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Comparison of Three Supply Distribution Systems for Medical and Surgical Supplies in the Veterans Administration Sierra Pacific Network

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December 2011

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COMPARISON OF THREE SUPPLY DISTRIBUTION SYSTEMS FOR MEDICAL AND SURGICAL SUPPLIES IN THE VETERANS ADMINISTRATION SIERRA PACIFIC NETWORK

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ABSTRACT

This project provides a case study for professors to use in the classroom environment to teach supply chain design, and supply chain inventory policies. It explores the supply chain distribution models being implemented at three Veteran Affairs health care systems within the Serra Pacific Network. Each system will include the main hospital and all of its off-site clinics. These three systems have different distribution models. In comparing and contrasting the distribution models, the goal is to find potential ways to improve efficiency, productivity, and reduce costs. While making specific recommendations (as to e.g., changes in stocking levels, or vendor agreements) for performance improvement is outside the scope of this project, the analysis based on sample data does suggest areas for further examination. However, with the difference in facility sizes, patient base, and complexity of services provided, "one fit" for all three facilities may not exist.

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LIST OF ACRONYMS AND ABBREVIATIONS

CDR	Cost Distribution Report
CLO	Chief Logistics Officers
CPIS	Custom Packaging Information System
EDI	Electronic Data Interchange
FTE	Full Time Employee
FTP	Internet File Transfer Protocol
GIP	Generic Inventory Package
JIT	Just-in-Time
LUM	Low Unit of Measure
PHS	Professional Hospital Supply, Inc.
POU	Point-of-Use
PV	Prime Vendor
SFVA	San Francisco Veterans Administration Medical Center
SPD	Supply, Processing, and Distribution
VA	Veterans Administration
VANCHCS	Veterans Administration Northern California Health Care System
VAPACHS	Veterans Administration Palo Alto Health Care System
VHA	Veterans Health Administration
VISN	Veterans Integrated Service Network 21 (VISN 21)

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I. INTRODUCTION

A. AREA OF RESEARCH

Research focuses on analyzing three major health distribution systems of the Veterans Administration Sierra Pacific Network, Veterans Integrated Service Networks (VISN 21). These systems are the San Francisco Veteran Administration Medical Center (SFVA), which uses a just-in-time system, the Veterans Administration Palo Alto Health Care System (VAPAHCS), which uses a hybrid distribution system, and the Veterans Administration Northern California Health care System (VANCHS), which uses a modified hub and spoke system and is based in Sacramento. This research compares and contrasts each system to assist in building a case study to allow students to determine efficiency and cost-effectiveness. Appendix B of this project appears in the form of a teaching case that may be used to teach supply chain management concepts for the Logistics Management curriculum. The case will enable students to identify possible alternatives and improvements to each distribution system, as well as identify constraints provide information to assist students in determining if the hospital organizations should maintain their current systems, implement one standardized system or a variety of systems. The remainder of the project provides supporting background and analysis for the teaching case.

B. PRIMARY RESEARCH QUESTIONS

This project intends to answer the following questions.

- What are the major structural differences in supply chain design between the three different distribution systems?
- What are the key metrics of productivity, costs and ability to service customer needs?
- What are the relative vulnerabilities of these three distribution systems to disruptions in demand and supply, or fluctuations in costs?
- Are inventory policies in system more vulnerable to variability than another?

- Variation in service levels
- Variation in safety stock
- Variation of on-hand inventory or base stock levels

C. BENEFITS OF THE STUDY

This project yields two major benefits. First, it provides professors at the Naval Postgraduate School a major case study in service supply chain design. Second, it informs VA supply chain design and redesign efforts.

II. BACKGROUND INFORMATION AND ASSUMPTIONS

A. VETERANS ADMINISTRATION SIERRA PACIFIC NETWORK (VISN 21)

VA Sierra Pacific Network is the 21st Veterans Integrated Service Networks (VISN 21) in the Veterans Health Administration (VHA). It serves 1.2 million veterans residing in northern and central California, northern Nevada, Hawaii, the Philippines, and several Pacific Islands including Guam and American Samoa (U.S. Veterans Administration, 2011).

1. VISN 21 Mission Statement

Honor America's veterans by providing exceptional health care that improves their health and well-being (U.S. Veterans Administration, 2011).

2. VISN 21 Core Values

Integrity, commitment, advocacy, respect and excellence, which can be summarized in the simple but appropriate acronym: "I CARE." (U.S. Veterans Administration, 2011)

3. VISN 21 Health Systems

The VISN 21 network is comprised of seven VA medical centers/health systems that manage 37 care sites. VISN 21's seven medical centers/health systems are as follows and as shown on the map in Figure 1 (U.S. Veterans Administration, 2011).

- VA Central California Health Care System
- VA Northern California Health Care System
- VA Pacific Island Health Care System
- VA Palo Alto Health Care System
- San Francisco VA Medical Center
- VA Sierra Nevada Health Care System
- Manila VA Regional Office and Outpatient Clinic

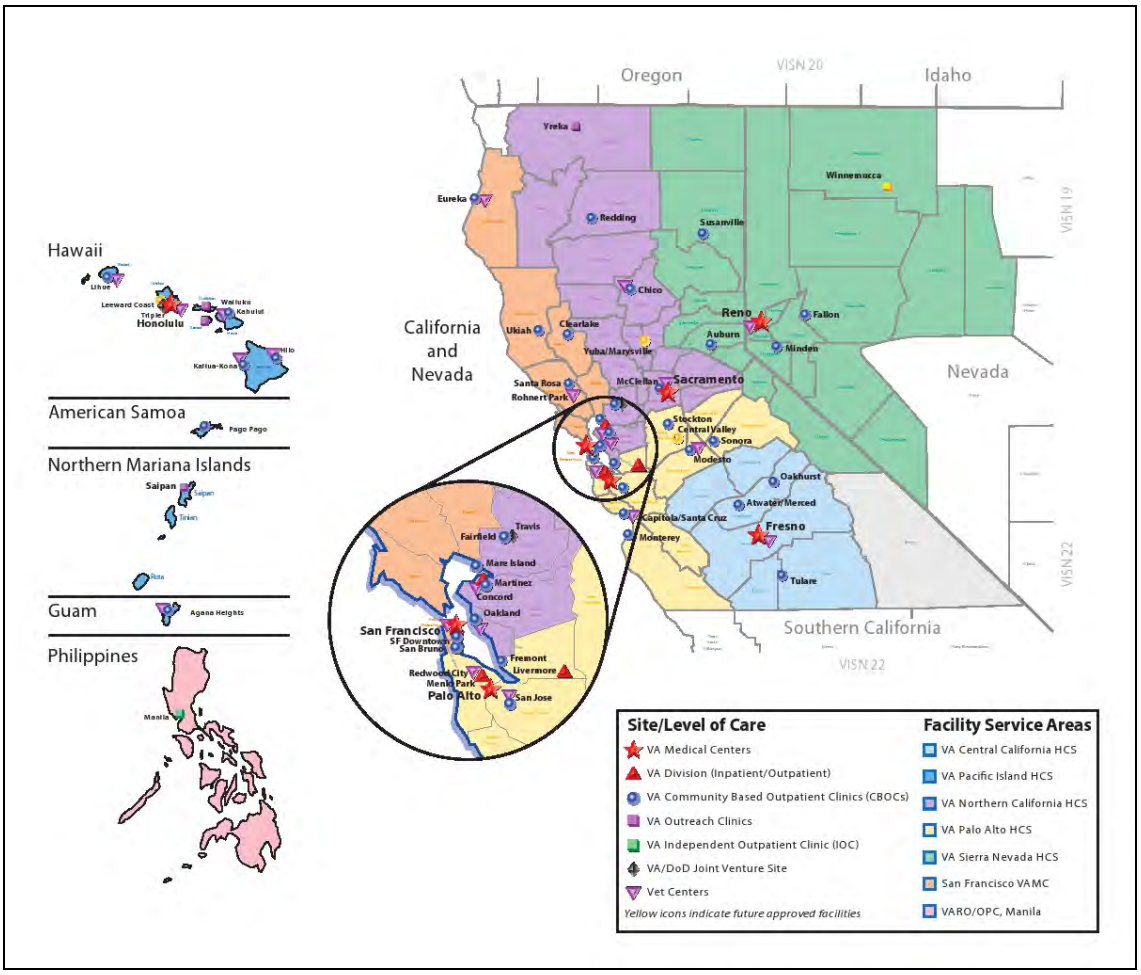

Figure 1. VISN 21 network map (From: U.S. Veterans Administration, 2011)

B. VISN 21 DISTRIBUTION SYSTEMS

In general, neither the VA nor VISN 21 has a prescribed process for the distribution of their medical and surgical supplies. The VA as a whole has tried to allow a level of autonomy in the running of each facility so they can serve their patients the way each facility sees fit.

