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DETERMINING OPTIMAL ALLOCATION OF NAVAL OBSTETRIC RESOURCES WITH LINEAR PROGRAMMING

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December 2013

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The U.S. Navy Bureau of Medicine and Surgery allocates funding for obstetric staffing resources such as doctors, nurses, and midwives. Furthermore, these resources operate within a fixed number of labor/delivery and postpartum rooms, thereby establishing a theoretical maximum capacity of delivery volume.

This study identifies the expected delivery volume created by the facility capacity of four major naval military treatment facilities (MTF) within the United States. Based on the calculated volume, this thesis utilizes a linear programming model to determine the optimum mix of doctors, nurses, and midwives to achieve the target delivery numbers. This is achieved while concurrently incorporating all relevant constraints within military medical treatment facilities. As a result, the model allows hospitals to meet target delivery volumes while simultaneously utilizing their allocated resources in the most effective manner. Additionally, the model can accommodate changes in the inputs and constraints and can be used to provide support for similar resource allocation decision problems.

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DETERMINING OPTIMUM ALLOCATION OF NAVAL OBSTETRIC RESOURCES WITH LINEAR PROGRAMMING

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Submitted in partial fulfillment of the requirements for the degree of

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The U.S. Navy Bureau of Medicine and Surgery allocates funding for obstetric staffing resources such as doctors, nurses, and midwives. Furthermore, these resources operate within a fixed number of labor/delivery and postpartum rooms, thereby establishing a theoretical maximum capacity of delivery volume.

This study identifies the expected delivery volume created by the facility capacity of four major naval military treatment facilities (MTF) within the United States. Based on the calculated volume, this thesis utilizes a linear programming model to determine the optimum mix of doctors, nurses, and midwives to achieve the target delivery numbers. This is achieved while concurrently incorporating all relevant constraints within military medical treatment facilities. As a result, the model allows hospitals to meet target delivery volumes while simultaneously utilizing their allocated resources in the most effective manner. Additionally, the model can accommodate changes in the inputs and constraints and can be used to provide support for similar resource allocation decision problems.

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LIST OF ACRONYMS AND ABBREVIATIONS

BHC	branch health clinic
BMC	branch medical clinic
BUMED	Bureau of Medicine and Surgery
CNM	certified nurse midwife
DRG	Diagnosis Related Group
FTE	full time equivalent
FY	fiscal year
HLM	hierarchal linear model
LP	linear programming
MCAS	Marine Corps air station
MCB	Marine Corps base
MCRD	Marine Corps Recruit Depot
MIU	mother infant unit
MTF	military treatment facility
NAF	naval air field
NAS	naval air station
NAVSTA	naval station
NBHC	naval branch health clinic
NHCL	Naval Hospital Camp Lejeune
NHCP	Naval Hospital Camp Pendleton
NICU	neonatal intensive care unit
NMCP	Naval Medical Center Portsmouth
NMCSD	Naval Medical Center San Diego
NSA	Naval Support Activity
OB	obstetric
OB/GYN	obstetrics and gynecology
OBMD	obstetric physician
RN	registered nurse

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I. INTRODUCTION

A. PURPOSE AND SCOPE

The goal of this study is to determine optimum obstetric (OB) staffing proportions for facilities under the command of Bureau of Medicine and Surgery (BUMED). Optimum staffing, for the purpose of this study, is defined as a target ratio of doctors, midwives, and nurses that can provide obstetric care that meets the delivery volume of specific facilities as well as the standards and vision of BUMED. Furthermore, optimum staffing, in effect, minimizes costs associated with the resources of Navy medicine.

Although OB departments normally consist of OB and gynecology (OB/GYN) physicians, midwives, nurse practitioners, nurses, corpsmen, and medical assistants, this study will focus on doctors, midwives, and nurses—as they are the three most significant contributors in any delivery event.

Throughout this study, staff contribution is measured in terms of full time equivalents (FTE), on an annual basis. FTE is the ratio of total paid hours by the number of maximum working hours in a full time schedule. This study will examine: (1) target delivery volumes, by diagnosis related group, at four major military treatment facilities (MTFs), (2) the average delivery contribution value of individual staff resources, and (3) the effects of fluctuating population on staffing size.

B. RESEARCH QUESTIONS

1. Primary Question

What is the optimum mix of obstetric doctors, midwives, and nurses that meets the standards and target delivery volume of Navy MTFs?

2. Secondary Question

How does the optimum mix of doctors, midwives, and nurses change with a sudden fluctuation in the volume of beneficiaries?

How does the optimum mix of doctors, midwives, and nurses change when each staffing resource (doctor, midwife, or nurse) is assigned varying delivery contribution values?

II. BACKGROUND

The U.S. Navy Bureau of Medicine and Surgery (BUMED) in Falls Church, Virginia, is the headquarters command for Navy Medicine. BUMED develops the policies and necessary guidelines to be carried out by uniformed personnel at their subordinate commands and facilities. With numerous regional medical centers, hospitals, health clinics, research facilities, hospital ships, and support units, BUMED's vision is to "enable readiness, wellness, and healthcare to Sailors, Marines, their families, and all others entrusted to [them] worldwide be it on land or at sea" (Bureau of Medicine and Surgery [BUMED], 2013).

In terms of patient volume, this study utilizes data from four of the largest BUMED Naval medical treatment facilities.

A. MILITARY TREATMENT FACILITY OVERVIEW

This study analyzes data from the following MTFs: Naval Medical Center San Diego (NMCSD), Naval Medical Center Portsmouth (NMCP), Naval Hospital Camp Lejeune (NHCL), and Naval Hospital Camp Pendleton (NHCP). Table 1 provides an overview of features and personnel from these MTFs.

Table 1. Military Treatment Facilities' Overview Information (Donaldson, Meddaugh, & Jenkins, 2009)

Hospital Staff	**NMCSD**	**NMCP**	**NHCL**	**NHCP**
Officers	1,200	1,161	240	323
Enlisted	2,000	1,688	600	826
Civilians	2,100	1,717	450	700
Contract Civilians	750	1,333	460	331
Facility				
Square Footage	1.2 M	1.3 M	354,000	580,000
Bed Count	277	500	236	61
Operating Rooms	18	17	5	6
MTF Enrollees	98,389	108,906	34,107	51,250

1. Naval Medical Center San Diego Overview

Naval Medical Center San Diego (NMCSD) is located on the Florida Canyon site, adjacent to Balboa Park, in San Diego, California. The facility is a training hospital for Navy medicine personnel. NMCSD mission statement is: "Prepare to deploy in support of operational forces, deliver quality health services, and shape the future of military medicine through education, training, and research" (Naval Medical Center San Diego [NMCSD], 2013a).

The MTF and naval branch health clinics (NBHC) under NMCSD operational control include:

- NMCSD Hospital Facility
- NBHC Chula Vista
- NBHC Eastlake
- NBHC East County
- NBHC Kearny Mesa
- NBHC Naval Air Field (NAF) El Centro
- NBHC Naval Base Coronado
- NBHC Naval Base San Diego
- NBHC Marine Corps Air Station (MCAS) Miramar
- NBHC Marine Corps Recruit Depot (MCRD) San Diego
- NBHC Rancho Bernardo

NMCSD facility is a 1.2 million square foot, multispecialty hospital with 277 beds. The facility provides outpatient and inpatient services to 98,389 beneficiaries of active duty, retirees, and family members enrolled (see table 1). The MTF has 18 operating rooms and 11 primary care clinics offering medical care to beneficiaries from Miramar to El Centro. NMCSD staff is comprised of 6,050 military, civilian, and contract personnel "providing world-class healthcare; anytime, anywhere." (NMCSD, 2013a)

2. Naval Medical Center Portsmouth Overview

Naval Medical Center Portsmouth (NMCP) is located in the southeastern corner of Virginia, commonly referred to as Hampton Roads. Hampton Roads includes the cities of Newport News, Hampton, Norfolk, Portsmouth, Virginia Beach, Chesapeake, and Suffolk. The facility is a training hospital for Navy medicine personnel (Naval Medical Center Portsmouth [NMCP], 2013a).

The NMCP mission statement is:

> First and Finest! Naval Medical Center Portsmouth is the pinnacle of joint military excellence. We answer the call across any dynamic from kinetic operations to global engagement. Our healthcare is patient-centered and provides the best value, preserves health, and maintains readiness. (NMCP, 2013a)

The MTF and naval branch health clinics (NBHC) under NMCP operational control include:

- NMCP
- NBHC Naval Air Station (NAS) Oceana
- NBHC Naval Station (NAVSTA) Norfolk
- NBHC Joint Expeditionary Base Little Creek
- NBHC Naval Weapons Station Yorktown
- NBHC Fleet Combat Training Center Dam Neck
- NBHC Norfolk Naval Shipyard
- NBHC Naval Support Activity (NSA) Northwest
- TRICARE Prime Clinic Chesapeake
- TRICARE Prime Clinic Northwest
- TRICARE Prime Clinic Virginia Beach

The NMCP facility is a 1.3 million square foot, multispecialty hospital with 500 beds. The facility provides outpatient and inpatient services to 108,906 beneficiaries of active duty, retirees and family members enrolled (see table 1). The MTF has 17 operating rooms and 11 primary care clinics offering medical care to beneficiaries across

Hampton Roads. NMCP staff is comprised of 5,899 military, civilian, and contract personnel providing healthcare at “the state of the art medical center.” (NMCP, 2013b)

3. Naval hospital Camp Lejeune (NHCL) Overview

NHCL is located aboard Marine Corps Base (MCB) Camp Lejeune in Jacksonville, North Carolina. The NHCL mission statement is: “To serve our military community through excellence in patient centered care, readiness, and professional development” (Naval Hospital Camp Lejeune [NHCL], 2013a).

The MTF and branch medical clinics (BMC) under NHCL operational control include:

- NHCL
- BMC Camp Johnson
- BMC Hadnot Point
- BMC HM3 Wayne Caron
- BMC Camp Geiger
- BMC Marine Corps Air Station (MCAS) New River

The NHCL facility is 354,000 square feet and has 236 available beds. It provides outpatient and inpatient services to 34,107 beneficiaries of active duty, retirees, and family members enrolled (see table 1). The NHCL has five operating rooms and six primary care clinics offering medical care to beneficiaries across Onslow County. NHCL staff is comprised of 1,750 military, civilian, and contract personnel delivering “high quality, compassionate, patient and family-centered care” (NHCL, 2013a).

4. Naval Hospital Camp Pendleton (NHCP) Overview

NHCP is located in Oceanside, California aboard MCB Camp Pendleton, overlooking Lake O’Neill. The NHCP mission statement is: “To train, deploy and deliver quality healthcare.” (Naval Hospital Camp Pendleton [NHCP], 2013a)

The MTF and branch health clinics under NHCP operational control include:

- NHCP
- BHC 13 Area Camp Pendleton

- BHC 21 Area Camp Del Mar
- BHC 31 Area Edson Range
- BHC 52 Area Infantry School West
- BHC Family Medicine Oceanside
- BHC Port Hueneme
- BHC Yuma, Arizona (AZ)
- Marine Corps Medical Clinics Camp Pendleton

The NHCP is a 580,000 square foot facility with 61 beds. The facility provides outpatient and inpatient services to 51,250 beneficiaries of active duty, retirees and family members enrolled (see table 1). The NHCP has six operating rooms and nine primary care clinics offering medical care to beneficiaries from Yuma, Arizona to Ventura County, California. NHCP staff is comprised of 2,180 military, civilian, and contract personnel providing healthcare to eligible beneficiaries (NHCP, 2013a).

B. OBSTETRICS DEPARTMENT OVERVIEW

The obstetrics (OB) department of each MTF provides a variety of obstetric care to include, but not limited to, the following services: hospitalization for labor, delivery, and postpartum care; anesthesia; cesarean section deliveries; fetal ultrasounds; and management of high-risk pregnancies. The services actually provided at the MTF OB departments are dependent on the complement of staff. Table 2 provides an overview of the MTF OB department and personnel at each of the four facilities.

