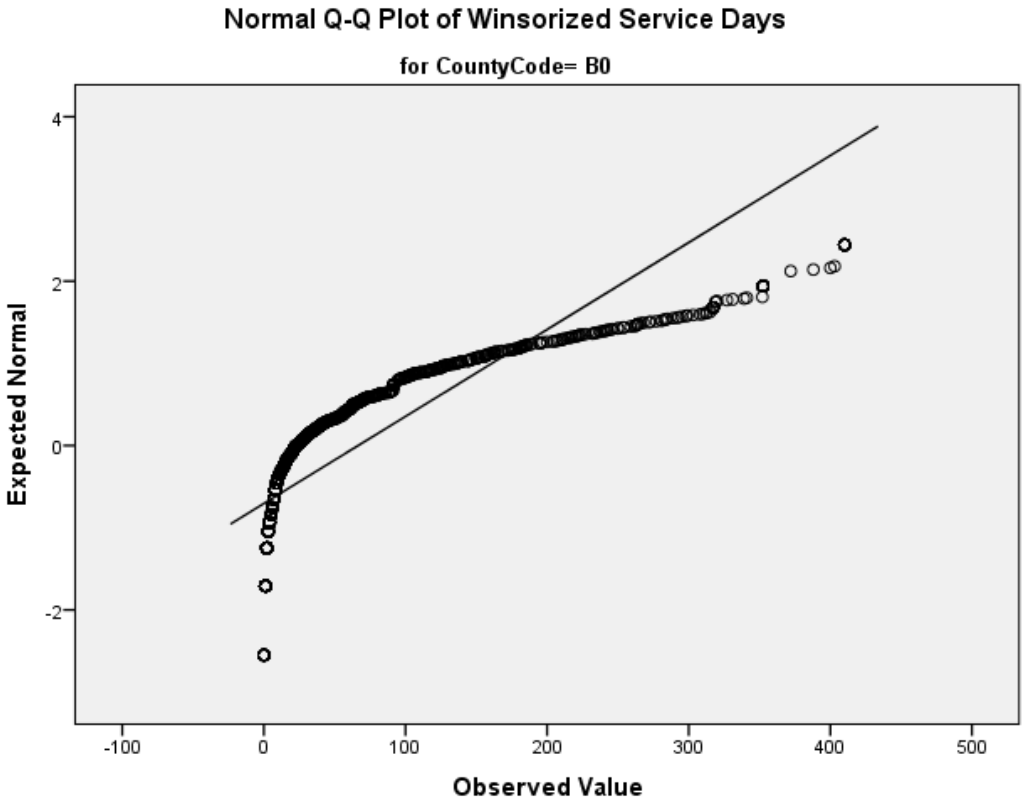

Figure B4. County B_0 service days (Winsorized) vs. normal curve.

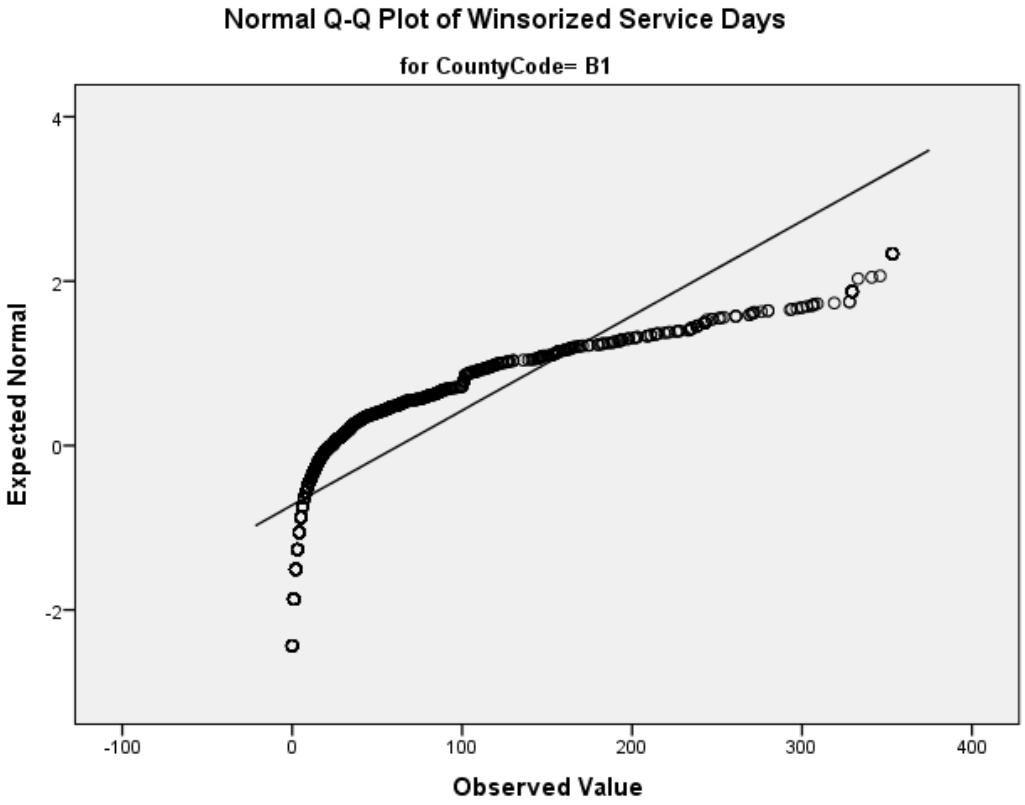

Figure B5. County B_1 service days (Winsorized) vs. normal curve.

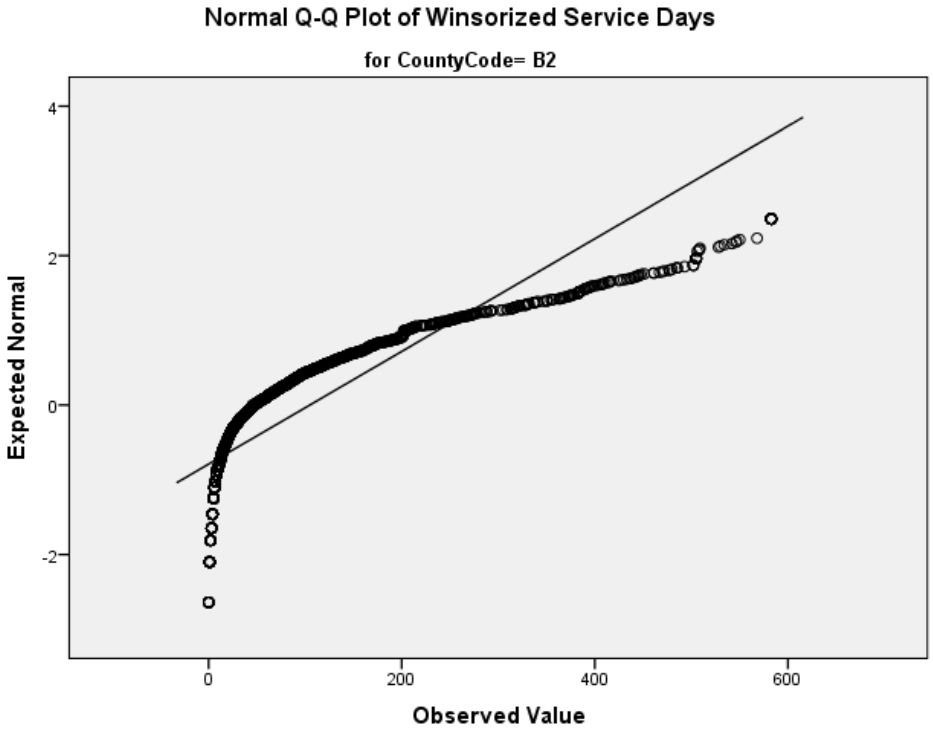

Figure B6. County B_2 service days (Winsorized) vs. normal curve.

