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A Study of Military Health Care Costs: Direct
Versus Purchased Care in a Geographical Region

THESIS

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AFIT-ENS-MS-18-M-143

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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A STUDY OF MILITARY HEALTH CARE COSTS: DIRECT VERSUS

PURCHASED CARE IN A GEOGRAPHICAL REGION

THESIS

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Abstract

Health care expenses are one of the largest contributing factors to increased personnel costs, the fastest-rising component of the Department of Defense's budget. This research examines the cost implications of developing a new military treatment facility in a specified geographical region, in an effort to reduce military health care spending. Care received at a military treatment facility is referred to as direct care, while care received in the private sector is referred to as purchased care. This research leverages existing information on direct and purchased medical care to gain insights into the workload costs for medical care in a geographical region. This research uses a Monte Carlo simulation approach to determine the direct and purchased care costs for general surgery and orthopedic specialties. The method is applied to the Atlanta, Georgia region and conclude that based on workload measures, it is cheaper in Atlanta to provide direct care at a new military treatment facility.

To my Family and Friends, for their endless love

and support throughout this entire endeavor.

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It's a beautiful day to be alive.

– Whitney Simmons

I would like to thank the members of my committee, Dr. Heidi Tucholski, Dr. Alan Johnson, and Dr. Raymond Hill for their outstanding support and motivation throughout this process. I would also like to thank my family and friends for their unwavering support.

Lindsey N. McEvoy

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A STUDY OF MILITARY HEALTH CARE COSTS: DIRECT VERSUS

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I. Introduction

1.1   Chapter Overview

This chapter introduces the motivation, background, research objectives, methodology, and assumptions and limitations in this study. This thesis provides insights for Air Force Medical Service and Air Force Medical Operations Agency into the costs of purchased medical care in a geographical area and the potential to reduce these costs. The goal is to provide this information by developing a Monte Carlo simulation-based methodology to compare the costs of purchased care with the costs of providing direct care at a military treatment facility (MTF). Ultimately, the aim of this research is to utilize the Monte Carlo simulation process to inform decision makers about potential costs of different forms of care. This information can be used in the future to determine if a new MTF is necessary, in a specified geographical area, to reduce medical care costs to the Department of Defense (DoD).

1.2   Motivation

Personnel costs, including military pay and allowances, military health care, civilian pay, and family support, encompass nearly half of the DoD's budget [1]. Over the last decade, personnel costs have been the fastest-rising component of the budget, driven to a considerable degree by expenses for health care. The DoD has seen funding for health care costs grow from 6 percent of the DoD's base budget in 2000

to nearly 10 percent in 2015 [2]. The DoD cannot afford to sustain this rate of growth for health care compensation.

Much of the increase is attributable to new and expanded TRICARE benefits and comparatively low out-of-pocket costs for people to use those benefits. Due to this, the number of users has increased as people switch from more expensive private plans to TRICARE. Additionally, TRICARE participants have increased the volume of health services they consume [1].

In a fiscal climate in which the department's overall budget is constrained, continued rapid growth in military health care costs could force the DoD to reduce spending in other areas, such as force structure, military readiness, and weapons modernization [3]. Therefore, because of these rising costs Air Force Medical Service and Air Force Medical Operations Agency asked for an analysis of the costs of providing purchased care in a given geographical area. They are interested in the possibility of reducing these purchased care costs through the development of a new MTF clinic which will provide direct care. Ideally, this research process provides a format for determining the potential costs of delivering direct and purchased care in any geographical location.

Air Force Medical Service

The mission of Air Force Medical Service is to ensure medically fit forces, provide expeditionary medics, and improve the health of all they serve to meet our Nation's needs [4]. Air Force Medical Service has four main goals that are aligned with the Military Health System's quadruple aim: increased readiness, better care, better health, and best value. Under readiness, Air Force Medical Service strives to maintain medically ready Airmen, ensure well-trained, well-equipped, and current medics, and support the full spectrum of military operations. The goal of better care consists of

providing safe care, delivering quality care, and promoting positive patient experiences and outcomes. Better health focuses on encouraging healthy behavior, enhancing resiliency and human performance, and reducing illness and injury. Finally, best value looks at providing quality care at the lowest cost.

Air Force Medical Service had a Fiscal Year 2017 budget of 6.16 billion dollars [4]. Air Force Medical Service's annual funding for military health care can be divided into two major categories: The Defense Health Program and military personnel. The defense appropriation act provides funding to the Defense Health Program for health-related operations and maintenance, other procurement, and research, development, test and evaluation. In the same appropriation act, under the military personnel section, funding for military personnel and the Medicare-Eligible Retiree Health Care Fund are included. Additional funds exist for military construction and overseas contingency operations.

Air Force Medical Operations Agency

Air Force Medical Operations Agency is firmly aligned with the Air Force Medical Service's strategy. The mission of Air Force Medical Operations Agency is to lead change for better care and mission support through policy execution across the Air Force Medical Service [5]. Air Force Medical Operations Agency serves the Military Health System, the Air Force Surgeon General, Major Command Surgeons, and Military Treatment Facility Commanders. For these customers, Air Force Medical Operations Agency participates in Defense Health Agency working groups, provides expertise for policy development and precise application of resources to requirements, consults on health care resourcing and operations issues, and coordinates the best processes, data analysis, and clinical expertise for efficient patient-centered health care [5]. Air Force Medical Operations Agency supports health care operations and

execution by enabling world-class medical logistics throughout the Air Force Medical Service.

1.3 Background

The Military Health System is a federated health care system responsible for providing health support for the full range of military operations (the "medical readiness mission") and for delivering safe, high-quality care for uniformed service members (both Active Duty and Reserve), retirees, survivors, and family members [6]. The Military Health System is responsible for both medical readiness of the force and the TRICARE program.

TRICARE

The TRICARE program is an integrated system of military health care providers and regional networks of civilian providers. In Fiscal Year 1994, Congress enacted law to establish the DoD health care benefit referred to as TRICARE. TRICARE was named for the initial three levels of coverage that it offered: TRICARE Prime, Standard, and Extra. Over the past few years, additional TRICARE health plan options have been developed. The current list of TRICARE plans include Prime, Prime Remote, Prime Overseas, Prime Remote Overseas, Select, Select Overseas, For Life, Reserve Select, Retired Reserve, Young Adult, and US Family Health Plan [7]. All TRICARE plans meet or exceed the requirements for minimum essential coverage under the Affordable Care Act.

TRICARE provides coverage to almost 9.5 million beneficiaries worldwide. The following groups of people are eligible to participate in TRICARE:

- All members of the four military branches as well as members of the Coast Guard and the commissioned corps of the Public Health Service and of the

National Oceanic Atmospheric Administration

- Families of current service members

- Retired service members and their families

Ultimately, plan availability depends on who the beneficiary is and where he/she lives.

TRICARE Prime

TRICARE Prime includes Prime, Prime Remote, Prime Overseas, and Prime Overseas Remote. Approximately 4.6 million beneficiaries are enrolled in the TRICARE Prime option [8]. Enrollees include active duty service members and their families, activated guard/reserve members and their families, retired service members and their families, and survivors. This plan is a managed care option similar to that provided by the health maintenance organization [7]. Individuals enrolled in TRICARE Prime are assigned to a primary care manager which is usually located at the closest MTF. In order to receive specialty care, enrollees must first be referred by their Primary Care Manager.

Under this plan there is no enrollment fee or cost-sharing deductible for active duty members and their families. There is an annual enrollment fee for retirees and family members not yet eligible for Medicare.

TRICARE Select

TRICARE Select, a new option which replaces TRICARE Standard and Extra, is a fee-for-service option that requires beneficiaries to enroll in order to participate. Those enrolled in TRICARE Select constitute 1.94 million of the TRICARE beneficiaries [7]. These plans include active duty family members, activated guard/reserve family members, retired service members and their families, and survivors.

Participants of the Select plan pay higher out-of-pocket costs to have greater freedom to select providers and to access care. Referrals are not required, but one may need prior authorization from the regional contractor for some services under the Select plan [7]. Beneficiaries of this plan must pay an annual outpatient deductible and any difference between a provider's billed charges and the rate of reimbursement allowed under the plan.

TRICARE For Life

TRICARE For Life is a Medicare wraparound program for military retirees who have Medicare Part A and B; it covers the remaining cost of care after Medicare has paid its share. Coverage under this plan is automatic if the beneficiary has Medicare Part A and B. Enrollment in the plan is not required, but the beneficiary must pay Medicare Part B premiums.

Direct Care versus Purchased Care

TRICARE provides care to its eligible beneficiaries in two broad settings: a system of DoD hospitals, clinics, and pharmacies (usually MTFs); and a supplemental network of participating civilian health care professionals, institutions, pharmacies, and suppliers [8]. The former is known as direct care, while the later is referred to as purchased care.

The Military Health System combines health care resources from both direct and purchased care components to provide access to high-quality health care, while maintaining the capability to support military operations worldwide. The Military Health System purchases more than 65 percent of the total care provided to beneficiaries through tailored contracts [2]. Currently, the DoD purchases care from the private sector because the direct care system does not have the capacity to meet the benefi-

ciary care demand, and the MTFs may sometimes lack the equipment and/or sufficient personnel with the requisite skills to perform certain procedures.

For our analysis, we use estimated resource and staff workload to determine the costs associated with both direct and purchased care. To compare the costs of providing direct and purchased inpatient care, we use Relative Weighted Products (RWPs) for non-mental health Diagnosis-Related Groups and bed days when no RWP value exists [3]. To calculate the value of outpatient care we use Relative Value Units (RVUs) and Ambulatory Payment Classification (APC) weights [3].

History of Health Care Reform

The DoD has submitted numerous reform plans since 2005, largely to control health care costs [1]. Commencing in Fiscal Year 2012, the DoD initiated a series of efforts to reduce the cost of doing business by identifying opportunities to better allocate resources in health care as well as other focus areas. In the Fiscal Year 2015 budget the effort was revived to control the rising health care costs. The Fiscal Year 2017 proposal included more emphasis on MTFs as the lowest cost option for care to make full use of capacity and provide needed readiness training workload for military providers [1]. Even with all these plans and proposals, the Fiscal Year 2018 budget request includes $51 billion to support the Military Health System [2]. We need to take steps to balance the rate of growth in health care costs. One small step to do this is to examine the amount the DoD pays for out-of-network health care and explore the possibility of reducing the amount they pay by providing care inside their network of MTFs.

1.4 Objective

The predominant objective of this thesis is to gain insight into the cost of purchased medical care in a geographical region and determine if there is a need for the development of a new MTF in order to reduce health care costs to the DoD. This objective is comprised of sub-objectives. The main research questions of interest for this thesis are:

1. Is there enough demand in the area to outweigh the costs of developing a new MTF?

2. Do the costs for care follow any underlying distributions?

3. How do the current purchased care costs compare to the potential costs of providing direct care at an MTF?

4. How does the health care delivery method affect medical and operational readiness?

The analysis in this thesis focuses on the Atlanta, Georgia region, specifically general surgery and orthopedic specialty care services. The research questions are addressed using the following process:

- Identify a 60 minute specialty care drive time radius around Atlanta, Georgia;

- Determine the zip codes encompassed in the radius;

- Capture the eligible enrollment data by zip code in the drive time radius;

- Determine the potential enrollment for the new MTF based on TRICARE beneficiary categories;

- Capture the current value of purchased care for the specialties in the radius;

- Identify the behavior of cost types based on known distributions;

- Simulate the costs of different types of care based on workload measures;

- Use the projected enrollment and simulated costs of care to estimate the costs of direct and purchased care in the area;

- Compare the potential performance of the MTF in Atlanta, Georgia with similar sized operational MTFs; and

- Characterize questions for future research.