Currently, VISN 21 is looking to find best practices throughout the VISN. They would like to see if the best practices will fit well for all of VISN 21 or if those identified as best practices are only applicable to those health systems showing themselves as highly effective processes.

This project's focus reviews three major facilities and their distribution systems. The facilities are San Francisco Medical Center, which uses a just-in-time system, the Palo Alto Health Care System, which uses a hybrid distribution system, and the Veterans Administration Northern California Health care System (Northern California), which uses a modified hub and spoke system. This research compares and contrasts each system to ascertain if one is more efficient and cost-effective to maintain the current setup of VISN 21 systems or to implement one standardized system throughout VISN 21.

C. VISN 21 CONTRACT FOR MEDICAL AND SURGICAL SUPPLIES

All Veteran Administration hospitals arrange medical and supply contracting through the regional office. VISN 21 has contracted with Professional Hospital Supply, Inc. (PHS), contract number VA797-P-0193 (Richards, 2010), to provide the majority of its medical and surgical supplies. Roughly 90% of its supplies are purchased through the contractor PHS. The remaining items are procured through a government purchase card. PHS allows the hospitals to order items in bulk, as well as low-unit-of-measure to avoid storing large inventories in a warehouse. In the current contract, all orders are "kill or fill." If PHS has the item on hand, the order is filled; otherwise, the order is canceled. No orders are placed on backorder.

The current contract has the following provisions.

- Distribution fees:
  - Conventional delivery method or bulk: 3.5%
  - Just-in-time delivery method or low-unit-of-measure (LUM): 7.5%
  - Note that, "distribution fees proposed for LUM must be quoted as a stand-alone fee. Fees proposed must not be incremental to the conventional/bulk delivery fee" (Richards, 2010)
- Fill rates:
  - Conventional: 95% deliveries per week
  - Just-in-time: 98% deliveries per week
- Emergency deliveries:
  - Four monthly deliveries per account at no additional cost thereafter: $125 per delivery.

D. PROFESSIONAL HOSPITAL SUPPLY, INC.

Founded in 1981, PHS has a vision of a streamlining supply system to improve the efficiency of hospital staff through distribution customized to its particular needs. PHS has embraced many innovative supply methods now becoming common in hospitals across the country. PHS is one of the nation's oldest regional suppliers of medical and surgical supplies and specializes in low-unit-of-measure items due to implementing just-in-time delivery systems, maintaining its own fleet of trucks, employing a qualified sales team, and keeping abreast of technological development.

PHS boasts of providing a custom packaging system. It strives to meet the needs of each hospital or health system in its own unique ways. PHS does not manufacture parts, which allows it to be flexible enough to include the pack components hospitals need and eliminates a hidden agenda to increase profits by including self-manufactured components. Consequently, it feels it receives a higher level of cooperation from manufacturers.

Figure 2. Sterile supplies carousel (Taken at PHS site)

PHS utilizes a Custom Packaging Information System (CPIS), which helps meet requirements in a timely and accurate manner especially with low-unit-of-measure items. CPIS consists of a comprehensive set of tools that maintains hospitals custom kit specifications, monitors hospital usage, and controls each production run. PHS can track hospital usage patterns and schedule the appropriate production runs to ensure uninterrupted service. PHS tracks all of its raw material component requirements, and maintains and factors historical lead-times into the production model. The system utilizes Electronic Data Interchange (EDI) and auto fax technology to work efficiently with its supplier partners (Professional Hospital Supply, Inc., 2011).

1. Professional Hospital Supply Inc. Packaging

Through touring PHS, it was found that PHS offers the following packaging systems.

- Custom Procedure Carts: This is a low-unit-of-measure system, which utilizes movable shelving carts brought to PHS and restocked to its sufficient levels. The carts are then returned to the ward or clinic to which they are assigned in the hospital. Carts are rotated while one is in placed on the ward the other is being restocked at PHS. As this is a supply option PHS offers, it is not employed in any of the VISN 21 systems.
- Bin Packaging: This is a low-unit-of-measure system. Medical materials in bulk packages are broken down to an "each" unit-of-measure for distribution. Each ward/clinic is assigned a plastic bin in which PHS employees place the ordered items. The bins are then delivered to the ward/clinic; generally, a number of bins are brought to the floor of each clinic. This is the only system that San Francisco uses. Northern California has a few clinics that use this system and Palo Alto is striving to move toward this system.
- Bulk Delivery: Items will be ordered from PHS in bulk (Boxed and put on a palate) and delivered to the central warehouse of the hospital/health system, and then broken down and delivered to each ward/clinic as needed.

Figure 3. PHS bins and carts staged for stocking (Taken at PHS site)

Figure 4. PHS bulk supplies (Taken at PHS site)

2. Areas for Servicing VISN 21 Health Systems

PHS has two areas in which it fills carts/bins. The first is the clean area in which items need to remain sterile. Syringes, needles and other similar items would be found in this area, as well as over 7,000 other items. The second is the main warehouse, which contains non-sterile items; however, a tour of the facility found it to be exceptionally clean for a warehouse environment. Items seen in the main warehouse consist of bed pads, bandages and other similar items. The warehouse carries between 27,000 and 31,000 store-keeping units.

3. Ordering With Professional Health Services Supplies, Inc.

PHS strives for convenient customer ordering. Customers can order electronically through electronic data interchange (EDI), or Internet file transfer protocol (FTP), which allows its customers to place orders and receive pricing and stock availability confirmation, 24 hours a day, 365 days a year. PHS also takes fax and phone orders through its team of customer service telephone representatives. The majority of the orders are done electronically through EDI in conjunction with the Omnicell systems at the hospitals/clinics. PHS Information was retrieved through a walkthrough of the facility (Professional Hospital Supply, Inc., 2011).

PHS and VISN 21 refer to the low unit of measure as JIT. The suggested benefit to PHS under the JIT program is that it captures a larger share of the hospital's total purchases. In addition, under this program, PHS has more visibility in the actual usage of the hospital, which reduces the bullwhip effect prevalent in many extended supply chains.

E. SUPPLY, PROCESSING, AND DISTRIBUTION

Supply, Processing, and Distribution (SPD) is a centrally managed section of the medical center responsible for receiving, storage, and distribution of medical and surgical supplies. SPD is a sterile area. Thus, all incoming medical and surgical supplies are removed from shipping boxes before entering storage. Shipping cartons are considered

contaminated and are not appropriate in the SPD clean/sterile storage areas. The goal of San Francisco, Palo Alto, and Sacramento hospital SPDs is to maintain three days of safety stock on hand.

The distribution area of SPD is responsible for the dissemination of the correct supplies to users, as well as in the correct quantity, quality, location, and condition for use. As a result, clinical staff can then spend its time on patient care needs, which also allows for large volume purchases and fewer orders to process that saves the medical center time and resources.

All VA facilities utilize point-of-use (POU) equipment or Omnicells for providing secured, automatic dispensing of supplies in medical departments. Access to supplies is limited to employees provided passwords. The POU equipment not only allows for tracking usage and ordering of supplies, but also reduces the consumption and loss of products. Items are sent to the Omnicells in the user areas via carts. Medical supply technicians have the responsibility of maintaining the inventory. In addition, each area has an assigned supply technician to replenish the supplies.

Purchased medical supplies are received into SPD in a breakout area in which supplies are removed from their outer shipping containers and boxes before being admitted into the clean/sterile storage area. Afterwards, the supplies are checked for expiration dates and inspected to ensure the packaging is not damaged, wet, or soiled. The type and quantity of items is verified before transporting them to the point of use. During transport, supplies are covered or enclosed to protect them from the environmental hazards.

