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Strategic Sourcing of Air Force Contingency Pharmaceuticals: A Cost-Benefit Analysis Approach

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STRATEGIC SOURCING OF AIR FORCE CONTINGENCY PHARMACEUTICALS: A COST-BENEFIT ANALYSIS APPROACH

THESIS

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Abstract

The purpose of this research is to identify and explore effective supply chain management principles as mitigating measures to improve contingency pharmaceutical item shortfalls in the Air Force Medical Service Contingency Pharmaceutical Program. Analysis of current pharmaceutical shortages demonstrates a significant trend of insufficient demand signals for various pharmaceutical items, resulting in instances of non-fulfillment by private sector suppliers.

Through the scope of transaction cost economics, a cost-benefit analysis for various alternatives was conducted. The proposed alternatives evaluated in this thesis include continuation of the status quo, centralized procurement models from a single site, and procurement from regionally designated ordering sites.

This research clearly shows that consolidating demand of shortage items across Active Duty War Reserve Material assemblages, though applications of centralized purchasing principles that leverage prime vendor contract fill rates, can lead to substantial increases in material availability at costs that justify the calculated benefits.

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STRATEGIC SOURCING OF AIR FORCE CONTINGENCY PHARMACEUTICALS: A COST-BENEFIT ANALYSIS APPROACH

I. Introduction

Background

Forecasts for the year 2020 project that supply chain expenses will become the largest expenditure for U.S. healthcare organizations, commanding more budgetary requirements than the previous top expense of labor (Paavola, 2019). This means that the materials which allow a healthcare facility to function could now attract more attention than the medical professionals who provide the actual service of healthcare. At the same time, organizations are experiencing increasing costs across the entire spectrum of healthcare provision which are further cutting into profit margins (Paavola, 2019). In a strategic effort to increase performance outcomes, organizations are shifting focus to the improvement of supply chain management as an efficiency driver. This information has healthcare leaders focusing on practices and policies to extract value and minimize waste from supply chain practices. Practices such as demand aggregation through group purchase organizations, efficient data processing and analysis, and item standardization have garnered attention of the biggest healthcare companies in the country in an effort to improve supply chain operations (Michigan State University, 2019).

This research takes the strategic supply chain focus found in the private sector, and applies lessons learned to make Air Force Medical Service (AFMS) operations more effective. Therefore, the purpose of this research is to identify, evaluate, and apply optimal supply chain efforts to address shortages in the Air Force Contingency Pharmaceutical Program. Analysis of current contingency pharmaceutical shortages

shows a significant trend of insufficient, individual site demand signals for various pharmaceutical items, resulting in non-fulfillment by private sector suppliers. This research applies a cost-benefit analysis to evaluate various alternatives through the theoretical scope of transaction cost economics. As a result, this research clearly shows that consolidating the demand of shortage items across Active Duty War Reserve Material (AD WRM) assemblages, though applications of centralized purchasing principles that leverage prime vendor contract fill rates, can lead to substantial increases in material availability for pharmaceutical items.

The AFMS currently manages a $1.3 billion contingency medical program comprised of over 5,100 assemblages across the globe at 87 unique locations (JMAR, 2019). According to the Air Force Medical Logistics Guide, this program supports the capabilities of medical units in contingency situations such as home station medical response, deployments, and humanitarian efforts (AFMOA/SGAL, 2017). A critical element of contingency medical assemblages are pharmaceutical items, which account for over $113 million of the program (JMAR, 2019). A crucial subset of the overarching contingency medical program, and a primary focus of this research, are AD WRM assemblages. These assemblages are durable and transportable kits that provide necessary medical items, including medical supplies, equipment, and pharmaceuticals to accomplish deployment or mobility objectives (AFMOA/SGAL, 2017). Pharmaceutical items, as a component of AD WRM assemblages, experience high turnover due to consumption or expiration, as items routinely have a shelf life of only 24 to 36 months (AFMRA MLD, 2019). As a result from an enterprise-level, the Air Force Medical Readiness Agency (AFMRA), Medical Logistics Readiness Support Branch, has

observed shortages in material availability for many of these pharmaceutical items (AFMRA MLD, 2019).

Problem Statement

Over 35 percent of all Air Force contingency medical assemblages, and 21 percent of AD WRM material assemblages, do not meet deployment requirement thresholds as defined by AFMAN 41-209 (JMAR, 2019). Deployment thresholds according to this guidance require a minimum of 90 percent material availability of commodity items contained in the assemblage (U.S. Air Force, 2019). A major driver of this shortfall is the inability to readily procure contingency pharmaceutical items, which account for 41 percent of all contingency item shortages across the entire contingency pharmaceutical program (JMAR, 2019). Due to the unpredictable nature of contingency operations many contingency pharmaceutical items have non-recurring or non-usage demands, compared to Medical Treatment Facility (MTF) day-to-day pharmaceutical demands which have established and frequent usage patterns that result from supporting a relatively predictable healthcare environment (AFRMA MLD, 2019). This ambiguity in demand leads to order rejections for contingency items as Department of Defense (DoD) contracted distributors are only obligated to fulfill items which have established usage demands (Defense Logistics Agency, 2013).

This contractual condition leaves the AFMS at a disadvantage in developing and maintaining adequate inventories to support current and future requirements, which could occur with the onset of contingency operations. According to the 2016 Defense Logistics Agency (DLA) Medical Supply Chain report, DoD pharmaceutical item purchases

through DLA Troop Support make up only 1 percent of the entire U.S. pharmaceutical industries' market share (Defense Logistics Agency, 2016). For this reason, the Air Force, as a DoD component, must ensure that demand signals for contingency items are as robust as possible to ensure adequate supply for required inventories. Ultimately, inefficiencies and shortfalls of contingency item supply chains could directly impact our Nations' readiness in military and humanitarian operations.

Purpose Statement

The purpose and primary goal of this analysis is to identify and explore effective supply chain principles, through the theory of transaction cost economics, as mitigation measures to improve current contingency pharmaceutical item shortfalls in the AFMS program. Through these approaches the resulting analysis will inform leaders about possible mitigation efforts, and their inherent costs and benefits, in an effort to remedy shortfalls in contingency pharmaceutical procurement methods.

Research Questions

RQ 1: Are there strategic supply chain integration efforts that can be employed to remedy current shortfalls?

RQ 2: What are the costs and benefits of possible strategic supply chain integration efforts?

Research Focus

First, the theoretical scope of transaction cost economics is reviewed to build the research foundation to conduct an assessment of contingency item procurement processes. The literature review also evaluates current contingency medical procurement

processes, introduces the concept of cost-benefit analysis, and highlights principles of strategic sourcing and demand aggregation. Subsequently, the data collection practices of this research and methodological applications of cost-benefit analyses are outlined. Lastly, findings are presented with a discussion on research limitations and areas for future research.

Methodology

The methodology utilized to gather information and present the findings of this research is a cost-benefit analysis. The cost-benefit analysis conducted in this thesis was influenced by the framework outlined in the text, *Cost-Benefit Analysis: Concepts and Practice*.

Assumptions

The main assumption of this thesis is that the AFMS will maximize use of the established DLA Pharmaceutical Prime Vendor (PPV) contracts to the fullest extent possible to procure needed contingency items. Demand, in terms of this research will be the current contingency pharmaceutical item shortages for each location. The DLA PPV contract defines a usage item as a pharmaceutical that is, “ordered by the ordering facility a minimum of once per month for a minimum quantity of one and is in the Medical Master Catalog (MMC). Usage data shall be provided by the customer during the

implementation period and will be reviewed by the customer and the PPV periodically" (Defense Logistics Agency, 2013, p. 41).

This thesis also applies the fact that all Air Force ordering stock record ordering locations are designated as Master Ordering Facilities (MOFs) under the PPV contract. These MOFs are authorized to order under the PPV contract for external DoD customers (Defense Logistics Agency, 2013). With this designation applied to AFMS ordering units, the centralized and regionalized ordering facilities, identified in the constructed alternatives, can set up delivery locations at external sites, given they are in the same geographical region (Defense Logistics Agency, 2013). This effort would minimize transportation expenses as there are no distribution fees for all MOF orders according to the PPV contract (Defense Logistics Agency, 2013). Lastly, ordering sites located in the Upper Prairie region will fall under the West region for demand aggregation, ordering, and resulting distribution of shortage items due to their proximity to the West region.

Limitations

The scope of this research focused specifically on the 120 AD WRM deployable unit type code allowance standards, shown in Appendix A. Therefore, the programs of Home Station Medical Response (HSMR), Force Health Protection (FHP), Mass Casualty First Aid Kits, and MAJCOM specific programs were not evaluated in this research. Also, this research did not include and in-depth evaluation or shortage remediation of non-pharmaceutical contingency items, including contingency medical equipment, repair, or supply items. Lastly, other military services' contingency pharmaceutical items, ordering policies, or budgetary information was not assessed in

this evaluation. These separate contingency commodity items and other service component programs will be addressed in the future research section of this thesis.

II. Literature Review

Chapter Overview

The purpose of this chapter is to provide the foundational knowledge used to support the decision of aggregating demand for shortage items across the enterprise in an effort to implement centralized procurement practices. This chapter begins with an evaluation of transaction cost economics theory. This topic will provide the theoretical foundation for the assessment of contingency item procurement purchasing processes.

This literature review will then highlight the various policies and regulations that form and govern the current processes in AFMS contingency item procurement. Through review of these methods, a concise and consolidated process will be outlined from the planning stage to the execution phase. This chapter also introduces the concepts and outlines the steps of a cost-benefit analysis. Lastly, supply chain principles of strategic sourcing are fully evaluated. The strategic sourcing component applied in this thesis is the concept of implementing centralized purchasing structures through practice of demand and purchasing aggregation to establish sufficient usage data for contingency pharmaceutical items.

Transaction Cost Economics

The review of applicable literature and theory for this research begins with a description of transaction cost economics. The basic premise of transaction cost economics theory instantiates that individuals or firms seek to make the best possible decisions for their organization. This theory holds that organizations select certain products, goods, or services over alternatives due to the economization, optimization, or

minimization of transaction costs (Williamson, 1979). In transaction cost economics theory, the unit of analysis is the singular transaction (Williamson, 2010). A transaction in this theory is defined as an economic exchange of a good or service from a provider to a separate user (Pint and Baldwin, 1997). Transaction costs can arise from a litany of organizational functions and actions, including sourcing selections, contract management, and performance measurements (Pint and Baldwin, 1997).

Since organizations usually operate in resource-constrained environments, it is paramount that they make economically efficient decisions in charting future financial and operational decisions (Mahoney and Ketokivi, 2015). As the AFMS is not immune to this prevalence of constrained operating environments, their business practices are highly suitable for evaluation through a scope of transaction cost economics. Limited budgets, constraints on contracting and purchasing avenues, and the unpredictable nature of military operations fuel the often constrained environment of Air Force procurement. These decisions in constrained environments can range from organizational structure constructs, personnel configuration, or purchasing efforts; however, all focus on a key idea of managing relationships and transactions to minimize waste while simultaneously creating value (Mahoney and Ketokivi, 2015).

Throughout the evaluation of transaction cost economics, the theme of bounded rationality emerges as a key concept. Bounded rationality implies that there are limits to time, control, and information throughout a system, which can result in suboptimal decisions, actions, and organizational principles (Pint and Baldwin, 1997). This means that entities of the system, including employees, processes, and agreements, may engage in or promote suboptimal behavior, that can be detrimental to effective decision making

in operations (Pint and Baldwin, 1997). Bounded rationality is not a result of incompetence or inability, but rather a product of the fact that humans have limitations that influence actions and strategy (Williamson, 2010). Williamson (2010) describes that humans are limited in their rationality due to complexities found in the business environment. Transaction cost economics suggests that when the resulting effects of bounded rationality greatly influence organizational transactions, organizational integration efforts could be used to ensure the value of transactions are captured (Pint and Baldwin, 1997). This concept of integration, through the implementation of centralized procurement procedures, will be further evaluated in this literature review.