Table 2. MTF OB Department Overview (Donaldson, Meddaugh, Jenkins, 2009)

	NMCSD	**NMCP**	**NHCL**	**NHCP**
General OB Physicians	13	15	10	7
Urogynecology Physicians	1	1	0	0
Maternal Fetal Medicine Physicians	2	5	0	0
Reproductive Endocrinologist and Infertility Physicians	2	1	0	0
Oncologist	1	2	0	0
Midwives	10	9	10	7
OB Residents	20	22	0	0
Total Providers	49	55	20	14

	NMCSD	NMCP	NHCL	NHCP
Labor and Delivery Rooms	11	10	10	7
Operating Rooms	3	3	2	1
Antepartum Rooms	21	7	5	0
Postpartum Rooms	19	31	10	18
NICU	32	24	0	0

1. Naval Medical Center San Diego Obstetrics Department

The Department of Obstetrics and gynecology (OB/GYN) focuses on providing comprehensive, compassionate, state-of-the-art obstetrical and gynecological care. They offer easy access to continuity of care with the medical provider of choice in a family-centered setting. Services are provided to active duty women, retired military, dependent wives, and daughters on a referral basis from the primary care clinics. Services include routine gynecology, prenatal care, and labor and delivery needs (NMCSD, 2013b).

The NMCSD OB department has 21 antepartum rooms, 11 labor and delivery rooms, 19 postpartum rooms, and three operating rooms (see table 2). Services are provided in the framework of small group practices within the department. Each group consists of OB/GYN physicians, midwives, nurse practitioners, nurses, corpsmen, and medical assistants. The department provides high quality OB care from normal complication free vaginal deliveries to complicated cesarean section deliveries. The Neo-natal Intensive Care Unit (NICU) has capacity to provide care for 32 patients (NMCSD, 2013b).

The NMCSD has a centering pregnancy program. Patients have the option of participating in a special prenatal program, which is an alternative to receiving care in the clinic setting. The program is designed specifically for women interested in learning as much as possible during pregnancy. The NMCSD has achieved national recognition by the Centering Healthcare Institute as an approved Centering Pregnancy site (NMCSD, 2013b).

2. Naval Medical Center Portsmouth Obstetric Department Overview

The Department of Obstetrics and Gynecology focuses on providing state-of-the-art obstetrical care. Services are provided to active duty women, retired military, dependent wives, and daughters on a referral basis from the primary care clinics. Services include routine gynecology, prenatal care, and labor and delivery (NMCP, 2013c).

The NMCP OB department has seven antepartum rooms, 10 labor and delivery rooms, 31 postpartum rooms, and three operating rooms (see Table 2). Family-centered care is provided on the mother infant unit (MIU) where parents and infant have the opportunity to room together. The OB department consists of OB/GYN physicians, midwives, nurse practitioners, nurses, corpsmen and medical assistants. The department provides high quality OB care from normal complication free vaginal deliveries to complicated cesarean deliveries. The neonatal intensive care unit (NICU) has state-of-the-art equipment to manage the most complex neonatal issues. A level III unit has specialty equipment and staff to provide intensive care to critically ill newborns. The NICU is a 24 bed level III unit with the latest technology and capabilities, including oscillatory ventilation and nitric oxide therapy (NMCP, 2013c).

3. Naval Hospital Camp Lejeune Obstetric Department Overview

The Department of Obstetrics and Gynecology services are provided to active duty women, retired military, dependent wives, and daughters on a referral basis from the primary care clinics. Services include routine GYN, prenatal care, and labor and delivery (NHCL, 2013b).

The NHCL OB department has five antepartum rooms, 10 labor and delivery rooms, 10 postpartum rooms, and two operating rooms (see Table 2). Family-centered care is provided on the MIU where parents and infant have the opportunity to room together. The OB department consists of 10 OB/GYN physicians and 10 midwives. The department provides high quality OB care for all non-complicated deliveries. The OB department also offers a variety of prenatal and post-natal classes (NHCL, 2013b).

4. Naval Hospital Camp Pendleton Obstetric Department Overview

The Department of Obstetrics and Gynecology services are provided to active duty women, retired military, dependent wives, and daughters on a referral basis from the primary care clinics. Services include routine GYN, prenatal care, and labor and delivery (NHCP, 2013b).

The OB department of the NHCP has zero antepartum rooms, seven labor and delivery rooms, 18 postpartum rooms, and one operating room. The department consists of nine OB/GYN physicians and seven midwives (see table 2). The department provides high quality OB care for all non-complicated deliveries. The MIU also provides labor induction and augmentation, and elective or indicated cesarean deliveries. The NHCP has a group prenatal care program. Patients have the option of participating in a special prenatal program, which is an alternative to receiving care in the clinic setting (NHCP, 2013b).

C. CHAPTER SUMMARY

This chapter presented the main features of the obstetric services provided at NMCSD, NMCP, NHCL, and NHCP. These features are considered in the model's construction and will be discussed later in the optimization model chapter.

III. LITERATURE REVIEW

The purpose of this chapter is to acknowledge and review the most relevant and current studies that assist leadership in decision making for both patient volume (demand) prediction and care giver (supply) optimization.

A. STUDIES THAT FORECAST FUTURE OBSTETRIC DEMAND

This study interprets historical data based on delivery volume, of various categories, at each MTF. Assuming resources such as medical doctors, nurses, and midwives are limited, the optimum employment provides the minimum requirement of said resources while meeting or exceeding target historical delivery volumes at each facility. Further, this study includes a sensitivity analysis of varying constraints.

According to Garg McClean, Barton, Meenan, and Fullerton (2012), numerous stochastic models have been proposed in healthcare literature to address resource planning. Those models include: queuing, discrete event simulation, Markov chain, linear, and hierarchical linear.

1. Queuing Theory

According to Balakrishnan, Render and Stair, Jr. (2013), "queuing theory is one of the oldest and most widely used decision-making model techniques." (Balakrishnan et al., 2013, p. 368) Queuing theory—also referred to as waiting lines—addresses the level of demand for a service. Based on probability theory and statistics, the queuing model utilizes the Poisson distribution to forecast patient arrival rates. Within healthcare organizations, this model has been used to determine wait time and bed requirements in various departments, most commonly in emergency departments.

2. Discrete Event Simulation

A discrete event simulation (DES) is a type of computer model that simulates real-world events as distinct occurrences in time. According to Hamrock, Paige, Parks Scheulen and Levin (2013), standard inputs to DES include universal elements of healthcare such as resources, arrival rates, patient care time, and processing logic. The DES model allows management to see the impact on resources when simulated changes are inputted, and—because the events are discrete—the system is unaffected between events, and therefore the model can jump from one event to the next. DES models have proven to be effective for many hospitals by enhancing resource utilization, bed occupancy, admission and discharge patterns, and staffing.

3. Markov Chain

A Markov chain model utilizes a mathematical system to analyze the sequence of events. The model is further characterized as a process in which the probabilities of occurrence evolve over time and future states depend on the present state of the system. According to medical scholars, "Markvo models assume that a patient is always in one of a finite number of discrete health states." (Sonnenberg & Beck, 1993) This model is useful in a healthcare setting where all events are represented as changeovers from one state to another.

4. Linear Programming (LP) Model

A linear programming model can assist management in decision making and effective use of resources. According to Balakrishnan, Render and Stair, Jr. (2013), "linear programming has been applied extensively to medical, transportation, accounting and financial problems." (Balakrishnan et al., 2013, p. 20) The linear programming model is developed within three steps: formulation, solution and interpretation. The models can be categorized as deterministic or probabilistic. Deterministic models assume that the information provided to solve the problem is fixed with known values. Probabilistic models assume that some values are unknown. In a hospital obstetrical department, the patient arrival rate is unknown. Due to the randomness of patient arrival rates, a probabilistic model is well suited for hospitals.

5. Hierarchical Linear Models

Hierarchal linear models (HLM) is a statistical technique that allows for analyzing data in a cluster or nested structure, such as patients nested within hospitals. The lowerlevel units of analysis are nested within higher-level units of analysis and have a degree of similarity with each other. According to Leung, Elashoff, Rees, Hasan and Legorreta (1998), “the HLM approach provides several advantages over traditional regression analysis.” (Leung et al., 1998) In determining maternity length of stay, the HLM uses cluster information that provides statistically efficient estimators, correct standard errors, and correct confidence intervals.

B. CHAPTER SUMMARY

Due to the characteristics of the information available to MTF management, we determined a linear programming model is best suited to answer the primary and secondary questions of this study. By acquiring historical data and determining necessary delivery specific constraints we determined a linear programming model would provide the most accurate information for optimum staffing.

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IV. METHODOLOGY

A. DECISION MODELING

Some of the most important and complex decisions that managers and leaders of organizations make are those involving effective apportionment of their limited resources. Linear programming is a decision-modeling option used to assist managers in determining the optimum value of such resources, whether their objective is to minimize cost, maximize profit or—in the case of this study—minimize resource requirements. In this chapter, we present the main elements of a linear optimization model and the steps involved in any optimization-based analysis.

This study takes the approach of linear programming to identify the optimum mix of obstetric staffing. In order to better illustrate the components and steps of conducting linear optimization, we will use a simple scenario of a toy maker wishing to maximize his profit from two products: wooden trains (T) and wooden cars (C).

B. COMPONENTS OF LINEAR OPTIMIZATION MODEL

There are four components to a mathematical programming decision model. They are described below.

1. The Decision Variables

Decision variables represent the resources for which the model will produce optimum values. They are the baseline components of the various equations to be used. For the toy maker scenario, the decision variables are T and C.

2. The Objective Function

The objective function is a single equation that expresses the purpose of the model in mathematical terms. In our example, the toy maker's objective is to produce the optimum number of wooden trains and cars in order to maximize his profits. In mathematical terms, the objective function equates profit maximization to the sum of profit gained for each toy: Maximum profit = profit per car x C + profit per train x T.

3. The Constraints

Constraints are mathematical expressions that specify the requirements and limitations within the problem. In the case of the toy maker, his toy production may be subject to several factors. For example, assume there is a limit of 500 machine hours for the toy maker to cut his toys. If each wooden train takes 30 minutes to cut and the wooden car takes 15 minutes, then the cutting hours constraint would be written as: $0.25 \times C + 0.5 \times T \leq 500$ hours. Notice the equation utilizes an equality symbol ensuring a production value not to exceed 500 hours. Additional constraints may include assembly time, hours available in each day, and minimum/maximum production requirements.

A nonnegativity constraint is essential so that the model does not produce a negative quantity of either variable. This constraint is written as: $T, C \geq 0$.

4. The Optimum Solution

The optimum solution is the profit and variable values generated by the computer program that best satisfy the problem.

C. STEPS IN CONDUCTING LINEAR OPTIMIZATION

1. Formulation

This initial step involves the expression of each aspect of a scenario in mathematical terms. These expressions are presented as a single objective function and as many constraints equations that are necessary to address all requirements and limitations within the scenario.

2. Solution

Once developed, these expressions are entered into a computer program and solved concurrently to produce an optimal solution to the problem at hand. In the case of the toy maker, the computer program produces an optimum value for each variable (C and T) to maximize profit, while concurrently satisfying the limitations of machine hours available, assembly hours required for each toy, and the minimum/maximum toys to produce.

3. Interpretation

In this final step, the decision maker determines the validity of the values produced and then applies the results as required. In the case of the toy maker, he now has a target number of each toy to produce in order to maximize his profits.

Further, the model can be used to determine the impact a modified resource has on others within the model. This is known as sensitivity analysis.

For this project, the objective function equates the minimization of resources with the contribution value of each resource. The weight applied to each resource is based on historical data and the significance of each resource associated with deliveries. The mathematical expressions, or constraints, define the parameters of the MTF facilities such as the maximum numbers of deliveries each resource can handle, the number of patients for which each MTF can provide, and the required resources for each type of delivery.

Lastly, there are four distinct properties of a linear programming model (Balakrishnan 2013):

- The problem seeks to maximize or minimize an objective.
- The degree to which the objective can be obtained is limited by constraints.
- There must be alternate courses of action to reach the objective.
- The objective and each constraint must be discussed in terms of linear relationships.