Figure 5. SPD at PHS (Taken from site visit at PHS)

Palo Alto and Northern California facilities utilize Generic Inventory Package (GIP) system to generate orders, whereas the San Francisco hospital uses the system embedded in the Omnicells directly. GIP is a VA-developed electronic system used to manage inventory within SPD. GIP data consists of primary inventories and secondary inventories. The SPD inventory is the primary inventory, and the secondary inventories, are the points of distribution. Other types of primary inventories within the medical center include pharmacy and warehouse. Within GIP, the SPD inventory (primary inventory) consists of all items stocked and/or procured by SPD. Stock levels are established to maintain constant availability of items. These levels are as follows.

- Normal stock levels—represent the largest number of items to be maintained in the primary (SPD shelves).
- Secondary stock levels—represent the number of items to be maintained in the Omnicells.

GIP has the ability to auto generate orders. In other words, the computer automatically reviews preset inventory levels against current amounts on hand and identifies those items below the preset levels so that they may be requisitioned. Primary and secondary inventories are reviewed on a regular basis utilizing GIP-generated reports, including the following.

- History of Distribution Report—shows the total dollar amount of supplies distributed to each secondary. This information is useful in computing quarterly and annual budget reports and compiling a Cost Distribution Report (CDR).
- Inactive Item Report—gives a list of items for a specific period of time that have been inactive, which allows a determination to be made as to whether an item should continue to be stocked.
- Usage Demand Analysis Report—used to evaluate item usage and show an increase/decrease in usage, and thereby, indicating a need to change stock levels.

Computerized bar code labels identify each item within the hospital's inventory. The medical supply technicians use bar code readers to scan the labels to identify the items and then enter the actual amounts. After scanning the inventory, the information is uploaded into GIP, and a picking ticket is generated, which identifies the items and amounts required to be restocked to the appropriate levels.

F. OMNICELL STORAGE CONTAINERS

Omnicell is a cabinet-based system intended to increase overall efficiency and productivity of health care facilities by providing a convenient, secure, and flexible system for managing health care supplies. The system allows quick and easy access to supplies, improves data capture, reduces consumption and inventory, and improves inventory and information management.

As shown in Figure 6, Omnicells enable efficient and clean storage of medical/surgical supplies. The cabinets are placed in the various wards throughout the hospital and accessed only by authorized users to pull inventory. Once an item is taken out the Omnicell cabinets, medical personnel input the transactions directly into the Omnicells' computers or by pressing "take" buttons located on the appropriate cabinets bin. These systems keep continuous inventory records and automatically can place orders based on the established reorder and order-up-to points. By applying accountability to staff using the inventory, Omnicell can assist in reducing shrinkage and increase cost capture.

Figure 6. Omnicell cabinet (Taken at site visit of Palo Alto Health System)

Another claimed benefit of Omnicell is that it allows for visibility into the entire hospital's inventory. For common consumables, a shortage in one ward can be mitigated with inventory from another ward until the next replenishment arrives. This advantage of added visibility from Omnicell increases the resiliency of the hospital supply chain under emergency demand situations.

A unique feature of Omnicell systems includes a server application that facilitates day-to-day operational management of multiple systems in a single or across multiple facilities. A materials manager in charge of a hospital and outlying clinics has full visibility of usage trends in all facilities. Standard and customized reports can be generated from a centralized database to provide complete information on supply inventory and product use. As with the case of VISN 21, Omnicells' distribution information system is integrated with the VA's own electronic supply system, which reduces manual data entry between different systems and departments.

Currently, no standardized ordering process within the VISN 21 health care systems exists. As such, the process is different at each of the three health care systems being comparing. The San Francisco health care system places orders directly from its

Omnicells at all facilities. The Palo Alto health care system places orders directly from its Omnicells only at Building Seven on the Palo Alto compound and at its off-site clinics. The VA Northern California health care system does not use Omnicell to place orders. This process is discussed in more detail in the distribution section of each health care system.

G. THREE VA HEALTH CARE SYSTEMS WITHIN VISN 21

1. VA Northern California Health Care System

The VA Northern California Health Care System (VANCHCS) is part of the Veterans Integrated Service Networks (VISN) in the Veterans Health Administration (VHA). VANCHCS has a network of 12 clinics in seven areas thought the northern California region. These clinics are listed as follows.

- Sacramento Mental Health Clinic
- McClellan Outpatient Clinic
- McClellan Dental Clinic
- Redding Outpatient Clinic
- Chico Outpatient Clinic
- Martinez Outpatient Clinic
- Community Living Center
- Oakland Outpatient Clinic
- Oakland Behavioral Health Clinic
- Fairfield Outpatient Clinic
- Mare Island Outpatient Clinic
- Yreka Rural Health Clinic

The Northern California network provides a plethora of services from dental, mental health, pharmacy, physical medicine and rehabilitation, women's health, surgery and social work services. Northern California has two divisions, each with an associate director. The Sacramento Valley division is comprised of medical facilities in Sacramento, Chico and Redding, while the East Bay division has medical facilities in

Fairfield, Vallejo, Martinez and Oakland. Northern California serves an area covering 17 counties, more than 40,000 square miles and over 377,700 veterans (VA Northern California Health Care System, 2011).

The Sacramento VA Medical Center is a 60-bed, state-of-the-art, inpatient facility offering a full range of comprehensive health care services including medical, surgical, primary and mental health care. The medical center, which is comprised of 24 medical-surgical beds, 16 TCU beds, 10 ICU beds, 10 PICU, and a four-room operating suite, also houses a cardiac catheterization lab, a gastrointestinal and endoscopy suite, angiography capability and 16,000 square-feet of research laboratory. The medical center offers a wide range of outpatient and diagnostic services, including mammography, magnetic resonance imaging, computerized axial tomography, and positron emission tomography scanning (VA Northern California Health Care System, 2011).

By providing these clinics, the VA is following the VA secretary's initiatives to have a patient centered focus on medical care for veterans by providing medical care at a location near their residence versus traveling long distances to seek care. As the clinics have become more decentralized, a unique problem occurs with how to supply the different clinics properly.

a. Northern California Distribution System

Like all VISN 21 networks, Northern California utilizes PHS as the primary vendor for its medical and surgical supplies. Most of the PHS shipments come to the main facility in Sacramento in bulk, are broken down, and then distributed out to the other sites. Once they arrive, the shipment is broken down for individual clinics and delivered to them.

Northern California strives to have as little of inventory as possible but enough to meet the demands of the clinics; however, Northern California strives to maintain three days of safety stock on hand. Limited inventory is maintained in the warehouse, and almost all inventory is stocked in the Omnicells of the individual clinics for whose use the supplies are intended. Some items are put in the SPD, which assists the medical center in maintaining a high level of service. This room is small considering the

level of supplies maintained at the medical center. Distribution is accomplished via a very complicated and confusing system. The Medical Center in Sacramento employs 23 full time supply technicians; however, not all of them are involved with the medical/surgical supplies. Time allocation for medical/surgical supplies is discussed in the next section.

b. Deliveries

To deliver all medical/surgical supplies to the medical center and the outlying clinics, Northern California uses a modified hub and spoke delivery system. The delivery schedule for the medical/surgical items is discussed as follows.

- Sacramento Medical Center receives bulk deliveries from PHS Monday through Friday. PHS delivers in the afternoon and all secondary areas or clinics are restocked by 0700 the following day, after which, new orders are manually placed in GIP. Four supply technicians inventory and break down supplies. The supplies are then pulled per order requests and staged for item managers to deliver thee supplies to individual wards and clinics throughout the medical center and its campus. The combined processes take on average 50 minutes. Four supply technicians need six hours to restock all individual Omnicells including the clean supply room. In addition to the supplies broken down for the Sacramento Medical Center, supplies are also broken down to fill order requests to be delivered to the following outpatient clinics via a VA supply technician: McClellan Clinic, Mare Island Clinic, Fairfield Clinic and the Oakland Clinic.
- McClellan Outpatient Clinic supplies go from PHS to the warehouse in the Sacramento Medical Center and then are broken down by one supply technician, which adds an additional 60 minutes to the breaking down of the bulk supplies and put in a van to be delivered to McClellan every Wednesday. One supply technician requires 60 minutes to restock all Omnicell cabinets and 25 minutes to drive the 13.1 miles from the Sacramento Medical Center.
- Mare Island Outpatient Clinic supplies go from PHS to the warehouse in the Sacramento Medical Center and then broken down, which requires one additional supply technician 30 minutes to prepare the Mare Island and Fairfield order, which is then put in a van to be delivered to the Mare Island Clinic every Sunday. One supply technician needs 30 minutes to restock all Omnicell cabinets and 66 minutes to drive the 70.4 miles from the Sacramento Medical Center. Currently, a supply technician will go to Mare Island and Fairfield on the same run. The Mare Island Clinic is 24.5 miles and 33 minutes southwest from the Fairfield Clinic.