Contingency Item Purchasing Processes and Shortfalls

There are undoubtedly various transaction costs associated with the procurement of contingency pharmaceuticals, but before the minimization of these costs and maximization of value can be pursued, the initial processes of contingency item demand, outlined in Appendix B, must be evaluated. The initial step of the planning process begins at the operational planning (OPLAN) level where Combatant Commanders' capability requirements for medical assets are defined and transferred to the Air Force Surgeon General's (AF/SG) Office (HQ USAF/SG, 2013). These resulting OPLANs lay out requirements for medical necessities in contingency instances such as number and types of beds based on projected casualty streams, number of personnel deployed in the area and aeromedical evacuation projections (AFMRA/SG4M, 2019). From these OPLAN requirements, the AF/SG publishes the Medical Planning and Programing

Guidance (MPPG) to determine future endeavors in contingency planning (HQ USAF/SG, 2013).

The MPPG, as the Air Force Medical community's planning and programming guidance document, ultimately determines the bottom up requirements to support medical program priorities, such as WRM, in support of combatant commander requirements (HQ USAF/SG, 2013). The process for putting the AF/SG vision, as outlined by the MPPG, into action is the Readiness Requirements Planning and Resourcing Process (RRPR). In the RRPR medical unit type code requirements are identified for these major OPLANs, which creates the total demand list (TDL) (HQ USAF/SG, 2013). The TDL is the resulting product of the RRPR that captures all combatant commander requirements, thus establishing the demand for the system (HQ USAF/SG, 2013). The establishment of the TDL, from the origins of the various OPLANs, concludes the planning phase of contingency item procurement. Execution of this process begins with the Medical Requirements List (MRL).

The MRL is a conglomeration of all AFMS possible personnel and equipment assignments, mission requirements, and expansion capabilities (HQ USAF/SG, 2013). Ultimately, this listing outlines where each required capability, as defined by the TDL, will be stationed and in what fiscal year the capability will be required (HQ USAF/SG, 2013). Once requirements are distributed amongst Air Force locations, via the MRL, assemblages are constructed, supported, and replenished at dictated sites through established procurement channels, including the Pharmaceutical Prime Vendor (PPV) contract.

The PPV contract, awarded through DLA, is the primary mechanism exercised for procuring contingency pharmaceutical items. The contract was awarded in 2014 and consists of one 30 month base period and three 30 month option periods, available through 2024 (Defense Logistics Agency Troop Support, 2019). In Fiscal Year (FY) 19, the breakdown of contingency pharmaceutical purchases shows utilization of the PPV contract over 70 percent of the time in pharmaceutical procurement actions (JMAR, 2019). According to DLA, fulfillment rates for the PPV contract typically range from 95-98 percent (Defense Logistics Agency Troop Support, 2019). This generalization was substantiated by obtaining access to information from the fill rate module managed by DLA. The average fill rate for the FY19 was 96.19 percent ("Fill Rate Application", 2019).

This fill rate percentage will be used as a factor in the cost-benefit analysis methodology to calculate remedied shortage amounts. According to the contract statement of work, "The PPV program provides worldwide support to DoD customers […] by providing pharmaceutical and pharmaceutical related products. The PPV will provide War Readiness Material (WRM) support" (Defense Logistics Agency, 2013, p. 31). After solicitation, the contract was awarded to Amerisource Bergin Drug Corporation (ABC), designating them as the primary supplier of pharmaceutical contingency items to the DoD (Defense Logistics Agency Troop Support, 2019). ABC services both CONUS and OCONUS contingency pharmaceutical demands from its nearly 30 U.S. distribution centers (Amerisource Bergin, 2015). All geographical regions are serviced by ABC, with the exception of the states of South Dakota, North Dakota, and Minnesota. These states are serviced by the Dakota Drug Company under the designation

of the Upper Prairie Region through a separately awarded small business contract (Defense Logistics Agency Support, 2019).

Under the current contract, the primary supplier must maintain a fill rate of 98 percent for all orders predicated upon sufficient usage demands (Defense Logistics Agency, 2013). This distinction is highly important, as it identifies that the fill rate will only be inclusive of products which meet usage requirements. Usage under the contract is defined as an item, "ordered by the ordering facility a minimum of once per month for a minimum quantity of one and is in the Medical Master Catalog (MMC). Usage data shall be provided by the customer" (Defense Logistics Agency, 2013, p. 40). With the shortcomings discussed above through the PPV contracts, it is clear that additional mitigating measures must be evaluated to address current system issues.

Cost-benefit Analysis

A cost-benefit analysis is a methodology for accurately assessing policies or projects based on their associated impacts, in terms of benefits and costs, that are valued in monetary terms (Boardman, Greenberg, Vining, and Weimer, 2011). Cost-benefit analyses are a common evaluation tool in military environments used to shape national security, set acquisition policies, and direct investments in service and supply procurement (Melese, Richter, and Soloman, 2015). According to Boardman et al. (2011), there are three types of cost-benefit analyses, including ex-ante, in medias res, and ex-post. Ex-ante analyses evaluate new initiatives that could possibly be implemented in the future (Boardman et al., 2011). In medias res analyses are actually conducted during the life of a current project, while ex-post analyses are completed after

a project has been completed or retired (Boardman et al., 2011). The current contingency pharmaceutical procurement program, supported primarily through the DLA PPV contract, will be analyzed through an in medias res cost-benefit analysis as the contract is still valid with options for continuation through 2024 (Defense Logistics Agency, 2013). In looking outside of the scope of current contracting vehicles, the findings of this cost-benefit analysis could also provide useful insight for future solicitations of DoD contingency item contracts.

An in medias res cost-benefit analysis can be accomplished through navigation of the following steps: specification of alternative projects, identification of project stakeholders, determination of costs and benefits, quantitative prediction of impacts over the life of the project, monetization of impacts, discounting of benefits to obtain present values, computation of the present value of each alternative, sensitivity analysis, and crafting of final recommendations (Boardman et al., 2011). For the purposes of this research, as the data provided encompasses single year contingency pharmaceutical procurement values, the steps of monetization of impacts, discounting of benefits to obtain present values, and computation of the final present values will be compressed into a single step designated as monetization. The resulting steps are illustrated below and will be used as this research's methodological framework to evaluate and compare alternative actions.

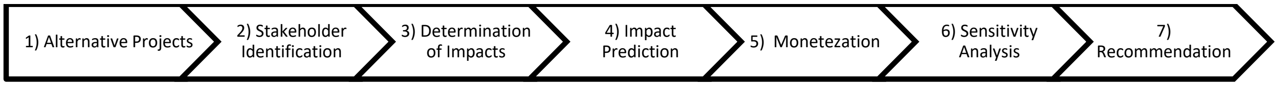


Figure 1. Cost-Benefit Analysis Process (Boardman et al., 2011)

The first step of the cost-benefit analysis is to clearly identify all possible options that could be undertaken in the given environment. In this first step of identifying alternative projects, the wide array of possible options must be defined and limited, as in most cases, there are a large number of viable options (Boardman et al. 2011). Within this set of alternatives, the current status quo, or instance of no change, should also be fully evaluated. Status quo information is needed to compare the current project to hypothesized options to determine if a new course of action, with its associated costs and efforts, should even be attempted (Boardman et al., 2011). In the methodology section, the status quo and possible alternative actions, with varying applications of centralized procurement, are defined.

Following the definition of alternatives stakeholders need to be properly identified. Identification of these stakeholders can be difficult to delineate and scope down to a relevant level for the given analysis being undertaken (Boardman et al., 2011). Projects can often be analyzed from a focused level excluding higher level or external stakeholders who may have a more global perspective (Boardman et al., 2011). Therefore, it is critical to evaluate possible stakeholders fully and then scope based on the level of connection to the project. In the AFMS contingency procurement model, certain benefits, as well as costs, could be felt at a local base level; however, there are likely additional costs and benefits that are realized at the enterprise level. Once all relevant stakeholders of the project are identified and informed, the costs and benefits of the project must be evaluated.

Evaluating the costs and benefits of a project are first done by identifying the physical impact categories of the possible alternatives (Boardman et al., 2011). The term impacts

include the inputs and outputs of a project, which are then cataloged as either a cost or a benefit to the project (Boardman et al., 2011). Boardman et al. (2011) provides a framework of identifying a cause and effect relationship between physical outcomes of the project and the affected parties. If there is a correlation between stakeholder action and outcome of the system, there is likely an impact category that can be identified as a benefit or a cost (Boardman et al., 2011). These resulting benefits and costs then need to be measured in some form of units. The method for measuring each impact is usually based upon the data from which the project is evaluated (Boardman et al., 2011). This means if there is monetary information, the resulting impacts will likely be measured in increased profit or cost avoidance; however, there are many ways that impacts can be measured, including time savings or operational efficiency improvements (Boardman et al. 2011).

After impacts have been identified, the task is to then predict the impacts over the life of the project (Boardman et al., 2011). Based on the calculated costs and benefits, the analyst needs to tie the impacts to a quantifiable output. The purpose of a cost-benefit analysis is to assess alternative courses of action which require prediction of outcomes supported by accurate data (Boardman et al., 2011). The methodology section of this research will apply data analysis of current information to predict impacts of different project implementations. Benefits resulting from changing processes, compared to current operations, can be analyzed through the in media res cost-benefit analysis.

Once cost and benefit predictions are established, it is important to assign monetary values in order to effectively compare outcomes as options may have differing costs and benefits that cannot be compared on a direct unit level. Effectively monetizing values can

allow for interpretation and comparison of results as it gives differing impacts similar units (Boardman et al., 2011). In some cases it is relatively simple to apply a monetary value to an impact, such as instances of cost avoidance; however, in many occurrences these monetary evaluations are not easily constructed. This is especially true in the military or defense environment.

In these instances where monetization is not straight forward, Boardman et al. (2011) advocates for avoiding reinvention of established practices through the use of plug in or estimated values when available. There is no silver bullet in connecting resulting outputs, such as increased material availability, with quantitative, economic inputs, such as money spent. However, a mechanism for quantifying the resulting impacts in military or defense situations is proposed in the military production function, which attempts to quantify defense outputs based on monetary inputs (Hartley and Soloman, 2015). According to Hartley and Soloman (2015) “Defense outputs involve a complex set of variables concerned with security, protection and risk management […] unlike private markets there are no precise benefit measures for defense output” (p. 44). Inputs, such as cost of procurement, are more easily identified and measured than resulting outputs, which in this research is material availability of contingency pharmaceutical items (Hartley and Soloman, 2015).

Therefore a cost-benefit analysis acts as a starting point to, “to identify the costs of defense and then ask whether defense provides at least a comparable level of benefits in the outputs produced” (Hartley and Soloman, 2015, p. 65). The methodology of this research will provide an estimated ratio that attempts to quantify the level of benefits, in

the terms of increased material availability, to the economic inputs, in terms of programmatic appropriations.

After monetary values have been established for various impacts to the different project sets, uncertainties of the process must be evaluated through sensitivity analysis. Utilizing sensitivity analysis allows users to evaluate possible what-if scenarios. Identifying possible outcomes can increase confidence in analysis, or help to identify areas for further evaluation to refine conclusions bolstered upon the conducted analysis (Georgiev, 2015). Sensitivity analysis can be conducted in numerous manners, all ranging in complexity and accuracy. The sensitivity analysis methods that will be used in this research are partial sensitivity analysis, which looks at how benefits change when a single assumption is varied while holding other aspects constant, and maximum and minimum case sensitivity analysis, which looks at the impact to benefits when the most or least favorable assumptions are applied (Boardman et al., 2011).

Once sufficient sensitivity analysis has been completed, the analyst can then make a recommendation based on the project with the largest present value (Boardman et al., 2011). It is important to remember that final present values are established from estimates of impacts and their resulting monetary values (Boardman et al., 2011). In many instances, specifically in the military, there are multiple variables, with different weights, that can lead to the selection of one project over another. This means that that completion of a cost-benefit analysis is only one input to the entire decision making process. There are often other contributing, and sometimes conflicting, factors such as politics, security, or legal requirements that can greatly influence final decisions (Boardman et al., 2011).

