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Contractual procurement alternatives of air force contingency pharmaceuticals: a cost-benefit analysis

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Abstract

Purpose – This paper aims to explore effective supply chain principles, through the theory of transaction cost economics, as measures to improve current contingency pharmaceutical item shortfalls in the Air Force Medical Service (AFMS) Contingency Pharmaceutical Programme.

Design/methodology/approach – In this research, AFMS contingency pharmaceutical data was collected from various databases, including the Joint Medical Asset Repository, Medical Contingency Requirements Workflow and the Medical Requirements List. Through the methodology of cost-benefit analysis, alternative sourcing and fulfilment practices are evaluated.

Findings – The findings of this research indicate that the application of centralized purchasing principles, in an effort to leverage prime vendor contract fill rates for shortage items, can lead to 12%–17% increases in pharmaceutical material availability across the programme.

Originality/value – This research clearly shows that consolidating demand for 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.

Keywords Strategic sourcing, Cost-benefit analysis, Pharmaceutical procurement

Paper type Research paper

Introduction

Forecasts for the year 2020 project that supply chain expenses will become the largest expenditure for US health-care organizations, commanding more budgetary requirements

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than the previous top expense of labor (Paavola, 2019). This means that the materials which allow a health care facility to function could now attract more attention than the medical professionals who provide the actual service of health care. At the same time, organizations are experiencing increasing costs across the entire spectrum of health-care providers 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 health-care leaders focussing 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 the attention of the biggest health-care companies in the country in an effort to improve supply chain operations (Michigan State University, 2019).

The Air Force Medical Service (AFMS) currently manages a $1.3bn contingency medical programme comprised of over 5,100 assemblages across the globe at 87 unique locations (JMAR, 2019). According to the Air Force Medical Logistics Guide, this programme 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 $113m of the programme (JMAR, 2019). A crucial subset of the overarching contingency medical programme, 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). The purpose of this research is to identify, evaluate and apply optimal supply chain efforts to address shortages in the Air Force Contingency Pharmaceutical Programme. Analysis of current contingency pharmaceutical shortages shows a significant trend of insufficient, individual site demand signals for various pharmaceutical items, resulting in non-fulfilment by private sector suppliers. This research applies cost-benefit analysis to evaluate various alternatives through the theoretical scope of transaction cost economics.

Over 35% of all Air Force contingency medical assemblages and 21% 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% 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% of all contingency item shortages across the entire contingency pharmaceutical programme (JMAR, 2019). Due to the unpredictable nature of contingency operations many contingency pharmaceutical items have non-recurring or non-usage demands, compared to a medical treatment facility (MTF) day-to-day pharmaceutical demands which have established and frequent usage patterns result from supporting a relatively predictable health-care environment (AFRMA MLD, 2019). Due to military-specific uniqueness, the commercial industrial sector requires known predictable demand signals. Consequently, without known demand signals, order unfulfilment occurs for contingency items as Department of

Defense (DoD) contracted distributors are only obligated to fulfil 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% of the entire US 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. The research will address the following questions:

RQ1. What are the strategic supply chain integration efforts that can be used to remedy current shortfalls?

RQ2. What are the costs and benefits of possible strategic supply chain integration efforts?

The structure of this research paper is as follows. Firstly, the theoretical scope of transaction cost economics is reviewed to provide the research basis for the assessment of contingency item procurement processes. The theory and background section also evaluates current contingency medical processes in the AFMS, introduces the concept of cost-benefit analysis and highlights principles of strategic sourcing. Subsequently, the data collection practices of this research and methodological applications of cost-benefit analyzes are outlined. Finally, findings are outlined with a discussion on research limitations and areas for future research.

Theory and background

Transaction cost economics

The review of applicable literature and theory for this research begins with a description of transaction cost economics. Next, procurement procedural aspects will be covered, followed by some strategic sourcing principals. Firstly, the basic premise of transaction cost economics theory instantiates that individuals or firms seeking to make the best possible decisions for their organization. This theory holds that organizations select specific 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). More specifically, transaction costs have been used to represent inputs related to searching, contract development, ex-ante and ex-post contractual actions, monitoring, retribution and resource acquisition activities (Rindfleisch and Heide, 1997).

As 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 (Simon, 1972; Williamson, 1979). This means that entities of the system, including employees, processes and agreements, may engage in or promote suboptimal behaviour, 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. According to the theory of information processing, when there is uncertainty in a given task or environment, there is a larger need for ensuring information processing to obtain desired outcomes (Landale *et al.*, 2017a, 2017b). Information processing can be improved through multiple avenues, including lateral relationships to share information (Landale *et al.*, 2017a, 2017b). Transaction cost economics suggests that when the resulting effects of bounded rationality greatly influence organizational transactions, organizational integration efforts or information sharing, could be used to ensure the value of transactions is 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, i.e. contractual, ordering, holding, personnel and facility costs, etc. For the purpose of this study, the main transaction cost focussed on is the shipping of material due to the data available. However, prior to 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 layout 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 Programming Guidance (MPPG) to determine future endeavours 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 programme 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.