- Fairfield Outpatient Clinic supplies go from PHS to the warehouse in Sacramento Medical Center and then broken down which takes one additional supply technician 30 minutes to prepare the Mare Island and Fairfield orders. Orders are then put in a van to be delivered to the Fairfield Clinic every Sunday. It takes 30 minutes to restock all Omnicell cabinets and 53 minutes to drive the 51.2 miles from Sacramento Medical Center
- Oakland Outpatient Clinic supplies go from PHS to the warehouse in the Sacramento Medical Center. On Monday and Wednesday, the morning crew runs an auto-generated report that prints the pick list. One supply technician requires 20 minutes to pull and pack the bins for Oakland supplies, which are then put on the van to be delivered to the Oakland Clinic. One supply technician needs 30 minutes to restock all Omnicell cabinets and 83 minutes to drive the 92 miles from the Sacramento Medical Center to the Oakland Clinic.
- Martinez Outpatient Clinic supplies are received from PHS directly every day. It utilizes the Omnicell system in 21 areas throughout the clinic. PHS items come in low-unit-of-measure (LUM) in bins to be delivered to each floor. Every morning, two supply technicians inventory and break down supplies in 60 minutes and four hours are needed to restock all Omnicell cabinets.
- Redding Outpatient Clinic supplies come from PHS directly five days a week in bulk. One supply technician requires 60 minutes to breakdown the delivery and four hours to restock all Omnicell cabinets. The Redding Clinic also receives supplies for the Chico Outpatient Clinic every other week on Wednesdays and one supply technician needs approximately 15 minutes to prepare that order.
- Chico Outpatient Clinic supplies go from PHS to the warehouse in Redding and then are broken down and put in a van to be delivered to the Chico Clinic every other week on Wednesdays. One supply technician needs an extra 15 minutes to prepare the delivery and 69 minutes to drive the 68.8 miles from the Redding clinic to the Chico clinic. One supply technician requires 20 minutes to restock all the Omnicell cabinets. However, if items came from the Sacramento Medical Center, it would take 105 minutes to drive the 104.3 miles from the Sacramento Medical Center.

H. VA SAN FRANCISCO

San Francisco Veterans Administration Medical Center (SFVA) includes a level one facility that provides services to more than 310,000 veterans living in an 8-county area of Northern California. The facility also manages six outlying clinics in the following areas.

- Downtown San Francisco
- Clearlake
- Eureka
- San Bruno
- Santa Rosa
- Ukiah

1. Distribution System

The SFVA Medical Center and its outlying clinics utilize a form of JIT inventory distribution system. When using JIT, PHS delivers medical/surgical supplies in low units of measure rather than bulk quantities. This type of distribution system often provides the additional benefits of reducing inventories, labor costs, and stock outs.

SF hospital maintains approximately three days of safety stock inventory on hand. The safety inventories of medical/ surgical supplies are stored in the SPD. It has also developed emergency response plans with PHS and other hospitals in the San Francisco Bay area to deal with any unexpected increases in demand, such as in the cases of man-made or natural disasters. This advanced planning has allowed for inventory costs to remain low without jeopardizing patient safety. San Francisco hospital's inventory cost was reduced by approximately 20% when it originally implemented JIT with Omnicell.

Once the orders are placed, PHS will break down all supplies into low units of measure and place them in bins for each requesting department or clinic. PHS charges a 4% additional handling and distribution fee for breaking down bulk, the separation of supplies by departments and individual deliveries to the clinics. Orders are delivered

daily to the SFVA medical center and on a weekly basis to the clinics. The items are delivered by truck and are dropped off at the facilities' loading docks. If the ordered quantity for the clinics is too small for truck delivery, the items are shipped via UPS.

The following provides information about the clinics and travel time in between the clinics.

- Down Town San Francisco Clinic: located 6.4 Miles from the SF Medical Center and it takes 24 minutes to drive there.
- Clearlake Clinic: located 107 miles from the SF Medical Center and it takes two hours and 26 minutes to drive there. However, it is 51.9 miles from Santa Rosa and a one hour and 20 minutes' drive. It is also takes 54.1 miles and one hour and 7 minutes to drive from the Clearlake Clinic to the Ukiah Clinic.
- Eureka Clinic: located 270 miles from the SF Medical Center and it takes 4 hours and 58 minutes to drive there.
- San Bruno Clinic: located 14.5 miles from the SF Medical Center and it takes 24 minutes to drive there.
- Santa Rosa Clinic: located 60.1 miles from the SF Medical Center and it takes one hour and 14 minutes to drive there.
- Ukiah Clinic: located 113 miles from the SF Medical Center and it takes 4 hours and 58 minutes to drive there.

Logistics management personnel of PHS and the San Francisco Veterans Affairs Medical Center share essential information about their operations to ensure that the JIT system is executed smoothly and improved over time. Their information distribution systems are connected, and provide vital reports, ordering information, and other tools of data management. It is also very beneficial to the hospital that PHS is located in close proximity, which allows for frequent deliveries and short lead times.

Once the items arrive at the hospital, the warehouse personnel separate them into three categories (medical/surgical items, equipment, and implants), and deliver them to the appropriate departments. One lead manager is assigned to oversee the separation and delivery of the items in the three categories mentioned. The warehouse does not store any excess supplies.

For the distribution of supplies to the departments, the hospital and the clinics use Omnicell cabinets. The SFVA health care system contains 150 Omnicells.

Medical/surgical items are delivered and placed in Omnicells every morning by the logistics personnel. In addition to storage, Omnicells are also used for placing electronic orders directly to PHS. Each day at 1400, the Omnicell computers generate orders via the hospital's main Omnicell server and send orders to PHS. This automated system simplifies the ordering process and accelerates the supply replenishment process. The item managers in the hospital's inventory management department and designated personnel in the clinics set the orders up to levels.

I. VA PALO ALTO

The VA Palo Alto Health Care System (VAPAHCS) is part of the Veterans Integrated Service Networks 21 (VISN 21) in the Veterans Health Administration (VHA). VAPAHCS consists of three inpatient facilities and seven outpatient clinics. In later analysis, the delivery schedule and stocking policies of the Palo Alto system are not examined in detail. Hence, detailed information about the delivery schedules and travel time are not provided. However, for the sake of completeness, a list of the Palo Alto facilities follows.

- Palo Alto Division (inpatient facility)
- Menlo Park Division (inpatient facility)
- Livermore Division (inpatient facility)
- Capitola Clinic
- Fremont Clinic
- Modesto Clinic
- Monterey Clinic
- San Jose Clinic

These facilities provide some of the world's finest medical care and cutting-edge technology (DoVA, 2011).

VAPAHCS is a teaching hospital, which provides a full range of patient care services with state-of-the-art technology, as well as education and research. Comprehensive health care is provided in the areas of medicine, surgery, psychiatry,

rehabilitation, neurology, oncology, dentistry, geriatrics, and extended care. With nearly 900 beds, including three nursing homes and a 100-bed homeless domiciliary, more than 85,000 enrolled veterans are served (DoVA, 2011).

VAPAHCS is home to a variety of regional treatment centers, including a Polytrauma Rehabilitation Center, Spinal Cord Injury Center, Comprehensive Rehabilitation Center, Traumatic Brain Injury Center, the Western Blind Rehabilitation Center, Geriatric Research Educational and Clinical Center, Homeless Veterans Rehabilitation program, and the National Center for Post-Traumatic Stress Disorder (PTSD) (DoVA, 2011).

VAPAHCS maintains one of the top three research programs in the VA with extensive research centers in geriatrics, mental health, Alzheimer's disease, spinal cord regeneration, schizophrenia, Rehabilitation Research and Development Center, HIV research, and Health Economics Resource Center.

An affiliation exists with the Stanford University School, which provides a rich academic environment including medical training for physicians in virtually all specialties and subspecialties. Over 1,300 university residents, interns, and students are trained each year (DoVA, 2011).