Strategic Sourcing - Centralized Purchasing through Demand Aggregation

The items that companies or governments procure are purchased to create value as a factor in production or meeting organizational requirements (Tate, Fawcett, Schoenherr, Ashenbaum, Carter, and Bals, 2016). Given that firms are in most cases required to make purchases to assist in their value creation proposition, strategic decisions must be made on how purchasing will be conducted throughout the organization. In alignment with the theory of transaction cost economics, "Given the considerable volume of resources involved, firms and governments always seek to optimize procurement so as to deliver value […] In pursuing such a goal often the first important decision is to choose between centralized and decentralized purchasing" (Dimitri, Gustavo, and Giancarlo, 2006, p. 47). Purchasing from a firm or organization perspective can take various shapes and is a strategic decision that must be made to maximize value of the system as a whole.

The three main purchasing systems include centralized, decentralized, and hybrid purchasing models (Dimitri et al., 2006). In a centralized purchasing model, decisions of organizational procurement including determinations of what products to buy, how to best navigate procurement channels, and when to make purchases are managed by a single entity in the organization (Dimitri et al., 2006). Advantages of centralized procurement structures include large scale aggregation of requirements, reductions in effort duplication, and more effective supply strategies (Tate et al., 2016).

In a fully decentralized procurement model, purchases for the organization are dispersed amongst different entities, who make more localized decisions of how, what and when to make acquisitions (Dimitri, 2006). Although this research supports movement away from the full decentralization of purchases, there are inherent benefits to

this purchasing structure. Decentralization of purchasing can be more responsive to the local units desires and allow for a better understanding of local requirements (Tate et al., 2016). The third type of procurement systems are hybrid models. In a hybrid purchasing model, purchasing decisions are made both centrally and locally depending on situational factors (Dimitri et al., 2006). In this structure, units can either make localized purchases, or communicate demand and spending information to a centralized purchasing unit that can look for aggregation opportunities leading to better fulfillment and cost savings (Tate et al., 2016).

Before the turn of the century, companies in many cases made strategic decisions to give individual business units more independence in terms of purchasing decisions (Rozemeijer, van Weele, and Weggeman, 2003). With the shift in increased competition in the business environment, these firms are now undergoing consolidation processes in their purchasing strategies as they are recognizing the benefits of pooling common requirements (Rozemeijer et al., 2003). Organizations are now exhibiting this shift in a transition to hybrid purchasing structures with centralized features that leverage sourcing benefits of the entire organization's demand portfolio (Trautmann, Bals, and Hartmann, 2009).

A challenge of implementing hybrid practices is clearly defining purchasing boundaries and policies. These boundaries involve determining which facets will fall under the authority of a centralized purchasing location to maximize organizational wide synergies and which facets of the organization will exercise local procurement (Trautmann et al., 2009). If organizations are able to overcome the challenges inherent to implementing more hybridized purchasing structures, there are numerous benefits. A

main benefit of harnessing the capabilities of hybrid purchasing organizations are purchasing synergies. Purchasing synergies are defined as resulting value from the combination of multiple business units' resources, information, and knowledge in purchasing (Trautmann et al., 2009).

A relevant example of purchasing synergies currently exhibited in the healthcare industry, are Group Purchasing Organizations (GPO). Demand aggregation practices are widely applied and utilized in the health care industry through GPOs. A GPO is an established entity that healthcare facilities or networks can join to purchase supplies, pharmaceuticals, and equipment. Joining the GPO leverages centralized procurement benefits, because the GPO consolidates demand from all users and captures the savings and efficiency of the larger volume; however, purchases are still made at the hospital or health network level under the GPO agreements (Dobson, Heath, Reuter, and DaVanzo, 2014). There are numerous benefits to procuring healthcare items through a GPO, such as greater economies of scale, volume purchasing, increased negotiating power and reduced administrative costs (Dobson et al., 2014). The increased economies of scale and volume purchasing result from the consolidation of various entities' demand for like items, which ultimately reduces transaction costs. Due to the benefits of GPOs, it is estimated that between 96 and 98 percent of U.S. Hospitals utilize GPO's in their procurement mix (Dobson et al., 2014).

As discussed previously in the medical contingency procurement process, the Air Force primarily obtains items through the DLA established PPV contract. The purchasing of required items for each location, based on requirements, is done on a site by site basis at the 87 separate stock record account number locations. These accounts do contain a

mix of other sub accounts, within their portfolio, however they are still ordered and maintained at the main location. For example, Wright Patterson Air Force Base supports 20 organizations assigned under their account. Of these 20 accounts, 19 are ordered from and physically located at Wright Patterson Air Force Base. Contingency items are maintained at the primary location and only sent to external locations if required (WPMC WRM, 2019). Therefore, this procurement system operates in a decentralized manner, with 87 main locations, shown in Appendix C, reporting demand to distributors to obtain pharmaceutical items for their site. The research and findings of this research will provide justification for the recommendation of transitioning to a model that maintains the local sites' abilities to procure more standard use items through government contracts at their own discretion, while harnessing the power of centralized purchasing models through demand aggregation to remedy contingency item shortages in the Air Force.

Relevant Research

AFMRA/SG4M utilizes an established reporting mechanism, the Air Force Shortage Summary Report, to identify and designate the service's top contingency pharmaceutical item shortages. Shortage rankings are designated using an algorithm that accounts for the criticality designation of items, individual material availability percentages, and assemblage instances with current shortages (JMAR, 2019).

Initial analysis of these top shortage items, identified on a per item basis in Appendix D and site aggregated basis in Figure 2, clearly demonstrated a pattern of insufficient site demand profiles correlated with top shortage items. The figure below is

highly skewed to the left, which signifies the preponderance of insufficient, or small, demand signals for identified items, ultimately resulting in shortages.

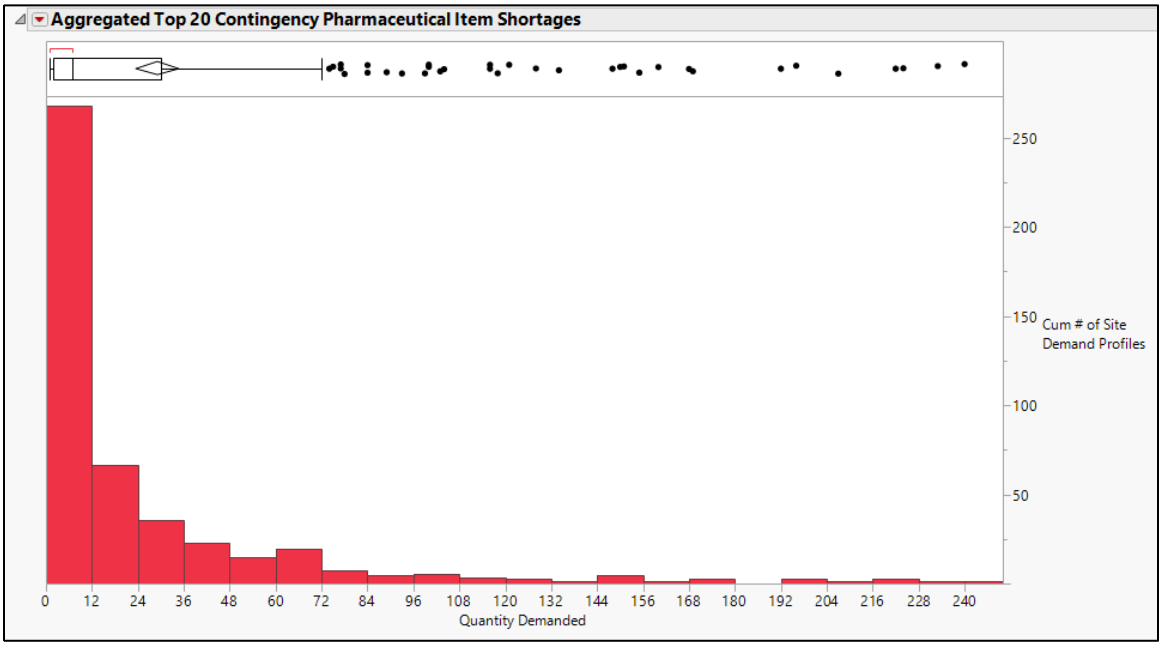


Figure 2. Aggregated Top 20 Contingency Pharmaceutical Items (JMAR, 2019)

Through aggregation of the top ten shortage items, 306 instances of item demand were identified. Of the 306 demand instances, 157 (51%) have usage demand profiles of less than one item per month. Expanding the pool to the top 20 shortage items shows an increasing pattern of 466 demand instances, with 288 occurrences (62%) registering a demand of less than one item per month. These sample sets of the program helped identify the core issue, insufficient demand signals dispersed across various locations leading to instances of shortages, for further analysis. The methodology and results will attempt to show how aggregating these small demand profiles will allow the Air Force to strategically reduce contingency item shortages.

Summary

The theory of transaction cost economics, with its robust theoretical history and application in today's economic environment, is the optimal theory on which to base this thesis and resulting cost-benefit analysis. It is clear that although there have been programmatic efforts to minimize contingency item shortages that there is still room for systematic improvement. The application of strategic sourcing, through leveraging the strengths of decentralized and centralized purchasing models, is tried and tested as shown by recent business research and findings.

In the next chapter, the methodology, will describe the avenues and methods for data collection and examination used to build the cost-benefit analysis of this thesis.

III. Methodology

Chapter Overview

The purpose of this chapter is to describe the primary data source and outline the construction of the model. The purpose of the model will describe the current situation and calculate relevant values such as shortage by location, acquisition costs, and transportation costs. The resulting data from the constructed model will then be utilized to initiate the cost-benefit analysis of this thesis.

Data Collection and Model Construction

The primary data source for this cost-benefit analysis is the Joint Medical Asset Repository (JMAR). According to the Defense Health Agency, JMAR is, "a web-enabled repository that captures inventory and transactions from distributed medical logistics systems at over 400 locations and provides flexible reporting on materiel inventory, status, movement and location" (Defense Health Agency, 2018). This data repository breaks down contingency medical assets by service component and allows for a thorough analysis of the current AFMS Contingency Pharmaceutical Program, with the granularity to drill down to individual locations and assemblage component items. Other pertinent information was gathered from the Medical Contingency Requirements Workflow (MCRW) and AFMRA Medical Requirements List (MRL). Through integrations of raw data and generated reports from these platforms, the current state of the AFMS Contingency Pharmaceutical Program can be illustrated. The compiled data shows that the AD WRM program is made of 2,533 assemblages, 21 percent of which do not meet AFMAN 41-209 deployment requirements (JMAR, 2019). These assemblages are

programmed for 827K pharmaceutical items to meet demand requirements (JMAR, 2019). Of these 827K items, there is a shortage of 159K items across 61 locations, resulting in a material availability of 80.7 percent.

After depicting the current pharmaceutical item shortages in the AD WRM portfolio, the model for this research was constructed. Pharmaceutical items shortages were aggregated based on the item's prime equivalent (PE) identification number, evaluated for PPV contract availability, and lastly assessed for minimum usage thresholds. Upon completion of this evaluation there were 646 unique pharmaceutical items that exhibited sufficient usage demand upon aggregation (JMAR, 2019). Ultimately, the purpose of this model construction is to establish all pertinent information necessary to conduct the costs benefit analysis.

Cost-benefit Analysis Application

The cost-benefit analysis of this thesis will follow the prescribed steps outlined in the literature review. Steps one through three of the cost-benefit analysis fall under the methodology portion of this thesis, while steps four through seven will be conducted in the subsequent analysis and conclusion sections.

In the first step of the cost-benefit analysis, four alternative projects were defined. The alternative projects to be assessed in this research are: continuation of the status quo, centralized purchasing at a single site, centralized purchasing at a single site for U.S. regions, and lastly, purchasing at various regional sites. The status quo is included as an alternative to act as a benchmark to determine if any resulting action should be taken in an attempt to improve the system. Alternative 1 assesses the current situation at sites with

AD WRM shortages. In this alternative there will be no proposed changes to consolidation of demand and sites will continue to procure items on an individual basis.