Appendix C: Service Days Histograms (Winsorized)

This appendix contains SPSS histograms for each county after Winsorization.

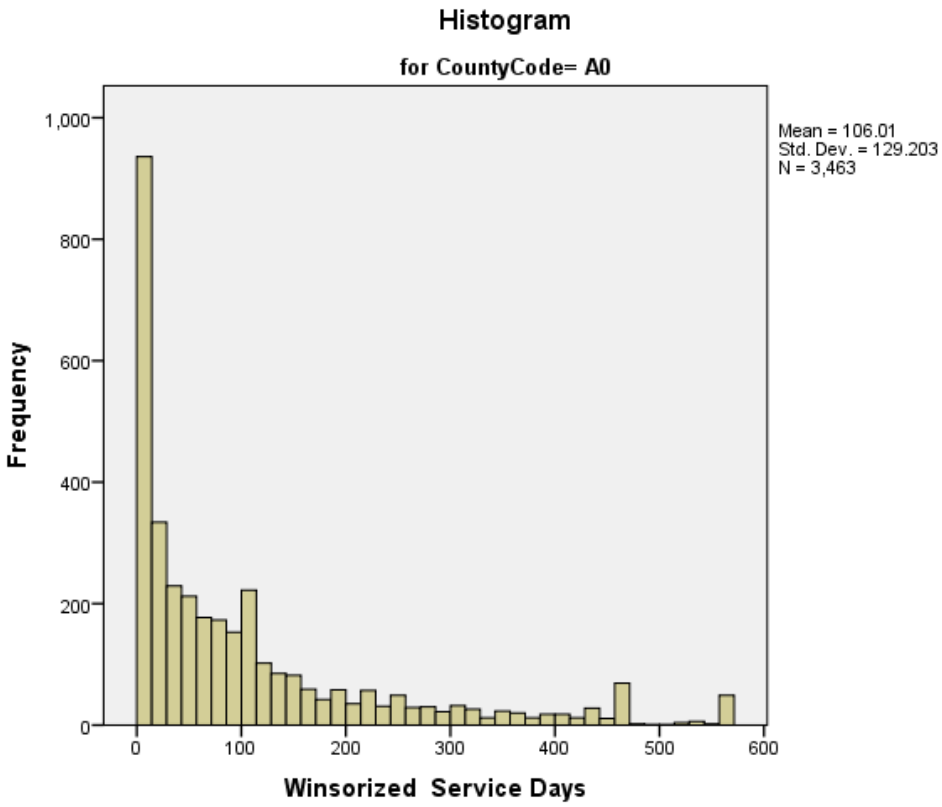

Figure C1. County A_0 service days histogram.

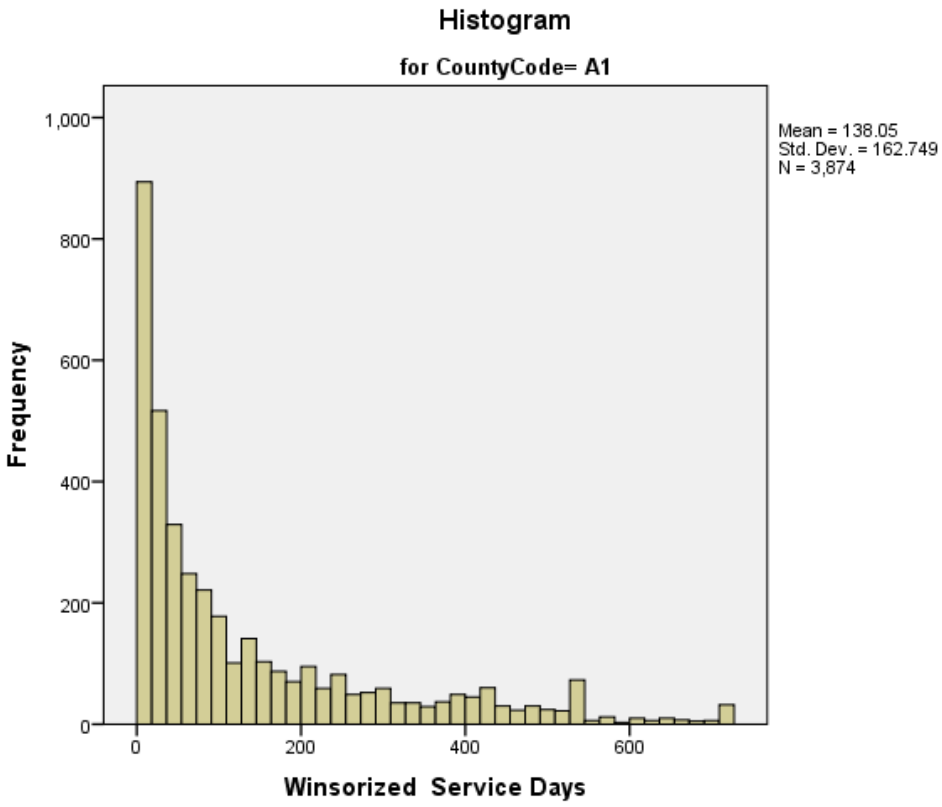

Figure C2. County A_1 service days histogram.

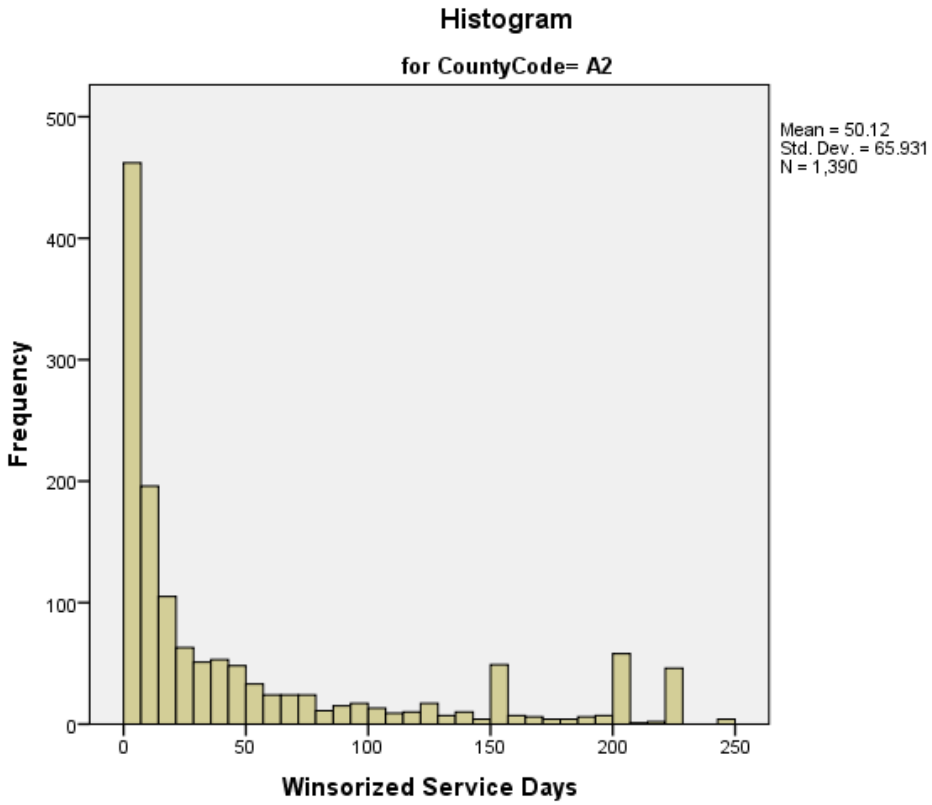

Figure C3. County A_2 service days histogram.