Commodities needed for governmental operations are procured through private sector contractors at a cost of nearly $400bn annually (Cohee *et al.*, 2018). 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, 2019). In Fiscal year (FY) 19, the breakdown of contingency pharmaceutical purchases shows the utilization of the PPV contract over 70% of the time in pharmaceutical procurement actions (JMAR, 2019). A key outcome measure of various types of government contracts is supplier performance (Landale *et al.*, 2017b). Supplier performance in the PPV contract is measured by fulfilment metrics. According to DLA, fulfilment rates for the PPV contract typically range from 95–98% (Defense Logistics Agency, 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% (Defense Logistics Agency Troop Support, 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 programme 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, 2019). ABC services both CONUS and OCONUS contingency pharmaceutical demands from its nearly 30 US distribution centres (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 Troop Support, 2019).

Under the current contract, the primary supplier must maintain a fill rate of 98% 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 Catalogue (MMC). Usage data shall be provided by the customer (Defense Logistics Agency, 2013, p. 40).

Providers of these pharmaceutical items are not government entities, and therefore must make money, as profit-seekers, in their efforts (Glas, 2017). To determine which customers are in the suppliers' best interest to serve, as many companies serve both private and governmental clients, the attractiveness of customers is evaluated (Glas, 2017). In the theme of customer attractiveness, it is apparent that usage requirements in the PPV contract act as a distinguishing factor to ensure economic attractiveness because specified and predictable usage or demand can allow companies to enhance their possible benefits of purchasing agreement execution (Glas, 2017). With the shortcomings discussed above through the PPV contracts, it is clear that additional mitigating measures must be evaluated to address current system issues.

Strategic sourcing principles – centralized purchasing through demand aggregation

Purchasing for organizations has shifted from a more transaction-oriented initiative to a strategic oriented action (Landale *et al.*, 2017a). The main aspect of this transformation is the execution of strategic sourcing which brings purchasing and supply management operations from a low-level process in a firm, to an impactful and high-level role in organizational strategic planning efforts (Landale *et al.*, 2017a). The items that companies or governments procure are purchased to create value as a factor in production or meeting organizational requirements (Tate *et al.*, 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 *et al.*, 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 the 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 *et al.*, 2006). Clearly, 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 the 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 fulfilment and cost savings (Tate *et al.*, 2016). For instance, small orders dispersed temporally may be unappealing to a manufacturer who is seeking to batch its production to minimize cost and enhance profits. Under the current procurement architecture, decentralized ordering lends itself to the condition where temporally dispersed orders are not economically attractive to manufacturers; however, in a centralized procurement structure orders can be aggregated across a range of time to capture a holistic enterprise level demand signal that can be economically batched thereby enhancing its appeal to industry.

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 *et al.*, 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 *et al.*, 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 in implementing more hybridized purchasing structures, there are numerous benefits. The main benefit of harnessing the capabilities of hybrid purchasing organizations are purchasing synergies. Purchasing synergies are defined as a 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 health-care industry, are Group Purchasing Organizations (GPO). Demand aggregation practices are widely applied and used in the health-care industry through GPOs. A GPO is an established entity that health-care 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 *et al.*, 2014). There are numerous benefits to procuring health-care 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. Because of the benefits of GPOs, it is estimated that between 96% and 98% of US Hospitals use 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 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.

Methodology

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 Programme, 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 MRL. Through integrations of raw data and generated reports from these platforms, the current state of the AFMS Contingency Pharmaceutical Programme can be illustrated.

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 finally 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

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 *et al.*, 2011). Cost-benefit analyzes 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 *et al.*, 2015). According to Boardman *et al.* (2011), there are three types of cost-benefit analyzes, including ex-ante, in medias res and *ex post*. *Ex ante* analyzes evaluate new initiatives that could possibly be implemented in the future (Boardman *et al.*, 2011). In medias res, analyzes are actually conducted during the life of a current project, while ex-post analyzes are completed after a project has been completed or retired (Boardman *et al.*, 2011). The current contingency pharmaceutical procurement programme, 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 the 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).

Step 1

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.

Step 2

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 focussed 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.

Step 3

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) provide 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 the 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

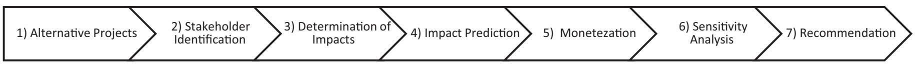

Figure 1.
Cost-benefit analysis process

avoidance; however, there are many ways that impacts can be measured, including time savings or operational efficiency improvements (Boardman *et al.*, 2011).

Step 4

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 the 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.

Step 5

Once cost and benefit predictions are established, it is important to assign monetary values to effectively compare outcomes as options may have different 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) advocate for avoiding the reinvention of established practices through the use of the plugin 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, “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.