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V. DATA

The data used in this study was provided by the BUMED and covers a period from fiscal year 2010 to fiscal year 2012 (total of three years). An abundance of raw data was provided, to include: patient dispositions by diagnosis related group (DRG), MTF patient volume by month and year, admission dates, and patient bed days. Additionally, we acquired data directly from the MTFs as to the average number of resources used for each DRG event, or delivery. For this study, we utilized the data in terms of the volume of each DRG by MTF and the consequential number of resources required for each DRG category.

A. MILITARY TREATMENT FACILITY OBSTETRIC DELIVERIES

1. Combined Deliveries by Diagnosis Related Group

The following DRGs are used in this study:

- DRG 370—cesarean section with complications and/or comorbidities,
- DRG 371—cesarean section without complications and/or comorbidities,
- DRG 372—vaginal delivery with complicating diagnoses
- DRG 373—vaginal delivery without complicating diagnoses

Figure 1 reflects the combined deliveries of all four MTFs by DRG for FY 2010. Figure 2 and 3 reflect the combined deliveries by DRG for FY 2011 and 2012, respectively.

Note: Data for figure 1, and subsequent figures and tables, was acquired from personal communication with Tim Link, Industrial Engineer (M81), Bureau of Medicine and Surgery on October 8th, 2013.

In fiscal year 2010, DRG 373 is the most common, representing 60 percent of total annual deliveries. Next is DRG 371, representing 20 percent. DRG 372 and 370 follow with 13 and seven percent, respectively. The volume of deliveries is relatively constant, per category, on a monthly basis.

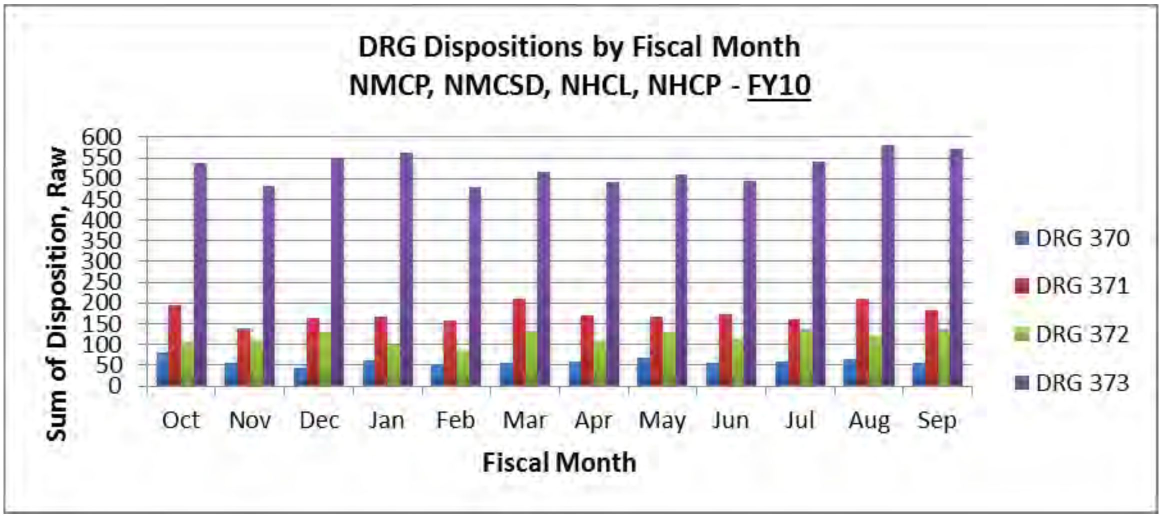

Figure 1. DRG Disposition by Fiscal Month (FY10)

In fiscal year 2011, DRG 373 is, again, the most common, representing 57 percent of total annual deliveries. Next is DRG 371, representing 20 percent of annual deliveries. DRG 372 and 370 follow with 15 and eight percent, respectively. The volume of deliveries is relatively constant, on a monthly basis, per category.

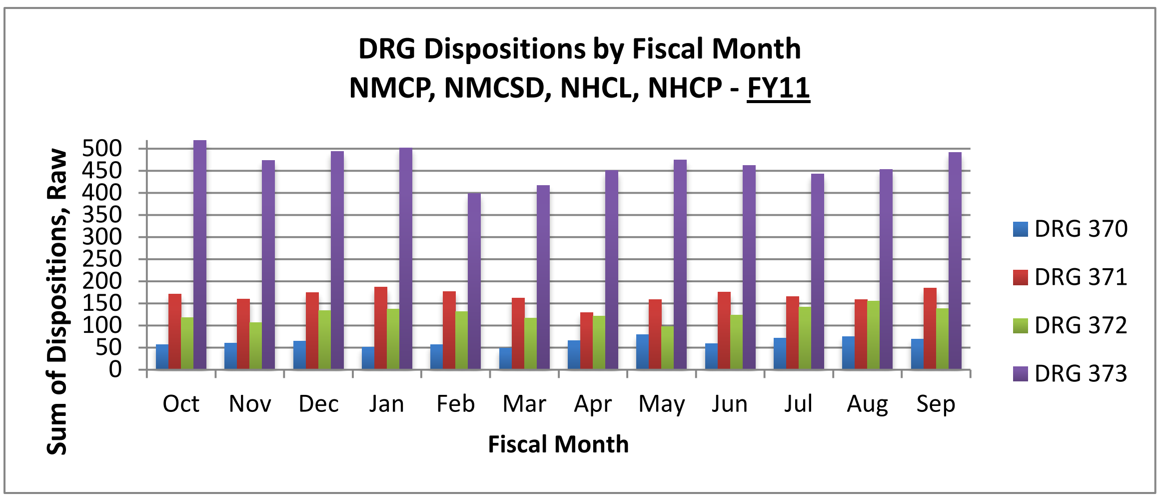

Figure 2. DRG Disposition by Fiscal Month (FY11)

In fiscal year 2012, DRG 373 is the most common, representing 58 percent of total monthly deliveries. Next is DRG 371, representing 19 percent. DRG 372 and 370 follow with 15 and eight percent, respectively. The volume of deliveries is relatively constant, per category, on a monthly basis.

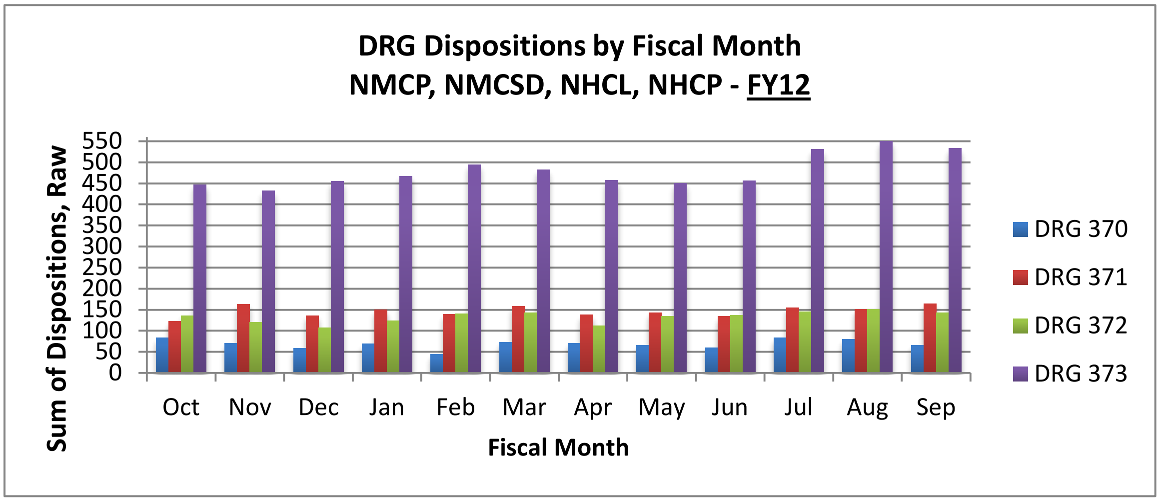

Figure 3. DRG Disposition by Fiscal Month (FY12)

2. Facility Deliveries by Diagnosis Related Group (DRG)

In response to the relatively similar delivery volume across the three fiscal years, we chose to continue this study on the basis of the three-year average. The following figures illustrate each MTF by the average number of deliveries of each DRG, over a period of three fiscal years. Figure 4 reflects hospital-specific delivery volume, by DRG, for NHCP. Figures 5, 6, and 7 reflect hospital-specific delivery volume, by DRG, for NHCL, NMCSD and NMCP, respectively.

At Naval Hospital Camp Pendleton, DRG 373 is the most common, representing 63 percent of average annual deliveries. DRG 372 and 371 had very close percentages with 17 and 16 percent, respectively. DRG370 represented the lowest percentage with five percent. Again, the volume of deliveries each year is relatively constant, per category.

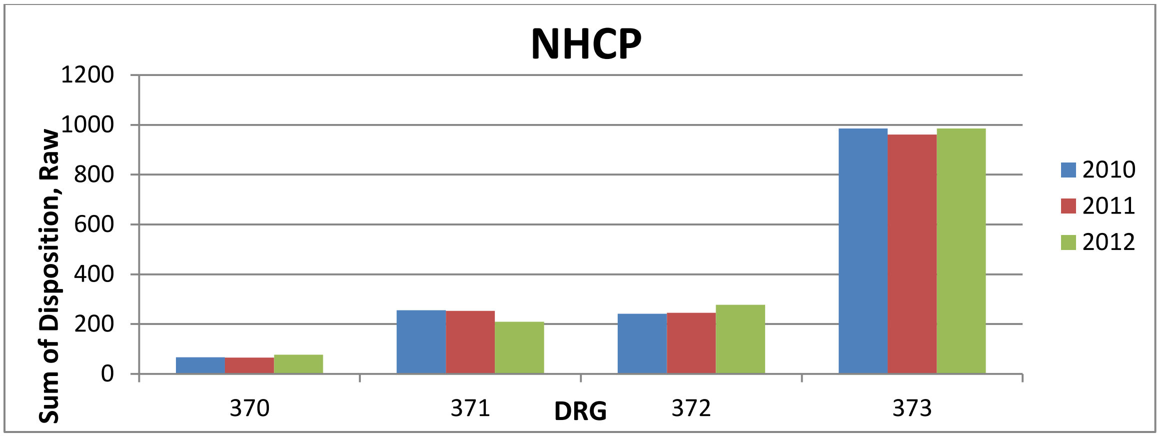

Figure 4. DRG Disposition for NHCP

At Naval Hospital Camp Lejeune, DRG 373 is the most common, representing 57 percent of average annual deliveries. DRG 372 and 371 had very close percentages with 18 and 19 percent, respectively. DRG370 represented the lowest percentage with seven percent. Again, the volume of deliveries each year is relatively constant, per category.

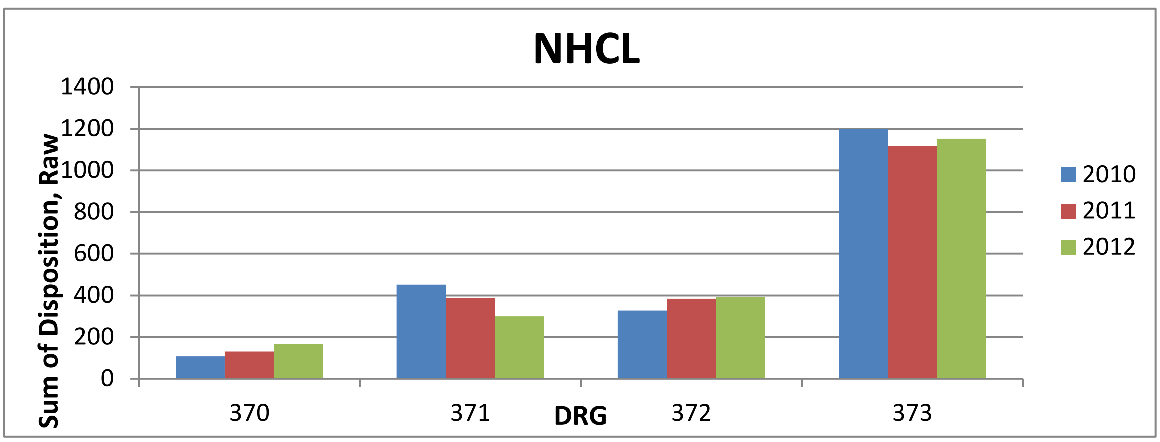

Figure 5. DRG Disposition for NHCL

At Naval Medical Center San Diego, DRG 373 is the most common, representing 62 percent of average annual deliveries. DRG 372 and 371 had very close percentages with 13 and 18 percent, respectively. DRG370 represented the lowest percentage with seven percent. Again, the volume of deliveries each year is relatively constant, per category.