1. Distribution System

VAPAHCS has a multi-echelon system utilizing two distribution processes, a hub and spoke model with centrally located stock and just in time utilizing low unit of measure supply chain distribution systems. The lead of all supply operations for the VAPAHCS primary facility is located on Palo Alto campus, and utilizes the hub and spoke distribution system at all the exterior facilities on campus with the exception of Building 7, which is using the JIT distribution system. Supply operations are conducted Monday–Friday and supplies are ordered each of the five days. All supplies are ordered from the PHS.

The main facility receives bulk and low unit of measure shipments from the PV. Bulk shipments are broken down and placed in the SPD storage area where the primary supplies are stored. Approximately 14,000 line items are stored in the SPD, an area from which all the wards and ancillary health care facilities or secondary facilities replenish their supplies every day. All supplies in the secondary's or clinics are stored in Omnicells, automated supply cabinets. Every day at 1400, the Omnicells sends pick orders to the Omnicell website. The logistics management personnel in the primary pull the new pick orders from the website and convert these orders into the GIP system to replenish supplies from the PV. Orders are received the next day and the process is restarted.

Building 7 is utilizing the JIT distribution system. At 1400, Omnicell downloads the pick orders for the next day, instead of going to the primary, these orders are sent directly to PHS. PHS breaks down this order into LUM, places them into bins and delivers this order to the loading decks of Palo Alto Hospital at 1000 the next day. At 1200, Building 7's item manager will pick up these bins and use them to replenish its Omnicells. This process also occurs Monday through Friday.

All VAPAHCS outlying facilities are utilizing the JIT supply chain distribution system. Once a week supplies are replenished through the Omnicell electronic ordering process. PHS delivers supplies in LUM directly to each outlying facility.

III. METHODOLOGY AND ASSUMPTIONS

A. INVENTORY MANAGEMENT METHODOLOGY

The analysis in this chapter is based on the research of each health care system's supply and demand data, the differences in each distribution processes, and interviews with the logistics management personnel and Chief Logistics Officers (CLO) within each VISN 21 health care system. The interviews with the logistics management personnel and CLOs provided insight into the variations in policy amongst the three health care systems, successful processes currently in place, and supply chain management areas of opportunity for improvement.

The VA assumes that all planning data is deterministic and to account for random events, a safety stock is used. Most health care systems in the VA are set up in which the primary, a single inventory location, serves a number of downstream nodes (i.e., wards, and clinics). To determine the required level of safety stock in a dynamic planning environment, such as the health care logistics arena, several stochastic inventory policies can be applied (Tempelmeier, 2011). In this case, the order-up-to and safety stock inventory levels are set based on the experience and estimations made by local item managers in each system.

The (S-1, S) policy is what VISN 21 facilities currently use to manage their supplies. This policy will be used in inventory management calculations to analyze all received data properly. This policy states that facility item managers set inventory levels at point "S", and when any items are used (if inventory drops below S-1), that amount is purchased to return to the designated "S" levels (Snapp, 2010).

The authors' intent is to demonstrate the consequences of current policies, and to suggest a systematic approach to setting the value of S for all inventory items. They examine only a single item, because a single item is sufficient to make the demonstration, and illustrate the differences between policies. Their analysis is not intended to be a systematic comparison between facilities. The analysis is based on the demand data

provided for Alcohol Pads, which is vendor item 6818. These pads are ordered from PHS in boxes of 200 each, which was the only commonly used item amongst all facilities for which data was available.

Assumptions on the order demand for the Oakland (Northern California) and San Jose (VAPAHCS) facilities were made, as the ordering information was only provided for the three main hospitals and San Francisco clinics. The price of each box is $1.60 for Palo Alto and Sacramento facilities and $1.66 for the San Francisco, because San Francisco facilities use the PHS low unit of measure service, which adds 4% to the product cost.

1. Terminology

- D — average monthly demand: This data is critical for making future demand forecasts.
- d — average daily demand: This data is critical for making future demand forecasts.
- σ_M — standard deviation of average monthly demand: The standard deviation is the average of all the averages of several sets of data.
- σ_d — standard deviation of average daily demand: The standard deviation is the average of all the averages of several sets of data.
- σ_l — standard deviation of lead time (in days). Calculated from variance in the delivery schedule, for those sites not receiving daily deliveries.
- σ_{ltd} — standard deviation of lead time demand, calculated from lead time, demand, standard deviation of demand and standard deviation of lead time using a formula given below. The formula assumes lead time and demand are independent.
- SS — safety stock. It is a level of extra stock maintained to mitigate risk of stock outs due to uncertainties in supply and demand.
- LT — replenishment lead time (in days): Total time for the external procurement of supplies.
- S — total order-up-to level: The amount of the supplies ordered to return stock levels to target levels.
- SL — service level: 1—(probability of stocking out). A measurement of the performance of a system or service. The service level is usually expressed as a percentage.

- TC total monthly cost: The total cost associated with ordering and carrying inventory.
- h holding cost. The cost of holding an item in inventory for one month.
- i an interest rate meant to model the opportunity cost of having funds tied up in inventory, rather than available for other investments. A rate of 7% per annum was assumed for the VA. Since monthly costs are being computed, it was converted to 7%/12 for analysis.
- C price of an item: Assumptions: The Palo Alto Hospital provided the price for alcohol pads. Since Sacramento and Palo Alto hospitals do not use low unit of measure contracts, their item cost is the same ($1.60 each box). San Francisco Hospital pays an additional 4% for utilizing low unit of measure ordering, so its price per item is $1.60 * 104% = $1.66.
- DOS days of supply: The total amount of days the facility has in stock on hand.
- Var(d) variance of daily demand. It is a measure of how far a set of daily demand numbers is spread out.
- (s, S) is a policy: (s) is the reorder point and (S) is the order up to point.
- (S-1,S) is a specialized case of (s, S). An order is triggered when inventory falls below S.

2. (S-1, S) Policy Formulation

- $z = \frac{SS}{\sigma_d * \sqrt{(LT)}}$
- $TC(S) = h * S + C * D$
- $h = i * c$
- SL = the percentage chance that a stock out will not occur, given the order-up-to level S, which was determined by (1) assuming a normal distribution for demand during lead time, and locating SS on that distribution, (2) translating the pattern of demand during lead time to a standard normal distribution and using the formula above to find the z score on that standard normal distribution, and then (3) using the inverse standard normal function (normdist( ) in Excel) with z to find the stock out probability associated with z, and hence, SS.
- $S = d * LT + SS$

- $Var(d) = \frac{\sigma_M^2}{30}$
- $\text{DOS} = \frac{\text{S}}{\text{d}}$
- $\sigma_d = \sqrt{Var(d)}$

Formulas below were utilized for the Oakland clinic with random lead time.

- $\text{S} = \text{d} * \text{LT} + \text{z} * \sigma_{ltd}$
- $\sigma_{ltd} = \sqrt{\text{d}^2 * \sigma_l{}^2 + \text{LT} * \sigma_d{}^2}$
- $z = \frac{SS}{\sqrt{\left(\left(d^2 * \sigma_l{}^2\right) + \left(LT * \sigma_d^2\right)\right)}}$

To calculate the amount of safety stock days needed at 99.75% service level, the number 2.80703377 was used, which is the z value for 99.75%. The formula is

- $SS\ days = \frac{z}{\frac{d}{\left((\sigma)_d * \sqrt{LT}\right)}}$.

B. COST EVALUATION METHODOLOGY

Hilton and Platt have defined Activity Based Management as:

> Activity based management is the use of activity-based costing information to support organizational strategy, improve operations, and manages costs. (Hilton & Platt, 2011, p. 220)

Activity based management gives the ability to review a two-dimensional model in evaluating different activities in two views. The first is the cost assignment view, which assigns resource costs to activity cost pool associated with significant activities and then examines cost objects using second-stage cost drivers to produce a cost object (products or services). The second is the process view, which observes the root causes that drive an activity, the events that trigger the activity, the activity itself and performance measures. The activities remain the central focus (Hilton & Platt, 2011, p. 220).

The use of activity based management is to identify and eliminate unnecessary and dispensable activities, or necessary but inefficient and improvable activities. This process ultimately removes non-value-added costs. To do this, Hilton and Platt provide a five-step strategy for eliminating non-value-added costs in service industries (Hilton & Platt, 2011, pp. 221–222). The steps include the following.