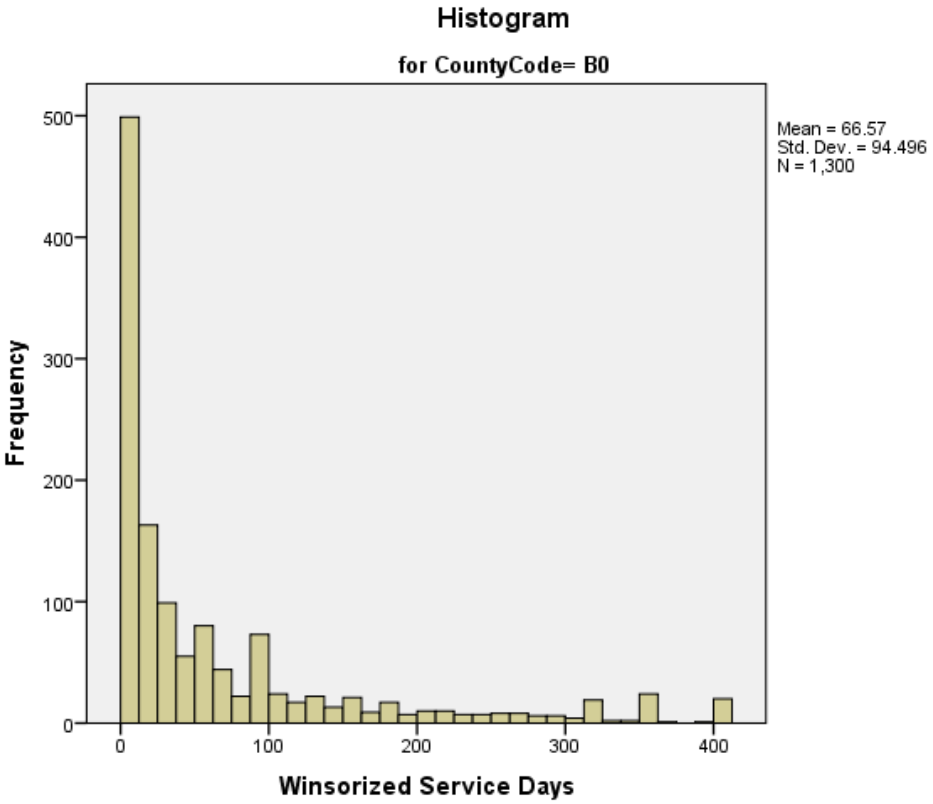

Figure C4. County B_0 service days histogram.

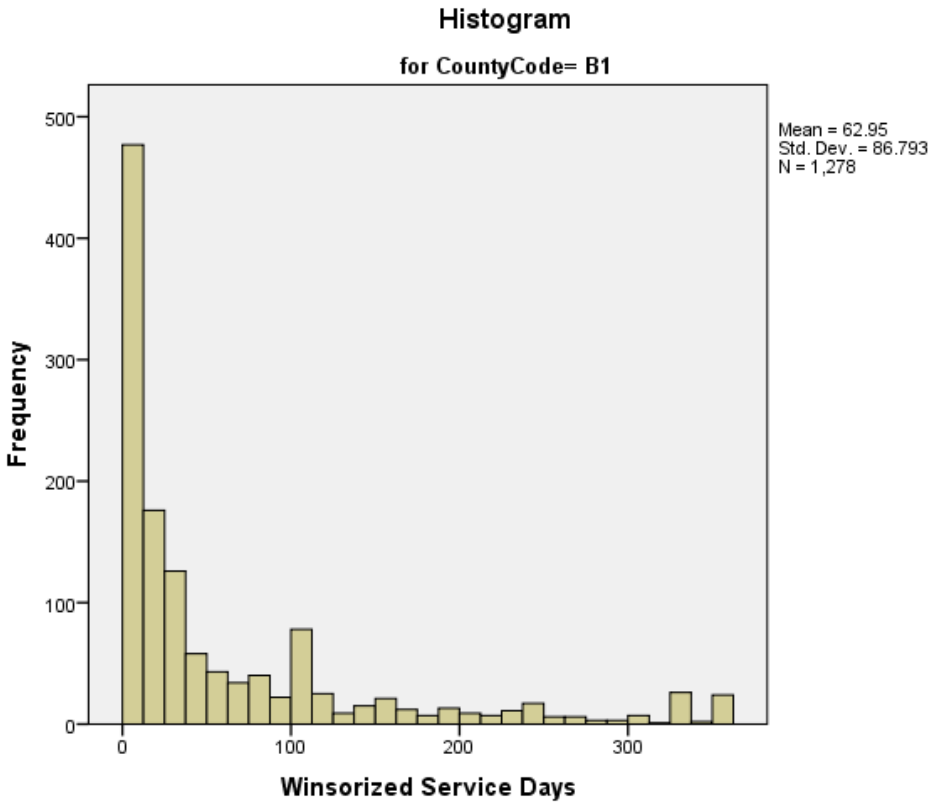

Figure C5. County B_1 service days histogram.

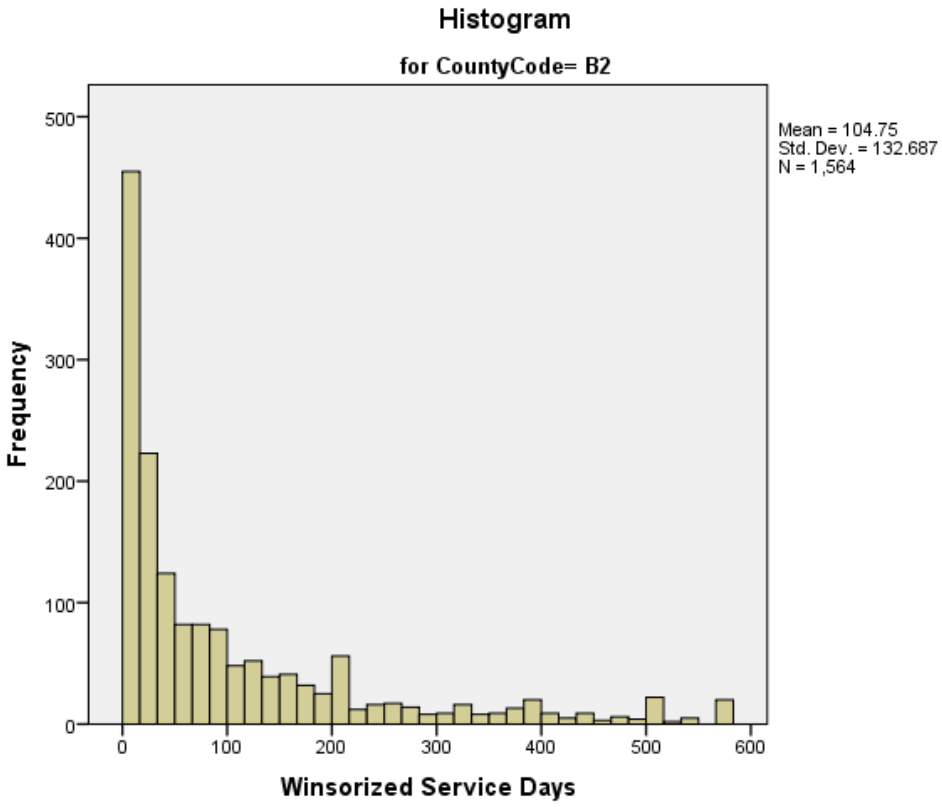

Figure C6. County B_2 service days histogram.

Appendix D: Service Days Profile Plots

This appendix contains SPSS line plots of MSD for each county pair and each county pair by case type.