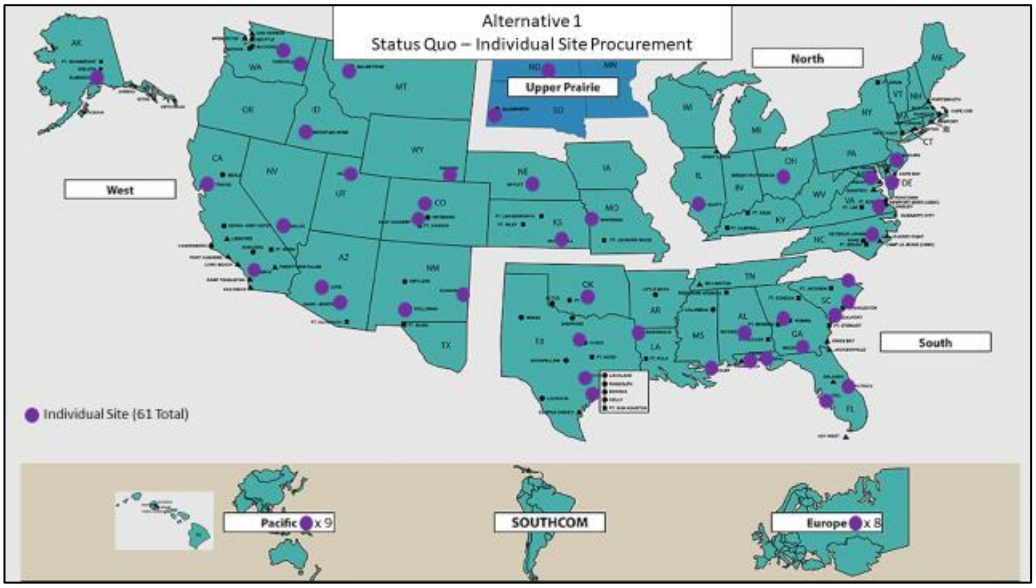


Figure 3. Alternative 1 Network (DLA Troop Support, 2016)

Alternative 2 identifies system wide level shortage aggregation opportunities from a single designated site to fulfill both U.S. and international site shortages. The site selected for this central hub was Kelly Field in San Antonio, Texas. When analyzing aggregated demand for each site, Kelly Field had the largest aggregated shortage amount of pharmaceutical items (JMAR, 2019).

Through centralization at Kelly Field, transportation instances would be minimized and the current consolidated storage and deployment center (CSDC) mission of Kelly Field best suits the demands of receiving, handling, and transporting large numbers of contingency medical items (Whitson, 2013).

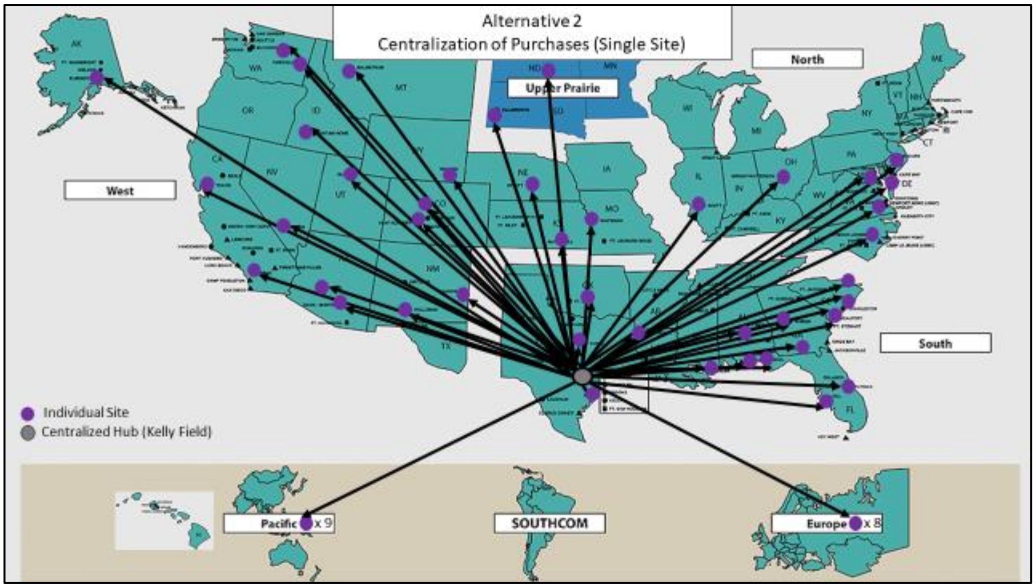


Figure 4. Alternative 2 Network (DLA Troop Support, 2016)

Alternative 3 mirrors the strategy and processes of alternative 2, but eliminates fulfillment of international region areas in an effort to assess changes in fulfillment and transportation costs based on the smaller distribution network. The thought process behind this change was that the network could still capture the aggregated demand profiles of the sites in the U.S. regions, while eliminating the international shipping costs that are required to ship procured items from Kelly Field to various OCONUS locations.

This process will still identify system wide level shortage aggregation opportunities at a single designated site, but only for the U.S. PPV regions of West, South, and North. The centralized ordering site for this action will remain at Kelly Field for the same justifications outlined in alternative 2.

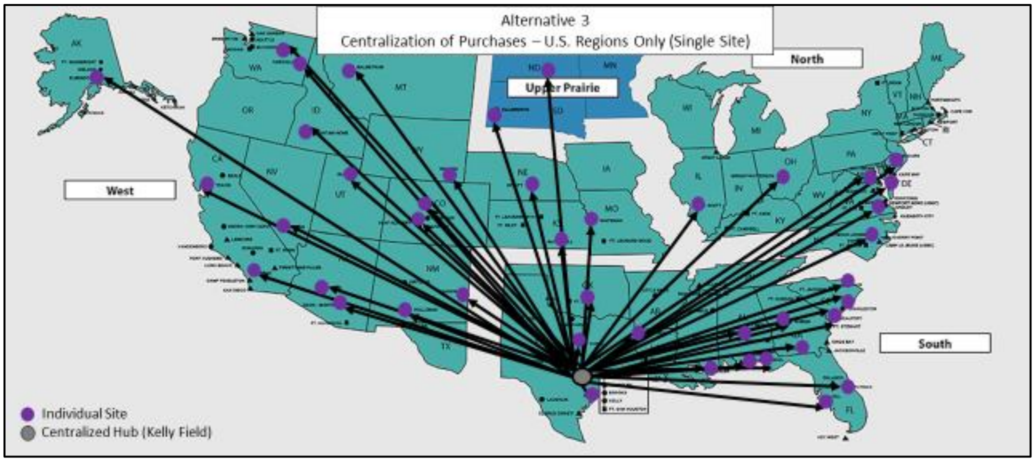


Figure 5. Alternative 3 Network (DLA Troop Support, 2016)

Lastly, the fourth alternative identifies global shortage aggregation opportunities at regionally designated sites. The sites selected for these regional hubs were designated by the Prime Vendor regional delineations of West, South, North, Pacific, and Europe (Defense Logistics Agency, 2013). In evaluating aggregated demand, the location with largest aggregated shortage amounts for each region were Travis AFB (West), McGuire AFB (North), Kelly Field (South), Kadena AB (Pacific), and Ramstein AB (Europe). Through centralized purchasing at these locations resulting transportation occurrences would be minimized as these ordering locations already have the highest regional demand when compared to peers.

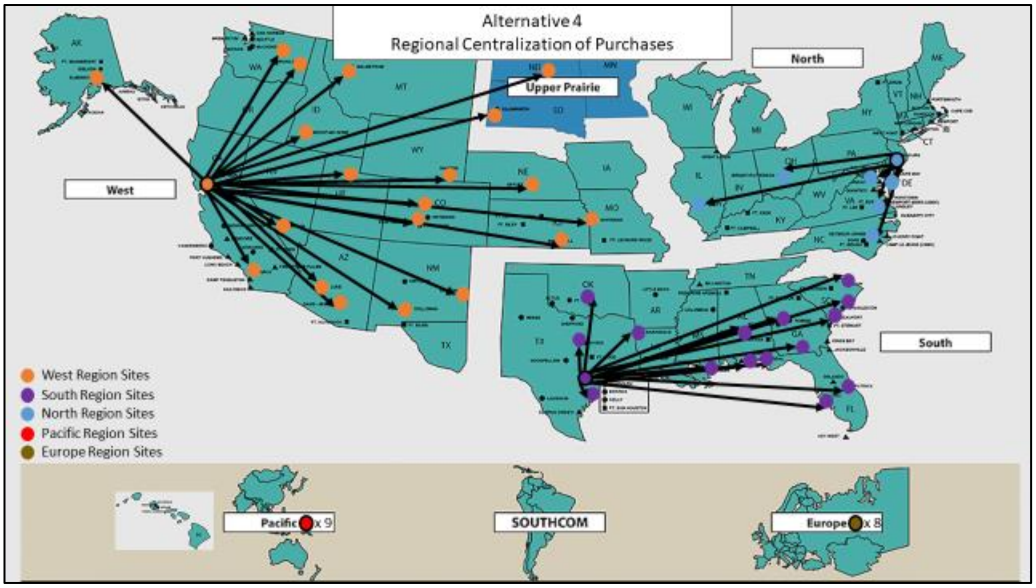


Figure 6. Alternative 4 Network (DLA Troop Support, 2016)

Once alternative projects are fully defined, in the second step of the cost-benefit analysis stakeholders need to be identified to ensure no relevant desires and limitations are overlooked. Although the identification of stakeholders in this cost-benefit analysis will not directly influence the calculated costs, it is important to identify these stakeholders from a systems perspective. Starting at the most micro level, the first stakeholder would be the local account managing the various assemblages assigned to their unit under the MRL. It is important to understand that there will be relatively incalculable individual transaction costs at this localized level from the various coordination that will take place. This research accounts for these resulting transaction costs as fixed costs, as work would be done under the current WRM service contract.

From the next stakeholder level, the higher headquarters or AFMRA level, these local transaction costs may not be realized, but it is important to understand that enactment of any of these alternative projects will likely place additional workload on the

individual units. At the higher headquarters level, there will need to be communication and guidance with the sites conducting the centralized ordering in the form of what items are need to be ordered, when orders need to be placed and, when items need to be distributed to the demanding locations.

Following the construction of alternative actions and stakeholder delineation, step three of the cost-benefit analysis outlines the costs and benefits of the project. Relevant costs to be assessed in this analysis include acquisition costs of procuring shortage items and transportation costs of shipping the procured items from the centralized ordering site to the demanding site. Acquisition cost as an impact to this cost-benefit analysis will be calculated by aggregating the shortage of each item to first determine the amount required. Once the shortage amount of each pharmaceutical item is determined, the acquisition cost is determined by multiplying the remedied shortage amount by the cost per unit established by the PPV contract.

Individual item weight information is maintained in the Medical Contingency Requirements Workflow (MCRW) portal. Weights, in pound increments, were gathered for each of the shortage items to establish a baseline estimate for total weight shipped in each alternative project. The average weight of the assessed items was 2.6 pounds, which was conservatively rounded up to 3 pounds for shipping cost calculations. Shipping costs for three pound shipments were then gathered from third party logistics (3PL) companies FedEx and DHL. These 3PL companies are the current Air Force shipping intermediaries for contingency pharmaceutical items. Estimated shipping rates used to calculate transportation costs were established by gathering shipping quotations for 3 pound shipments from Kelly Field to each unique site. From the 60 unique shipping quotations,

it was determined that the average domestic shipping cost was $12.02 for a three pound shipment and the average international shipping cost was $103.94 for a three pound shipment (JMAR, 2019). These values were then proportionally applied to the breakdown of anticipated domestic and international shipping amounts, which were 72 percent and 28 percent of shipments, respectively (JMAR, 2019).

This resulted in an estimated 3 pound shipping rate of $37.30. This calculation of $37.30 per shipment is conservative in nature because shipping costs from the 3PL companies are not directly linear when looking at pound increments. This means that a 3 pound domestic shipment, costing roughly $12.02, would not jump to $24.02 for a shipment of 6 pounds. In fact a 6 pound shipment from Kelly Field to Wright Patterson AFB, as an example, would only cost $16.64, which less than a 40 percent price increase from the shipment containing only 3 pounds. This means that consolidated shipments of larger total weights could further optimize total transportation costs.