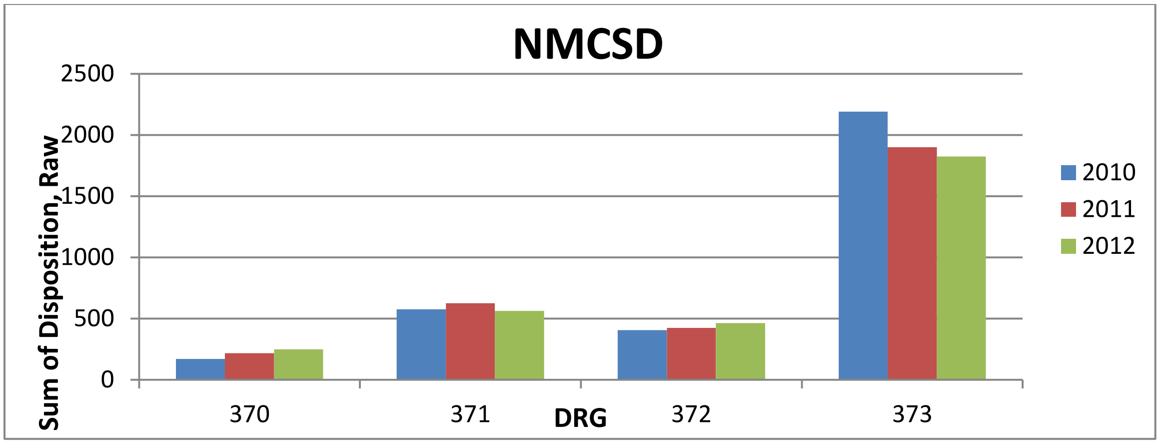

Figure 6. DRG Disposition for NMCSD

At Naval Medical Center Portsmouth, DRG 373 is the most common, representing 54 percent of average annual deliveries. Next is DRG 371, representing 22 percent of deliveries. DRG 372 and 370 represented the lowest percentages with 14 and 10 percent, respectively. The volume of deliveries each year is relatively constant, per category.

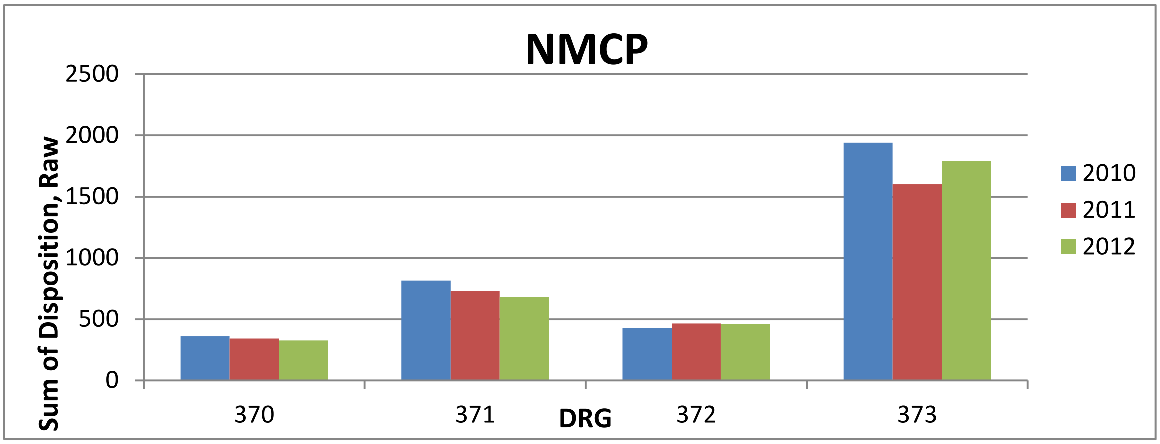

Figure 7. DRG Disposition for NMCP

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VI. OPTIMIZATION MODEL FOR NAVAL OBSTETRIC RESOURCES

A. INPUT DATA DISCUSSION

In order to answer our research question, we acquired data from the M81 office at BUMED. Specifically, the raw data encompasses all births in facilities under the domain of BUMED over a three-year period (FY10-13). Because the data was presented with many categories, we chose to filter the data using a pivot table in Microsoft Excel.

Table 3. DRG by Fiscal Year

Sum of Dispositions, Raw	**FY 10**	**FY 11**	**FY 12**	**Grand Total**
DRG 370	708	756	821	2285
DRG 371	2099	2000	1754	5853
DRG 372	1404	1518	1592	4514
DRG 373	6316	5581	5752	17649
Grand Total	10527	9855	9919	30301

In order to calculate the most accurate answers, we chose to filter the data by specific hospitals, versus numerical averages of the four diagnosis related groups (DRG). In the pivot table below, we filtered data from Naval Hospital Camp Lejeune to illustrate a breakdown of DRG by fiscal year. In doing so, we noticed that birth rates are relatively similar across the three-year research period. As a result, we use an average of the three FYs to represent each DRG.

Table 4. NHCL DRG Breakdown

Sum of Dispositions, Raw	FY 10	FY 11	FY 12	Grand Total
DRG 370	108	130	168	406
DRG 371	451	389	300	1140
DRG 372	327	384	391	1102
DRG 373	1199	1118	1151	3468
Grand Total	2085	2021	2010	6116

As illustrated in Table 4, at Naval Hospital Camp Lejeune from FY2010 through FY2012, there was an average of 135 cesarean section deliveries with complications (DRG 370). There was an average of 380 cesarean section deliveries without complications, 367 vaginal deliveries with complications, and 1156 vaginal deliveries without complications.

Once this information was calculated, we created a table to compare the contribution value of each healthcare provider role (OBMD, CNM, or RN) to each DRG. For this study, contribution simply answers whether or not the healthcare provider is involved in the DRG. The value of each healthcare provider's contribution, although generalized, was acquired from active duty members of subject facilities.

For the OBMD category, we assumed 1.5 doctors are required for DRG 370, 1 for DRG 371, 0.4 for DRG 372 and 0.4 for DRG 373. We assumed cesarean deliveries with complications require a contribution average of one to two doctors so we averaged the values to 1.5. Cesarean section deliveries without complications require one doctor, hence the value of 1. For both vaginal delivery DRGs we assumed, on average, doctors contribute to 40 percent of the contribution, with midwives handling the remaining 60 percent.

For the CNM category, we determined that midwives were not required for cesarean DRGs and, therefore, were assigned a contribution value of zero. As abovementioned, we determined that midwives have a 60 percent contribution value to both vaginal DRGs, and their values are assigned accordingly.

For this study, we assume a single nurse will care for the mother during the delivery event and disregard those required for post-delivery care. As a result, assuming contribution is required for all DRGs we assigned RNs a contribution value of 1. Accordingly, we removed nurses from the study at this point in the research as their optimum FTE contribution can be calculated on a 1:1 basis.

Table 5. Healthcare Provider Contribution Values

	DRG 370	DRG 371	DRG 372	DRG 373
OB Physician (OBMD)	1.5	1.0	0.4	0.4
Midwife (CNM)	0.0	0.0	0.6	0.6
Nurse (RN)	1.0	1.0	1.0	1.0

B. LINEAR PROGRAMMING MODEL

This study develops a linear programming decision model to address the question of best allocation of OB resources. We created a linear programming model to minimize the number of full time equivalent (FTE) healthcare providers required to meet average DRG deliveries, subject to a set of constraints, as discussed below.

1. Decision Variables

Because OBMDs and CNMs potentially contribute to each DRG category, there are a total of eight decision variables:

- Let $OBMD_{370}$ equal the minimum FTE OBMDs required for DRG 370.
- Let $OBMD_{371}$ equal the minimum FTE OBMDs required for DRG 371.
- Let $OBMD_{372}$ equal the minimum FTE OBMDs required for DRG 372.
- Let $OBMD_{373}$ equal the minimum FTE OBMDs required for DRG 373.
- Let CNM_{370} equal the minimum FTE CNMs required for DRG 370.
- Let CNM_{371} equal the minimum FTE CNMs required for DRG 371.
- Let CNM_{372} equal the minimum FTE CNMs required for DRG 372.
- Let CNM_{373} equal the minimum FTE CNMs required for DRG 373.

2. Objective Function

The objective function is a minimization statement equivalent to the sum of each decision variable, subject to its contribution value to each DRG:

Minimize FTE = $OBMD_{370}$*(1.5) + $OBMD_{371}$*(1) + $OBMD_{372}$*(0.4) + $OBMD_{373}$*(0.4) + CNM_{370}*(0.0) + CNM_{371}*(0.0) + CNM_{372}*(0.6) + CNM_{373}*(0.6)

3. Constraints

This objective function is subject to the following constraints:

1. The sum of OBMD and CNM contributing to all DRGs is at least 2039.
2. OBMD will contribute to at least 135 DRG 370 events.
3. OBMD will contribute to at least 380 DRG 371 events.
4. OBMD and CNM contribute to at least 367 DRG 372 events.
5. OBMD and CNM contribute to at least 1156 DRG 373 events.
6. An average of 1.5 OBMD FTE contributes to each DRG 370 event.
7. 1 OBMD FTE will contribute to each DRG 371 event.
8. OBMD will contribute to a maximum of 40 percent of all DRG 372 events.
9. OBMD will contribute to a maximum of 40 percent of all DRG 373 events.
10. CNM will contribute to a maximum of 60 percent of all DRG 372 events.
11. CNM will contribute to a maximum of 60 percent of all DRG 373 events.

C. RESULTS AND DISCUSSION

Below we present and discuss the optimization results for each of the four MTFs included in our study. Because the four MTFs have unique statistics for each DRG category, we created four MTF-specific LP models. Healthcare provider values, however, remain constant for all models. Utilizing Microsoft Excel's Solver tool, we attained optimum solutions for each MTF.

1. Naval Hospital Camp Lejeune

OBMDs contribute to a total of 1125 deliveries, considering constraints identified for NHCL. Likewise, CNMs contribute to a total of 914. The full details of this model are illustrated in Appendix A. When combined, the delivery contributions of NHCL OBMDs and CNMs relate in a 55/45 ratio. When applied to the calculated healthcare provider contribution values, the model determined a total of 1376 OBMDs and CNMs FTEs.

Said differently, in order to match the NHCL historical rate of 2039 deliveries per year, in addition to supplementary identified constraints, the minimal staffing level of OBMDs and CNMs combined is 1376 FTE healthcare providers. Therefore, in accordance with their ratio values, the optimum staff for NHCL is 757 FTE OBMDs and 619 FTE CNMs.

2. Naval Hospital Camp Pendleton

OBMDs contribute to a total of 802 deliveries, considering constraints identified for NHCL. Likewise, CNMs contribute to a total of 739 deliveries. The full details of this model are illustrated in Appendix A. When combined, the delivery contributions of NHCL OBMDs and CNMs relate in a 52/48 ratio. When applied to the calculated healthcare provider contribution values, the model determined a total of 985 OBMDs and CNMs FTEs.

Said differently, in order to match the NHCL historical rate of 1541 deliveries per year, in addition to supplementary identified constraints, the minimal staffing level of OBMDs and CNMs combined is 985 FTE healthcare providers. Therefore, in accordance with their ratio values, the optimum staff for NHCL is 512 FTE OBMDs and 473 FTE CNMs.