1.5 Methodology

This research leverages existing information on direct and purchased medical care in a geographical area to gain insight into the potential need for a new MTF. A first step is to estimate the distributions of different care types. Then a Monte Carlo simulation approach helps determine the different direct and purchased care cost margins by care type. From the Monte Carlo simulation, the workload costs of providing direct and purchased care based on two enrollment scenarios are compared. The first scenario, labeled Wright Patterson Air Force Base enrollment, calculates the workload costs for the observed number of encounters experienced at Wright Patterson Air Force Base. The second scenario, labeled Atlanta enrollment, uses the current enrollment numbers in the Atlanta region to predict the number of encounters. The predicted number of encounters is then used to calculate the workload costs for direct and purchased care. For this thesis, the overarching objective is to minimize health care costs in the region while also maintaining medical and operational readiness. To achieve this objective, two potential alternatives are considered:

1. Do nothing and continue to purchase care in the area; or

2. Develop a new MTF in the area.

The work starts with a large amount of data exported from Air Force Medical Service Analytics' CAPE-RS system. The existing data helps determine the feasibility of meeting the readiness component and focus the research on adequately modeling the workload costs for direct and purchased care in the region. The performance of the model is measured in terms of dollars saved. Sensitivity analysis on key parameters in the model helps predict the costs of providing direct care at a MTF and determine the break-even point between the two scenarios.

1.6 Assumptions and Limitations

There are many geographical areas that have high values of purchased care, but to identify and analyze all these regions would require extensive effort and time beyond the capacity of this research. Therefore, this research limits the scope to the Atlanta, Georgia geographical area. Additionally, sponsors indicated specific interest in the general surgery and orthopedics specialties. So only these two specialties are considered in regards to MTF development and costs of care. The model can expand to analyze additional services at a later time. This research helps illustrate the potential process by which decisions about MTF development are made. Assumptions and limitations applied to the model include the following:

- The process is performed as planned;

- The necessary budget exists to execute any strategy;

- Any recommendations can be implemented immediately;

- The costs are represented in 2018 dollars;

- The potential MTF clinic address will be located at the address of the existing VA hospital in Atlanta, Georgia;

- The number of beneficiaries will stay relatively constant, with no dramatic increase or decrease in beneficiary numbers in any category;

- The costs the provide health care will stay relatively constant;

- Neither policy makers nor the DoD will institute new benefits that will expand the eligible TRICARE population or the cost of the program;

- No consideration is given to activities related to research, development, test and evaluation, other procurement, or military construction;

- Startup costs are not estimated;

- Funding allocated directly to the Departments of the Army, Navy, and Air Force for providing medical care is excluded;

- The TRICARE structure as of January 1, 2018 is used for this analysis;

- The results of this analysis do not extrapolate to every geographical area; and

- Other health insurance is not considered when determining potential cost savings.

1.7 Thesis Outline

The remainder of this thesis is organized as follows. Chapter 2 provides a literature review on the past efforts to reduce military health care costs and the different facets of a MTF. Chapter 3 presents the methodologies and model formulation applied to this research. Chapter 4 presents the results and analysis of our model. Chapter

5 summarizes the contributions of this research and proposes directions for further studies.

II. Literature Review

2.1 Overview

This literature review focuses on addressing different facets of military health care and appropriate strategies to improve them. This chapter begins by reviewing previous approaches to reduce spending on military health care and change the military health care design and delivery system. The costs of providing care at military treatment facilities (MTFs) and private sector facilities are reviewed. An understanding of these areas of study along with the relevance of the health care system to the United States Air Force is crucial to explain the importance of our model. Following a review of the cost-focused areas, recent literature is discussed covering the performance of MTFs and the importance of Air Force Medical Service readiness.

2.2 Spending on Military Health Care

The rapid growth in military health care spending is encroaching on Department of Defense (DoD) funds available for readiness and modernization requirements. Therefore, there is growing interest in examining the costs of the military health care system and approaches to reduce those costs. The Institute for Defense Analysis (IDA) examined the Unified Medical Program, which consists of all appropriations that fund the Military Health System. IDA highlights the trends in recent Unified Medical Program funding. There was a temporary decrease in Fiscal Year 2013, but this drop has not altered the increasing trends in the three largest expenditure categories; direct care, purchased care, and military personnel [8]. In addition, total Unified Medical Program funds continue to increase annually, reaching an estimated $52.55 billion in Fiscal Year 2017 [9].

According to a study conducted by the United States Congressional Budget Office

(CBO) in 2014, causes for medical care cost growth include the new and expanded TRICARE benefits, increased utilization fostered by financial incentives to use TRICARE, and medical costs of recent wars [10]. CBO found the first two factors to explain most of the growth in military health care cost since 2000 [10]. By contrast the third factor has a comparatively small effect on the DoD's spending [9].

Policy makers have considered various initiatives to slow the rate of growth for health care spending in general. CBO and IDA examined the following approaches: better managing chronic diseases, more effectively administering the military health care system, increasing cost sharing for retirees who use TRICARE, and restructuring the TRICARE program [10].

Better Management of Chronic Diseases

Previous studies examined the first program instituted by TRICARE to manage treatment of three chronic conditions: asthma, congestive heart failure, and diabetes [11]. It was found that TRICARE beneficiaries with those diseases incurred lower medical costs than the control group. However, the program yielded a net savings of only $5.8 million [12]. CBO's analysis further supports this research as they conclude TRICARE's disease management programs do not produce substantial savings. CBO estimates that savings would be less than $46 million per year, only 0.1 percent of total TRICARE costs for 2014, for the entire population to participate in disease management programs [10].

Administer the Military Health Care System More Effectively

The DoD could reduce health care spending by altering its operations without affecting patients directly. CBO explored two approaches: educate military physicians in a less costly way and hire additional auditors [10]. Previous research has

indicated that a student at the Uniformed Services University of the Health Sciences, the DoD's medical school, costs three times as much as a comparable student using the scholarship program [13]. CBO estimates closing the Uniformed Services University of the Health Sciences and funding additional scholarships for physicians would reduce spending by as much as $150 million per year and would have a relatively small effect on the DoD's overall budget [10]. Meanwhile, hiring additional auditors to reduce fraud, waste, and abuse in federal health care programs would result in an even smaller fraction of savings. CBO projected that doubling the number of auditors would increase spending by about $1.3 million per year for an estimated reduction of only $2 million per year [10].

Increased Cost Sharing

CBO investigated three specific options that would institute changes to TRICARE's current health care cost sharing structure. The first option increases medical cost sharing for beneficiaries who have already retired from the military but who are not yet eligible for Medicare [10]. Option two is to make working-age retirees and their families ineligible for TRICARE prime, but allow them to continue using other TRICARE plans after paying an annual fee [10]. Lastly, option three introduces minimum out-of-pocket requirements for Medicare-eligible retirees and their family members to access TRICARE for Life [10]. The predicted net reduction in the federal deficit would be $18 billion for option one, $60 billion for option two, and $31 billion for option three over the 10-year period spanning from 2014 to 2023 [10]. The estimated spending reductions realized by implementing these options would not necessarily be additive. However, options one or two could be combined with option three.

CBO conducted a follow-up effort to examine an option to increase cost sharing for most beneficiaries who use TRICARE, not just retirees. CBO found that this option

would primarily affect the demand of health care as savings would accrue straight to the government because beneficiaries would use fewer health care services and switch to cheaper TRICARE plans or to other sources of health insurance. This option could save a net of $2.5 billion a year [14].

Restructure the TRICARE Program

The TRICARE program constantly undergoes changes aimed at increasing beneficiary health care choices, improving access to care, and simplifying cost shares. The most recent changes to the TRICARE program went into effect on January 1, 2018. Under the new program, regions in the United States were consolidated from three regions down to two. Two new contractors, Humana Military and Health Net Federal Services, administer to these regions at a total cost close to $60 billion over five years [15]. This creates a simpler and streamlined process for both the administrator and user. These actions are projected to reduce costs, though the magnitude of cost reduction is currently uncertain. The TRICARE program has faced additional restructuring with both the Standard and Extra plans being replaced by the new Select plan both stateside and overseas. With the new plan comes additional preventative care services aimed at reducing the need for managed care of chronic conditions. Additionally, many cost shares were replaced with fixed amount copays under the new program [16]. However, literature on the realized resultant improvements for changes in the TRICARE program is non-existent due to the recency of the updates.

As part of restructuring the design and delivery of the military health care benefit, IDA estimated the steady-state cost of providing health care to a portion of DoD beneficiaries through a premium-based insurance model consistent with an employer-sponsored benefit program offering numerous private health plan options [8]. Under this model proposed by the Military Compensation and Retirement Modernization

Commission, IDA estimated a potential budgetary savings of $3.2 billion once the model is fully implemented and a savings as high as $7.5 billion if beneficiaries enroll in lower cost private insurance plans [8].

In 2017, CBO analyzed a specific option to replace TRICARE with a choice of commercial insurance plans for most beneficiaries. Based on reforms proposed by the Military Compensation and Retirement Modernization Commission, the option would offer commercial insurance and incorporate MTFs into those networks [14]. This approach is attractive as it would change both the supply and demand side of the market by substantially restructuring the TRICARE benefit and its delivery system, including adding new cash allowances for families of active duty members and raising out-of-pocket costs for working age retirees [14]. CBO examined the effects when the policy changes are fully implemented, concluding there would be an increase of $700 million annually on the funding deficit.

2.3 Cost Comparison of Military and Private Sector Care

The DoD periodically conducts analyses to examine ways of improving the overall efficiency and effectiveness of its health care system. Care received at MTFs (direct care) cost an estimated $17.73 billion in 2017, consuming the largest share of the DoD's health care funding [9]. The number of health care providers in the military and the capacity of MTFs have remained essentially fixed while increases in the demand for health care have grown, leading to the growing use of, and increased costs for, purchased care. Purchased care accounted for the second largest portion of health care funding with costs estimated to be $15.74 billion in 2017 [9].

One approach for improved health care delivery that receives a great deal of attention is to evaluate whether it is more cost-effective to provide care at MTFs or purchase the care from the private sector. The cost difference between direct and

purchased care is uncertain. If MTFs can provide care less expensively than TRI-CARE contractors, policies that encourage greater use of those facilities would not only improve the operational readiness but also reduce the overall cost of care [14]. If the opposite were true, the DoD could potentially reduce the size of the direct care network without compromising readiness, outsource more care to the private sector, and thereby reduce spending [14].

An initial study was conducted by IDA in 1994 to examine the "make versus buy" decision strategy for military health care [17]. As the military medical care program grew, a follow-up study was conducted by the Center for Naval Analysis in 2003. The Center for Naval Analysis study compared the costs of direct and purchased care [18]. Both analyses concluded that in general it was less expensive for the DoD to provide direct care. Meanwhile, the TRICARE Management Activity conducted a similar study where they concluded the opposite to be true; purchased care was generally less expensive to the DoD [19]. The conflicting results are a consequence of differing perspectives and data sources. Results varied depending on how the costs were measured. IDA and the Center for Naval Analysis focused their calculations on the total cost to provide a given level of services, whereas the TRICARE Management Activity considered cost only to the DoD [9].

In 2016, as more detailed and complete data on workload and costs became available, IDA performed research to estimate the relative costs of the MTF and private sector workload. The research compared the actual cost of producing care at a given MTF with an estimate of what that same care would have cost if priced at private sector rates [9]. For inpatient workload, IDA used Relative Weighted Products (RWPs) for non-mental health Diagnosis-Related Groups and bed days for mental health Diagnosis-Related Groups. IDA concluded that the costs of providing inpatient direct care at the 41 domestic MTFs would have been 34 percent lower had the

care been purchased in the private sector, and 49 percent lower if only the costs to the DoD is considered [9]. For inpatient care by Major Diagnostic Category, IDA found direct care is 61 percent more costly than the same purchased care (68 percent if only the cost to DoD is considered) [9]. The IDA study examined outpatient costs using two measures of workload: Relative Value Units (RVUs) and Ambulatory Payment Classification (APC) weights for facility procedures [9]. Results of their MTF outpatient workload analysis indicate cost would have been 35 percent lower in the private sector (43 percent lower if only cost to DoD is considered) [9]. The Major Diagnostic Category outpatient analysis yields similar results as costs would be 39 percent lower for purchased care [9].