The primary benefit to be assessed in this cost-benefit analysis is remedied shortage units which will impact the material availability percentage. Shortage units will be remedied through the demand aggregation at single and regional ordering sites. The remedied shortage amount is finalized by applying a coefficient of .9619, as the average fulfillment rate for the contract in FY19 was 96.19 percent. This refinement accounts for the fact that although there will be newly generated adequate demand profiles, the contract likely will not fulfill 100 percent of the requests.

Summary

This methodology consisting of descriptive data analysis and cost-benefit analysis steps of alternative project determination, stakeholder identification and determination of impacts quantitatively depicts the current state of AD WRM contingency pharmaceutical item shortages. The analysis and results section of this thesis will address the final cost-benefit analysis steps of impact prediction, monetization and sensitivity analysis.

IV. Analysis and Results

Chapter Overview

The analysis and results section of this thesis will finalize the cost-benefit analysis initiated in the methodology section through a theme of predictive analytics by outlining cost and benefit predictions, monetization, and sensitivity analysis. Completion of this analysis and interpretation of results will set up the final recommendation.

Analysis and Results

The results and analysis of this research continues the cost-benefit analysis through step four of impact prediction and quantification. Completion of this step facilitates the comparison of various alternatives identified earlier in the methodology. The below table depicts resulting remedied shortage amounts and shipping weights from the various alternatives.

Table 1. Impact Predictions

Alternatives	Remedied Shortage Units	Final Shortage Units	Shipping Weight (Lbs.)	Increased MAV%	Final MAV%
1 Status Quo	No Change	158,139	No Change	No Change	80.8
2 Single Site Procurement	141,607	16,532	258,745	21.3	98.0
3 Single Site Procurement (U.S. Regions)	98,689	59,450	184,462	14.8	92.8
4 Regional Site Procurement	136,210	21,929	247,764	20.4	97.3

After impact prediction and quantification is complete, the results are monetized for further comparison. The fifth step of monetization in this cost-benefit analysis will account for the resulting acquisition and transportation costs, defined earlier, as well as monetized values for resulting material availability. The monetary value of increases in material availability were established using the principles of the military production function, which quantifies militaristic outputs based on monetary inputs (Hartley and Soloman, 2015).

The resulting benefit ratio was calculated using the total AD WRM programmed expense of $24.8 million for pharmaceutical procurement. This means that the acquisition cost of obtaining full material availability has a value of $24.8M based on contractually negotiated pharmaceutical item prices. Therefore, the value of increased material availability is calculated to be $248K/percent increase, which was calculated by dividing the $24.8M in programmed expenses by total fulfillment. With this estimation, and applications of previously discussed monetization of acquisition and transportation costs, the final monetization results of the cost-benefit analysis are depicted below.

Table 2. Cost-benefit Analysis Results with Monetization

Alternatives	Acquisition Cost	Transportation Cost	Benefits	Net Results (Benefits minus Costs)
1 Status Quo	No Change	No Change	No Change	No Change
2 Single Site Procurement	$ (3,544,601)	$ (1,243,016)	$ 5,287,493	$ 499,875
3 Single Site Procurement (U.S. Regions)	$ (2,038,018)	$ (886,157)	$ 3,684,969	$ 760,793
4 Regional Site Procurement	$ (3,033,908)	$ (9,076)	$ 5,085,973	$ 2,042,988

It was determined through additional research of the PPV contract that there are provisions which covers transportation expenses for intra-region shipping, when orders are placed by a Master Ordering Facility (MOF) within the same region (Defense Logistics Agency, 2013). This finding was crucial to the estimations and presentations of transportation costs, as it would eliminate many transportation expenditures when centralized orders are made intra-region.

Each of the designated ordering hubs, in all alternatives are currently designated as Master Ordering Facilities (AFMRA/SG4M, 2019). The decrease in additional transportation costs was accounted for South region orders in alternatives 2 and 3, as the designated centralized ordering hub of Kelly Field is located in the South Region. Also, in alternative 4, the only resulting transportation costs captured in this analysis arise from shipment of items from Travis AFB, in the West region, to the Upper Prairie region locations.

After monetization is conducted, the sixth step of sensitivity analysis is completed to evaluate uncertainties or what-if scenarios of the alternative options. As these pharmaceutical items are procured for uncertain contingency situations, current demand could either decrease drastically in instances of contingency draw downs, or increase substantially in situations where new conflicts or emergencies arise. The sensitivity analysis for this research evaluates shifts in demand through Monte Carlo simulations, conducted through the Microsoft Visual Basic Application (VBA). This code was constructed to take small scale simulation efforts conducted on a single item to a platform such as VBA, which automates the simulations for multiple items simultaneously. The

VBA code applied in this research simulates changes in demand patterns for all 1124 shortage items assessed in this research. Through base case, maximum case, and minimum case scenarios validity of the proposed consolidation methods in varying situations can be tested.

In the simulation, a standard deviation of 10 percent ($\sigma = .1$) was applied to the AD WRM platform's authorizations for pharmaceutical items to account for possible variability in future climates. Shifts in these factors were simulated 10,000 times for each item to allow for determining maximum case (ramp up), and minimum case (draw down) what-if scenarios.

Table 3. Cost-benefit Analysis Sensitivity Analysis

Alt 4 Simulation Results	Allow Qty	Remedied Shortage Units	Final Shortage Units	Shipping Weight (Lbs)	Increased MAV%	Final MAV%
Base Case	824294	136210	21929	247764	20.4	97.3
Draw Down (Min Values)	506839	68970	30401	148501	16.9	94.0
Ramp Up (Max Values)	1143028	163723	56488	350084	17.7	95.1
Average (Mode)	821980	115867	43800	248279	17.4	94.6

The outcomes this sensitivity analysis, shown here for alternative four, highlights that even in instances of varying and uncertain demand, proposed consolidation methods could be highly beneficial in terms of improving fulfilment. When looking at resulting costs, there is some uncertainty especially in "ramp up" situations. Due to the conservative nature of transportation cost estimates used in this research, the calculated transportation costs reflect single item shipments with an average weight of three pounds. If optimized shipping cost methods were used, for instance by increasing the weight

amount of each shipment by sending multiple items in a single shipment, the calculated value for transportation cost in each ramp up situation would dramatically decrease and make what-if scenarios more attractive in terms of net results. A full outline of the simulation results and VBA code are provided in Appendices E and F.

Summary

This analysis and results section is bolstered by the fourth, fifth, and sixth steps of the cost-benefit analysis process. The fourth step, outlines the resulting impacts being assessed in this cost-benefit analysis, which are acquisition costs, transportation costs, and material availability. By making the decision to not undertake any demand consolidation, the AD WRM program will remain at current material availability levels for contingency pharmaceuticals. This cost-benefit analysis suggests that if demand aggregation efforts are undertaken that material availability can increase by a range of 14-21%, depending on which alternative is exercised.

The fifth step of monetization computes the discussed impacts into dollar formats to allow aid managerial decisions of selecting projects with positive outcomes. Sensitivity analysis, conducted through Monte Carlo simulations accounting for variability in demand, shows that these practices of aggregating demand and ordering from a centralized or regionalized hub are beneficial, even under significant levels of uncertainty. The last step of the cost-benefit analysis process will be addressed in the final section of this thesis, the conclusion and recommendation.

V. Conclusions and Recommendations

Conclusions of Research

This research determined that there are strategic supply chain management efforts, mainly demand aggregation and centralized procurement, which could be employed to mitigate the current AFMS contingency pharmaceutical procurement shortfalls. The costs and benefits of these supply chain principles were determined and all three proposed alternatives rendered a positive net value. Regardless of decisions made on which course of action to undertake, be it a full implementation of one of the identified alternatives or a small scale implementation of aggregated purchasing for strategically identified items, this research shows the positive effects of practicing centralized ordering procedures based on demand aggregation of shortage items.

Enacting the principles of centralized ordering procedures for shortage items can lead to over 20 percent increases in material availability of contingency pharmaceutical items. However, as pharmaceuticals are only one subset of the medical contingency item platform, this increased availability of pharmaceutical items is only one part of the availability issue facing the AFMS in contingency item procurement. To improve the material availability of the total AD WRM program, additional efforts will need to be taken to diminish shortages in the supply, equipment and repair item areas of the program.

Recommendations for Action

The final step of the cost-benefit analysis is to provide a final recommendation. After determining the flexibility of the PPV contract to utilize Master Ordering Facilities,

which can lower intra-region shipping costs, it is recommended to pursue alternative 4 which advocates for regional procurement hubs across the globe. This alternative has the largest net result as it capitalizes on transportation savings, while only experiencing minimal decreases to fulfilment levels compared to a single source for procurement of all items.

For instance alternative 4, which evaluates five regional procurement hubs, would result in less remedied shortage items than a single procurement site. However, the transportation savings resulting from intra-region transportation amount to one million dollars. Leaders would have to make the determination if the resulting unfulfilled units from alternative 4 is an acceptable shortage when the relevant savings are taken into account. The use of the military production function, and assertion that each percent increase in material availability renders $248K value, shows that the small difference in material availability between alternatives 2 and 4 likely would not be worth the cost of the increased transportation expenses resulting from the single ordering and distribution point of alternative 2.

Unless resulting transportation costs of alternative 2 could be drastically minimized through optimization of shipping processes, alternative 4 is determined to be the optimal solution. Initial concerns in the conduction of this research was that moving from a single centralized ordering point to the regional ordering site model would drastically diminish the aggregated demand profiles, which would lead to decreased fulfillment levels. However, breaking the demands down by region did not have a drastic impact on theoretical fulfillment as hypothesized initially.

Future Research

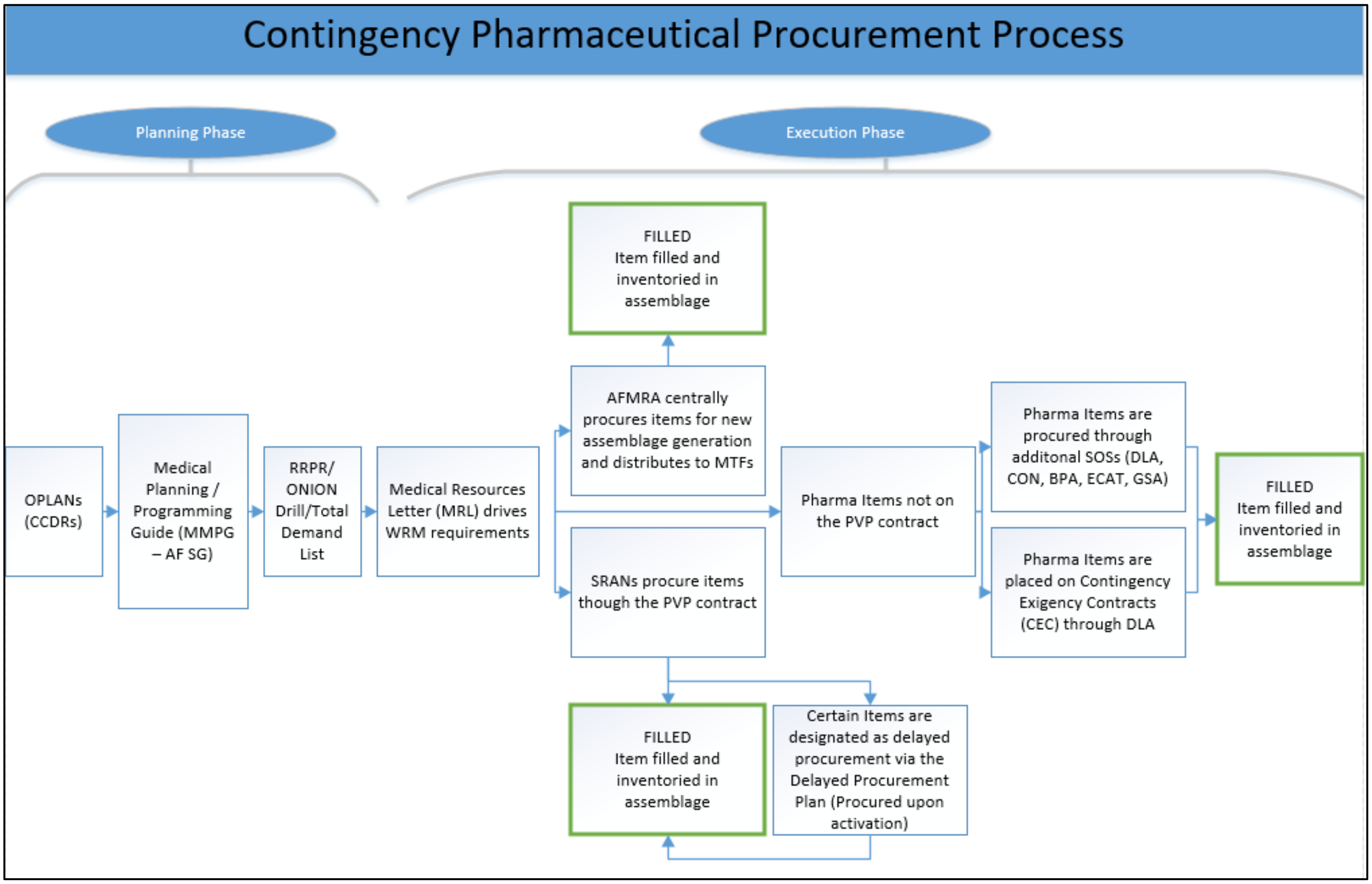
As contingency pharmaceutical items are only one aspect of the AFMS contingency item program, future research could be conducted to determine more effective ordering policies for those non-pharmaceutical items including contingency medical supplies, equipment, and repair items. Completion of this research would provide a more robust for necessary actions to fully mitigate all AFMS contingency item shortages. Future research could also be addressed at a joint, or Defense Health Agency (DHA), level comprised of aggregated Army, Navy and Air Force data. Future shifts in military medicine practices, administration, and logistics will see programs moving to a more joint service perspective under the DHA. This would undoubtedly result in even larger demand signals, which could further improve DoD material availability of contingency medical items.