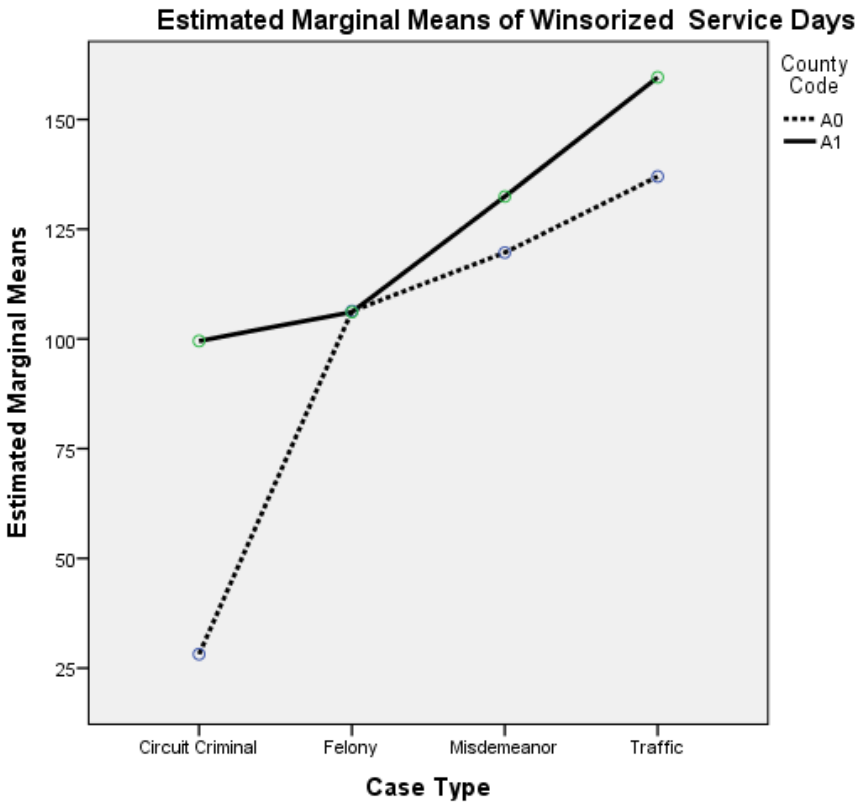

Figure D1. County Pair A_0A_1 service days by case type profile plot. The base line county without e-warrants is represented by the dashed line. Note: The mean difference for felony case types was found to be not statistically significant at the alpha .05 level.

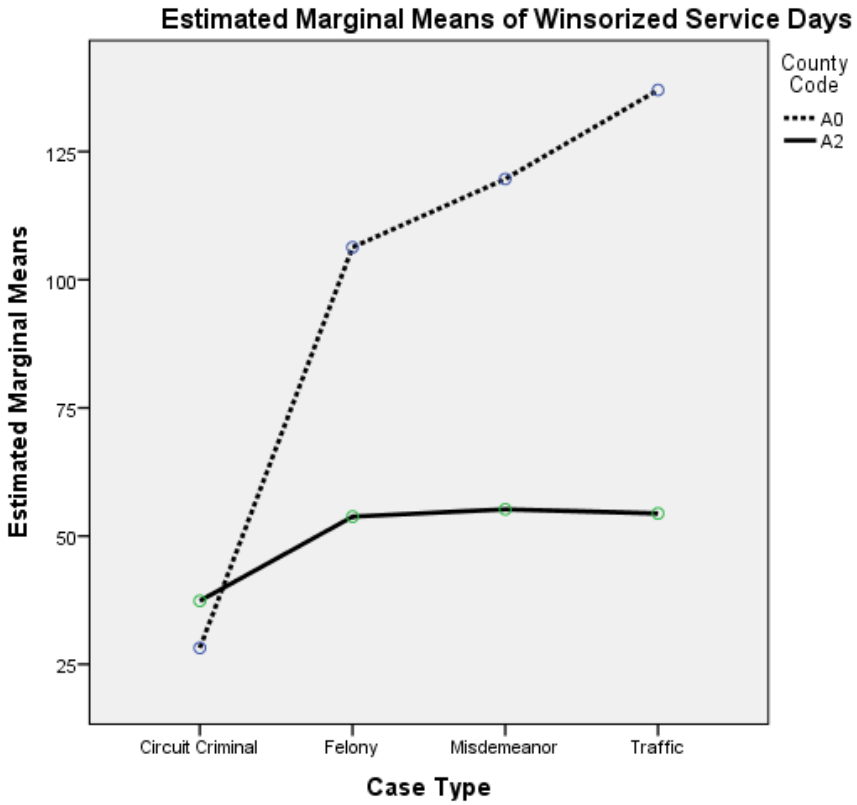

Figure D2. County A_0A_2 service days profile plot. The base line county without e-warrants is represented by the dashed line. Note: The mean difference for circuit criminal case types was found to be not statistically significant at the alpha .05 level.

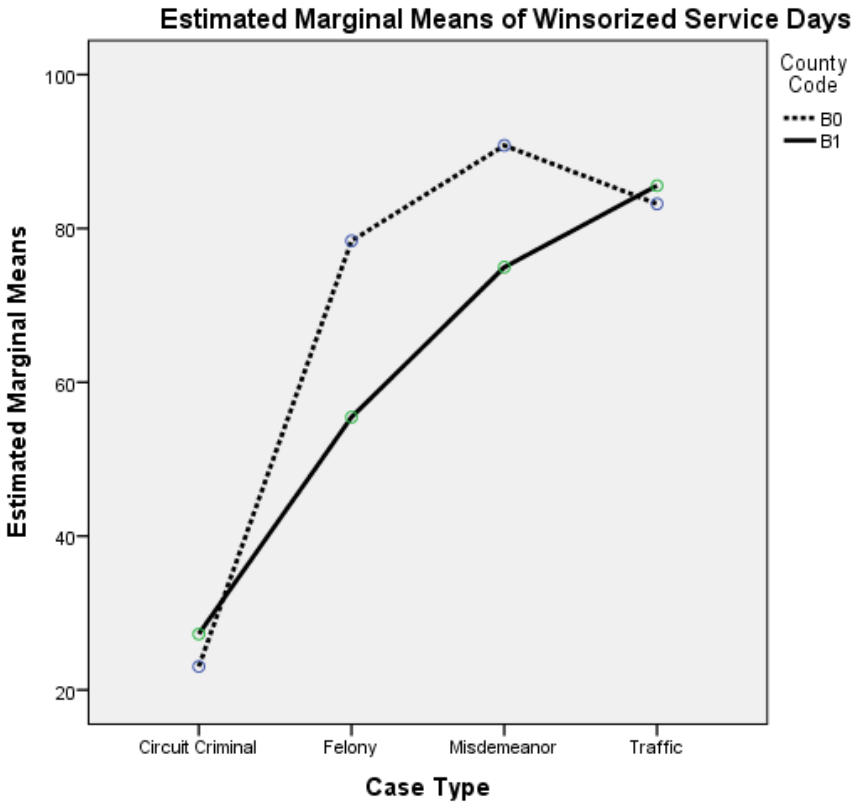

Figure D3. County B_0B_1 service days profile plot. The base line county without e-warrants is represented by the dashed line. Note: The mean difference for circuit criminal and traffic case types were found to be not statistically significant at the alpha .05 level.