- Identifying activities: Look at the most fundamental level
- Identifying non-value-added activities: by asking is the activity necessary? Is the activity efficiently performed? Is an activity sometimes value-added and sometimes non-value-added?
- Understanding activity linkages, root causes, and triggers: Understand how activities match up and work together to yield a final product or service.
- Establishing performance measures: Compare performance with other like activities and/or against a benchmark.
- Reporting non-value-added costs: Provides management the ability to improve and eliminate non-value-added costs.

This evaluation reviews the activity of ordering and delivering medical surgical supplies from the supplier PHS and delivering to the individual hospital wards and clinics. To create a standard of measurement, the three health care systems and their distribution are evaluated and reviewed to determine their associated costs, as well as cost variances between the different systems to show the cost effectiveness. Cost variance refers to the comparison of actual costs incurred to a set of standard costs (Hilton & Platt, 2011, p. 441). If a cost variance occurs that is less costly for the actual costs as compared to the created standard cost, then a favorable cost variance has occurred. If the actual cost is more costly than the standard cost to which it is compared, an unfavorable cost variance has then occurred.

The standard costs associated with the delivery and distribution of the supplies are examined, which include the following cost drivers: the quantity and price of the supplies, direct labor quantity and its cost, which is based on an average wage cost, vehicle costs and transportation costs, and the PHS contract fees. The direct-material cost variance, direct-material quantity variance, and the direct-labor cost variances are also reviewed. To do this effectively, models using (1) JIT/LUM and (2) the

conventional/break-bulk distribution systems with their accompanying costs are created, which are then compared directly to the actual systems to ascertain if one is more cost effective than the other.

In essence, a comparison of the fees paid to PHS for JIT/LUM delivery, vice the costs to do conventional/break bulk deliveries is completed. Costs reviewed in the conventional/break bulk delivery processes involve labor costs to break-bulk and perform in-house delivery, as well as any associated transportation costs. Note that any other logistics labor and overhead are not included in the scope of the analysis.

C. ASSUMPTIONS

1. Inventory Assumptions

Actual demand data was not directly available, only orders. Thus, an assumption was made that the average monthly/daily demand equaled the average monthly/daily quantities ordered over the period of one year.

Data gathered from Northern California and Palo Alto on orders received did not break down to the clinic level. Demand for the Oakland and San Jose clinics was derived from estimates based on the ordering information from the San Francisco clinics. Ordering information was only provided for the three main hospitals and San Francisco clinics. These assumptions were based on calculating the proportional order percentages of Palo Alto and Sacramento hospitals to the orders of San Francisco Hospital, and adjusting them to the San Bruno clinic level orders.

2. Cost Assumptions

Costing data information received was limited. VISN 21 provided a report that gave the LUM costs and number of LUM items for each system evaluated, but it was assumed that those numbers did not include any service costs. Other cost items were derived from indicated percentages of LUM to bulk items ordered by the three separate systems. Service costs were based off the LUM/bulk number of items ordered with the assumption previously mentioned, and what the PHS contract indicates.

Labor hours are derived from flow sheets provided by VISN 21. However, some assumptions were made on outlying clinics as only Northern California gave specific times for the outlying clinics. The authors were not given data for the Palo Alto and San Francisco outlying clinics. Therefore, labor hours for those outlying clinics are merely ad hoc assumptions based on the given times for Northern California clinics and their experience with similar medical care systems in the military. The numbers for the hub and spoke model for San Francisco were developed based of the information gathered from interviewing the logistics management staff. The authors also made assumptions on the time that it would take for Sacramento to breakdown supplies for the LUM costing example, which was based on the estimations from interviewing the logistics management staff.

Hourly labor costs for all three systems drive all labor costs, which are comprised of an average cost provided by Northern California of $20.00 per hour. An assumption was made that fringe benefits were 40%, which results in a total hourly labor cost, with overhead, of $28.00 per hour. All labor costs are for supply technicians only.

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IV. ANALYSIS

A. INVENTORY MANAGEMENT ANALYSIS

By properly managing inventory, the VA health care facilities can achieve higher service levels and lower supply costs. It is important to avoid overstocking and under stocking in both the primary and secondary inventories. Overstocking ties up a considerable amount of money in stock and increases the risk of damage, expiration, or obsolescence of the items. Under stocking creates the risk of unavailability of supplies, which affects the quality of patient care, which also creates additional purchase costs for emergency delivery costs and adversely affects the trust users have in the inventory management department.

To analyze data provided by VISN 21 staff properly, inventory management calculations were used. Calculations were based on the (S-1, S) policy, under which the VA facilities operate. This policy states that facility item managers set inventory levels at point S, and when any items are used (S-1), that amount is purchased to return to the designated S levels.

Although the information on monthly orders was provided for the entire year, data for January, February, March, and May was not used. Order quantities for these months at the Palo Alto, San Francisco, and San Bruno facilities were significantly out of normal ordering ranges. As the authors know of no change in underlying demand that would explain this fluctuation, it was assumed the fluctuation was caused by other factors (e.g., errors in order processing), and hence, eliminated the data for these months from the analysis. San Francisco hospital ordered 10,732 boxes of alcohol pads in February and negative 361 boxes (most likely they were returned to PHS) in March. The ordering range for the other eight months of the year at the San Francisco hospital was between 303 and 468 boxes per month. San Bruno clinic ordered 1,216 boxes of alcohol pads in February. The ordering range for the other eight months of the year at the San Bruno clinic was between 19 and 33 boxes per month. Palo Alto hospital ordered 311 boxes of

alcohol pads in January, 1,180 boxes in February and only 81 boxes in May. The ordering range for the other eight months of the year at the Palo Alto hospital was between 597 and 718 boxes per month.

San Francisco's and San Bruno's drastically higher orders in February could be due to a flawed quantity entry into the Omnicell machines by staff members. As the automatic Omnicell ordering system is fairly new to these facilities, it is possible that the quantities taken out of the Omnicells were entered at the higher amounts than the actual numbers, and Omnicells ordered higher quantities than needed. Similarly, wrong quantities could have been entered into the Omnicell machines at the Palo Alto hospital in January, February and May. Another explanation for high variability in orders for Palo Alto hospital during the months of January and February could be that in January, the facility did not order enough pads and had to order a higher quantity in February to increase its supplies.

San Francisco and Palo Alto facilities should consider implementing better ordering controls to avoid drastic variations in their orders. San Francisco can do this by setting up parameters in its Omnicell ordering system, which would not allow exceeding a certain number of items to be ordered. Palo Alto item managers would need to be more vigilant when placing manual orders to ensuring proper quantities are ordered. All facilities can also set parameters in all Omnicell machines, which would limit the numbers of taken items entered to the order up to levels. Providing additional training on proper usage of Omnicell machines to the users can also be very helpful. In addition, the inventory managers at the different facilities can ask PHS to be on the lookout for any unusual orders and inform the facilities of any findings.

The analysis examines demand, the standard deviation, lead time, safety stock and order up to levels, inventory costs, and services levels. In comparing these, what is currently being done and what will have to be changed to achieve a 99.75% service level is also reviewed, which is an efficient level that provides a constant stock protection.

1. Demand

Palo Alto hospital had the highest average monthly demand for alcohol pads of 670 boxes in comparison to San Francisco's demand of 408 boxes, and Sacramento's demand of 420 boxes. San Bruno clinic had the highest monthly demand of alcohol pads of 22 boxes in comparison to San Jose clinic's demand of 12 boxes, and Oakland clinic's demand is eight boxes.

Palo Alto hospital had the highest average daily demand for alcohol pads of 22 boxes in comparison to San Francisco's demand of 13 boxes, and Sacramento's demand of 14 boxes. San Bruno's clinic had the highest daily demand of alcohol pads for the clinic, which is 0.76 boxes in comparison to San Jose's demand of 0.4 boxes, and Oakland's demand is 0.27 boxes.

Facility	D	d
Sacramento hospital	420.94	14.03
Palo Alto hospital	670.64	22.35
San Francisco hospital	408.88	13.63
San Bruno clinic	22.74	0.76
Oakland clinic	8.16	0.27
San Jose clinic	12.05	0.40

Table 1. Average monthly and daily demand

2. Standard Deviation

San Francisco hospital had the highest standard deviation of average daily demand for alcohol pads of 11.15 in comparison to 8.37 at Palo Alto, and 5.44 at Sacramento. San Bruno's clinic had the highest standard deviation of average daily demand of 0.62 in comparison to 0.33 at San Jose, and 0.22 at Oakland.