Appendicies

Appendix A. Allowance Standards (“Allowance Standard Management System,” 2019)

Allowance Standard List								
AS	Title	UTC	AS	Title	UTC	AS	Title	UTC
885A	Med Hospital Surgical Expansion Package-Surg Equip (HSEP)	FFEES	902V	Transport Isolation System IMC	FFTS2	915H	Med Air Transportable Clinic Equipment	FFLGE
885B	Med Hospital Expansion Package-Equip Inc 1 (HMEP)	FFEEW	902Y	Transport Isolation System Spares-Repairs Kit	FFTS5	915I	Medical Theater Epidemiological Equipment Pkg	FFHAE
885G	Med CT Scan Equipment Package	FFHAG	902Z	Transport Isolation Refit Kit	FFTS6	915K	National Airborne Operations Center (NAOC)	HCBA C
885H	Med Ancillary Care Team	FFAN1	903A	Med Deployable Oxygen Package	FF0X2	916E	Med PAM Team ADVON Equipment (Blk 20)	FFPM4
885I	Med Intensive Care Equipment	FFCC1	903B	AE Oxygen Support Package	FF0X3	916F	Med PAM Sustainment Equipment	FFPM5
885J	Med Radiology Equipment Package	FFRA5	903C	AE Contingency Support Package	FFAM1	917A	Medical Behavioral Health Equipment	FFBHE
887A	AE Inflight Kits	FFQDM	903F	Electronic Personal Dosimeters	FFPD1	917B	Med Behavioral Health Small Equip Package	FFBHS
887B	AE Inflight Kit Resupply	FFQDH	903G	Mobile Oxygen Storage Tanks (MOST) Package	FFMT1	917C	Med Pediatrics Equipment	FFPE1
887C	Tactical Critical Care Evacuation Team	FFTC1	903K	Pediatric and Geriatric Support Package	FFAM3	917D	Med Neurosurgical Augmentation Equipment	FFNE1
887D	Stacking Litter System	FFQD1	903N	En Route Care Ex Package	FFEC1	917E	Med ENT Augmentation Equipment	FFET1
887E	Electronic Health Record (EHR)	FFEHR	903O	AE Operations Team Augmentation (AEOT AUG) Equipment Package	FFQC2	917F	Med Ophthalmology Equipment	FFEY1
887F	Small Aircraft Inflight Kit	FFQD4	903U	Patient Loading System	FFPLS	917G	Med Thoracic/Vascular Equipment	FFGKQ
887H	Critical Care Air Transport Team (CCATT) Adult Resupply	FFCCB	903V	AES AE Liaison TM Equip Pckg	FFQL1	917H	Med Urology Augmentation Team Equipment	FFPP1
887I	Stacking Litter Adapters	FFQD2	903Y	AE Operations Tm Equip Pkg.	FFQN1	917I	Med Dental Equipment Package	FFF0E
887M	Portable Ultra Sound System	FFCC5	903Z	AE Command Sq Equip Pkg	FFQC1	917J	High Altitude Air Drop Mission Support	FFQB1
887N	Critical Care Air Transport Team (CCATT) Adult	FFCC4	904E	Deployable Maintenance Equipment Package	FFBM1	917L	Med OB/GYN Equipment	FFGY1
887O	CCATT Pediatric Augmentation	FFCC2	904F	En Route Patient Staging System (ERPSS) 10	FFPS1	917P	Med Oral Surgery Equipment	FFMA1
887P	Patient Movement Items	FFQP3	904G	En Route Patient Staging System (ERPSS) Equipment PKG - 50	FFPS2	917Q	Med Optometry Augmentation Team Equipment	FFD01
887Q	Deployable Patient Movement Item Tracking System (PMITS)	FFQP4	904H	En Route Patient Staging System (ERPSS) Expendable PKG - 50	FFPS3	917R	Med EMEDS HA Augmentation Tm Equipment	FFP0E
887R	Patient Isolation Unit	FFP1U	904I	En Route Patient Staging System (ERPSS) Facility PKG - 50 Bed	FFPS4	920A	EMERGENCY CRASH CART	CCART
893A	Blood Donor Center (WHMC)	1FBLD	904J	En Route Patient Staging System (ERPSS) Support Package	FFPS7	937N	Med Ambulance Augmentation Package	FFAMB
893B	CONUS Blood Donor Center (600 Pint)	2FBLD	904K	En Route Patient Staging System (ERPSS) Resupply	FFPS8	938B	Med EMEDS +10/AFTH-Equip Inc 2	FFEE2
893C	Med Expeditionary Blood Support Center Equipment	FFLB1	905A	Medical Support Package	FFSR1	938C	Med EMEDS +25/AFTH-Equip Inc 3	FFEE3
893E	Blood Processing Laboratory (ASWBPL)- McGuire	3FBLD	912C	SOF Surgical Primary Response Equipment	FFQEF	938D	Med EMEDS Basic Resupply	FFEE4
893F	Frozen Blood Program Equipment	FZNBP	912D	SOF Surgical Electrical Equipment Augmentation	FFQEE	938E	Med EMEDS +10/AFTH Resupply	FFEE5
893I	Blood Processing Laboratory (ASWBPL) - Travis	4FBLD	912G	SOF MED Oxygen	FFQEU	938F	Med EMEDS +25/AFTH Resupply	FFEE6
893J	Med Expeditionary Blood Transhipment System Equipment	FFBE1	912H	SOF Base Medical Support - Air Trans Treatment Unit (ATTU)	FFQEL	938G	Med Mobile Field Surgical Team Equipment (MFST)	FFMF1
902A	Med Patient Decontamination Equipment	FFGLC	912K	SOF Medical Element Augmentation Equipment	FFQEG	938J	Med Critical Care Equipment	FFEPE
902B	Med BEE NBC Team Equipment	FFGL7	912L	Casualty Evacuation Module	FFQEN	938M	Med Water Distribution System WDS	FFWD S
902C	Med Biological Augmentation Equipment	FFBA1	912M	SOF Surgical Sustainment Equipment	FFQES	938P	Med EMEDS HRT Equipment Inc 1	FFHR1
902G	Med AFRAT-Rad/Nuc Crisis ADVON Team	FFRN1	912N	SOF Critical Care Evac Primary Response Equipment	FFQEB	938Q	Ground Surgical EQ	FFGS1
902H	Med AFRAT RAD/NUC Surveillance Tm	FFRN2	912O	SOF Rapid Response Deployment Kit	FFQEM	948A	Med CP Medical Tent With Airlock	FFCPS
902J	Med Infectious Disease Team Equipment	FFHAF	912Q	SOF Critical Care Evac Equipment	FFQEC	948E	Med CP Water Distribution System Without Airlock	FFCPW
902K	Med Contagious Casualty Management - CCM	FFCCM	912R	SOF Extended Reach Medical Equipment	FFQED	948F	Med CP Hospital Surgical Expansion Package	FFCPE
902L	Med AFRAT RAD/NUC Surveillance Aug Equipment	FFRND	912S	SOF PEDS	FFQEJ	948G	Med CP Hospital Medical Expansion Package	FFCPF
902M	Med AFRAT RAD/NUC Laboratory Team	FFRN4	912W	SOF Irregular Warfare	FFQEW	948H	MED CP ONE TENT W/AIRLOCK	FFCP1
902N	Med AFRAT RAD/NUC Laboratory Aug Equipment	FFRNB	913J	Pararescue Medical Support Kits	81SBD	948I	MED CP 4 TENT W/AIRLK/CPEL	FFCP2
902O	Med AFRAT RAD/NUC Dosimetry Team	FFRN6	913K	Pararescue Medical Support Accessory Kits	81SLG	948J	MED CP 3 TENT W/AIRLOCK	FFCP3
902P	Med AFRAT RAD/NUC Dosimetry Aug Equipment	FFRNC	913N	NASA Assemblage	NASA1	948K	MED CP 3 TENT CPEL	FFCP4
902U	Transport Isolation System (TIS) AM and IME	FFTS1	915G	Medical Global Reach Laydown Team	FFGR1	948L	MED CP ONE TENT	FFCP5

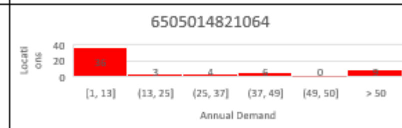
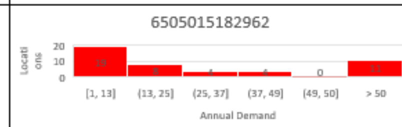
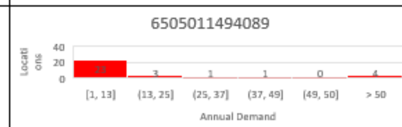
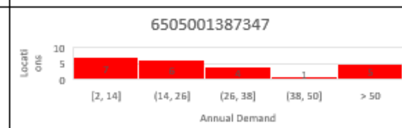
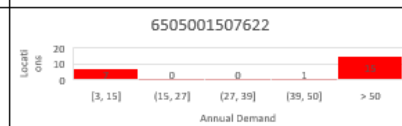
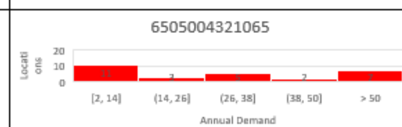
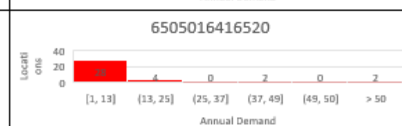
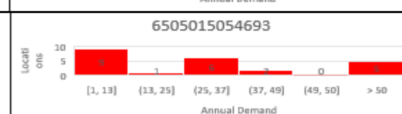
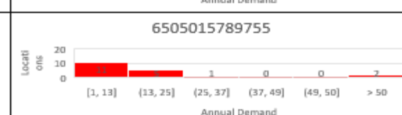
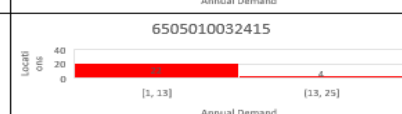
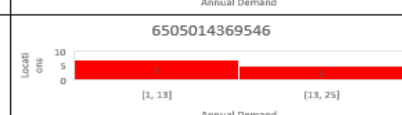
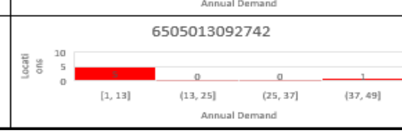
Appendix B. Procurement Process (HQ USAF/SG, 2013), (AFMRA/SG4M, 2019)