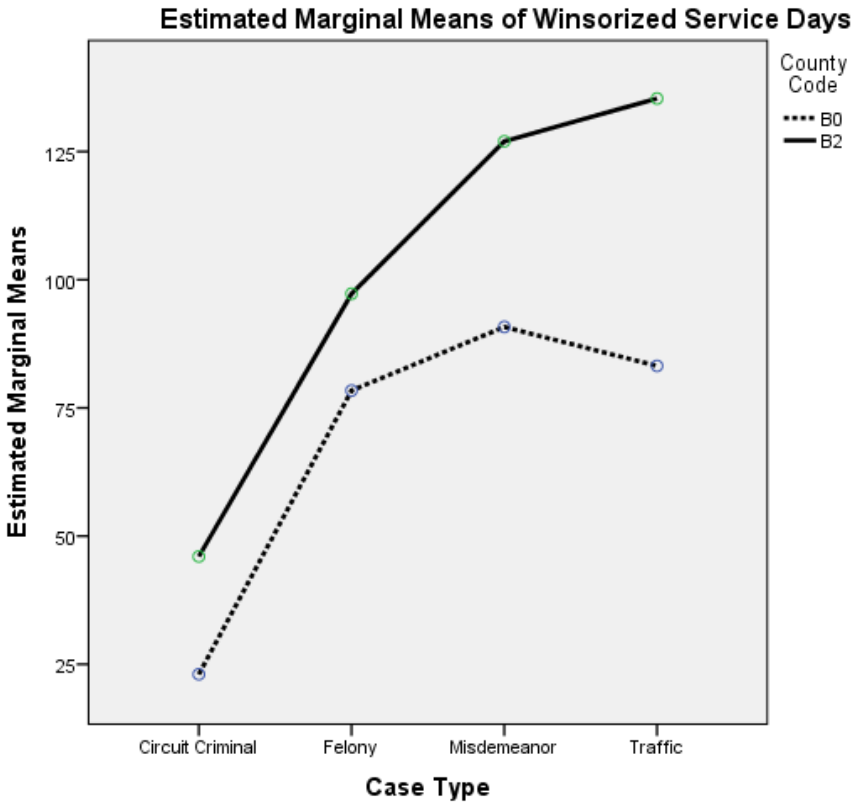

Figure D4. County B_0B_2 service days profile plot. The base line county without e-warrants is represented by the dashed line. Note: The mean difference for felony case types was found to be not statistically significant at the alpha .05 level.

Appendix E: Percent Warrants Served Profile Plots

This appendix contains SPSS line plots of PWS for each county pair by case type.

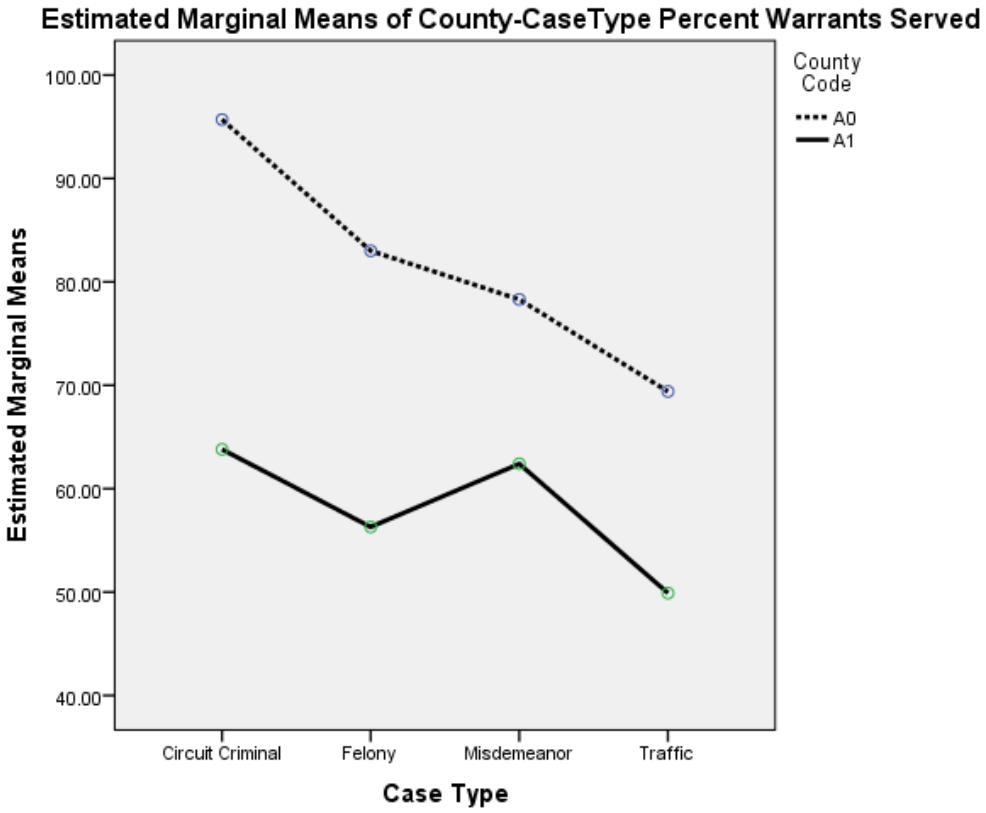

Figure E1. County Pair A_0A_1 PWS by case type profile plot. The base line county without e-warrants is represented by the dashed line.

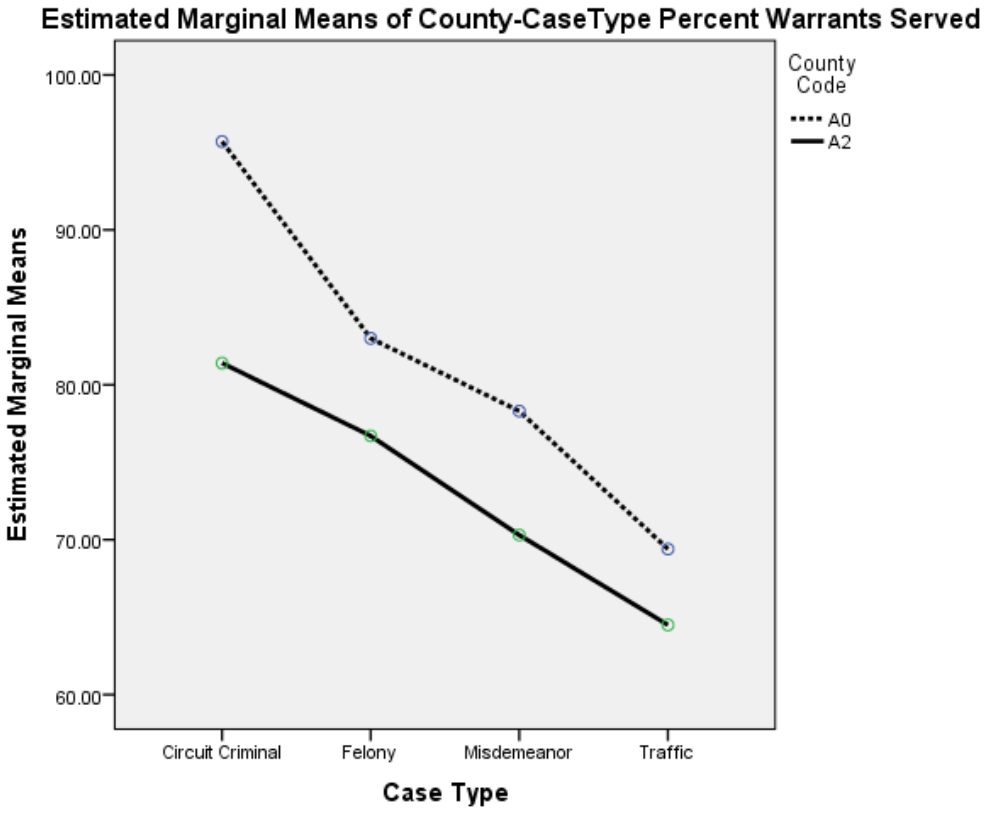

Figure E2. County Pair A_0A_2 PWS profile plot. The base line county without e-warrants is represented by the dashed line.