3. Naval Medical Center San Diego

OBMDs contribute to a total of 1764 deliveries, considering constraints identified for NHCL. Likewise, CNMs contribute to a total of 1442. The full details of this model are illustrated in Appendix A. When combined, the delivery contributions of NHCL OBMDs and CNMs relate in a 55/45 ratio. When applied to the calculated healthcare provider contribution values, the model determined a total of 2159 OBMDs and CNMs FTEs.

Said differently, in order to match the NHCL historical rate of 3206 deliveries per year, in addition to supplementary identified constraints, the minimal staffing level of OBMDs and CNMs combined is 2159 FTE healthcare providers. Therefore, in accordance with their ratio values, the optimum staff for NHCL is 1187 FTE OBMDs and 971 FTE CNMs.

4. Naval Medical Center Portsmouth

OBMDs contribute to a total of 1978 deliveries, considering constraints identified for NHCL. Likewise, CNMs contribute to a total of 1337. The full details of this model are illustrated in Appendix A. When combined, the delivery contributions of NHCL OBMDs and CNMs relate in a 60/40 ratio. When applied to the calculated healthcare provider contribution values, the model determined a total of 2417 OBMDs and CNMs FTEs.

Said differently, in order to match the NHCL historical rate of 3315 deliveries per year, in addition to supplementary identified constraints, the minimal staffing level of OBMDs and CNMs combined is 2417 FTE healthcare providers. Therefore, in accordance with their ratio values, the optimum staff for NHCL is 1450 FTE OBMDs and 967 FTE CNMs.

D. SENSITIVITY ANALYSIS

For the purpose of increasing our understanding of the relationship between OB resource contribution values and target delivery volumes, we conducted two sensitivity analyses. Each analysis tested the sensitivity of the model after manipulation of the delivery target numbers and/or the contribution value of each resource.

1. Change in Volume

The first sensitivity analysis simulates a sudden change in population within the catchment area of an MTF. For example, if an aircraft carrier with a crew size of 5000 sailors changes homeports, what impact would the influx of patients have on FTE requirements? We assume that 10 percent of the 5000 sailors are female and 30 percent of the males have dependents (spouses). Consequently, that population growth of female beneficiaries in the catchment area is assumed to be 2,000.

To simulate the effect of said volume increase in female beneficiaries, we increased the LP model demand by 10 percent. The net effect resulted in an expected increase in FTEs required; however, the optimal proportion of healthcare providers for each MTF remained the same. Appendix B shows the results of the increase.

2. Change in Contribution Value

The second sensitivity analysis simulates a change in healthcare provider contribution value for DRG 372 and 373. This simulation is considered in case CNMs experience an increased capacity for vaginal deliveries. Accordingly, the contribution value was decreased to 30 percent for OBMDs and increased to 70 percent for CNMs. Appendix C shows the results of these contribution changes.

a. Naval Hospital Camp Lejeune

The net effect was an increase in FTEs from 1,375 to 1,467 and a change in OBMD/CNMs delivery contribution ratio, from 55/45 to 48/52.

b. Naval Medical Center San Diego

At NMCSD, the net effect was an increase in FTEs from 2,159 to 2,303 and a change in OBMD/CNM delivery contribution ratio from 55/45 to 48/52.

c. Naval Hospital Camp Pendleton

At NHCP, the net effect was an increase in FTEs from 985 to 1,059 and a change in OBMD/CNM delivery contribution ratio from 52/48 to 44/56.

d. Naval Medical Center Portsmouth

At NMCP, the net effect was an increase in FTEs from 2,417 to 2,550 and a change in OBMD/CNM delivery contribution ratio from 60/40 to 53/47.

In summary, each sensitivity analysis produced different results. With an increase in patient volume, for example when an aircraft carrier changes homeports, facilities can expect an increase in the requirement of FTEs. The allocation of CNM and OBMDs, however, remain proportional to the original model. Conversely, by changing the contribution value of each resource, facilities can expect both an increase of FTEs as well as a shift in resource allocation.

VII. CONCLUSIONS AND RECOMMENDED FURTHER RESEARCH

A. CONCLUSIONS

In conclusion, this project produced optimal ratios of OB resources, in terms of FTE, in order to meet or exceed delivery volumes at specific Naval facilities. We utilized historical data from four major MTFs to extract consistent target delivery volumes, specific to each facility. By breaking the numbers down to terms of a monthly basis, we were able to show consistency and reliability of data, in regards to delivery volumes by DRG. Once we were confident with the accuracy and uniformity of data, we constructed a linear programming model to accommodate the limits correlated to each decision variable. Because OBMD, CNM, and RNs provide unique care, each resource was assigned a unique contribution value. Additionally, each DRG category demanded distinctive proportions of resources, and was accounted for accordingly.

Once constructed in a method that addressed all constraints, we were able to produce answers to our projects inquiries. First was the question of optimal resource allocation. This was an important question to answer because each hospital has a copious amount of historical data regarding delivery volumes and dispositions by DRG, but none that addresses the best apportionment of resources to meet those numbers. Accordingly, with a few assumptions, we used the historical data of each hospital to formulate a best-fit answer of target resources.

Our main findings included OBMD to CNM ratios ranging from 52/48 to 60/40. Although a higher OB requirement was expected, due to their higher contribution value attributed to DRG 370 and 371 restrictions, we saw a varying ratio at each hospital. At NHCP, for example, the model produced a ratio of 52/48, OBMDs to CNM. This illustrated a relatively equal staffing requirement of each resource. At NHCP, however, the ratio was a bit more skewed with a 60/40 split. The varying proportions can be attributed to the degree of care available to patients in each facility. NMCP, for example, has a larger capacity to accommodate complicated deliveries requiring Neonatal Intensive

Care Unit (NICU) resources. NHCP does not provide such services, and is therefore restricted to handling non-complicated deliveries, on a majority basis.

Based on the results of our findings, OB staffing should be constructed in a FTE OBMDs to CNM proportion ranging from 52/48 to 60/40. The numbers will change in accordance with facility-specific data. Those facilities with resources capable of handling more advanced complications will likely require an increased number of OBMD. This logic is based on the fact that only OBMD are certified to handle deliveries with complications.

B. RECOMMENDED FURTHER RESEARCH

- Identify the required number of FTEs on staff to fulfill the annual OB FTE requirement.
- Determine the weekly workload schedule.
- Determine the impact on demand if rooms for labor and delivery, and postpartum, are reduced or increased.

APPENDIX A. LINEAR PROGRAMMING MODEL BY FACILITY

NHCL										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		1125.20	913.80	2039
Decision Variable	136.00	380.00	146.80	462.40	0.00	0.00	220.20	693.60		55%	45%	
									FTE			
MIN Staff	1.50	1.00	0.40	0.40	0.00	0.00	0.60	0.60	1375.96			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	2039	>=	2039	
DRG 370	1								136	>=	135	
DRG 371		1							380	>=	380	
DRG 372			1				1		367	>=	367	
DRG 373				1				1	1156	>=	1156	
OBMD 370	1								136	<=	203	
OBMD 371		1							380	<=	380	
OBMD 372			1						146.8	<=	147	
OBMD 373				1					462.4	<=	462	
CNM 372							1		220.2	<=	220	
CNM 373								1	693.6	<=	694	

NMCSD										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		1763.60	1442.40	3206
Decision Variable (Deliveries)	213.00	589.00	172.80	788.80	0.00	0.00	259.20	1183.20		55%	45%	
									FTE			
MIN Staff	1.50	1.00	0.40	0.40	0.00	0.00	0.60	0.60	2158.58			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	3206	>=	3206	
DRG 370	1								213	>=	213	
DRG 371		1							589	>=	589	
DRG 372			1				1		432	>=	432	
DRG 373				1				1	1972	>=	1972	
OBMD 370	1								213	<=	320	
OBMD 371		1							589	<=	589	
OBMD 372			1						172.8	<=	173	
OBMD 373				1					788.8	<=	789	
CNM 372							1		259.2	<=	259	
CNM 373								1	1183.2	<=	1183	

NHCP										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		801.80	739.20	1541
Decision Variable (Deliveries)	70.00	239.00	102.00	390.80	0.00	0.00	153.00	586.20		52%	48%	
									FTE			
MIN Staff	1.50	1.00	0.40	0.40	0.00	0.00	0.60	0.60	984.64			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	1541	>=	1541	
DRG 370	1								70	>=	70	
DRG 371		1							239	>=	239	
DRG 372			1				1		255	>=	255	
DRG 373				1				1	977	>=	977	
OBMD 370	1								70	<=	105	
OBMD 371		1							239	<=	239	
OBMD 372			1						102	<=	102	
OBMD 373				1					390.8	<=	391	
CNM 372							1		153	<=	153	
CNM 373								1	586.2	<=	586	

NMCP										OBMD	CNM	
	OBMD 370	**OBMD 371**	**OBMD 372**	**OBMD 373**	**CNM 370**	**CNM 371**	**CNM 372**	**CNM 373**		1977.60	1337.40	3315
Decision Variable (Deliveries)	**343.00**	**743.00**	**180.40**	**711.20**	**0.00**	**0.00**	**270.60**	**1066.80**		60%	40%	
									FTE			
MIN Staff	**1.50**	**1.00**	**0.40**	**0.40**	**0.00**	**0.00**	**0.60**	**0.60**	**2416.58**			
									LHS		**RHS**	
All Deliveries	**1**	**1**	**1**	**1**			**1**	**1**	**3315**	>=	**3314**	
DRG 370	**1**								**343**	>=	**343**	
DRG 371		**1**							**743**	>=	**743**	
DRG 372			**1**				**1**		**451**	>=	**451**	
DRG 373				**1**				**1**	**1778**	>=	**1778**	
OBMD 370	**1**								**343**	<=	**515**	
OBMD 371		**1**							**743**	<=	**743**	
OBMD 372			**1**						**180.4**	<=	**180**	
OBMD 373				**1**					**711.2**	<=	**711**	
CNM 372							**1**		**270.6**	<=	**271**	
CNM 373								**1**	**1066.8**	<=	**1067**	

APPENDIX B. SENSITIVITY ANALYSIS DEMAND INCREASE

NHCL										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		1237.72	1005.18	2243
Decision Variable	149.60	418.00	161.48	508.64	0.00	0.00	242.22	762.96		55%	45%	
									FTE			
MIN Staff	1.50	1.00	0.40	0.40	0.00	0.00	0.60	0.60	1513.56			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	2242.9	>=	2243	
DRG 370	1								149.6	>=	149	
DRG 371		1							418	>=	418	
DRG 372			1				1		403.7	>=	404	
DRG 373				1				1	1271.6	>=	1271.6	
OBMD 370	1								149.6	<=	223	
OBMD 371		1							418	<=	418	
OBMD 372			1						161.48	<=	161	
OBMD 373				1					508.64	<=	509	
CNM 372							1		242.22	<=	242	
CNM 373								1	762.96	<=	763	

NMCSD										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		1939.96	1586.64	3527
Decision Variable (Deliveries)	234.30	647.90	190.08	867.68	0.00	0.00	285.12	1301.52		55%	45%	
									FTE			
MIN Staff	1.50	1.00	0.40	0.40	0.00	0.00	0.60	0.60	2374.44			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	3526.6	>=	3527	
DRG 370	1								234.3	>=	234	
DRG 371		1							647.9	>=	648	
DRG 372			1				1		475.2	>=	475	
DRG 373				1				1	2169.2	>=	2169.2	
OBMD 370	1								234.3	<=	351	
OBMD 371		1							647.9	<=	648	
OBMD 372			1						190.08	<=	190	
OBMD 373				1					867.68	<=	868	
CNM 372							1		285.12	<=	285	
CNM 373								1	1301.52	<=	1302	