Facility	σ_M	σ_d
Sacramento hospital	29.79	5.44
Palo Alto hospital	45.84	8.37
San Francisco hospital	61.08	11.15
San Bruno clinic	3.37	0.62
Oakland clinic	1.21	0.22
San Jose clinic	1.79	0.33

Table 2. Standard deviation of monthly and daily demand

3. Lead Times

Lead times vary amongst the VA facilities. San Francisco hospital has a lead time of one day, since the ordered items arrive daily at 0700, are restocked before 1400, and ordered automatically by an Omnicell server at 1400. Sacramento and Palo Alto hospitals have lead times of 2 days each. PHS delivers supplies to the Palo Alto hospital at 1000 and the items are restocked from SPD in the Omnicells around 1530. Afterwards, the orders are placed manually in the GIP using the Omnicell reports. Since the orders are placed after 1500, which is the same day order cut-off point for PHS, PHS receives an order the following day and delivers the next morning. Sacramento items are delivered from PHS in the afternoon and are restocked by 0700 the following day, after which new orders are manually placed in GIP.

The lead times at the clinics vary as well. Whereas the hospital staff delivers supplies for the Sacramento's Oakland clinic on Mondays and Wednesdays, the San Francisco and Palo Alto clinics have lead times of two days each because their supplies are delivered to them directly by PHS. Therefore, Northern California's Oakland clinic is the only one in this analysis with an average lead time of 3.57 days, whereas San Francisco has a lead time of one day, and all other facilities have lead times of 2 days each.

4. Current Safety Stock and Order Up To Levels

Sacramento hospital has three days and its Oakland clinic has four days of safety stock on hand. Palo Alto and San Francisco hospitals and their clinics maintain three days of safety stock. Based on the ordering history of the three main facilities, San Francisco hospital carries 40 boxes of alcohol pads on hand as a safety stock, and its order up to point is set at 54 boxes, for a total of four days of on hand supplies. Palo Alto hospital carries 67 boxes of alcohol pads on hand as a safety stock, and its order up to point is set at 111 boxes, for a total of five days of on hand supplies. Sacramento hospital carries 42 boxes of alcohol pads on hand as a safety stock, and its order up to point is set at 70 boxes, for a total of five days of on hand supplies. San Bruno clinic carries 2.3 boxes of alcohol pads on hand as a safety stock, and its order up to point is set at 3.8 boxes, for a

total of five days of on hand supplies. Oakland clinic carries 1.1 boxes of alcohol pads on hand as a safety stock, and its order up to point is set at 2.1 boxes, for a total of 7.6 days of on hand supplies. San Jose clinic carries 1.2 boxes of alcohol pads on hand as a safety stock, and its order up to point is set at two boxes, for a total of five days of on hand supplies.

Facility	SS	S	DOS
Sacramento hospital	42.1	70.2	5
Palo Alto hospital	67.1	111.8	5
San Francisco hospital	40.9	54.5	4
San Bruno clinic	2.3	3.8	5
Oakland clinic	1.1	2.1	7.6
San Jose clinic	1.2	2.0	5

Table 3. Current days of supply, safety stock, and order up to levels

5. Inventory Costs

San Francisco hospital's total monthly inventory cost for the alcohol pads is $681. Palo Alto hospital's total monthly cost for the alcohol pads is $1,074. Sacramento hospital's total monthly cost for the alcohol pads is $674. San Bruno clinic's total monthly cost for the alcohol pads is $38. San Jose clinic's total monthly cost for the alcohol pads is $19. Oakland clinic's total monthly cost for the alcohol pads is $13.

Facility	Monthly TC
Sacramento hospital	$674
Palo Alto hospital	$1,074
San Francisco hospital	$681
San Bruno clinic	$38
Oakland clinic	$13
San Jose clinic	$19

Table 4. Total monthly inventory costs

6. Current Service Levels

Based on the calculations, San Francisco hospital's current service level for alcohol pads is 99.987714%, Palo Alto's is 99.999999%, Sacramento's is 99.999998%, San Bruno's is 99.547432%, Oakland's is 96.827326%, and San Jose's is 99.547432%.

Facility	SL
Sacramento hospital	99.999998%
Palo Alto hospital	99.999999%
San Francisco hospital	99.987714%
San Bruno clinic	99.547432%
Oakland clinic	96.827326%
San Jose clinic	99.547432%

Table 5. Current service levels

In other words, for example, Sacramento should expect to stock out about two days (two inventory cycles) out of every 100,000,000 days, or about once every 136,986 years. San Jose, on the other hand, should expect to stock out about five days (five inventory cycles) out of every 1,000, or about 1.8 times each year. Clearly, a large variation exists in the service levels attained at the various clinics. (Oakland is different, because it does not have a daily inventory cycle)

7. Adjustment of Service Levels and Their Impact

Bringing the inventory maintenance of medical/surgical items to 99.75% service levels (less than once per year for a facility with a daily inventory cycle) will provide for proper inventory rates and ensure that no overstocking or under stocking occurs in the facilities. To achieve these levels, the three hospitals will need to decrease their safety stock levels, and the clinics will need to increase their stock levels slightly.

To achieve a service level of 99.75%, San Francisco would need to maintain 2.3 days of safety stock on hand, which is a 23% decrease to 31 boxes. It would also need to set the order up to point at 45 boxes, which is an 18% decrease from the current order up to level. San Francisco's days of stock on hand would decrease 18% with a total of 3.3 days of stock on hand.

Palo Alto hospital would need to maintain 1.5 days of safety stock on hand, which is a 50% decrease to 67 boxes. It would also need to set the order up to point at 78 boxes, which is a 30% decrease from the current order up to level. Palo Alto's days of stock on hand would decrease 30% with a total of 3.5 days of stock on hand.

Sacramento hospital would need to maintain 1.5 days of safety stock on hand, which is a 49% decrease to 22 boxes. It would also need to set the order up to point at 50 boxes, which is a 29% decrease from the current order up to level. Sacramento's days of stock on hand would decrease 29% with a total of 3.5 days of stock on hand.

San Bruno clinic would need to maintain 3.2 days of safety stock on hand, which is an 8% increase to 2.4 boxes. It would also need to set the order up to point at 3.9 boxes, which is a 4% increase from the current order up to level. San Bruno's days of stock on hand would increase 4% with a total of 5.2 days of stock on hand.

Oakland clinic would need to maintain 4.3 days of safety stock on hand, which is an 8% increase to 1.2 boxes. It would also need to set the order up to point at 2.6 boxes, which is a 27% increase from the current order up to level. Oakland's days of stock on hand would increase 27% with a total of 9.6 days of stock on hand.

San Jose clinic would need to maintain 3.2 days of safety stock on hand, which is an 8% increase to 1.3 boxes. It would also need to set the order up to point at 2.1 boxes, which is a 5% increase from the current order up to level. San Jose's days of stock on hand would increase 5% with a total of 5.2 days of stock on hand.

Facility	**Current SS**	**SS at 99.75% SL**	**% change**
Sacramento hospital	42.1	21.6	-49%
Palo Alto hospital	67.1	33.2	-50%
San Francisco hospital	40.9	31.3	-23%
San Bruno clinic	2.3	2.4	8%
Oakland clinic	1.1	1.2	8%
San Jose clinic	1.2	1.3	8%

Table 6. Current safety stock levels vs. safety stock levels at 99.75% service levels

Facility	Current S	S at 99.75% SL	% change
Sacramento hospital	70.2	49.7	-29%
Palo Alto hospital	111.8	77.9	-30%
San Francisco hospital	54.5	44.9	-18%
San Bruno clinic	3.7	3.9	5%
Oakland clinic	2.1	2.6	27%
San Jose clinic	2.0	2.1	5%

Table 7. Current order up to levels vs. order up to levels at 99.75% service levels

Facility	Current DOS	DOS at 99.75% SL	% change
Sacramento hospital	5	3.5	-41%
Palo Alto hospital	5	3.5	-43%
San Francisco hospital	4	3.3	-21%
San Bruno clinic	5	5.2	4%
Oakland clinic	7.6	9.6	21%
San Jose clinic	5	5.2	4%

Table 8. Current days of supply vs. days of supply at 99.75% service levels

B. COST ANALYSIS

To begin the cost analysis, the original data is presented that drives the costs of procuring the medical/surgical items, the associated labor, and the transportation costs associated with the items. The results are discussed and then post-hoc analyses of costs are done that would occur if the individual health systems were to move to either a strictly conventional/bulk delivery process or to a strictly LUM/JIT delivery process.