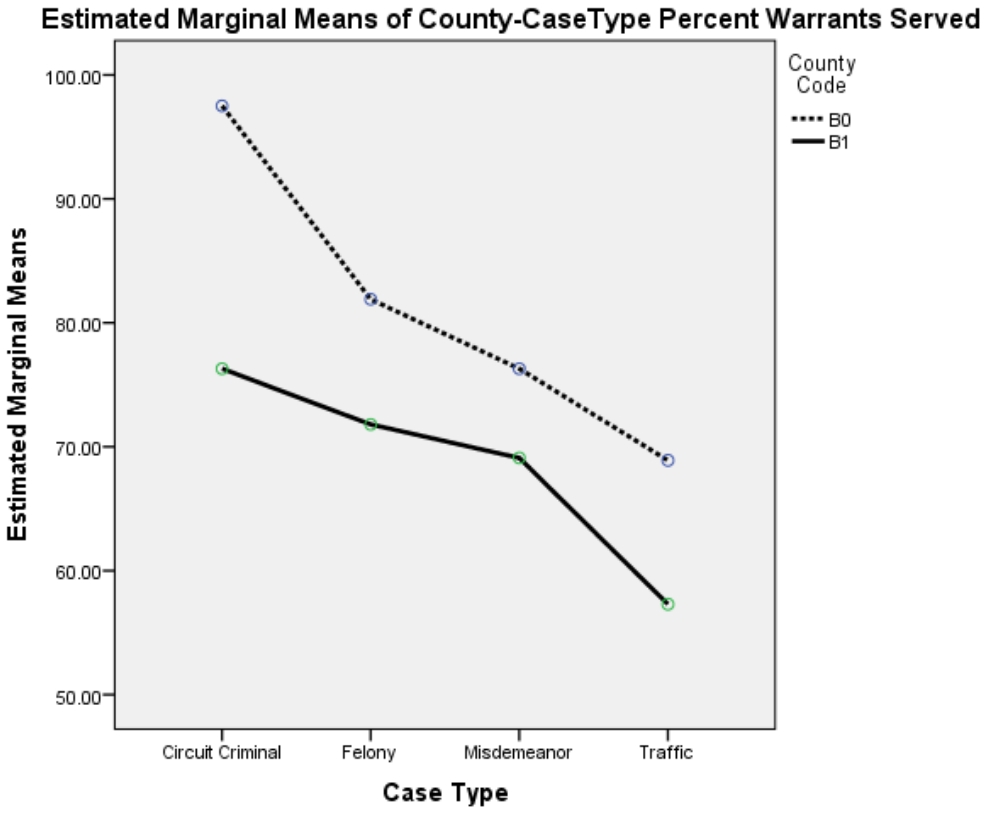

Figure E3. County Pair B_0B_1 PWS profile plot. The base line county without e-warrants is represented by the dashed line.

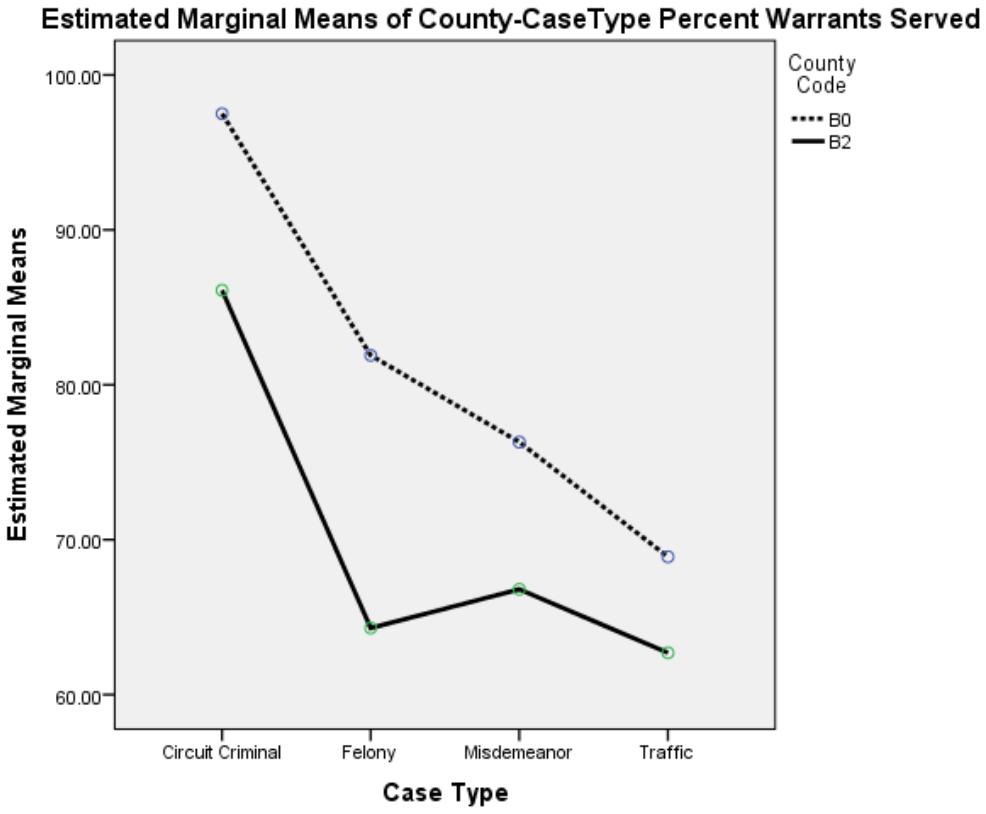

Figure E4. County Pair B_0B_2 service days profile plot. The base line county without e-warrants is represented by the dashed line. Note: The mean difference for felony case types was found to be not statistically significant at the alpha .05 level.

Appendix F: Two-way ANOVA Results on Mean Service Days

This appendix contains results and SPSS output of two-way ANOVA tests on the dependent variable MSD. The results of these tests are deprecated due partial assumption failures noted in Chapter 4.

Null hypothesis Ho_{1A} comparing MSD across counties is rejected, and the alternate hypothesis Ha_{1A} is supported at the 95% confidence level for all four county pairs. Results are depicted in Table F1, and mean differences are shown in Table F2.

Table F1

Two-Way ANOVA Results for Winsorized Service Days

County Pair	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
A_0A_1	CountyCode	858540.230	1	858540.230	41.021	0.000	0.006
	CaseType	5677404.262	3	1892468.087	90.422	0.000	0.036
	CountyCode* CaseType	794356.333	3	264785.444	12.651	0.000	0.005
A_0A_2	CountyCode	1516177.452	1	1516177.452	125.595	0.000	0.025
	CaseType	2453023.711	3	817674.57	67.734	0.000	0.040
	CountyCode* CaseType	1238259.691	3	412753.23	34.191	0.000	0.021
B_0B_1	CountyCode	562341.373	1	562341.373	44.952	0.000	0.015
	CaseType	3123203.59	3	1041067.863	83.219	0.000	0.080
	CountyCode* CaseType	117072.225	3	39024.075	3.119	0.025	0.003
B_0B_2	CountyCode	562341.373	1	562341.373	44.952	0.000	0.015
	CaseType	3123203.59	3	1041067.863	83.219	0.000	0.080
	CountyCode* CaseType	117072.225	3	39024.075	3.119	0.025	0.003

Table F2

Two-Way ANOVA Mean Differences for Winsorized Service Days by County Pair (all Case Types)

County Pair	F-Statistic	Mean Diff. (L-R)	Sig.	Partial Eta Squared
A_0A_1	40.021	-26.622	0.000	0.006
A_0A_2	125.595	47.596	0.000	0.025
B_0B_1	4.606	8.042	0.032	0.002
B_0B_2	44.952	-32.555	0.000	0.015

Null hypothesis Ho_{2A} comparing case types across counties is rejected, and the alternate hypothesis Ha_{2A} is supported at the 95% confidence level for all four county pairs. Results of research question 2A were mixed. Two-way ANOVA results are summarized by case type in Tables F3 through F6. Shaded cells indicate ANOVA results that were not significant at the 95% confidence level. Mean differences shown are calculated left minus right (L-R). For example, mean difference for pair A_0A_1 was calculated as mean of A_0 minus the mean of A_1. Therefore, a negative mean difference indicates that the e-warrant county in the pair had a longer MSD than the basis (non-e-warrant) county. A negative mean difference suggests that the e-warrant system had the negative effect of increasing warrant service times, and a positive mean difference suggests that e-warrants improved (shortened) service times. Five county*case type pairs showed faster service time with e-warrants, and six showed worse service times with e-warrants.