Step 6

After monetary values have been established for various impacts on the different project sets, uncertainties of the process must be evaluated through sensitivity analysis. Using 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 favourable assumptions are applied (Boardman *et al.*, 2011).

Step 7

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 the 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).

Cost-benefit analysis application

In the first step of the cost-benefit analysis, four alternative projects were defined. The alternative projects to be assessed in this research are, namely, the continuation of the status quo, centralized purchasing at a single site, centralized purchasing at a single site for US regions and finally, purchasing at various regional sites. The status quo is included as an alternative to acting 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 the consolidation of demand and sites will continue to procure items on an individual basis.

Alternative 2 identifies system-wide level shortage aggregation opportunities from a single designated site to fulfill both USA and international site shortages. The site selected for this central hub was Kelly Field in San Antonio, TX. 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 centre (CSDC) mission of Kelly Field best suits the demands of receiving, handling and transporting large numbers of contingency medical items (Whitson, 2013). Alternative 3 mirrors the strategy and processes of alternative 2 but eliminates fulfilment of international region areas in an effort to assess changes in fulfilment 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 US 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 US 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.

Finally, 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 the 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.

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 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% and 28% 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% 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 0.9619, as the average fulfilment rate for the contract in FY19 was 96.19%. This refinement accounts for the fact that although there will be newly generated adequate demand profiles, the contract likely will not fulfil 100% of the requests.

Results and analysis

The results and analysis of this research continue the cost-benefit analysis through step four of impact prediction and quantification. The completion of this step facilitates the comparison of various alternatives identified earlier in the methodology. Through integrations of raw data and generated reports from these platforms, the current state of the contingency pharmaceutical programme can be illustrated. The compiled data shows that the AD WRM programme is made of 2,533 assemblages, 21% 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 158,139 items across 61 locations, resulting in a material availability percentage of 80.8%. As demand streams are iteratively aggregated through the progressive alternatives, the shortage of units dissipates. This is a consequence of order batches exceeding the manufacturing providers contracted threshold to initiate order fulfilment. The below table depicts resulting remedied shortage amounts and shipping weights from the various alternatives (Table 1).

After impact prediction and quantification are 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 was 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 $24.8m 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 fulfilment. 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).

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 (US 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

Table 1. Impact predictions

It was determined through additional research of the PPV contract that there are provisions, which cover 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, 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 the 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 drawdowns 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 1,124 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% (σ = 0.1) 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 (drawdown) what-if scenarios. (Table 3)

Table 2.
Cost-benefit analysis results with monetization

Alternatives	Acquisition cost	Transportation cost	Benefits	Net results
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 (US 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

Table 3.
Cost-benefit analysis of sensitivity analysis

Alt 4 simulation results	Allow Qty	Remedied shortage units	Final shortage units	Shipping weight (lbs)	Increased MAV%	Final MAV%
Base case	824,294	136,210	21,929	247,764	20.4	97.3
Draw down (min values)	506,839	68,970	30,401	148,501	16.9	94.0
Ramp up (max values)	1,143,028	163,723	56,488	350,084	17.7	95.1
Average (mode)	821,980	115,867	43,800	248,279	17.4	94.6

The outcomes of 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.

Discussion

This research determined that there are strategic supply chain management efforts, mainly demand aggregation and centralized procurement, which could be used at various levels of implementation 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. While the primary focal point for costs was related to shipping, other costs such as those pertaining to administrative and ordering may render greater efficiencies not examined in this study. 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 while leveraging current practices and contractual purchasing agreements.

Enacting the principles of centralized ordering procedures for shortage items can lead to over 20% 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 programme, additional efforts will need to be taken to diminish shortages in the supply, equipment and repair item areas of the programme.

Managerial implications

The final step of the cost-benefit analysis is to provide a final recommendation. After determining the flexibility of the PPV contract to use 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 the 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 1m dollars. Leaders would have to make the determination of the resulting unfulfiled 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 the 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 were 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 fulfilment levels. However, breaking the demands down by region did not have a drastic impact on theoretical fulfilment as hypothesized initially.

Limitations

There are numerous AFMS contingency programmes, as identified in the research problem statement. The scope of this research focussed specifically on the 120 AD WRM deployable UTC allowance standards. Therefore, the programmes of Home Station Medical Response (HSMR), Force Health Protection (FHP), Mass Casualty First Aid Kits and MAJCOM specific programmes were not evaluated in this research.

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. Other military services' contingency pharmaceutical items, ordering policies or, budgetary information was not assessed in this evaluation.

There are additional cost savings that could be leveraged such as contractual, ordering, holding, personnel and facility costs. Due to the data set and scope of this research, these other aspects were not included, which will likely lead to financial implications through the reduction of the required input to facilitate a disaggregated procurement architecture. Future research should account for these aspects to provide greater fidelity on this issue.

Future research

As contingency pharmaceutical items are only one aspect of the AFMS contingency item programme, 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 programmes 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.

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