The results of the 2016 IDA study indicated that in the long run it is cheaper to provide inpatient and outpatient care through purchased care at private sector rates. This research focused on the costs of delivering the TRICARE benefit as it was constituted at the time. Since this work, however, the TRICARE benefit has evolved and the costs of health care have increased, so it is unknown whether the results are still accurate. There is no discussion of how the change from MTF to private sector care would effect the access, choice, and value of care for beneficiaries. Additionally, the study does not consider the ready medical force mission and the need to train and keep our doctors current.

In a MHS modernization study, the DoD acknowledged that the average cost of medical care provided to TRICARE beneficiaries in the direct care system is usually higher than the cost of purchased care [20]. However, the study noted that MTF buildings and equipment represent sunk costs. Additionally, because the number of military personnel is determined by readiness needs, the authors concluded that the costs of operational uniformed personnel are fixed [20]. The study recommends that the direct care system be filled to capacity first before excess care beyond that

capacity is sent to civilian providers [14].

2.4 Relevant to the Air Force

The United States Air Force knows that taking care of their people helps ensure mission success. As a part of this, the Air Force provides Airmen and their families with attractive health insurance plans. Service members, retirees, and their families receive excellent rates and low cost, comprehensive medical and dental care at military or civilian facilities. These benefits to join ensure an all-volunteer force while helping improve the service member and their family's quality of life. Therefore, changing the way the TRICARE system is designed or delivered could affect the behavior of current TRICARE beneficiaries and potentially affect the United States Air Force's mission. Options to reduce federal health care spending by increasing the user out-of-pocket cost could discourage some people from using health care services. Higher costs could cause some patients to delay seeking care, causing adverse health outcomes and affecting personnel readiness.

Active Duty and Their Family

In 2012, the DoD estimated that a family enrolled in TRICARE prime would pay about one-sixth of what a similar family would pay for coverage in a civilian Health Maintenance Organization [21]. Even though active duty service members represent a relatively small portion of all TRICARE beneficiaries and tend to use the system less than other groups, they and their families should receive easy and low-cost access to health care [10]. This price is relevant for the Air Force so that family health issues and related financial burdens do not weigh on the minds of service members, especially those deployed overseas.

Retirees and Their Family

The current health insurance system favors only a small fraction of Air Force members because most people who join the Air Force do not serve an entire career and will never qualify for retiree medical care through TRICARE [10]. Still, it is important to consider this subset of the population when developing approaches to reduce health care spending. Some approaches consider increasing the cost-sharing burden on the retired user. However, some current Air Force retirees argue that they initially joined and remained in the Air Force for their entire careers with the understanding that they would receive medical care for free or at a very low cost after retiring [10]. Significantly limiting TRICARE coverage for military retirees and their dependents could be considered unfair as it would impose an unexpected financial cost on many of those beneficiaries and could adversely affect military retention [10]. The anticipation of low out-of-pocket costs in the future may encourage older members to remain for an entire career, and the experience those longer serving members provide would benefit the Air Force [10].

2.5   Performance of Military Treatment Facilities

The Patient Centered Medical Home operations focus on delivering the "highest quality, evidence-based, patient-centered care to enrolled patients through team-oriented processes, enhanced access, improved provider continuity, superior communications and coordinated prevention, education, and management of patients" [22]. The Patient Centered Medical Home operations will provide operational health and readiness for all military members and promote clinical currency for the members of the team for optimal MTF performance [22]. It is pertinent for MTFs to perform at optimal levels in order to reduce health care costs, ensure medical readiness, and treat the most patients.

A 2011 RAND article, considered efforts to assess the performance of MTFs in cost-effectively managing health care under the DoD's TRICARE program [23]. The study conducted a qualitative review of the performance assessment in health care. The results indicate that systematic factors such as the TRICARE benefit, deployments of medical and other personnel, and the health status and typical health care needs of MTF enrollees affect MTF utilization and cost performance measures [23]. RAND also concluded that the performance of health care managers is a factor affecting overall MTF performance. MTF leaders influence the amount and efficiency of care provided based on the policies set in place by the leader [23]. The effectiveness of performance assessments for MTFs is generally greater for larger facilities. Still, RAND suggests alternatives such as more targeted but complex assessments which could help to diagnose MTF performance problems more reliably and methods to treat them more effectively [23].

To help improve MTF performance, the DoD has considered setting goals for health care utilization in MTFs and rewarding or penalizing MTFs according to their performance [23]. This initiative assumes that MTF leaders are able to cost-effectively manage care, just as physicians do in the private sector. This would be particularly advantageous in areas in which TRICARE costs are high at private hospitals. In that case MTF leaders could improve their performance assessments by encouraging beneficiaries to be treated at military hospitals with spare capacity [23].

After the RAND study, the DoD's researchers conducted an internal study of the performance of the direct care system. A study released in 2014, reviewed the efficiency of MTFs [24]. The researchers found that overall access, quality, and safety of MTFs were appropriate, but on the individual level MTF performance varied widely. Surgical complications were statistically more frequent than expected in almost half of the MTFs that voluntarily reported data on the incidence of disease and mortality

[24]. Analysis showed that there were persistent problems in three MTFs even though three others were performing at the top tier nationally [24]. The differences may be due to the systematic factors identified in the RAND study.

2.6 Air Force Medical Service Readiness

The Military Health System aims to ensure that service members are healthy enough to deploy and that military clinicians are adequately trained to care for personnel during both peacetime and wartime [14]. The former is often referred to as medical readiness, while the latter is known as operational readiness. MTFs play a pertinent role in guaranteeing that personnel are ready for combat. The Military Health System is highly efficient and effective for ensuring medical readiness, as all military personnel are screened at MTFs before they deploy overseas and again when they return home. However, achieving operational readiness is a much more difficult task. This is due to the breath of requirements and uncertainty surrounding methods to ensure medical professionals and MTFs can sufficiently meet demand at home and in the deployed environment.

Operational Readiness

The DoD pursues its operational readiness goals by maintaining its own system of clinics and hospitals and by training its own uniformed clinicians. Thus, the DoD is responsible for certifying that its MTFs run efficiently. As a part of the global war on terror, the medical departments of the three military services support combat operations in Iraq and Afghanistan. Specialty care physicians, specifically surgeons, operating room nurses, and technicians, are in high demand. Deployments of these highly trained specialists due to the in-theater staffing requirements present Air Force Medical Service with the MTF efficiency problem of determining how to provide for

the home-station health care needs these specialists would normally provide were they not deployed [25].

A benefit of the DoD running its own network of treatment facilities is that they can ensure health care providers are adequately trained with enough frequency to ensure competence. The primary means by which military medical personnel develop and maintain their skills is by providing care at MTFs to TRICARE beneficiaries [14]. Specialty care teams must operate on patients with a wide variety of health needs in order to stay ready for wartime and maintain their surgical skills in peacetime [25]. However, there are questions as to whether military providers can deliver high-quality care in the combat setting because the variety of cases that these providers encounter during peacetime do not normally match the types typically seen in combat. The general medicine practiced in most MTFs means there is little specialization, which potentially adversely affects the outcomes of complex medical procedures and surgeries required in combat settings [14]. However, regular surgery helps to provide specialty care teams with the surgical experience necessary to maintain their technical proficiency, which will be necessary for treating severe wounds and injuries in a combat setting [25].

Methods to Improve Operational Readiness

RAND suggests that in order to maintain a staff of critical-care specialists ready for deployment, Air Force Medical Service may need to increase its inpatient work-load at MTFs or find alternatives for training critical-care specialists at hospitals not run by the military [25]. In their report, RAND mentions training alternatives, which could include assignments to other services' hospitals, partnerships with Veterans Affairs or civilian hospitals, or greater use of the Air National Guard or Air Force Reserve medical personnel in wartime [25]. Additionally, Air Force Medical

Service must recruit, train, and retain a highly skilled medical force because graduate medical education and military-unique specialized training are critical to supporting operational readiness [25]. RAND suggests this can be accomplished by providing professional opportunities that help attract high-quality medical personnel.

CBO considered an approach aimed to identify the costs of ensuring operational readiness. A better understanding of the cost of providing health care and the costs of activities needed to ensure readiness could help decision makers develop more efficient ways of meeting the readiness goal. If the military medical establishment is too large for wartime missions and providers see too few patients to maintain their proficiency, the DoD may be paying more than necessary for readiness [14]. Currently, the DoD allocates funding to different portions of the Military Health System in a manner that makes it difficult to track the cost of ensuring operational readiness [14]. Military physicians receive their salaries through the military personnel appropriation, while individual hospitals receive an overall budget for their supplies, materials, and equipment through the operations and maintenance appropriation. More transparency of the costs of providing operational readiness could help DoD operate the Military Health System more efficiently [14].

2.7 Summary

The aforementioned works emphasize the rising health care costs to the DoD and describe previously formulated approaches to decrease these costs. Many sources recommend increased cost-sharing for TRICARE beneficiaries as it would decrease costs to the DoD by the greatest magnitude. In reviewing the cost comparisons between producing medical care at MTF or purchasing the same care from the private sector, there remains no agreement as to whether direct or purchased care is more economical. this research will address this problem for the Atlanta, Georgia region.

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Providing the health care benefit is relevant to Air Force personnel sustainability. However, drastic changes in the TRICARE program that increase cost to the user could potentially negatively impact retention rates.

Variations of some of the approaches previously mentioned in this literature review have been implemented. Many of these past efforts have focused on military health care spending as a whole. However, these approaches are costly for the health care user, difficult to implement, and/or infeasible due to operational and medical readiness requirements. Little research has been completed to examine the minute levels. This is due to the believed small cost savings that would result. Thus, this research is important because it can be applied on a large scale for cities where an increasing trend in purchased care or enrollment exists.

There is a need for a new approach for reducing military health care costs to the DoD. This research focuses on determining whether the current amount of purchased care in a geographical area reaches a benchmark level to ensure the medical and operational readiness of the force and justify the costs of providing the same care in-house. The new methodology is presented in the next chapter.

III. Methodology

3.1 Overview

This chapter outlines the approach to analyzing the different types of military medical care with respect to constraints and capabilities on the care workload. The data provided by Air Force Medical Operations Agency is described along with the process of cleaning the data and how the data is utilized. The simulation used to perform the research is then described, followed by a description of the model created to increase the tractability of the analysis. Lastly, is a discussion of utilizing Monte Carlo simulations to bolster the significance of the findings as well as the approach to verify and validate the model.