NHCP										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		881.98	813.12	1695
Decision Variable (Deliveries)	77.00	262.90	112.20	429.88	0.00	0.00	168.30	644.82		52%	48%	
									FTE			
MIN Staff	1.50	1.00	0.40	0.40	0.00	0.00	0.60	0.60	1083.10			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	1695.1	>=	1695	
DRG 370	1								77	>=	77	
DRG 371		1							262.9	>=	263	
DRG 372			1				1		280.5	>=	281	
DRG 373				1				1	1074.7	>=	1074.7	
OBMD 370	1								77	<=	116	
OBMD 371		1							262.9	<=	263	
OBMD 372			1						112.2	<=	112	
OBMD 373				1					429.88	<=	430	
CNM 372							1		168.3	<=	168	
CNM 373								1	644.82	<=	645	

NMCP										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		2175.36	1471.14	3647
Decision Variable (Deliveries)	377.30	817.30	198.44	782.32	0.00	0.00	297.66	1173.48		60%	40%	
									FTE			
MIN Staff	1.50	1.00	0.40	0.40	0.00	0.00	0.60	0.60	2658.24			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	3646.5	>=	3645	
DRG 370	1								377.3	>=	377	
DRG 371		1							817.3	>=	817	
DRG 372			1				1		496.1	>=	496	
DRG 373				1				1	1955.8	>=	1955.8	
OBMD 370	1								377.3	<=	566	
OBMD 371		1							817.3	<=	817	
OBMD 372			1						198.44	<=	198	
OBMD 373				1					782.32	<=	782	
CNM 372							1		297.66	<=	298	
CNM 373								1	1173.48	<=	1173	

APPENDIX C. SENSITIVITY ANALYSIS CONTRIBUTION CHANGE

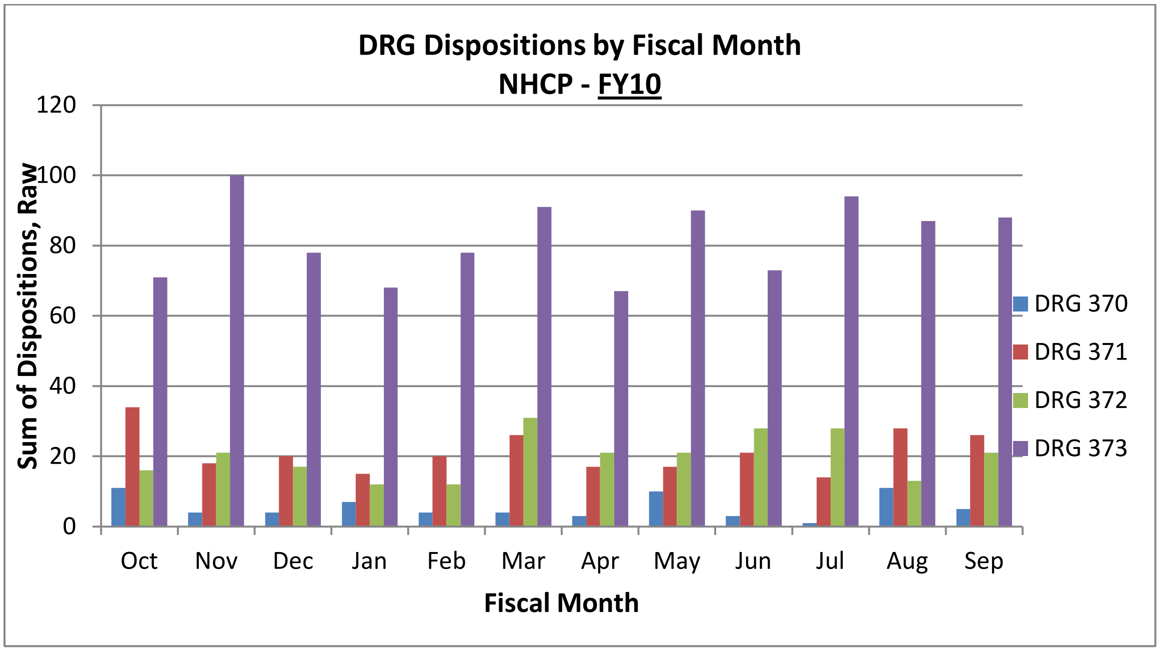
NHCL												
										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		972.90	1066.10	2039
Decision Variable	136.00	380.00	110.10	346.80	0.00	0.00	256.90	809.20		48%	52%	
									FTE			
MIN Staff	1.50	1.00	0.30	0.30	0.00	0.00	0.70	0.70	1467.34			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	2039	>=	2039	
DRG 370	1								136	>=	135	
DRG 371		1							380	>=	380	
DRG 372			1				1		367	>=	367	
DRG 373				1				1	1156	>=	1156	
OBMD 370	1								136	<=	203	
OBMD 371		1							380	<=	380	
OBMD 372			1						110.1	<=	110	
OBMD 373				1					346.8	<=	347	
CNM 372							1		256.9	<=	257	
CNM 373								1	809.2	<=	809	

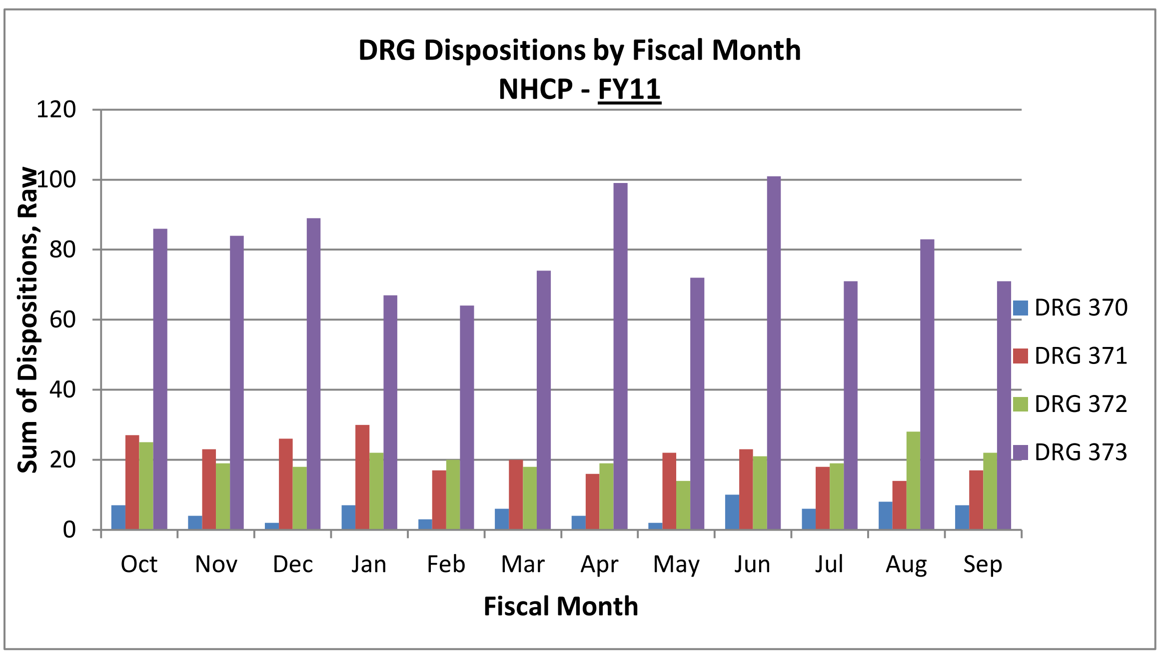
NMCSD												
										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		1523.20	1682.80	3206
Decision Variable (Deliveries)	213.00	589.00	129.60	591.60	0.00	0.00	302.40	1380.40		48%	52%	
									FTE			
MIN Staff	1.50	1.00	0.30	0.30	0.00	0.00	0.70	0.70	2302.82			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	3206	>=	3206	
DRG 370	1								213	>=	213	
DRG 371		1							589	>=	589	
DRG 372			1				1		432	>=	432	
DRG 373				1				1	1972	>=	1972	
OBMD 370	1								213	<=	320	
OBMD 371		1							589	<=	589	
OBMD 372			1						129.6	<=	130	
OBMD 373				1					591.6	<=	592	
CNM 372							1		302.4	<=	302	
CNM 373								1	1380.4	<=	1380	

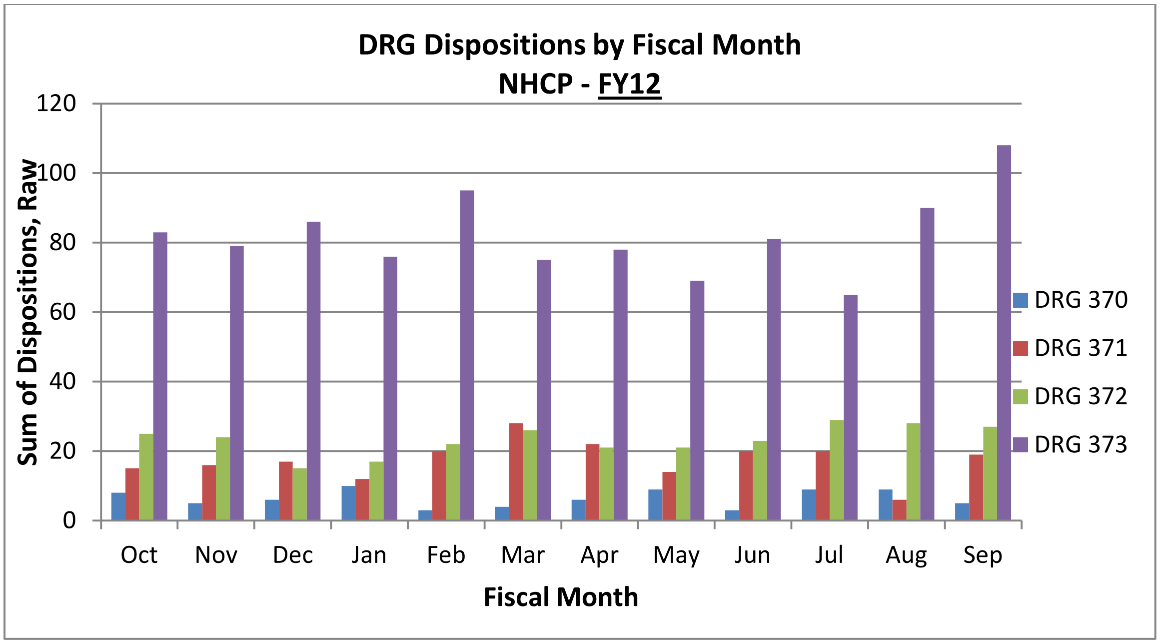
NHCP												
										OBMD	CNM	
	OBMD 370	OBMD 371	OBMD 372	OBMD 373	CNM 370	CNM 371	CNM 372	CNM 373		678.60	862.40	1541
Decision Variable (Deliveries)	70.00	239.00	76.50	293.10	0.00	0.00	178.50	683.90		44%	56%	
									FTE			
MIN Staff	1.50	1.00	0.30	0.30	0.00	0.00	0.70	0.70	1058.56			
									LHS		RHS	
All Deliveries	1	1	1	1			1	1	1541	>=	1541	
DRG 370	1								70	>=	70	
DRG 371		1							239	>=	239	
DRG 372			1				1		255	>=	255	
DRG 373				1				1	977	>=	977	
OBMD 370	1								70	<=	105	
OBMD 371		1							239	<=	239	
OBMD 372			1						76.5	<=	77	
OBMD 373				1					293.1	<=	293	
CNM 372							1		178.5	<=	179	
CNM 373								1	683.9	<=	684	

NMCP										OBMD	CNM	
	OBMD 370	**OBMD 371**	**OBMD 372**	**OBMD 373**	**CNM 370**	**CNM 371**	**CNM 372**	**CNM 373**		1754.70	1560.30	3315
Decision Variable (Deliveries)	**343.00**	**743.00**	**135.30**	**533.40**	**0.00**	**0.00**	**315.70**	**1244.60**		53%	47%	
									FTE			
MIN Staff	**1.50**	**1.00**	**0.30**	**0.30**	**0.00**	**0.00**	**0.70**	**0.70**	**2550.32**			
									LHS		**RHS**	
All Deliveries	**1**	**1**	**1**	**1**			**1**	**1**	**3315**	>=	**3314**	
DRG 370	**1**								**343**	>=	**343**	
DRG 371		**1**							**743**	>=	**743**	
DRG 372			**1**				**1**		**451**	>=	**451**	
DRG 373				**1**				**1**	**1778**	>=	**1778**	
OBMD 370	**1**								**343**	<=	**515**	
OBMD 371		**1**							**743**	<=	**743**	
OBMD 372			**1**						**135.3**	<=	**135**	
OBMD 373				**1**					**533.4**	<=	**533**	
CNM 372							**1**		**315.7**	<=	**316**	
CNM 373								**1**	**1244.6**	<=	**1245**	