Table F3

*Circuit Criminal Cases Two-Way ANOVA Results for Service Days by County*Case Type*

County Pair	F-Statistic	Mean Diff. (L-R)	Sig.	Partial Eta Squared
A_0A_1	66.675	-71.343	0.000	0.009
A_0A_2	1.650	-9.172	0.199	0.000
B_0B_1	0.440	-4.221	0.507	0.000
B_0B_2	8.806	-22.974	0.003	0.003

Note. Mean Differences are based on SPSS estimated marginal means, not the actual sample means. Shaded cells mark results that are not statistically significant ($p < .05$).

Table F4

*Felony Cases Two-Way ANOVA Results for Service Days by County*Case Type*

County Pair	F-Statistic	Mean Diff. (L-R)	Sig.	Partial Eta Squared
A_0A_1	0.000	0.214	0.985	0.000
A_0A_2	16.704	52.539	0.000	0.000
B_0B_1	5.021	22.924	0.025	0.002
B_0B_2	1.798	-18.881	0.180	0.001

Note. Mean Differences are based on SPSS estimated marginal means, not the actual sample means. Shaded cells mark results that are not statistically significant ($p < .05$).

Table F5

*Misdemeanor Cases Two-Way ANOVA Results for Service Days by County*Case Type*

County Pair	F-Statistic	Mean Diff. (L-R)	Sig.	Partial Eta Squared
A_0A_1	5.539	-12.764	0.019	0.001
A_0A_2	120.395	64.438	0.000	0.024
B_0B_1	5.873	15.835	0.015	0.002
B_0B_2	19.464	-36.206	0.000	0.007

Note. Mean Differences are based on SPSS estimated marginal means, not the actual sample means.

Table F6

*Traffic Cases Two-Way ANOVA Results for Service Days by County*Case Type*

County Pair	F-Statistic	Mean Diff. (L-R)	Sig.	Partial Eta Squared
A_0A_1	15.675	-22.594	0.000	0.002
A_0A_2	180.030	82.579	0.000	0.036
B_0B_1	0.153	-2.370	0.696	0.000
B_0B_2	52.642	-52.157	0.000	0.018

Note. Mean Differences are based on SPSS estimated marginal means, not the actual sample means. Shaded cells mark results that are not statistically significant ($p < .05$).

Partial eta squared values are very low--all under 4% indicating a very small influence on dependent variable MSD.

Figures F1 and F2 contain summary clustered bar charts for county Group A and county Group B, respectively. Figure F1 reveals a consistently low service time for county A_2 in all case types; with a MSD of 50.1 compared to 106.0 for county A_1 and 138.1 for county A_2. This suggests that the low service times may be due to other factors. Figure F2 shows that county B_0 had service times between B_1 and B_2 in misdemeanor cases, felony cases, and overall. County B_0 had the shortest MSD for the more serious circuit criminal cases. It is notable that the non-e-warrant county in both groups had the best (shortest) MSD of the group for the most serious circuit criminal case types.

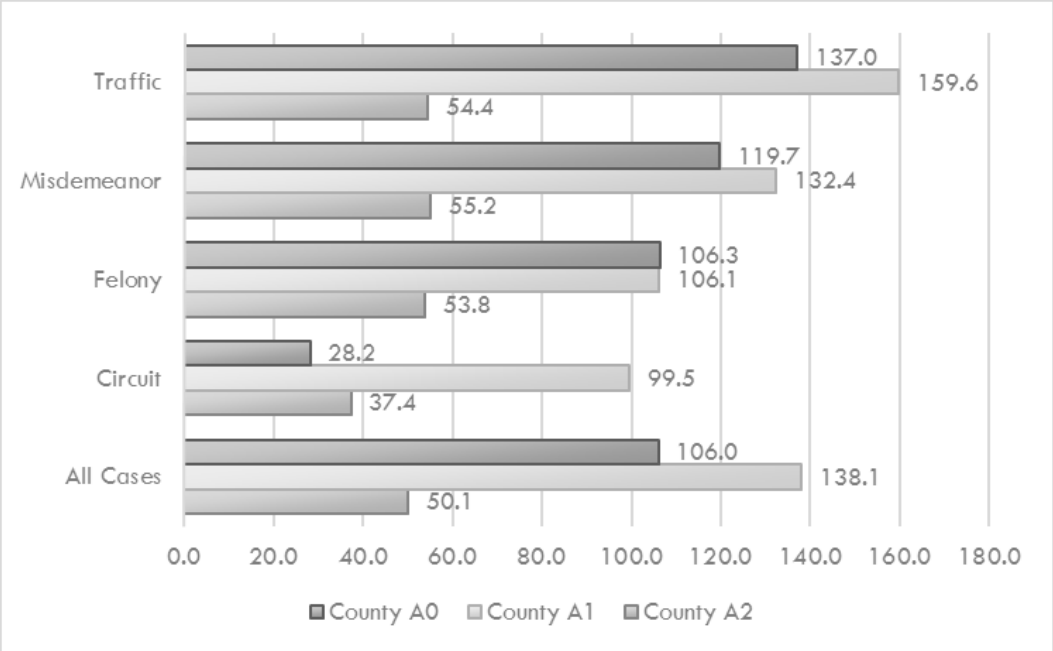

Figure F1. County Group A mean service days (Winsorized).

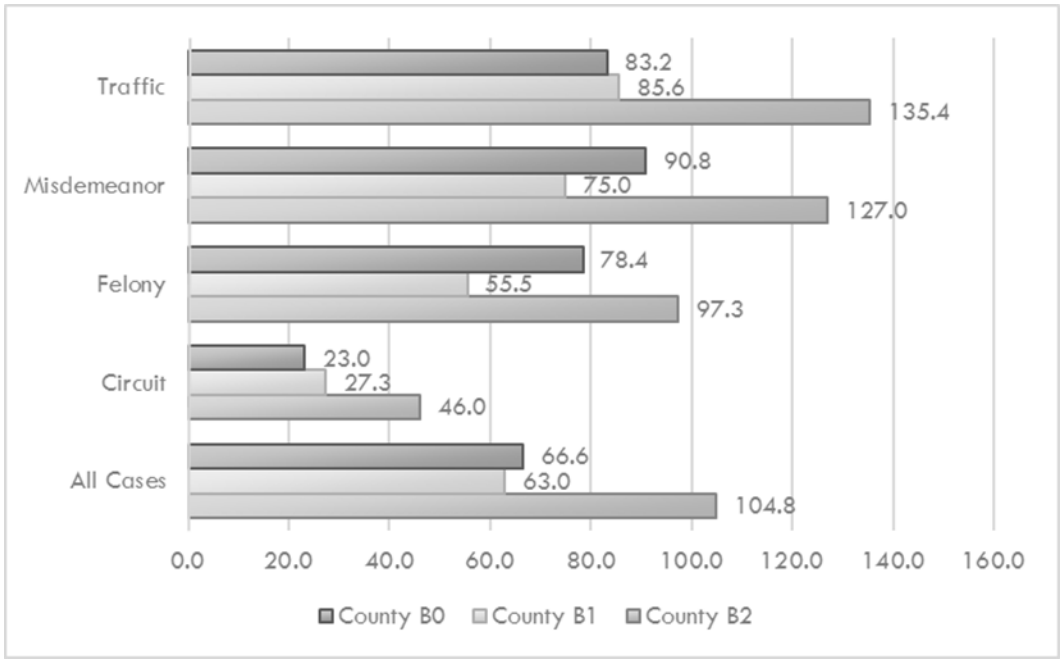

Figure F2. County Group B mean service days (Winsorized).

Appendix G: Two-way ANOVA Results on Percent Warrants Served

This appendix contains results and SPSS output two-way ANOVA tests on dependent variable PWS. These results are included for information only. Due to failure of all three two-way ANOVA assumption tests, these results were not considered in the interpretation of results.

Due to test assumption failures, null hypothesis Ho_{1B} comparing PWS across counties could not be rejected, and likewise the alternate hypothesis Ha_{1B} cannot be supported for all four county pairs. Results are depicted in Table G1.