3.2 Data

The focus of the research is on specialty medical care, namely general surgery and orthopedics, provided in and around Atlanta, Georgia. Access to care standards indicate that specialty care should be provided within a 60 minute drive time for the patient. Therefore, to find the demand for general surgery and orthopedic care in the specified geographical area it was necessary to first identify a 60 minute specialty care drive time radius around Atlanta, Georgia with traffic considered. This involved the haversine formula in conjunction with R software code. The haversine formula is an equation used to approximate distance, giving great-circle distances between two points on a sphere from their longitudes and latitudes. The haversine formula is

$$hav(\theta) = sin^2\left(\frac{\theta}{2}\right) = \frac{1 - cos(\theta)}{2}. \tag{1}$$

Microsoft Office Excel Visual Basic for Applications (VBA) code implemented the haversine formula and was used to find all zip codes located within 100 miles of the origin. In this research, the θ represents a central angle anchored at the origin. The origin is the current Decatur VA hospital located at 1670 Clairmont Rd, Decatur, GA 30033. The VBA haversine code returned 743 unique zip codes. However, not all of these zip codes are within a 60 minute drive time radius of Atlanta. R software called Google to geocode an address and create a 60 minute drive time isoline with traffic enabled around the origin. This radius is illustrated in Figure 1.
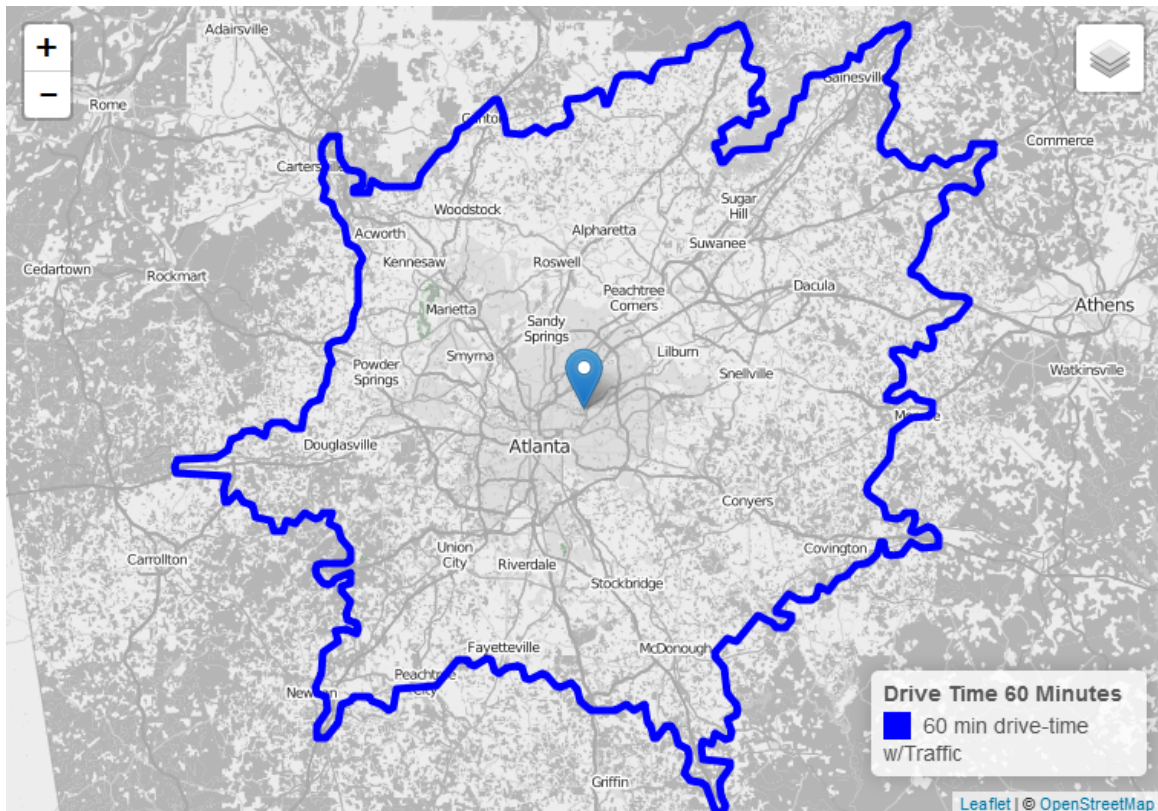
Figure 1. 60 Minutes Drive Time Radius for Atlanta, Georgia

The next step was to determine the zip codes encompassed in the radius depicted in Figure 1. The output from the R code consisted of the longitudes and latitudes of the points along the isoline. To obtain the zip codes in the radius, the given longitudes and latitudes were reverse geocoded into a readable address. This process

only gave the zip codes along the isoline. The initial list of 743 zip codes produced from the haversine formula were used to restrict the zip code set to those captured inside and along the isoline. This resultant zip code list consisted of 297 zip codes within a 60 minute drive time of the origin. It is important to determine the zip codes encompassed in this area because the available enrollment data is based on the zip code the beneficiary resides in. This zip code is then used to determine what military treatment facility (MTF), if any, the beneficiary is assigned to. If there is no assigned MTF, as is the case with most of the Atlanta-based zip codes, then the care is purchased.

TRICARE enrollment and purchased inpatient and outpatient care for the zip codes encompassed in the Atlanta, Georgia specialty care radius for Fiscal Years 2014-2017 was requested along with TRICARE enrollment and inpatient and outpatient direct care data from Wright Patterson Air Force Base (WPAFB) for the same fiscal years due to the specialty care capabilities available at the MTF. WPAFB can conduct both general surgery and orthopedic procedures which is the main focus for care in the Atlanta, Georgia market. The data sets from Air Force Medical Operations Agency were obtained from the Military Health System Data Repository (MDR) and Military Health System Management Analysis and Reporting Tool (M2) query tool.

MDR and M2

MDR and M2 are the most commonly used systems operated by TRICARE. The MDR is a centralized data warehouse that captures, archives, validates, integrates, and distributes the most complete collection of data about beneficiaries of the Military Health System and their health care. MDR receives data from the Department of Defense's (DoD's) worldwide network of medical facilities and from non-DoD, out-of-network, health care facilities. MDR operates in a secure SAS-based computing

environment and is maintained by for expert programmers and analysts. The MDR contains historical raw and processed records on all health care events paid for by the Military Health System, regardless of setting. It also contains robust direct and purchased care data, MTF accounting data, beneficiary data, clinical data, staffing data, and many other data files. Information in the MDR is accessible as statistical analysis system datasets.

Most of the data available in the MDR is also available in M2 in a more accessible form. M2 is a powerful ad hoc query tool used to manage and oversee operations across the Military Health System [3]. M2 offers a quick and economical way to access large amounts of data and export the data to other software for more detailed analysis [3]. This system is especially beneficial to the Defense Health Agency for it provides proactive health care management, monitors patients' use of services, and supports strategic health care planning and the delivery of quality health care at an affordable cost, while improving medical readiness. M2 delivers summary and detailed clinical, population, and financial data. The clinical data includes information on both direct and purchased inpatient care, outpatient care, pharmacy services, and ancillary services. The financial data includes summary expense and manpower information from the Medical Expense and Performance Reporting System. The Medical Expense and Performance Reporting System is the standard cost accounting system for the Military Health System, containing financial, personnel, and summary workload data from reporting MTFs.

Enrollment Data

Air Force Medical Operations Agency provided the TRICARE enrollment eligibility data for WPAFB and the Atlanta, Georgia region. To extract the WPAFB enrollment data from the MDR the Defense Medical Information System Identifier

for the WPAFB MTF. There is no Defense Medical Information System Identifier if a MTF does not exist, therefore the list of zip codes encompassed in the isoline radius was used to capture the enrollment data for Atlanta, Georgia. Within the datasets, one record exists on an individual registered in the Defense Enrollment Eligibility Reporting System per month. Included in the WPAFB dataset were nearly half a million observations from October, 2013 to September, 2017. In the Atlanta, Georgia dataset were over one million observations from October, 2013 to March, 2016. For a single observation the age, beneficiary category, zip code, and Alternate Care Value (ACV) group of the individual was recorded. The beneficiary category is a numeric value from one to four, each number denoting a subset of the population. Table 1 outlines the different beneficiary categories and the population they represent. The ACV group characterizes the individual based on program enrollments such as TRICARE Prime, TRICARE Plus, Reliant, and other.

Table 1. TRICARE Beneficiary Categories

Category 1	Dependents of Active Duty or Guard/Reserve on Active Duty
Category 2	Retired
Category 3	All Others
Category 4	Active Duty and Guard/Reserve on Active Duty

Workload Measures

Workload measures were developed as a basis for physician reimbursement and are pertinent to account for the relative resource intensity across different procedures. For example, a well patient visit is assigned a smaller workload value than an invasive surgery. To measure outpatient resource intensity, distinct Relative Value Unit (RVU) values are recorded for each medical, surgical, and diagnostic service included in the Current Procedural Terminology code set. This analysis used the Provider Aggregate Total RVU for direct care outpatient data records. A Provider Aggregate Total

RVU is the sum of two components: a Work RVU and a Practice Expense RVU. The Work RVU accounts for the time, technical skill, and intensity required by a physician to perform a particular service. The Practice Expense RVU accounts for the physician's office expenses, staff, and administrative overhead. For purchased care outpatient data records we use the Enhanced Total RVU, which is comprised of the same components as the Provider Aggregate Total RVU. A similar concept to RVUs are Ambulatory Payment Classifications (APCs). An APC is recorded for a patient who receives outpatient surgery, outpatient clinic care, emergency department services, or observation services. APCs are not recorded for purchased care claim data.

While RVUs and APCs apply to outpatient care, the Relative Weighted Product (RWP) and bed days workload measures exist for inpatient services. RWPs are based on non-mental health Medicare Severity Diagnosis-Related Group codes and the relative complexity of services and resources utilized. In this analysis, bed days are used to calculate costs when a RWP value is not recorded. RWPs and bed days are included in both direct and purchased care datasets. This research used the bed day measure for the Atlanta purchased care dataset, where 169 out of 13,094 observations used the bed day value multiplier to find workload costs.

The Prospective Payment System values were used as a multiplier to determine a dollar value associated with the RVU, APC, RWP, and bed day workload measures. The Prospective Payment System rates were developed by the Military Health System and are based on Fiscal Year. The Air Force Medical Service uses Prospective Payment System rates for all calculations. The values are provided in Table 2, where FY denotes Fiscal Year.

Table 2. Prospective Payment System Values

Measure	FY14	FY15	FY16	FY17
RWP	$8,849	$8,930	$9,159	$9,082
Bed Day	$887	$915	$925	$955
APC	$72.672	$74.271	$75.552	$74.909
RVU	$35.823	$35.823	$35.934	$35.889

WPAFB Direct Care Data

The WPAFB direct care data consisted of two different datasets: the Standard Inpatient Data Record (SIDR) and the Comprehensive Ambulatory Provider Encounter Record (CAPER). The datasets include beneficiary data, coverage information, service-related information, and demographics for each observation. Within the SIDR dataset, the focus was on the following information for each observation: the Medicare Severity Diagnosis-Related Group RWP value, ACV group, age, beneficiary category, pseudo person identifier, Medicare Severity Diagnosis-Related Group code, admission and discharge dates, and the Medical Expense and Performance Reporting System dispositioning description. The Medical Expense and Performance Reporting System dispositioning description is used to determine the product line the patient received care from, either general surgery or orthopedic. The SIDR dataset includes nearly 2500 observations from Fiscal Years 2014-2017.

The CAPER dataset contains over 750,000 outpatient care observations from the same Fiscal Years. The data examined in this set includes similar descriptive identifiers to the SIDR dataset such as the ACV group, age, beneficiary category, pseudo person identifier, and product line. However, instead of RWPs, CAPER includes the Provider Aggregate Work, Practice Expense, and Total RVU as well as the APC aggregate weight if one exists.

Atlanta Purchased Care Data

Similar to the WPAFB care data, the Atlanta, Georgia purchased care data is separated into an inpatient and an outpatient care dataset for Fiscal Years 2014-2017. Inpatient care is recorded under TRICARE Encounter Data Institutional (TEDI) and outpatient care under TRICARE Encounter Data Non-Institutional (TEDNI). A single TEDI observation includes the same information as the WPAFB SIDR data set except there is no Medical Expense and Performance Reporting System dispositioning description. The TEDNI outpatient data is analogous to the WPAFB CAPER data except there is no APC weight. Additionally, there is no product line identifier, instead there is the service nature. The service nature is a code indicating the clinical nature of the type of service.