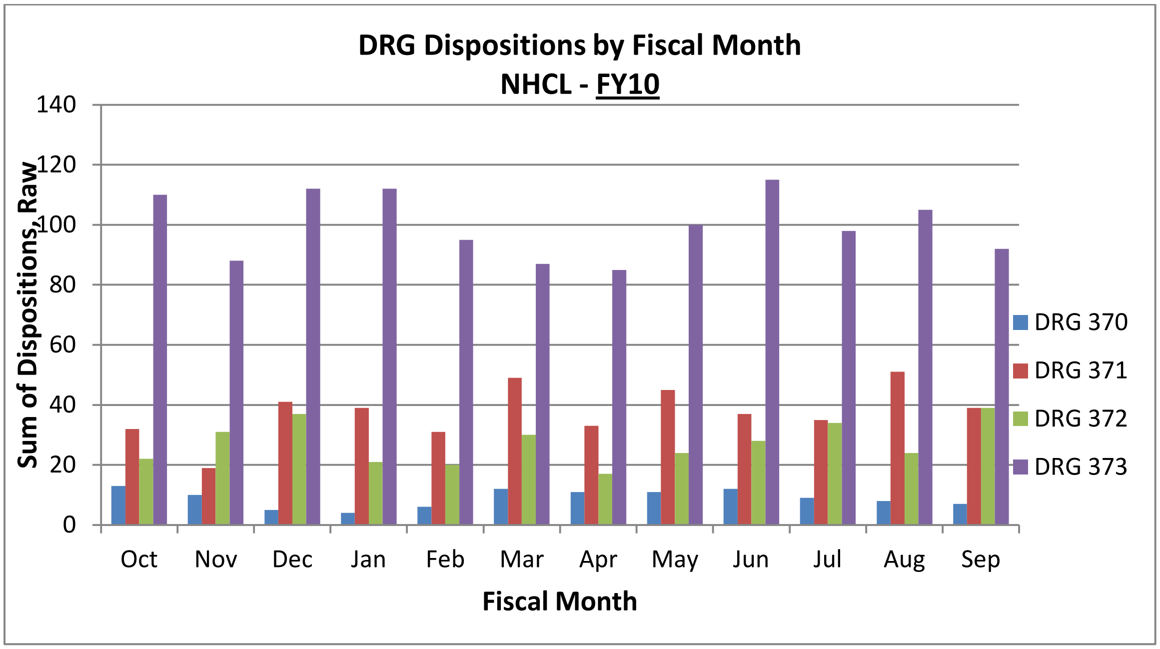
APPENDIX D. NHCP DRG DISPOSITIONS

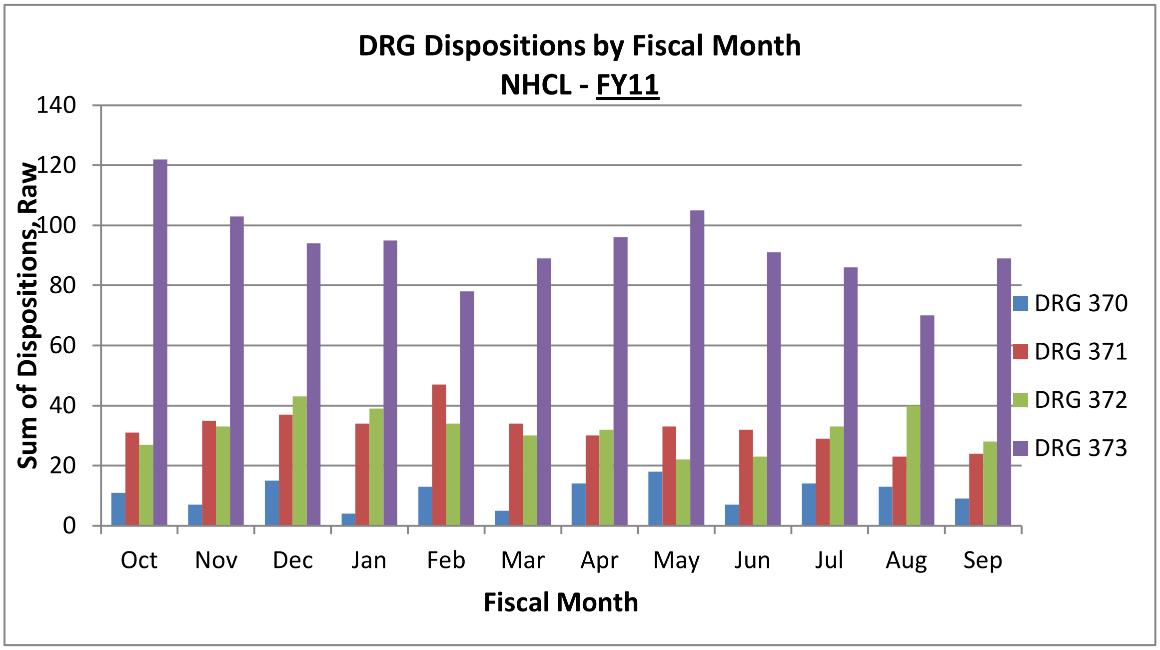


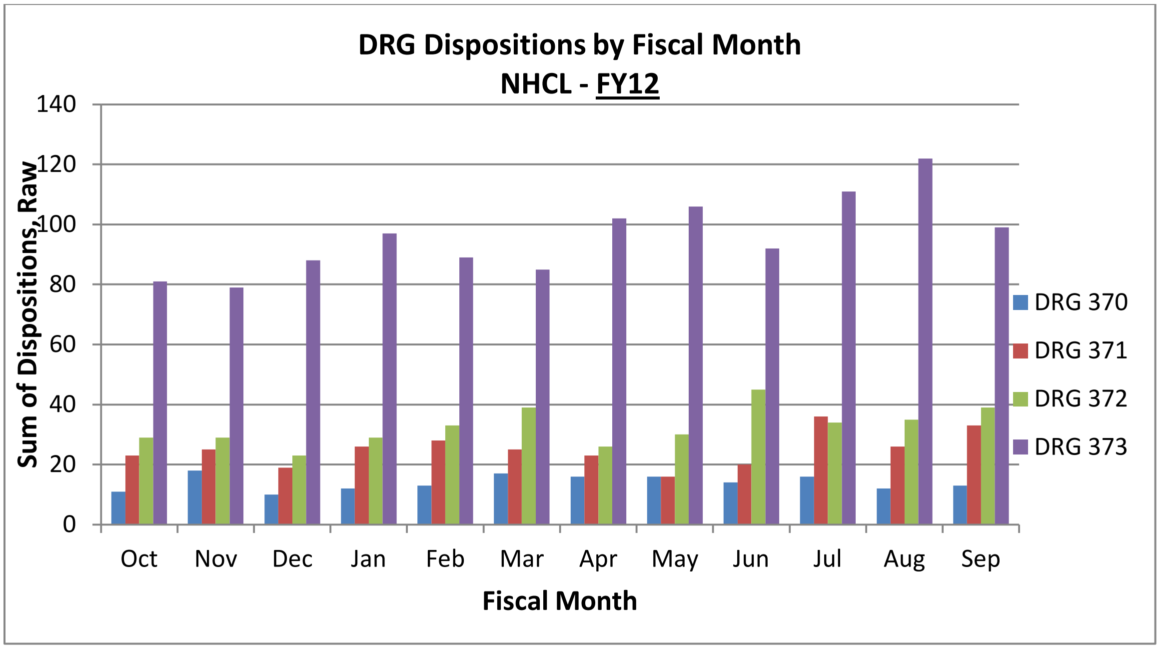



DRG Dispositions by Fiscal Month
NHCP - FY12
Sum of Dispositions, Raw
120
100
80
60
40
20
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Fiscal Month
DRG 370
DRG 371
DRG 372
DRG 373