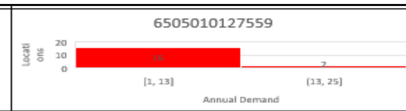
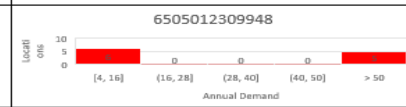
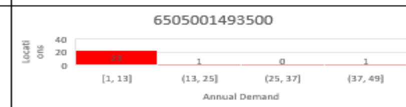
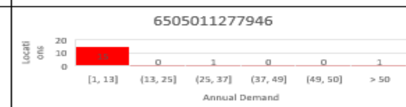
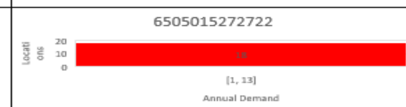
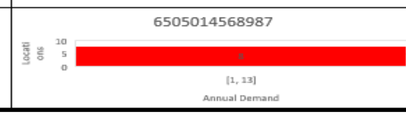


Appendix C. Stock Record Account Number Designations (JMAR, 2019)

Main SRAN and Sub Locations					
Main Location	Sub Locations	Main Location	Sub Locations	Main Location	Sub Locations
FM2020	FFMQL0, FFW0M0	FM4484	103RQS, FF0970, FF4ZV0, FFMFH0, FFMFP0, FFMGK0, FFMGL0, FFS7K0, FFS7N0, FFTLV0	FM5000	FF0B90, FF1DD0, FFS1Q0
FM2030	FFMKW0, FFWYB0	FM4497	FF4ZS0	FM5004	FFGS40
FM2060	FFL330, FFLJ00, FFMFD0	FM4528		FM5202	
FM2300	FF3K00, FFBF70, FFF6Q0, FFL560, FFL6F0, FFL7K0, FFL910, FFL950, FFLG20, FFLJJ0, FFLJQ0, FFLNX0, FFMJ30, FFMJ90, FFMJC0, FFMJP0,	FM4600		FM5205	
FM2500	FF3KW0	FM4608	FFLK50	FM5240	FFH2B0
FM2504	FF0TX0, FFL200	FM4610	FFL110, FFL1V0	FM5260	FFH270, FFL4V0
FM2520	FF4G30	FM4613	FFMST0, FFWZL0	FM5270	3H5886, FF07F0, FF0850, FFDCT0, FFJ840
FM2805		FM4620	FFMRF0	FM5280	
FM2816		FM4621	FFBY10, FFL670, FFL7D0	FM5284	
FM2823	FFV7F0	FM4625	FFLMN0, FFMCT0, FFTJB0	FM5288	FHBDV0
FM2835		FM4626	FFMDH0, FFRRF0	FM5294	FHBKP0
FM3010	FF8DF0, FFL7Y0, FFLNH0, FFMB90, FFMCB0, FFMCJ0	FM4659		FM5587	FFLXC0, FFLXD0, FFWTM0, FFWTN0, SUBMEN
FM3016	FF49Z0	FM4661		FM5606	FF41K0
FM3020	FFMPR0, FFWY10	FM4668	FM4856	FM5612	FY4486
FM3022		FM4686	FFBGF0, FFL1T0, FFLP00, FFQFD0	FM5655	
FM3029		FM4690		FM5682	FFKZ50, FFTD20
FM3030		FM4800	FF1F10, FFMGS0, FFMQ20	FM6382	CMSPCN, FFW060, FFW200, FFW210, FFW230, FFW240, FFW250, FFW2D0, FFW3B0, FFW3G0, FFW3H0, FFW3J0, FFW3K0, FFW3L0, FFW3N0, FFW3P0, FFW3S0, FFW3T0, FFW3Y0, FFW3Z0, FFW410, FFW420, FFW430, FFW440, FFW450,
FM3047	FF6MZ0, FFMP20, FFTMW0, FM3089	FM4801		FM6471	FY6478
FM3099		FM4803	FFMHV0, FFMNB0, FFMPF0	FM6615	FFJI80, FFL2B0, FFLGN0
FM3300	FFLL50, FFLZ00, FFLZ30	FM4809	FF79L0	FM6902	FM6925, FM6942
FM4407	FF66G0, FFL5F0, FFL5N0, FFL5T0, FFL6Y0, FFLM80, FFMB00, FFMBQ0, FFMBY0, FFMDR0, FFMH40, FFMKL0, FFMNL0, FFMNV0, FFMSB0, FFMSJ0, FFTDQ0, FFXSW0	FM4814	FF3VJ0, FF5SV0, FFLVJ0, FFMMR0	FM6912	
FM4417	DETOOO, FF6D20, FFC9X0, FFDYZ0, FFF300, FFWV80	FM4819		FM6913	FM6916
FM4418	FF4ZQ0, FFL4H0	FM4830	DETEEE, FF53F0, FFC800, FFIRF0, FFL3T0	FM6917	
FM4419		FM4852	FF1DZ0	FM6924	
FM4425	FF4G20, FFL290, FFL3D0, FFL3L0, FFL770, FFL8S0, FFL8Z0, FFL9B0, FFL9K0, FFLJB0, FFMD60, FFMM20, FFMQV0, FFMR10, FFQ5L0, FFWZQ0, FFX180, FHH4W0, FM7054	FM4855	FFHWL0, FFWK40	FM7000	
FM4427	FF4ZT0, FF4ZY0, FFL1M0, FFLQ50, FFMK70, FFMR20, FFR4W0	FM4856	FFMR10	FM7080	ARMY01, ARMY02, FF1VK0, FF1WK0, FFGTS0, , FFLTJ0, K453AA, K457AG, K457AI, K457AJ, K457AN, K457AO, K457AP, K528AA, K528AB, K528AC, K955AA, K955AE, KANS01, PJAKLY,
FM4444		FM4877	FFHLX0, FFTND0	FM9133	BLDP12, BLDP14, BLDP15, BLDP16, BLDP17, BLDP18, BLDP19, BLDSPT, DETGUS, DETSUP, IMITEC, LUMSUS, NAVY17, OPRSPT, PCAF18, RBDP17, RBDP18, RBDP19, SGMANG
FM4460	FFL040, FFL090, FFMN50, FFVQ40	FM4887	FF43H0, FFL0L0	FM9911	FF09T0, FF1VT0, FF1WT0, FF8CZ0, FFCRH0
FM4469	FFBGG0	FM4897	FFL440, FFNN61	FM9912	FF1VC0, FF1WC0, FF3N60, FFD170, FFH7T0, FFLM20, FFMHW0, FFQBF0

Appendix D. Contingency Pharmaceutical Item Shortages (JMAR, 2019)

Top 20 Contingency Pharmaceutical Item Shortages										
Prime ID	Item	# Unique Locations w/Item	# of Assemblages w/Item	# of Assemblages w/Shortage	% of Assemblages w/Shortage	Total Qty Demanded	Total Qty Short	Sites With Insufficient Demand	% Sites With Insufficient Demand	Qty Demanded By Locations
6505014821064	KETOROLAC 60 MG/2 ML CARPUJECT 2ML	58	1128	1007	89.27%	1990	1788	36	62.07%	
6505015182962	DIPHENHYDRAMINE 50 MG/ML VIALML	46	553	487	88.07%	2398	2112	19	41.30%	
6505011494089	DOPAMINE 40 MG/ML VIAL 5ML	32	359	262	72.98%	724	438	23	71.88%	
6505001387347	MARCAINE 0.5% VIAL 50ML	23	287	256	89.20%	797	711	7	30.43%	
6505001507622	SYSTANE NIGHTTIME EYE OINTMENT 3.5GM	23	343	213	62.10%	2757	1520	7	30.43%	
6505004321065	GENTAMICIN SULFATEOPH	28	256	204	79.69%	997	759	11	39.29%	
6505016416520	LORAZEPAM 1 MG TABLET UD 100S	36	284	200	70.42%	360	231	28	77.78%	
6505015054693	DEMEROL 100 MG/ML CARPUJECTML	23	232	177	76.29%	1003	756	9	39.13%	
6505015789755	FENTANYL CITRATE OTFC 800 MCG 30S	19	177	133	75.14%	312	225	11	57.89%	
6505010032415	HALOPERIDOL 1 MG TABLET 100S	26	119	106	89.08%	201	179	22	84.62%	
6505014369546	HYDROMORPHONE 2 MG/ML CARPUJCTML	12	128	74	57.81%	128	74	7	58.33%	
6505013092742	METOPROLOL TART 5 MG/5 ML VIAL 5ML	6	71	65	91.55%	78	68	5	83.33%	

6505010127559	PANCURONIUM BROM 10ML	18	102	66	64.71%	102	63	16	88.89%	
6505012309948	BACITRACIN ZN 500 UNIT/GM OINT 15GM	11	81	49	60.49%	748	515	6	54.55%	
6505001493500	SENSORCAINE 0.25% VIAL 50ML	25	46	40	86.96%	103	25	23	92.00%	
6505011277946	MARCAINE 0.5% VIAL 30ML	17	45	41	91.11%	139	132	15	88.24%	
6505015272722	METHYLENE BLUE 1% VIAL 10ML	18	37	28	75.68%	37	28	18	100.00%	
6505014568987	TOPROL XL 50 MG TABLET 100S	8	34	26	76.47%	34	26	8	100.00%	

Appendix E. Simulation Results (JMAR, 2019)

Alt 1 Simulation Results	Allow Qty	Remedied Shortage Units	Final Shortage Units	Shipping Weight (Lbs)	Increased MAV%	Final MAV%	Est Acq Costs	Est Trans Cost	Est Benefits	Net Results (Benefits minus Costs)
Base Case	824294	0	158139	0	0.000%	80.815%	$ -	$ -	$ -	$ -
Draw Down (Min Values)	510055	0	97475	0	0.000%	80.889%	$ -	$ -	$ -	$ -
Ramp Up (Max Values)	1141899	0	219204	0	0.000%	80.804%	$ -	$ -	$ -	$ -
Average (Mode)	825767	0	158530	0	0.000%	80.802%	$ -	$ -	$ -	$ -
Alt 2 Simulation Results	**Allow Qty**	**Remedied Shortage Units**	**Final Shortage Units**	**Shipping Weight (Lbs)**	**Increased MAV%**	**Final MAV%**	**Est Acq Costs**	**Est Trans Cost**	**Est Benefits**	**Net Results (Benefits minus Costs)**
Base Case	824294	141607	16532	258745.49	21.257%	97.994%	$ (3,544,601.24)	$ (1,243,016.49)	$ 5,287,493.20	$ 499,875.48
Draw Down (Min Values)	506930	85899	11139	158114.53	20.956%	97.803%	$ (2,094,808.20)	$ (753,115.99)	$ 5,212,655.91	$ 2,364,731.72
Ramp Up (Max Values)	1140621	197683	22265	361905.26	21.472%	98.048%	$ (5,023,947.20)	$ (1,723,792.48)	$ 5,340,775.32	$ (1,406,964.36)
Average (Mode)	823789	141488	16707	257743.15	21.257%	97.972%	$ (3,540,293.69)	$ (1,227,657.49)	$ 5,287,502.69	$ 519,551.51
Alt 3 Simulation Results	**Allow Qty**	**Remedied Shortage Units**	**Final Shortage Units**	**Shipping Weight (Lbs)**	**Increased MAV%**	**Final MAV%**	**Est Acq Costs**	**Est Trans Cost**	**Est Benefits**	**Net Results (Benefits minus Costs)**
Base Case	824294	98689	59450	184461.90	14.815%	92.788%	$ (2,038,018.39)	$ (886,359.16)	$ 3,684,969.08	$ 760,591.53
Draw Down (Min Values)	506930	60476	36562	113007.15	14.754%	92.788%	$ (1,182,504.47)	$ (538,264.84)	$ 3,669,898.12	$ 1,949,128.82
Ramp Up (Max Values)	1140621	137308	82640	258568.58	14.914%	92.755%	$ (2,870,203.95)	$ (1,231,589.10)	$ 3,709,631.98	$ (392,161.08)
Average (Mode)	823789	98256	59939	183451.77	14.762%	92.724%	$ (1,994,237.94)	$ (873,799.91)	$ 3,671,893.48	$ 803,855.63
Alt 4 Simulation Results	**Allow Qty**	**Remedied Shortage Units**	**Final Shortage Units**	**Shipping Weight (Lbs)**	**Increased MAV%**	**Final MAV%**	**Est Acq Costs**	**Est Trans Cost**	**Est Benefits**	**Net Results (Benefits minus Costs)**
Base Case	824294	136210	21929	247764	20.447%	97.340%	$ (3,033,908.26)	$ (9,076.46)	$ 5,085,973.50	$ 2,042,988.78
Draw Down (Min Values)	506839	68970	30401	148501	16.926%	94.002%	$ (1,712,106.81)	$ (5,099.39)	$ 4,210,242.50	$ 2,493,036.30
Ramp Up (Max Values)	1143028	163723	56488	350084	17.742%	95.058%	$ (4,468,875.36)	$ (13,109.09)	$ 4,413,005.81	$ (68,978.64)
Average (Mode)	821980	115867	43800	248279	17.494%	94.671%	$ (3,032,616.09)	$ (9,093.14)	$ 4,351,478.83	$ 1,309,769.60