Data Cleaning

Since the Atlanta, Georgia purchased care data does not have any product lines attached to care, it was necessary to assign an appropriate type of care to each observation. The VBA code in Appendix A assigned all observations a type of care based on Medicare Severity Diagnosis-Related Group. The inpatient TEDI observations, required a list of Medicare Severity Diagnosis-Related Group codes performed at the WPAFB MTF. It is assumed that any procedure performed at the WPAFB MTF can be performed at an MTF or clinic developed in Atlanta, Georgia. The Medicare Severity Diagnosis-Related Group codes were matched to types of care, either general surgery, orthopedics, or not performed at an MTF. If the Medicare Severity Diagnosis-Related Group was listed under both the general surgery and orthopedic product lines, the Medicare Severity Diagnosis-Related Group was assigned to the product line with the most number of occurrences. There were two ties where there were the same number of occurrences between product lines so we assigned one to gen-

eral surgery and the other to orthopedics. There were only 22 out of 246 Medicare Severity Diagnosis-Related Group codes performed at an MTF that had observations with both general surgery and orthopedics. If the Medicare Severity Diagnosis-Related Group code was not performed at WPAFB, it was assumed it could not be performed at a potential MTF in Atlanta and was designated as not performed at an MTF. For example, in the TEDI there was an observation for a Medicare Severity Diagnosis-Related Group code one. This Medicare Severity Diagnosis-Related Group represents a heart transplant or implant of heart assist system with major complications or comorbidity. Realistically, an MTF would not perform this procedure and the care would be purchased. This happened for 3108 out of 13091 observations.

The same process could not assign product lines to the TEDNI observations because TEDNI data did not include Medicare Severity Diagnosis-Related Group codes. The WPAFB CAPER data was used to determine the percentages of general surgery and orthopedic observations for each year. It was assumed the Atlanta purchased care outpatient data would follow the same percentages as the WPAFB CAPER data. Therefore, the TEDNI observations were randomly assigned to either the general surgery or orthopedics product line based on the percentages per year observed in the CAPER data.

Additionally, the Air Force Medical Operations Agency indicated that both Atlanta based purchased care data and WPAFB direct care data may have duplicate entries for inpatient and outpatient encounters. Therefore, the VBA code in Appendix B was used to identify these duplicate entries and mark them for removal. Detecting duplicates in the purchased care data sets utilized the pseudo person identifier and begin date of care. There were 9,911 duplicate observations removed from the TEDNI set. The duplicate entries in the direct care data sets were identified through VBA code in Appendix C. This code found duplicates based on the pseudo identifier of the

patient as well as the month and year the care was received. One CAPER entry per duplicate SIDR observation was removed, a total of 2,284 observations.

The WPAFB direct care CAPER data set included both RVU and APC values. However, APC values are not recorded for the Atlanta purchased care TEDNI. APC values for the Atlanta purchased care data are needed for proper workload cost comparisons. An initial attempt was to determine if the care should be RVU or APC based on the service nature. However, this procedure did not produce values consistent with direct care APCs. Therefore, APC values were assigned based on a multiplier determined from the cost ratio of purchased to direct care for an individual. The multiplier values are listed as part of the sensitivity analysis in the next chapter.

Lastly, to ensure clean datasets 569 general surgery and 6,984 orthopedic outpatient WPAFB CAPER encounters were removed. From the Atlanta TEDNI set, 3,574 general surgery and 17,540 orthopedic encounters were removed. These observations were removed because they did not contain any workload data.

3.3 Monte Carlo Simulation

A simulation is the imitation of the operation of a real-world process or system over time [26]. A Monte Carlo simulation is used to draw insights on the cost of direct and purchased medical care. Monte Carlo simulations use stochastic methods to generate a partial sequence of independent and identically distributed random vectors $X_1, X_2, ..., X_n$ having the mass function $P\{X = x_j\}, j \geqslant 1$ [27]. The Monte Carlo simulations' repeated random sampling helps obtain numerical results and measures of the risk involved.

3.4 Model Overview

Modeling began with differing types of care data that were filtered and aggregated into manageable inputs for use within the simulation. These data were utilized to to define 13 different types of care considered in the simulation. Table 3 depicts how these types of care are abbreviated for future use in the research. Abbreviations are consistent between direct and purchased care descriptions.

Table 3. Abbreviations Corresponding to Each Type of Care

Type of Care	Abbreviation
Orthopedic Inpatient RWP	Ortho Inpat
Orthopedic Outpatient APC	Ortho Outpat APC
Orthopedic Outpatient RVU	Ortho Outpat RVU
General Surgery Inpatient RWP	GS Inpat
General Surgery Outpatient APC	GS Outpat APC
General Surgery Outpatient RVU	GS Outpat RVU
Not Performed at MTF Inpatient RWP	Not Inpat

The data are assumed to follow the lognormal distribution for all 13 different types of care. The lognormal is a continuous heavy-tailed probability distribution closely related to the normal distribution, but the random variable, X, assumes only positive values. A random variable X has a lognormal distribution if its probability distribution (pdf) is

$$
f(x) = \begin{cases} \frac{1}{\sqrt{2\pi}\sigma x} exp\left[-\frac{(lnx-\mu)^2}{2\sigma^2} \right], & x > 0 \\ 0, & otherwise \end{cases} \tag{2}
$$

where $\sigma^2 > 0$, μ represents the mean also referred to as the shape parameter and σ represents the standard deviation also referred to as the scale parameter.

JMP version 13.2.1 software fit an appropriate lognormal distribution to each of the four beneficiary categories in each of the 13 different types of care. An example of the JMP distribution output is depicted in Figure 2, where the lognormal distribution

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was fit for purchased general surgery inpatient beneficiary category one care. The lognormal distribution passes the Kolmogorov-Smirnov goodness of fit test. This distribution fitting process was executed for all types of care.
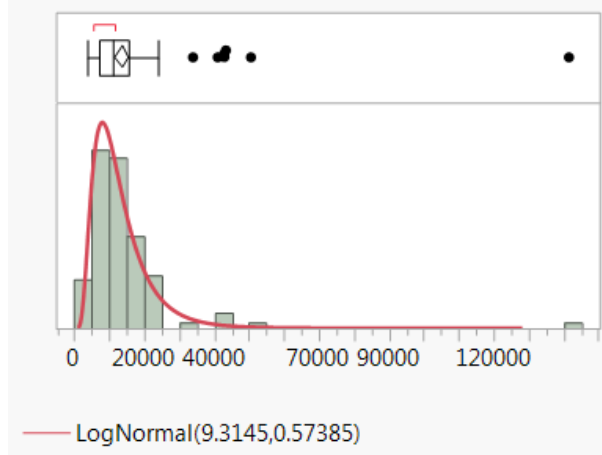
Figure 2. Lognormal Distribution for GS Inpat Category One Purchased Care

Table 4 illustrates the shape and scale parameters for the fitted lognormal distribution corresponding to the beneficiary category of each type of purchased care. The same information is displayed in Table 5 for all direct care types.

Table 4. Purchased Care Shape and Scale Parameters by Beneficiary Category

	Category 1	Category 2	Category 3	Category 4
Ortho Inpat	9.86725, 0.52469	9.88231, 0.30996	9.88459, 0.33826	9.9502, 0.45105
Ortho Outpat RVU	4.34233, 0.89434	4.37281, 0.86421	4.34373, 0.83395	4.4364, 0.94266
GS Inpat	9.3145, 0.57385	9.45545, 0.62449	9.42344, 0.59444	9.39466, 0.56815
GS Outpat RVU	4.33131, 0.86087	4.36641, 0.8632	4.34458, 0.83767	4.44586, 0.95534
Not Inpat	9.72423, 0.97396	9.90292, 0.83585	9.77159, 0.83126	9.83745, 0.93407

Table 5. Direct Care Shape and Scale Parameters by Beneficiary Category

	Category 1	Category 2	Category 3	Category 4
Ortho Inpat	9.60803, 0.74272	9.83415, 0.34022	9.84964, 0.40579	9.79745, 0.48876
Ortho Outpat APC	7.49313, 1.26527	7.85051, 0.84838	7.69484, 1.04419	7.94337, 0.84209
Ortho Outpat RVU	4.07712, 0.62307	4.34604, 0.75236	4.2969, 0.77875	4.15058, 0.64265
GS Inpat	8.9785, 0.53722	9.16386, 0.59317	9.18937, 0.52972	9.08362, 0.48164
GS Outpat APC	7.71237, 0.59781	7.58402, 0.67191	7.60138, 0.65159	7.71805, 0.63205
GS Outpat RVU	4.57125, 0.70754	4.60267, 0.7786	4.63426, 0.84802	4.61788, 0.71395

Cumulative distribution functions (cdfs) were created from each unique pdf for all types of care and beneficiary category. The cdfs were developed to find the total cost of care for a particular care type partitioned by the costs for each beneficiary category. These cdfs were used to find the overall cost of purchased or direct care for a specific enrollment. An example cdf is displayed in Table 6 for purchased general surgery inpatient care.

The Monte Carlo simulation was tested using the VBA code in Appendix D. To start a U(0,1) random variable was generated. This indicated the beneficiary category in the cdf from which the corresponding pdf was used to generate a cost. For example, using the cdf in Table 6, if the random number was 0.5 then the random entity would follow the pdf from category three. A second random number in the LOGNORM.INV function in Excel, along with the pdf parameters, produced a cost. The distribution parameters provided by JMP's distributions tool conveniently match the format of Excel's LOGNORM.INV function. JMP produces the shape parameter, which is equivalent to the mean, μ, and the scale parameter, which is equivalent to the standard deviation, σ. Therefore, a single entity moving through the simulation will first be assigned a random number. Depending on where that random number falls, the cost for care is generated from the appropriate cost distribution.

Table 6. Purchased Care GS Inpat CDF

Category 1	Category 2	Category 3	Category 4
0.073597	0.463661	0.953082	1

This procedure was used to generate costs for 100,000 entities moving through the system. This number of entities yields a very small standard error of the mean. The standard error of the mean is not based on the assumption of a normally distributed population, therefore it is applicable for the lognormally distributed population. The standard error of the mean is calculated by

$$\sigma_{\overline{x}} = \frac{\sigma}{\sqrt{n}}, \tag{3}$$

where σ is the standard deviation of the population and n is the number of observations of the sample. Running this simulation for a higher number of entities would consume additional time for no additional benefit. Additionally, we ran one replication occurs for each instance because all factors are assumed to be independent, thus making any additional runs futile.

A count of the number of entities is maintained for each category. Using this count yields cost margins for an individual for each type of care in the simulation. The mean cost of a particular care type j, noted $\overline{X_j}$, is calculated using

$$\overline{X_j} = \frac{1}{n} \sum_{i=1}^{n} X_{ij}, \tag{4}$$

where X_{ij} represents the ith value of the sample and n represented the sample size. The various individual costs for a given care type are evaluated in the following chapter.

Determining the costs for an individual in a given beneficiary category and care helped to develop two scenarios. The first scenario determines the costs of providing both direct and purchased care at WPAFB's historical number of encounters for each category over three years. This scenario is called the WPAFB enrollment in the next chapter. The second scenario, referred to as Atlanta enrollment, determines the same costs, but at predicted Atlanta encounter numbers for three years for each care and beneficiary category. Atlanta encounter numbers were predicted based on the ratio of each beneficiary category's enrollment to WPAFB.

3.5 Verification and Validation

Verification and validation are separate procedures that are essential to ensure the credibility and accuracy of any information and analyses in a simulation model. Verification is concerned with assuring the model is built correctly and behaves as intended. Validation is concerned with building the correct model and ensuring the model behaves the same as the real system.

For this research to ensure model adequacy, the model was verified by extending the parameters to extreme values and monitoring how the simulation responded. The means of each distribution were increased by 10 and the resulting mean cost per beneficiary category observed. For example, consider changing the mean of the pdf for the purchased general surgery inpatient beneficiary category one care. After running the simulation, the individual cost of care increased by a magnitude of four. A separate instance varied the standard deviations in each pdf and monitored the behavior of the simulation. Again, the Monte Carlo simulation produced differing cost results. Since the differing cost results when varying the two parameters is expected, there is confidence the model is correctly built.