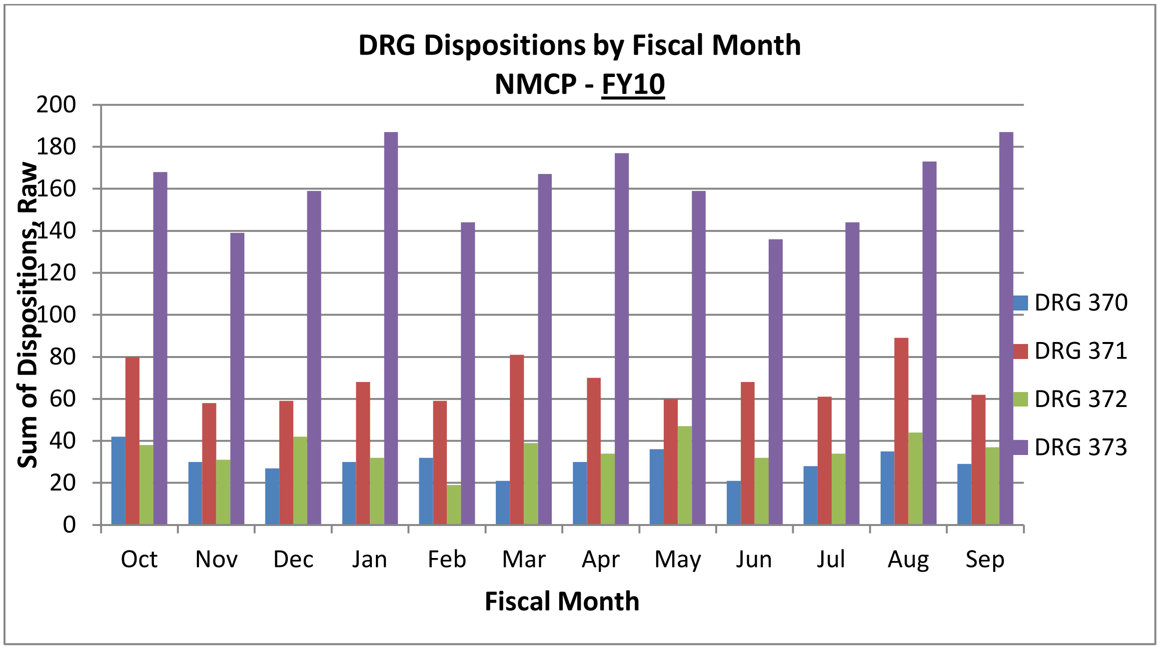
APPENDIX E. NHCL DRG DISPOSITIONS

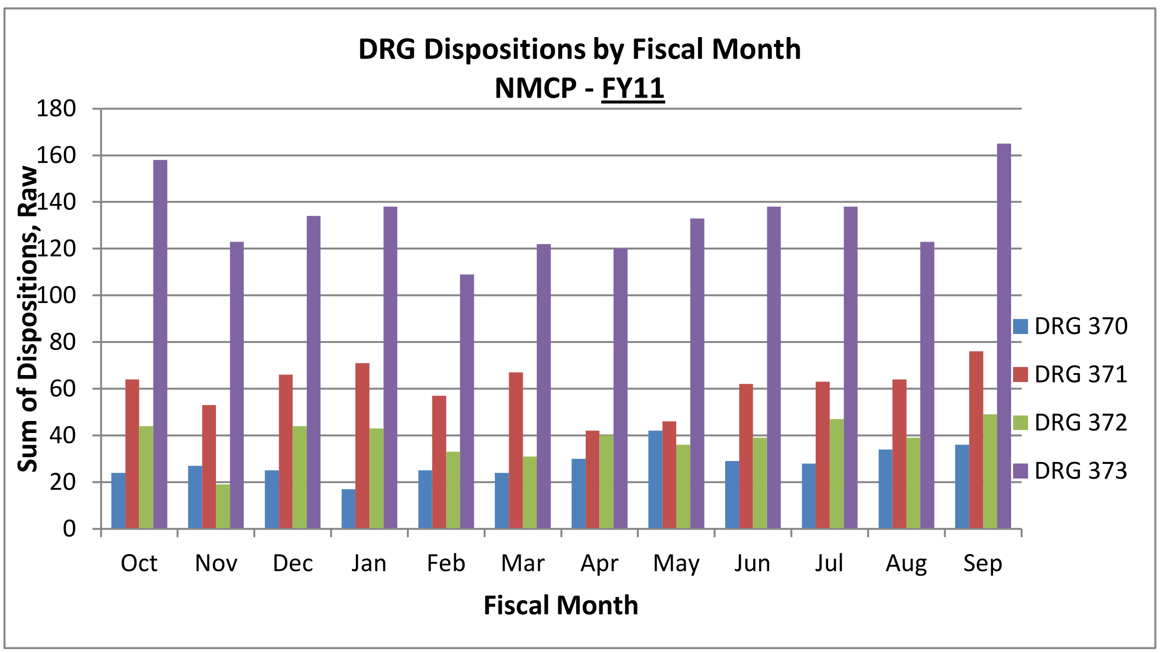


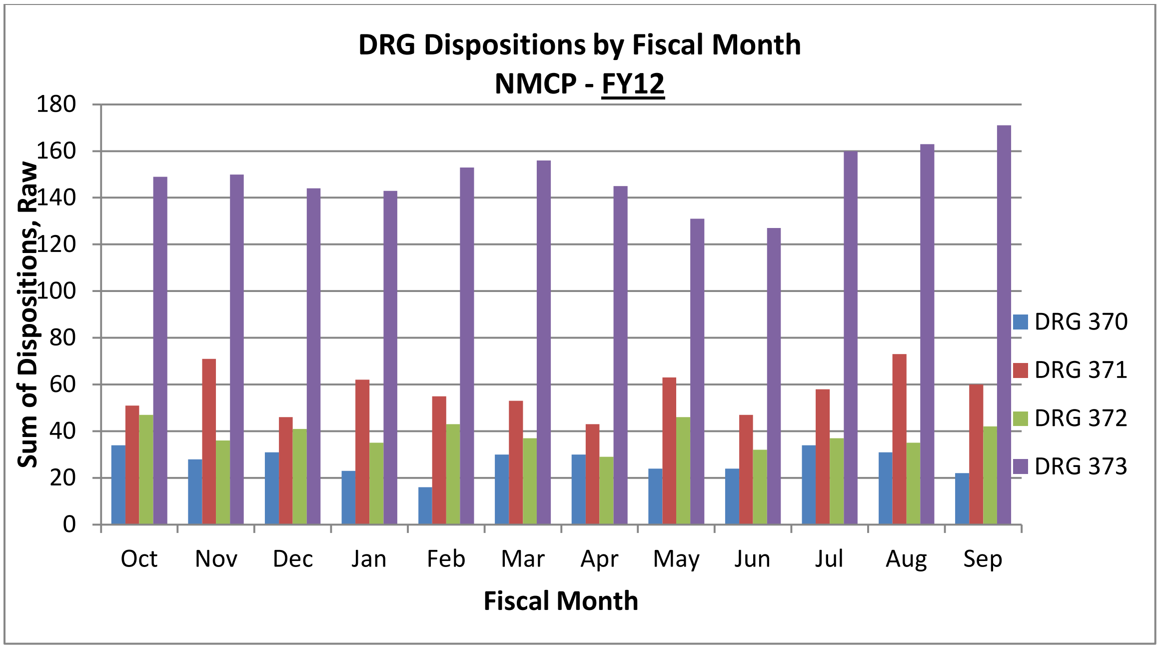



DRG Dispositions by Fiscal Month
NHCL - FY12
Sum of Dispositions, Raw
140
120
100
80
60
40
20
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Fiscal Month
DRG 370
DRG 371
DRG 372
DRG 373

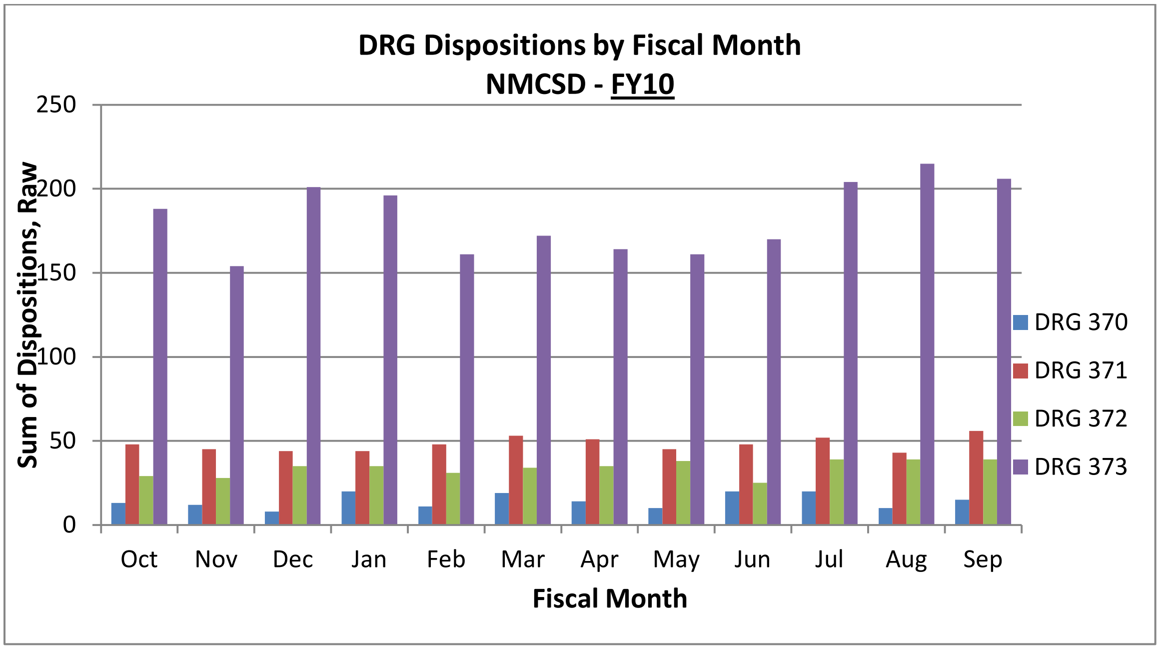
APPENDIX F. NMCP DRG DISPOSITIONS

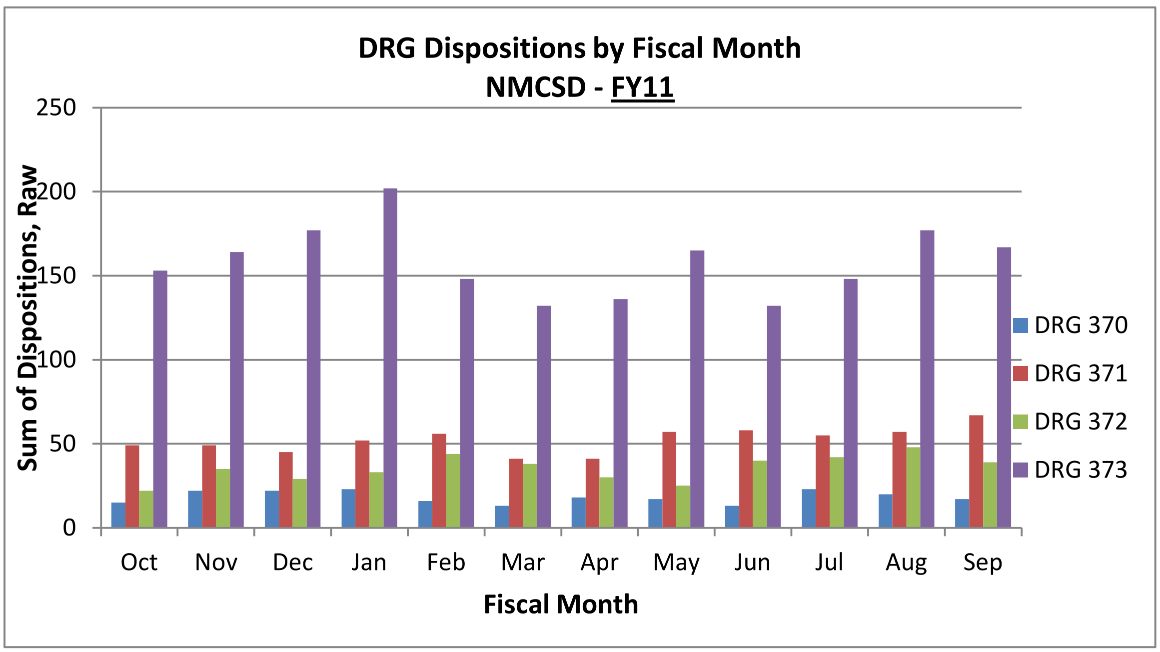


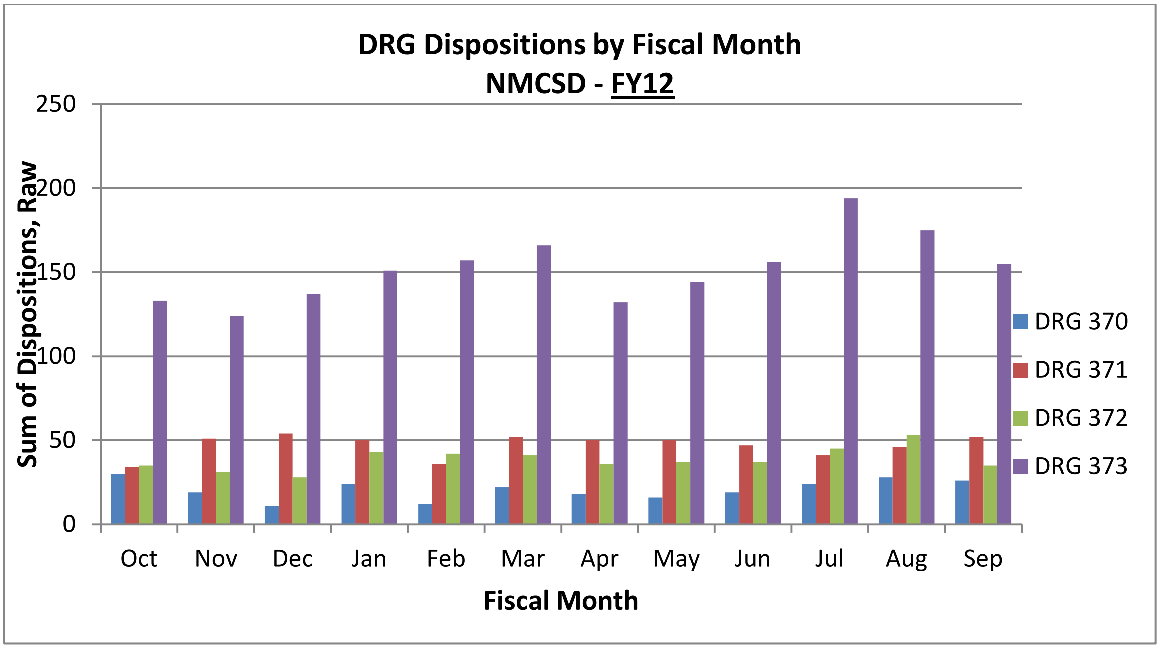



DRG Dispositions by Fiscal Month
NMCP - FY12
Sum of Dispositions, Raw
180
160
140
120
100
80
60
40
20
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Fiscal Month
DRG 370
DRG 371
DRG 372
DRG 373

APPENDIX G. NMCSD DRG DISPOSITIONS






DRG Dispositions by Fiscal Month
NMCSD - FY12
Sum of Dispositions, Raw
250
200
150
100
50
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Fiscal Month
DRG 370
DRG 371
DRG 372
DRG 373

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