Appendix F. VBA Code

```
Sub Databuild()
   Dim i As Double
   Dim k As Double
   Dim R As Double
   Dim x As Double
   Dim a As Double
   Dim b As Double
   Dim q As Double
   Dim Z As Double
   Dim ZZ As Double
Dim xrow As Integer
Dim Drug As String
Dim DrugCount As Double
Dim Allow_QtyMn As Double
Dim Allow_QtySD As Double
Dim Allow_Qty As Double
Dim DemandMn As Double
Dim DemandSD As Double
Dim Demand As Double
Dim PVP As Integer
Dim Aggregate As Long
Dim Remedied As Long
Dim sim1() As Variant
Dim sim2() As Variant
Dim sim3() As Variant
Dim sim4() As Variant
Dim sim5() As Variant
Dim SimCount As Long
Dim NormDistFx As Long
Dim Rng1 As Range
Dim Rng2 As Range
Dim StartTime As Double

StartTime = Timer

   Application.ScreenUpdating = False

Worksheets("Output").Range("A1") = "Drug"
Worksheets("Output").Range("B1") = "Minimum Rem"
Worksheets("Output").Range("C1") = "Mean Rem"
Worksheets("Output").Range("D1") = "Median Rem"
Worksheets("Output").Range("E1") = "Mode Rem"
Worksheets("Output").Range("F1") = "Maximum Rem"
Worksheets("Output").Range("G1") = "Maximum Allow"
Worksheets("Output").Range("H1") = "Minimum Allow"
Worksheets("Output").Range("I1") = "Mode Allow"
Worksheets("Output").Range("J1") = "Median Allow"
Worksheets("Output").Range("K1") = "Mean Allow"
Worksheets("Output").Range("L1") = "Minimum Short"
Worksheets("Output").Range("M1") = "Maximum Short"
Worksheets("Output").Range("N1") = "Mode Short"
Worksheets("Output").Range("O1") = "Median Short"
Worksheets("Output").Range("P1") = "Mean Short"

SimCount = Worksheets("Data").Range("O4").Value
a = 0
i = 0
k = 0
If Worksheets("Data").Range("N4").Value = "" Then
   MsgBox "Please enter a tolerance"
   Exit Sub
End If

Do Until Worksheets("Data").Range("I3").Offset(k, 0) = ""
If Worksheets("Data").Range("I3").Offset(i, -1) < 1 Then
   i = i + 1
   k = k + 1
   Else
   Drug = Worksheets("Data").Range("I3").Offset(k, -7).Value
   DrugCount = DrugCount + 1
   Worksheets("Data").Range("I3").Offset(k, -
7).Interior.ColorIndex = 5
   Allow_QtyMn = Worksheets("Data").Range("I3").Offset(k, -
4).Value
   Allow_QtySD = Worksheets("Data").Range("N4").Value *
Allow_QtyMn
   If Allow_QtySD <= 1 Then Allow_QtySD = 1
   DemandMn = Worksheets("Data").Range("I3").Offset(k, -
3).Value
   DemandSD = Worksheets("Data").Range("N4").Value *
DemandMn
   Aggregate = Worksheets("Data").Range("I3").Offset(k, -
1).Value
   Remedied = Worksheets("Data").Range("I3").Offset(k, -
1).Value
   If Worksheets("Data").Range("I3").Offset(k, -5) = "PVP" Then
      PVP = 1
      Else
      PVP = 0
   End If
   xrow = 0
   ReDim sim1(0 To xrow)
   ReDim sim2(0 To xrow)
   ReDim sim3(0 To xrow)
   ReDim sim4(0 To xrow)
   ReDim sim5(0 To xrow)
   Do Until xrow = SimCount
   q = Rnd()
   If q = 1 Or q = 0 Then
   q = Rnd()
   End If
   Debug.Print
   NormDistFx = WorksheetFunction.Norm_Inv(q, Allow_QtyMn,
Allow_QtySD)
   NormDistFx = Round(NormDistFx, 0)
   Allow_Qty = NormDistFx
   sim1(xrow) = Allow_Qty
   sim3(xrow) = PVP
   q = Rnd()
   If q = 1 Or q = 0 Then
   q = Rnd()
   End If
   NormDistFx = WorksheetFunction.Norm_Inv(q, DemandMn,
DemandSD)
   NormDistFx = Round(NormDistFx, 0)
   Demand = NormDistFx
   sim2(xrow) = Demand
   Aggregate = NormDistFx / 12
   sim4(xrow) = Aggregate
   If Aggregate > 1 Then
   Remedied = Demand * 0.96
   Else
   Remedied = 0
   End If
   sim5(xrow) = Remedied
   xrow = xrow + 1
   ReDim Preserve sim1(0 To xrow)
   ReDim Preserve sim2(0 To xrow)
   ReDim Preserve sim3(0 To xrow)
   ReDim Preserve sim4(0 To xrow)
   ReDim Preserve sim5(0 To xrow)
   Loop

Do Until Worksheets("Sim").Range("B2").Offset(0, a) = ""
   If Sheets("Sim").Range("B2").Offset(0, a) <> "" Then
   a = a + 1
   End If
Loop

   If Worksheets("Sim").Range("B2").Offset(0, a).Value = "" Then
```

```
    Worksheets("Sim").Range("B2").Offset(0, a) = "Allow_Qty"
    Set Rng1 = ActiveSheet.Range("B2").Offset(1, a)
    Worksheets("Sim").Range("B2").Offset(1, a).Resize(SimCount)
= WorksheetFunction.Transpose(sim1)
    a = a + 1
    Worksheets("Sim").Range("B2").Offset(0, a) = "Demand"
    Set Rng2 = ActiveSheet.Range("B2").Offset(1, a)
    Worksheets("Sim").Range("B2").Offset(1, a).Resize(SimCount)
= WorksheetFunction.Transpose(sim2)
    a = a + 1
    Worksheets("Sim").Range("B2").Offset(0, a) = "PVP"
    Worksheets("Sim").Range("B2").Offset(1, a).Resize(SimCount)
= WorksheetFunction.Transpose(sim3)
    ReDim sim3(0)
    a = a + 1
    Worksheets("Sim").Range("B2").Offset(0, a) = "Aggregate"
    Worksheets("Sim").Range("B2").Offset(1, a).Resize(SimCount)
= WorksheetFunction.Transpose(sim4)
    ReDim sim4(0)
    a = a + 1
    Worksheets("sim").Range("A2").Offset(-1, a + 1) = Drug
    Worksheets("Sim").Range("B2").Offset(0, a) = "Remedied"
    Worksheets("Sim").Range("B2").Offset(1, a).Resize(SimCount)
= WorksheetFunction.Transpose(sim5)
    Worksheets("Output").Range("A2").Offset(R, Z) = Drug
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Min(sim5())
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Average(sim5())
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Median(sim5())
    Z = Z + 1
    If SimCount > 100 Then
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Mode(sim5())
    Else
    Worksheets("Output").Range("A2").Offset(R, Z) = "Sim size
too small"
    End If
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Max(sim5())
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Max(sim1())
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Min(sim1())
    Z = Z + 1
    If SimCount > 100 Then
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Mode(sim1())
    Else
    Worksheets("Output").Range("A2").Offset(R, Z) = "Sim size
too small"
    End If
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Median(sim1())
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Average(sim1())
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Min(sim2())
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Max(sim2())
    Z = Z + 1
    If SimCount > 100 Then
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Mode(sim2())
    Else
    Worksheets("Output").Range("A2").Offset(R, Z) = "Sim size
too small"
    End If
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Median(sim2())
    Z = Z + 1
    Worksheets("Output").Range("A2").Offset(R, Z) =
Application.WorksheetFunction.Average(sim2())
    Z = Z + 1
    Z = 0
    R = R + 1
    a = a + 1
    End If
    i = i + 1
    k = k + 1
    End If
Loop
    Calculate
    MsgBox Format(Timer - StartTime, "00.00") & " seconds"

End Sub

Sub ClearSim()
    Sheets("Sim").Select
    Cells.Select
    Selection.ClearContents
    Sheets("Data").Select

    Range("B:B").Select
    With Selection.Interior
        .Pattern = xlSolid
        .PatternColorIndex = xlAutomatic
        .ThemeColor = xlThemeColorDark1
        .TintAndShade = 0
        .PatternTintAndShade = 0
    End With

End Sub
Sub ClearOutput()
    Sheets("Output").Select
    Cells.Select
    Selection.ClearContents
    Sheets("Data").Select

End Sub
Sub Test()
    Dim DrugCount As Double
    Dim Z As Double
    Dim ZZ As Double
    DrugCount = 640
    Do Until ZZ = DrugCount
If Worksheets("sim").Range("A1").Offset(0, Z) = "" Then
Z = Z + 1
Else
Worksheets("sim").Range("A:A").Offset(0, Z).Copy
Worksheets("Output").Range("A:A").Offset(0, ZZ).PasteSpecial
ZZ = ZZ + 1
Z = Z + 1
End If
Loop

End Sub
```

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Vita

Captain Adam J. Brubakken was born January 15, 1992 in Rapid City, South Dakota. He graduated from Rapid City Stevens High School in May 2011. Captain Brubakken is a distinguished graduate of the United States Air Force Academy, where he earned a Bachelor of Science degree in Management. In May 2015, he commissioned as a Hospital Administrator in the Air Force Medical Service Corps.

His first assignment was as the Deputy Flight Commander, TRICARE Operations and Patient Administration Flight, at the 88th Medical Group at Wright Patterson Air Force Base, Ohio. In 2017, Captain Brubakken then transitioned to the Medical Logistics Flight, where he served as the Material Manager for the Wright Patterson Medical Center.

Captain Brubakken entered the Graduate School of Engineering and Management, Department of Operational Sciences, Air Force Institute of Technology (AFIT) in September 2018. In March 2020, he graduated with a Masters Degree in Logistics and Supply Chain Management. Upon graduation, he will serve as a Hospital Administrator at the 48th Medical Group, RAF Lakenheath, England. Captain Brubakken is married to his high school sweetheart who will graduate from the University of Dayton, Doctor of Physical Therapy Program, in May 2020.

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14. ABSTRACT
The purpose of this research is to identify and explore effective supply chain principles, through the theory of transaction cost economics, as mitigating measures to improve current contingency pharmaceutical item shortfalls in the Air Force Medical Service Contingency Pharmaceutical Program. Through the methodology of cost benefit analysis, various alternative measures constructed upon supply chain practices of demand aggregation and centralized procurement are evaluated. The findings of this research suggests that application of centralized purchasing principles, which leverage prime vendor contract fill rates for shortage items, can lead to significant increases in pharmaceutical material availability.

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