Model Validation involved setting aside one fiscal year of data. Fiscal Year 2014 is the validation set because there were no significant policy changes influencing the way military health care is delivered or any considerable changes to military authorization numbers. Results with this validation dataset led to concluding there are no factors that may affect the behavior of the data. The validation dataset followed the same process to determine the applicable distribution. The shape and scale parameters for the Fiscal Year 2014 lognormal distributions for purchased and direct care are displayed in Appendix E. The dataset ran through the same Monte Carlo simulations, adjusting for the different pdfs. Due to the stochasticity of the simulation process an exact match is unlikely, however similar cost results are expected. Figure 3 displays

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the commonalities between the purchased care orthopedic outpatient RVU values from the test and validation datasets.
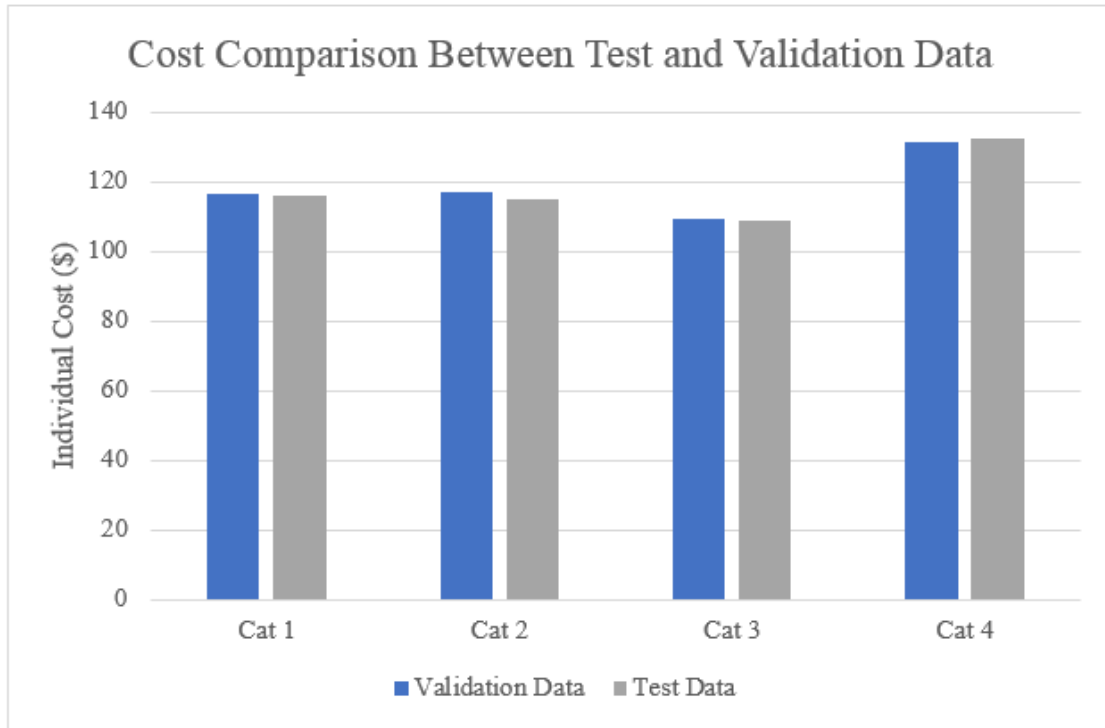
Figure 3. Cost Comparison Between the Test and Validation Data

3.6 Summary

This chapter outlined the methodology for developing a deterministic cost model used to compare the workload costs of providing health care at a MTF versus in the private sector. the chapter first described the process to determine the radius of TRICARE enrolled individuals in the Atlanta, Georgia region. Next, it described where the data came from as well as the specific enrollment data received. It then discussed the workload measures used in the analysis and the nature of the direct and purchased care datasets. The procedures used to produce clean and comparable datasets for the Monte Carlo simulation were outlined. Finally, the Monte Carlo

simulation model and the steps performed to verify and validate the model were presented. The analysis and results of this applied methodology are discussed in the next chapter.

IV. Analysis

4.1   Overview

In this analysis section, the research methodology is used to represent the costs to provide direct and purchased medical care based on workload measures. Dsts between direct and purchased care for the general surgery and orthopedics specialties are discussed. Sensitivity analysis on the fiscal impacts of developing a new military treatment facility (MTF) in Atlanta, Georgia to the Department of Defense (DoD) are also discussed. Finally, results are summarized in terms of their application to the original problem statement that motivated the research.

4.2   Analysis

The Monte Carlo simulation first determines the cost for an individual in any given type of care and beneficiary category. The individual cost results are displayed in Table 7 for direct care costs and Table 8 for purchased care costs.

Table 7. Direct Care Individual Cost

	Category 1	Category 2	Category 3	Category 4
GS Outpat APC	$2,661.04	$2,467.47	$2,474.37	$2,757.94
GS Outpat RVU	$121.98	$134.89	$146.71	$130.84
GS Inpat	$9,113.26	$11,437.09	$11,249.17	$9,848.66
Ortho Outpat APC	$4,009.56	$3,684.05	$3,784.99	$3,972.64
Ortho Outpat RVU	$71.81	$102.76	$99.81	$77.79
Ortho Inpat	$19,420.26	$19,770.56	$20,524.23	$20,240.68

Table 8. Purchased Care Individual Cost

	Category 1	Category 2	Category 3	Category 4
GS Outpat RVU	$110.67	$114.94	$109.13	$135.82
GS Inpat	$13,136.33	$15,610.66	$14,723.30	$14,158.93
Ortho Outpat RVU	$115.78	$115.13	$108.73	$132.19
Ortho Inpat	$22,258.26	$20,534.62	$20,780.57	$23,315.89
Not Inpat	$27,038.21	$28,304	$24,961.59	$28,856.85

Results do not define the general surgery or orthopedics outpatient Ambulatory Payment Classification (APC) individual cost values for purchased care. These outpatient APC costs are considered uncertain parameters. Estimating APC cost values in the sensitivity analysis allows a full comparison between direct and purchased military health care. These individual costs, along with the number of encounters, were used to calculate the costs of direct and purchased care for each of the scenarios. The number of encounters over a three year time period for each type of care and beneficiary category in the Wright Patterson Air Force Base (WPAFB) enrollment scenario are displayed in Table 9.

Table 9. Encounters for WPAFB Enrollment Scenario

	Category 1	Category 2	Category 3	Category 4
GS Outpat APC	196	748	684	220
GS Outpat RVU	895	2,787	3,486	1,059
GS Inpat	62	222	339	82
Ortho Outpat APC	184	508	723	611
Ortho Outpat RVU	3,531	11,598	15,462	8,441
Ortho Inpat	22	338	509	100

The enrollment datasets from WPAFB and the new Atlanta market were used to calculate a ratio of enrollment for each beneficiary category between the two regions. These ratios were then used to determine the number of encounters for each type of care and beneficiary category in the Atlanta enrollment scenario. The predicted encounter values for the Atlanta enrollment scenario are displayed in Table 10.

Table 10. Predicted Encounters for Atlanta Enrollment Scenario

	Category 1	Category 2	Category 3	Category 4
GS Outpat APC	432	1,034	1,353	688
GS Outpat RVU	1,972	3,854	6,896	3,311
GS Inpat	137	307	671	256
Ortho Outpat APC	405	703	1,430	1,910
Ortho Outpat RVU	7,778	16,039	30,588	26,389
Ortho Inpat	48	467	1,007	313

4.3 Sensitivity Analysis

Sensitivity analysis was conducted on uncertain parameters to monitor the performance of the results. The uncertain parameters for both scenarios are the individual APC cost values for general surgery and orthopedic purchased care. To obtain a cost value for the uncertain parameters, first calculate the cost ratios between direct and purchased outpatient Relative Value Unit (RVU) care. Then, assign a ratio to the outpatient purchased care APC values using the known outpatient RVU ratios. Multiply this ratio by the cost of direct outpatient APC care for each beneficiary categories in the two specialties. For example, the general surgery outpatient RVU ratio for beneficiary category one is 0.91. Multiply this ratio by $2,661.04, which is the cost for a beneficiary category one individual to receive general surgery outpatient APC direct care. This resulted in an estimated purchased care general surgery outpatient APC cost value of $2,414.35. For the sensitivity analysis, consider a range of RVU ratios from -0.3 to +0.3 in increments of 0.1 and apply these incremented ratios to all beneficiary categories. Table 11 displays the increments and the corresponding total APC cost for the general surgery and orthopedic care types for the WPAFB enrollment scenario. Table 12 displays the same information for the Atlanta enrollment scenario.

Table 11. WPAFB Enrollment Sensitivity Analysis On Unknown Purchased Care APC Parameters

Increment	General Surgery Total APC Cost	Orthopedic Total APC Cost
-0.3	$2,534,613.26	$8,059,945.18
-0.2	$3,001,258.02	$8,837,253.93
-0.1	$3,467,902.79	$9,614,562.68
0	$3,934,547.56	$10,391,871.43
+0.1	$4,401,192.32	$11,169,180.18
+0.2	$4,867,837.09	$11,946,488.93
+0.3	$5,334,481.86	$12,723,797.68

Table 12. Atlanta Enrollment Sensitivity Analysis on Unknown Purchased Care APC Parameters

Increment	General Surgery Total APC Cost	Orthopedic Total APC Cost
-0.3	$4,992,709.21	$19,147,245.21
-0.2	$5,887,339.49	$20,868,773.13
-0.1	$6,781,969.77	$22,590,301.04
0	$7,676,600.04	$24,311,828.96
+0.1	$8,571,230.32	$26,033,356.87
+0.2	$9,465,860.60	$27,754,884.78
+0.3	$10,360,490.88	$29,476,412.70

Table 11 and Table 12 results show that the costs increase in a linear fashion for both general surgery and orthopedics as the increment increases. Additionally, the costs in Table 12 are almost twice as high as those costs in Table 11 because the enrollment is higher for the Atlanta market for all beneficiary categories. The enrollment in Atlanta is 2.2, 1.38, 1.98, and 3.13 times higher than WPAFB for beneficiary category one, two, three, and four respectively.

The sensitivity analysis helped determine that the total value of purchased care ranges from $46.85 to $71.72 million for the WPAFB enrollment scenario. For the Atlanta enrollment scenario, there is a higher range of values, from $94.55 to $142.99 million. Comparatively, for direct care the cost to operate under the WPAFB enrollment scenario is $44.53 and $87.19 million for the Atlanta enrollment scenario. The comparison between these purchased and direct care costs can be observed in Figure

4 for WPAFB Enrollment scenario and Figure 5 for the Atlanta enrollment scenario. Figure 4 and Figure 5 represent the range of total purchased care costs with the gray shaded area of the stacked column.
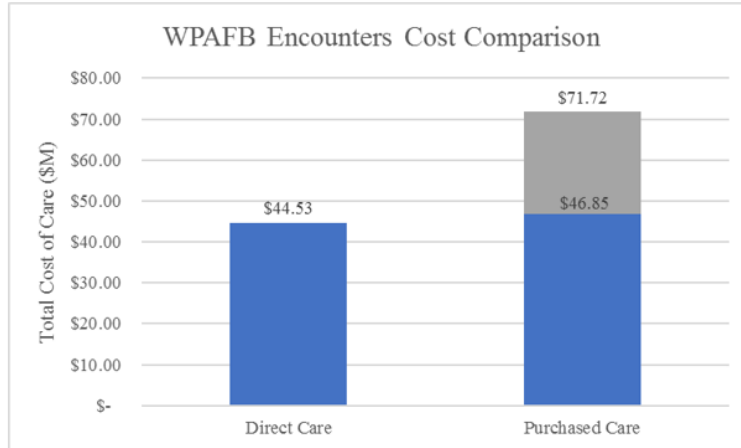
Figure 4. WPAFB Enrollment Cost Comparison Between Direct and Purchased Care
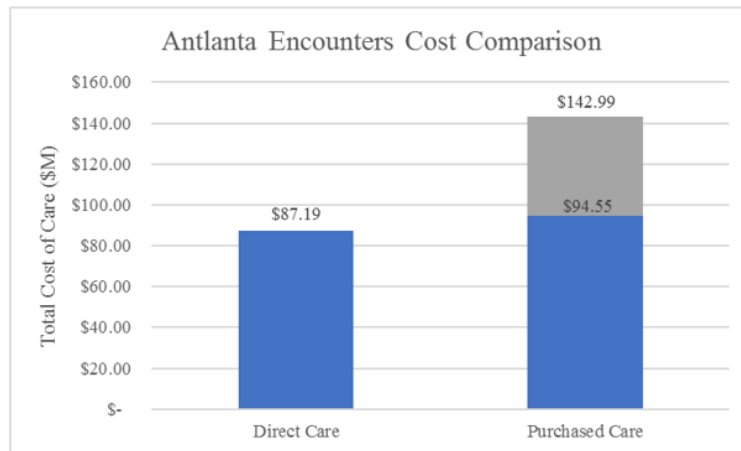
Figure 5. Atlanta Enrollment Cost Comparison Between Direct and Purchased Care

4.4 Summary

This chapter presents the analysis used to help Air Force Medical Operations Agency gain insights on the value of direct and purchased military health care and the need for a new MTF in Atlanta, Georgia. The analysis indicates that providing direct care is always cheaper than providing purchased care except for general surgery outpatient procedures for all beneficiaries except active duty service members.