Table G1

Two-Way ANOVA Results for Percent Warrants Served

County Pair	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
A_0A_1	CountyCode	974328.853	1	974328.853	1.63115E+27	0.000	1.000
	CaseType	508907.856	3	169635.952	2.83991E+26	0.000	1.000
	CountyCode* CaseType	77515.25	3	25838.417	4.32567E+25	0.000	1.000
A_0A_2	CountyCode	61302.189	1	61302.189	.	.	1.000
	CaseType	337731.075	3	112577.025	.	.	1.000
	CountyCode* CaseType	15850.56	3	5283.52	.	.	1.000
B_0B_1	CountyCode	112464.173	1	112464.173	.	.	1.000
	CaseType	300525.728	3	100175.243	.	.	1.000
	CountyCode* CaseType	23992.845	3	7997.615	.	.	1.000
B_0B_2	CountyCode	90330.244	1	90330.244	.	.	1.000
	CaseType	393358.355	3	131119.452	.	.	1.000
	CountyCode* CaseType	10705.277	3	3568.426	.	.	1.000

Note. Empty cells denote an invalid result (e.g. divide by zero) due to failed test assumptions. The two-way ANOVA test was run at the alpha = .05 level.

Tables G2 and G3 are included to illustrate the compared mean differences in the sample data sets by all case types and by each case type, respectively.

Table G2

Two-Way ANOVA Results for Percent Warrants Served by County (all Case Types)

County Pair	Mean Diff. (L-R)	Sig.
A_0A_1	23.50	.
A_0A_2	8.36	.
B_0B_1	12.53	.
B_0B_2	11.75	.

Note. Empty cells denote an invalid result (e.g. divide by zero) due to failed test assumptions. The two-way ANOVA test was run at the alpha = .05 level.

Table G3

*Two-Way ANOVA Results for Percent Warrants Served by County*Winsorized Case Type*

County Pair	Circuit		Felony		Misdemeanor		Traffic	
	Mean Diff.	Sig.	Mean Diff.	Sig.	Mean Diff.	Sig.	Mean Diff.	Sig.
A_0A_1	31.90	.	26.70	.	15.90	.	19.50	.
A_0A_2	14.30	.	6.30	.	8.00	.	4.90	.
B_0B_1	21.20	.	10.10	.	7.20	.	11.6	.
B_0B_2	11.40	.	17.60	.	9.50	.	6.20	.

Note. Empty cells denote an invalid result (e.g. divide by zero) due to failed test assumptions. The two-way ANOVA test was run at the alpha = .05 level.

Figures G1 and G2 contain summary clustered column charts for county Group A and county Group B, respectively. County A_0 in Group A had the best clearance rate for every case type and overall. Similarly, county A_1 experienced the worst clearance rate, and county A_2 had the middle clearance rate in all categories.

Figures G1 and G2 are included to illustrate the relative means in the sample data sets by all case types and by each case type for county Group A and Group B, respectively. In Group B, County B_0 had the best performance across all categories. Counties B_1 and B_2 were very close overall (66.8% and 69.5% respectively), and they were split between second and third position in the case type categories.

Consistently higher PWS appears counter-intuitive, suggesting that other significant factors may have influenced warrant service performance. A set of profile

plots for each of the four county pairs depicting PWS for every case type is contained in Appendix E.

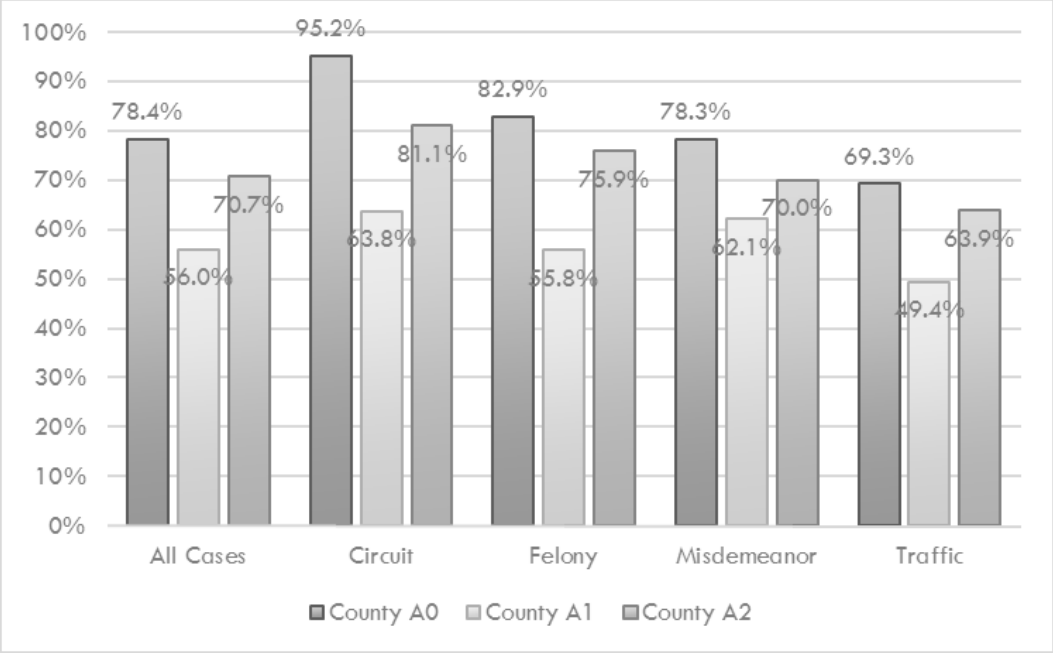

Figure G1. County group A percent warrants served.

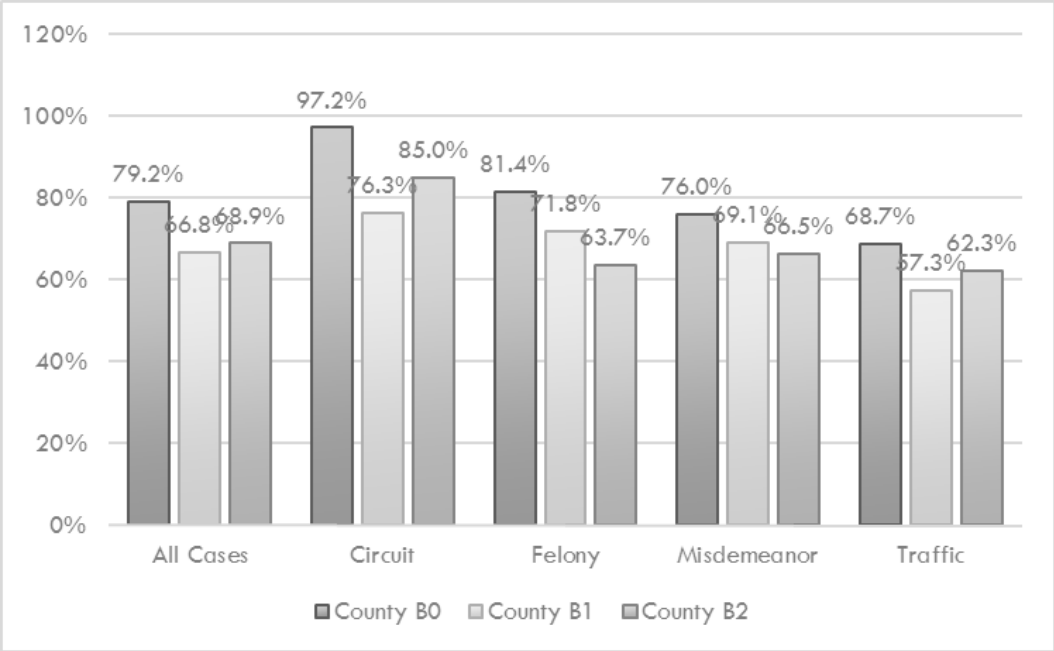

Figure G2. County group B percent warrants served.