For direct care the cost to provide care for three years under the WPAFB enrollment scenario is about $44.53 and $87.19 million for the Atlanta enrollment scenario. To provide the same purchased care under the WPAFB enrollment scenario would cost anywhere from $2.33 to $27.2 million more than if it were performed at a direct care facility. For the Atlanta enrollment scenario, the purchased care is $7.36 to $55.8 million more expensive than the same direct care.

V. Conclusions and Future Research

5.1 Overview

This final chapter presents the conclusions, the limitations, and future areas of research.

5.2 Conclusions

The comparatively high enrollment numbers for the Atlanta, Georgia region combined with the discounted costs to provide direct care warrant the consideration of developing a new military treatment facility (MTF) in the region. The analysis indicates that the enrollment in Atlanta is higher than Wright Patterson Air Force Base for all four beneficiary categories. This result indicates that there is enough demand in the region to justify the development of a new MTF. Additionally, the analysis focused specifically on workload costs, which closely follow the lognormal distribution. Based on workload measures, it is cheaper to deliver both general surgery and orthopedic care at a MTF. A new MTF in Atlanta, Georgia would better ensure operational readiness by providing an additional site for clinicians to train. However, one cannot determine the effects to medical readiness.

The Air Force Medical Service and Air Force Medical Operations Agency should consider developing a new MTF in the Atlanta, Georgia region in order to reduce health care costs to the Department of Defense. The methodology applied in this research to the Atlanta region can be applied to any geographical region to determine the possibility of reduced costs. The development of additional MTFs, combined with other efforts aimed at achieving savings and efficiencies within the operational environment of the Military Health System, can help the Department of Defense control the rising costs of military health care. The Department of Defense must also

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continue to pursue reasonable health benefit reform as part of a balanced approach.

5.3 Limitations

The model developed in this work considered the costs of direct and purchased military medical health care based on workload measures. The model did not consider any fixed startup costs, nor any annual costs such as clinicians salaries or building operational costs. Additionally, the model does not capture the potential compensation a MTF would receive from other health insurance. Reimbursement from other health insurance would reduce the costs of providing direct care at a MTF.

The scope of this research was limited to general surgery and orthopedic specialties. However, the methodology in this research can be applied to all specialty and primary care types. Additionally, the workload measures for a type of care are calculated based on beneficiary categories. The work does not consider other identifying characteristics such as age or Alternate Care Value group. The TRICARE program was restructured beginning in January of 2018. Therefore, any information gained from the Alternate Care Value group identifier may be obsolete for the updated structure. Additionally, the model does not account for any drastic changes in the cost to deliver direct or purchased health care.

The work assumes that if a MTF were developed the MTF would experience enough encounters to be fiscally beneficial and will operate at a similar efficiency as Wright Patterson Air Force Base. This research cannot predict the future MTF efficiency or performance. These outcomes are often based on how well the MTF leader manages care. Additionally, for a fair comparison between direct and purchased care, malpractice expenses are not incorporated into the calculations. The Malpractice Expense Relative Value Unit represents the cost of liability insurance for a provider. Malpractice Expense Relative Value Units are recorded only for purchased

care. There are no Malpractice Expenses recorded for direct care because military clinicians are protected from medical malpractice lawsuits.

Medical teams are assumed to treat a minimum number of patients and meet the operational readiness mission. It is assumed MTF clinicians will maintain adequate training to care for personnel in both peace and war time and the medical teams at a MTF will have the availability and capability to keep a medically ready force and meet the medical readiness mission.

5.4   Future Research

This analysis assists Air Force Medical Service and Air Force Medical Operations Agency in deciding if a new MTF in the Atlanta, Georgia region will help reduce military health care costs to the Department of Defense. However, in order to make an informed decision, the Air Force Medical Operations Agency should consider future research into the problem. Future work might consider a full cost analysis, to include fixed and variable costs, on each of the two alternatives. Additionally, future research might examine methods to reduce costs through different building options. Instead of the DoD constructing and staffing their own facility, it may be beneficial to lease or rent the space.

This analysis provides a means to examine primary care and other care specialties. Extensions might consider the age group and other characteristics to see if there is a statistically significant difference in the cost of care. The analysis provides insights on the cost of care based on beneficiary categories. Those individuals in beneficiary category four must be seen at an MTF unless there is a referral. However, all other beneficiary categories are not required to receive care at an MTF. Therefore, future research could examine the potential to recapture care. Recapture care here means to determine the number of beneficiaries who will switch from private sector care and in-

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stead choose to receive care at a MTF. Future researchers should know the population, understand the services, and leverage medical informatics to provide a comprehensive recommendation on the development of a new MTF in any geographical area.

Appendix A. Inpatient Product Line VBA Code

```vba
Sub MeprsCode()


    Dim Count As Double

    Dim i As Double

    Dim DataRange As Range

    Dim TEDi As Worksheet

    Dim MsDrg As Double

    Dim MeprsID As String




    Set TEDi = Sheets("TEDI")


    Set DataRange = Range(TEDi.Cells(2, 1), TEDi.Cells(2, 1).End(xlDown))
    Count = WorksheetFunction.Count(DataRange)




    i = 2
    MsDrg = TEDi.Range("R" & i).Value


    For i = 2 To Count + 1
        Select Case MsDrg
            Case 29, 30, 42, 81, 162, 169, 305, 454, 455, 457, 458, 459,
            460, 462, 464, 465, 467, 468, 469, 470, 471, 472, 473, 481, 482,
            483, 484, 486, 488, 489, 490, 491, 493, 494, 496, 497, 504, 511,
```

```
512, 513, 514, 515, 516, 517, 518, 519, 520, 536, 554, 556, 558,

560, 561, 563, 566, 572, 857, 858, 902, 903, 906, 909, 940, 951,

982, 983, 987


    MeprsID = "ORTHOPEDICS"

    TEDi.Range("S" & i).Value = MeprsID


Case 27, 132, 133, 134, 145, 148, 149, 151, 156, 167, 170, 184,

185, 186, 198, 200, 201, 204, 206, 225, 227, 244, 264, 300, 301,

309, 310, 312, 313, 315, 316, 326, 327, 328, 329, 330, 331, 333,

335, 336, 337, 339, 340, 341, 342, 343, 344, 345, 346, 348, 349,

351, 352, 354, 355, 357, 358, 370, 371, 372, 373, 375, 376, 379,

381, 384, 385, 386, 388, 389, 390, 391, 392, 393, 394, 395, 409,

414, 416, 417, 418, 419, 420, 421, 434, 439, 440, 443, 444, 445,

446, 459, 460, 464, 467, 468, 470, 473, 481, 482, 488, 489, 490,

491, 492, 493, 494, 502, 544, 552, 570, 571, 576, 578, 580, 581,

582, 583, 585, 599, 601, 603, 614, 626, 627, 640, 641, 655, 660,

661, 663, 682, 683, 690, 694, 696, 699, 700, 708, 709, 710, 713,

714, 734, 735, 736, 742, 743, 748, 749, 769, 775, 776, 781, 799,

801, 804, 812, 821, 825, 827, 828, 856, 862, 863, 864, 871, 880,

908, 920, 921, 947, 948, 949, 950, 963, 981, 988, 989


    MeprsID = "GENERAL SURGERY"

    TEDi.Range("S" & i).Value = MeprsID


Case Else
```

```
                    MeprsID = "Not Performed at MTF"

                    TEDi.Range("S" & i).Value = MeprsID


        End Select

        MsDrg = TEDi.Range("R" & i + 1).Value

    Next



End Sub
```

Appendix B. Purchased Care Duplicates VBA Code

```
Sub FindDuplicates()


      Dim Inpat As Worksheet

      Dim Outpat As Worksheet

      Dim Dup As Worksheet

      Dim InID As String

      Dim InCM As Double

      Dim InCY As Double

      Dim OutID As String

      Dim OutCM As Double

      Dim OutCY As Double

      Dim InCount As Double

      Dim OutCount As Double

      Dim InDataRange As Range

      Dim OutDataRange As Range

      Dim i As Double

      Dim n As Double

      Dim LastRow As Double



      Set Inpat = Sheets("Inpat")

      Set Outpat = Sheets("Outpat")

      Set Dup = Sheets("Duplicates")
```

```
Set InDataRange = Range(Inpat.Cells(2, 1), Inpat.Cells(2, 1).End(xlDown))

InCount = WorksheetFunction.Count(InDataRange)


Set OutDataRange = Range(Outpat.Cells(2, 1), Outpat.Cells(2, 1).End(xlDown))

OutCount = WorksheetFunction.Count(OutDataRange)



For i = 2 To InCount

    InID = Inpat.Range("H" & i).Value

    InCM = Inpat.Range("M" & i).Value

    InCY = Inpat.Range("N" & i).Value

    For n = 2 To OutCount

        OutID = Outpat.Range("E" & n).Value

        OutCM = Outpat.Range("L" & n).Value

        OutCY = Outpat.Range("M" & n).Value

        If OutID = InID Then

            If OutCM = InCM Then

                If OutCY = InCY Then

                    LastRow = Dup.Range("A" & Rows.Count).End(xlUp).Row + 1

                    Dup.Range("A" & LastRow).Value = OutID

                    Dup.Range("B" & LastRow).Value = OutCM

                    Dup.Range("C" & LastRow).Value = OutCY

                    Dup.Range("D" & LastRow).Value = n

                    Dup.Range("E" & LastRow).Value = i

                Else

                    n = n
```

```
                    End If

            Else

                    n = n

            End If

        Else

                n = n

        End If

    Next n

Next i


End Sub
```

Appendix C. Direct Care Duplicates VBA Code

```
Sub FindDuplicates()


    Dim SIDR As Worksheet

    Dim CAPER As Worksheet

    Dim Dup As Worksheet

    Dim SidrID As String

    Dim SidrCM As Double

    Dim SidrCY As Double

    Dim CaperID As String

    Dim CaperCM As Double

    Dim CaperCY As Double

    Dim SidrCount As Double

    Dim CaperCount As Double

    Dim SidrDataRange As Range

    Dim CaperDataRange As Range

    Dim i As Double

    Dim n As Double

    Dim LastRow As Double



    Set SIDR = Sheets("WPAFB SIDR")

    Set CAPER = Sheets("WPAFB CAPER")

    Set Dup = Sheets("Duplicates")
```

```
Set SidrDataRange = Range(SIDR.Cells(2, 1), SIDR.Cells(2, 1).End(xlDown))

SidrCount = WorksheetFunction.Count(SidrDataRange)


Set CaperDataRange = Range(CAPER.Cells(2, 1), CAPER.Cells(2, 1).End(xlDown))

CaperCount = WorksheetFunction.Count(CaperDataRange)


i = 2

SidrID = SIDR.Range("AA" & i).Value

SidrCM = SIDR.Range("H" & i).Value

SidrCY = SIDR.Range("I" & i).Value


n = 2

CaperID = CAPER.Range("Y" & n).Value

CaperCM = CAPER.Range("N" & n).Value

CaperCY = CAPER.Range("O" & n).Value


For i = 2 To SidrCount

    For n = 2 To CaperCount

        CaperID = CAPER.Range("Y" & n).Value

        CaperCM = CAPER.Range("N" & n).Value

        CaperCY = CAPER.Range("O" & n).Value

        If CaperID = SidrID Then

            If CaperCM = SidrCM Then

                If CaperCY = SidrCY Then

                    LastRow = Dup.Range("A" & Rows.Count).End(xlUp).Row + 1

                    Dup.Range("A" & LastRow).Value = CaperID
```

```vba
                Dup.Range("B" & LastRow).Value = CaperCM

                Dup.Range("C" & LastRow).Value = CaperCY

                Dup.Range("D" & LastRow).Value = n

                Dup.Range("E" & LastRow).Value = i

                CaperID = CAPER.Range("Y" & n + 1).Value

                CaperCM = CAPER.Range("N" & n + 1).Value

                CaperCY = CAPER.Range("O" & n + 1).Value

            Else

                CaperID = CAPER.Range("Y" & n + 1).Value

                CaperCM = CAPER.Range("N" & n + 1).Value

                CaperCY = CAPER.Range("O" & n + 1).Value

            End If

        Else

            CaperID = CAPER.Range("Y" & n + 1).Value

            CaperCM = CAPER.Range("N" & n + 1).Value

            CaperCY = CAPER.Range("O" & n + 1).Value

        End If

    Else

        CaperID = CAPER.Range("Y" & n + 1).Value

        CaperCM = CAPER.Range("N" & n + 1).Value

        CaperCY = CAPER.Range("O" & n + 1).Value

    End If

Next n

SidrID = SIDR.Range("AA" & i + 1).Value

SidrCM = SIDR.Range("H" & i + 1).Value

SidrCY = SIDR.Range("I" & i + 1).Value
```

```
        Next i


End Sub
```

Appendix D. Monte Carlo Simulation VBA Code

```vba
Sub PC_GS_Inpat()


    Dim RndNum As Double

    Dim i As Double

    Dim Cat1TotalCost As Double

    Dim Cat2TotalCost As Double

    Dim Cat3TotalCost As Double

    Dim Cat4TotalCost As Double

    Dim Cost As Double

    Dim RndNum2 As Double

    Dim n As Double


For n = 1 To 100

    For i = 1 To 10000

        RndNum = Rnd()

        RndNum2 = Rnd()


        If RndNum < 0.073598 Then

            Cost = WorksheetFunction.LogNorm_Inv(RndNum2, 9.3145, 0.57385)

            Cat1TotalCost = Cost + Cat1TotalCost


        ElseIf RndNum > 0.073597 And RndNum < 0.463662 Then

            Cost = WorksheetFunction.LogNorm_Inv(RndNum2, 9.45545, 0.62449)

            Cat2TotalCost = Cost + Cat2TotalCost
```

```
    ElseIf RndNum > 0.463661 And RndNum < 0.953083 Then

        Cost = WorksheetFunction.LogNorm_Inv(RndNum2, 9.42344, 0.59444)

        Cat3TotalCost = Cost + Cat3TotalCost


    Else

        Cost = WorksheetFunction.LogNorm_Inv(RndNum2, 9.39466, 0.56815)

        Cat4TotalCost = Cost + Cat4TotalCost


    End If


Next


Sheets("PC GS Inpat").Range("A" & n + 1).Value = Cat1TotalCost

Sheets("PC GS Inpat").Range("B" & n + 1).Value = Cat2TotalCost

Sheets("PC GS Inpat").Range("C" & n + 1).Value = Cat3TotalCost

Sheets("PC GS Inpat").Range("D" & n + 1).Value = Cat4TotalCost


Cat1TotalCost = 0

Cat2TotalCost = 0

Cat3TotalCost = 0

Cat4TotalCost = 0

Next


End Sub
```

Appendix E. Validation Data Shape and Scale Parameters

Table 13. Purchased Care Shape and Scale Parameters 2014

	Category 1	Category 2	Category 3	Category 4
Ortho Inpat	9.68559, 0.58972	9.90679, 0.3493	9.83713, 0.37601	9.98971, 0.482
Ortho Outpat RVU	4.37374, 0.88526	4.38707, 0.85958	4.36266, 0.82562	4.4722, 0.90466
GS Inpat	9.15786, 0.5638	9.42022, 0.6208	9.39767, 0.57853	9.43294, 0.63715
GS Outpat RVU	4.42363, 0.88856	4.39423, 0.84628	4.3858, 0.8271	4.44273, 0.89054
Not Inpat	9.79664, 0.92027	9.90165, 0.74852	9.79533, 0.75479	9.72031, 0.8834

Table 14. Direct Care Shape and Scale Parameters 2014

	Category 1	Category 2	Category 3	Category 4
Ortho Inpat	9.51938, 0.89406	9.6907, 0.48509	9.71258, 0.51774	9.61394, 0.62424
Ortho Outpat APC	7.73144, 0.99948	7.67858, 1.06865	7.64591, 1.21098	7.87613, 1.01529
Ortho Outpat RVU	4.075, 0.67155	4.25825, 0.74867	4.19452, 0.74585	4.13659, 0.70468
GS Inpat	9.02343, 0.53522	9.3148, 0.6301	9.25407, 0.59299	9.16513, 0.62883
GS Outpat APC	7.77341, 0.62008	7.3772, 0.79553	7.26369, 0.72937	7.67698, 0.65327
GS Outpat RVU	4.59086, 0.98896	4.62184, 1.04749	4.59685, 0.94779	4.62108, 0.86344

Bibliography

1. Office of the Under Secretary of Defense (Comptroller) Chief Financial Officer, "Defense Budget Overview: United States Department of Defense Fiscal Year 2017 Budget Request," *President's Annual Defense Budget*, February 2016.

2. Office of the Under Secretary of Defense (Comptroller) Chief Financial Officer, "Defense Budget Overview: United States Department of Defense Fiscal Year 2018 Budget Request," *President's Annual Defense Budget*, May 2017.

3. P. M. Lurie, "Comparing the Costs of Military Treatment Facilities with Private Sector Care," *Institute for Defense Analyses*, February 2016.

4. Air Force Medical Service, "About the AFMS." http://www.airfocemedicine.af.mil, October 2016. Accessed: 2018-01-01.

5. Air Force Medical Service, "AFMOA." http://www.airforcemedicine.af.mil/AFMOA, April 2017. Accessed: 2018-01-01.

6. Office of the Under Secretary of Defense (Comptroller) Chief Financial Officer, "Defense Health Program: Fiscal Year (FY) 2017 Budget Estimates," *President's Annual Defense Budget*, February 2016.

7. TRICARE, "TRICARE Health Plans." https://tricare.mil/Plans/HealthPlans, January 2018. Accessed: 2018-01-05.

8. S. K. Burns, P. M. Lurie, and S. A. Horowitz, "Analysis of Military Healthcare Benefit Design and Delivery: Study in Support of the Military Compensation and Retirement Modernization Commission," *Institute for Defense Analyses*, January 2015.

9. Defense Health Agency, Decision Support Division, "Evaluation of the TRICARE Program: Fiscal Year 2017 Report to Congress," *Military Health System*, May 2017.

10. C. T. Murray, "Approaches to Reduce Federal Spending on Military Health Care," *Congressional Budget Office*, January 2014.

11. W. Yang, T. M. Dall, Y. Zhang, P. F. Hogan, D. R. Arday, and C. J. Gantt, "Disease Management 360: A Scorecard Approach to Evaluating TRICARE's Programs for Asthma, Congestive Heart Failure, and Diabetes," *Medical Care*, vol. 48, pp. 683–693, August 2010.

12. T. M. Dall, A. W. R.C., Y. Zhang, W. Yang, D. R. Arday, and C. J. Gantt, "Outcomes and Lessons Learned From Evaluating TRICARE's Disease Management Programs," *American Journal of Managed Care*, vol. 16, pp. 438–446, June 2010.

13. R. A. Levy, E. W. Christensen, and S. Asamoah, "Raising the Bonus and Prospects for DoD's Attracting Fully Trained Medical Personnel," *CNA Corporation*, February 2006.

14. C. T. Murray and E. Bass, "Approaches to Changing Military Health Care," *Congressional Budget Office*, October 2017.

15. Defense Health Agency, "Military Health System: The Defense Health Agency in 2017," *Defense Health Agency*, February 2017.

16. TRICARE, "Changes are Coming to TRICARE: Are you Ready?." https://www.health.mil/News/Articles/2017/08/31/Changes-Are-Coming-to-TRICARE-Are-You-Ready, August 2017. Accessed: 2018-01-03.

17. M. S. Goldberg, S. Chin, J. F. Dorris, S. A. Horowitz, J. A. Lee, and D. B. Levine, "Cost Analysis of the Military Medical Care System: Final Report," *Institute for Defense Analyses*, September 1994.

18. M. S. Goldberg, V. Johnson, and J. Grefer, "Comparing the Costs of Military Treatment Facilities and Purchased Care," *Center for Naval Analysis*, November 2003.

19. TRICARE, "TRICARE Management Activity (TMA)/Health Program Analysis and Evaluation 2003," *Department of Defense*, 2003.

20. Department of Defense, "Military Health System Modernization Study Team Report," *Department of Defense*, May 2015.

21. Department of Defense, "Evaluation of the TRICARE Program - Access, Cost and Quality: Fiscal Year 2013 Report to Congress," *Department of Defense*, February 2013.

22. Air Force Instruction 44-171, "Patient Centered Medical Home Operations," *Department of the Air Force*, November 2014.

23. N. Nicosia, B. O. Wynn, and J. A. Romley, "Assessing the Performance of Military Treatment Facilities," *RAND Corporation*, 2011.

24. Department of Defense, "Military Health System Review: Final Report to the Secretary of Defense," *Department of Defense*, August 2014.

25. J. C. Graser, D. Blum, K. Brancato, J. J. Burks, E. W. Chan, N. Nicosia, M. J. Neumann, H. V. Ritschard, and B. F. Mundell, "The Economics of Air Force Medical Service Readiness," *RAND Corporation*, 2010.

26. J. Banks, J. S. Carson II, B. L. Nelson, and D. M. Nicol, *Discrete-Event System Simulation*. Pearson, 2014.

27. S. M. Ross, *Introduction to Probability Models*. Elsevier, 2014.

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14. ABSTRACT

Health care expenses are one of the largest contributing factors to increased personnel costs, the fastest-rising component of the Department of Defense's budget. This research examines the cost implications of developing a new military treatment facility in a specified geographical region, in an effort to reduce military health care spending. Care received at a military treatment facility is referred to as direct care, while care received in the private sector is referred to as purchased care. This research leverages existing information on direct and purchased medical care to gain insights into the workload costs for medical care in a geographical region. We use a Monte Carlo simulation approach to determine the direct and purchased care costs for general surgery and orthopedic specialties. We apply our method to the Atlanta, Georgia region and conclude that based on workload measures, it is cheaper in Atlanta to provide direct care at a new military treatment facility.

15. SUBJECT TERMS

Monte Carlo Simulation, Lognormal Distribution, Military Treatment Facility, TRICARE

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