To create a standard of measurement, the three health care systems and their distribution processes are evaluated and examined to determine their associated costs. Cost variances between the different systems are evaluated and examined to show the cost effectiveness. As a reminder, cost variance refers to the comparison of actual costs incurred to a set of standard costs (Hilton & Platt, 2011, p. 441).

1. Data

Table 9 is a breakdown of the weekly delivery schedules. The delivery schedule shows the time for three major processes, which are breaking down the deliveries,

repackaging for clinic deliveries, and the time to restock the items into the Omnicell cabinets. All time is shown as labor minutes that it takes to accomplish the tasks just mentioned. The times shown on the delivery schedule for all of the main hospitals were gathered through a number of flow charts mapping the main sites processes, which were provided by VISN 21 and found in Appendix A. In addition, staff members were interviewed. The times in the delivery schedule for Northern California's outlying clinics were derived from interviewing staff members. Times indicated in the delivery schedule for Palo Alto Health Care System and San Francisco's outlying clinics were made based off the Northern California system. The authors took the time to do the different parts of the processes and applied that same methodology to the clinics where no time was given. When some of the clinics could not be derived appropriately, prior experience within military health care was used to estimate the time it would take to do the processes.

Weekly Delivery Schedules

All time is labor in minutes

Facility	Breakdown/Staging Time	# Technicians Breakdown/Staging	Total Breakdown/Staging Time	Repackaging Time	# Technicians Repackaging	Total Repackaging Time	Stocking Time	# Technicians Restocking	Total Restocking Time	# Deliveries per week	Travel Time	Miles Traveled	Total Time/Week
Sacramento Medical Center	300	4	1,200	0	0	0	1,800	4	7,200	5	0	0	8,400
McClellan Outpatient Clinic	0	0	0	60	1	60	60	1	59	1	50	26	169
Mare Island Outpatient Clinic	0	0	0	30	1	30	30	1	29	1	66	49	125
Fairfield Outpatient Clinic	0	0	0	0	0	0	30	1	29	1	106	102	135
Oakland Outpatient Clinic	0	0	0	40	1	40	60	1	60	2	332	368	432
Martinez Outpatient Clinic	420	2	840	0	0	0	1,680	2	1,678	7	0	0	2,518
Redding Outpatient Clinic	300	1	300	0	0	0	1,200	1	1,199	5	0	0	1,499
Chico Outpatient Clinic	0	0	0	15	1	15	20	1	20	1	138	138	173
Northern California TOTALS	1,020		2,340	145		145	4,880		10,274		692	683	13,451
San Francisco Medical Center	210	5	1,050	0	0	0	2,100	5	10,500	7	0	0	11,550
Down Town San Francisco	0	0	0	0	0	0	60	1	60	1	0	0	60
Clearlake	0	0	0	0	0	0	60	1	60	1	0	0	60
Eureka	0	0	0	0	0	0	60	1	60	1	0	0	60
San Bruno	0	0	0	0	0	0	60	1	60	1	0	0	60
Santa Rosa	0	0	0	0	0	0	60	1	60	1	0	0	60
Ukiah	0	0	0	0	0	0	60	1	60	1	0	0	60
San Francisco TOTALS	210		1,050	0		0	2,460		10,860		0	0	11,910
Palo Alto Medical Center Bulk	450	7	3,150	375	7	2,625	600	7	4,200	5	0	0	9,975
Palo Alto Building 7 LUM	70	7	490	0	0	0	840	7	5,880	7	0	0	6,370
Menlo Park	0	0	0	0	0	0	60	1	60	1	0	0	60
Livermore	0	0	0	0	0	0	60	1	60	1	0	0	60
San Jose	0	0	0	0	0	0	60	1	60	1	0	0	60
Capitola	0	0	0	0	0	0	60	1	60	1	0	0	60
Monterey	0	0	0	0	0	0	30	1	15	0.5	87	74	102
Stockton	0	0	0	0	0	0	60	1	60	0	0	0	60
Modesto	0	0	0	0	0	0	60	1	60	0	0	0	60
Sonora	0	0	0	0	0	0	60	1	60	0	0	0	60
Fremont	0	0	0	0	0	0	60	1	60	0	0	0	60
Palo Alto Totals	520		3,640	375		2,625	1,950		10,575		87	74	16,927

Notes:

Mare Island and Fairfield are done in the same run Mare Islands distance is shown from the Fairfield Clinic.

Clinics that list zero in time/technicians is because breakdown and restocking time are combined and only put under restocking.

Times are cut in half for Monterey Clinic because it receives one order every other week along with a technician drives down to restock cabinets

Table 9. Weekly delivery schedules

Tables 10 through 12 show the costs derived from an average labor rate, the delivery schedule above, cost of leasing vehicles, the number of items ordered, and their associated fees from the PHS. As stated in Chapter II, the supply technician labor cost per hour is estimated at $28.00 with fringe benefits. San Francisco has 26 FTEs who work in logistics management; not all are dedicated to medical/surgical inventory management. Palo Alto has 29 FTEs who work in logistics management; not all are dedicated to medical/surgical inventory management. Sacramento has 23 FTEs who work in logistics management; not all are dedicated to medical/surgical inventory management.

All costs are direct cost to medical/surgical items only. Indirect costs are not shown as they were not given by VISN 21 and are separate from the cost of other material and equipment procured through the VA systems. Other logistics labor and overhead are not included in the scope of the analysis.

To determine the number of LUM and bulk items, the authors received spreadsheets from VISN 21, which were assumed only LUM items and their costs, excluding the delivery charges. Through interviewing staff members, the authors found the percentages of LUM and bulk items for each of the three health care systems. The percentages are as follows: San Francisco's LUM items comprise approximately 5%, Palo Alto's 23%, and Northern California's 43%. The only LUM items ordered for Northern California are ordered from the Martinez location. Bulk items were derived from the percentage of LUM items and by applying the associated cost for the items, excluding the contracted delivery fee.

Transportation variable costs are for miles traveled, and the fixed cost is for the vehicles, the authors assumed that all vehicles are being leased. Transportation costs were derived from utilizing Google Maps, which provided the time and distances from the main hospitals to the outlying clinics. Some of the clinics are close to each other, and therefore, can be made on the same run, which is indicated in the tables if this were the case.

2. Current State

As shown in the annual costing data, a number of differences exist between the three different systems. The total costs are broken down to an average cost per item to eliminate the differences in the number of items ordered. As indicated in the annual costs sheets in Tables 10 through 12, Palo Alto purchases the most items of the three for a total of 385,354 items. Northern California purchases the second most orders, which totaled 136,035 items. San Francisco orders the least, by ordering 82,999 items. Thus, an indication of size and average cost per item can been seen, but as shown below, a large difference exists between the base price of each item ordered.

San Francisco Medical Center and its Outlying Clinics Annual Costs

124 Beds with 120 Nursing Beds
Total items ordered was 82,999

Items	Number of Items	Fixed Costs	Variable Costs	Total Costs
Bulk/Conventional items	3,952		$ 100,311.33	
Bulk/Conventional Fees 3.5%			$ 3,510.90	
Total Bulk Costs				$ 103,822.23
JIT/LUM Items	79,047		$ 2,006,226.63	
JIT/LUM Distribution Fees 7.5%			$ 150,467.00	
Total JIT/LUM Costs				$ 2,156,693.63
Labor	**Labor Hours**			
Breakdown/Staging Labor	910		$ 25,480.00	
Repackaging Labor	0		$ -	
Restocking Labor	9,412		$ 263,536.00	
Travel Time Labor	0			
Total Labor hours	10,322			$ 289,016.00
Transportation	**Mileage**			
Mileage Costs	0		$ -	
Vehicle Leas		$ -	$ -	
Total Transportation Costs				$ -
TOTAL				$ 2,549,531.86

Table 10. San Francisco Medical Center annual costs

Palo Alto Health Care System Annual Costs

897 Beds total items ordered was 385,354

Items	Number of Items	Fixed Costs	Variable Costs	Total Costs
Bulk/Conventional items	295,869		$ 6,482,589.71	
Bulk/Conventional Fees 3.5%			$ 226,890.64	
Total Bulk/Conventional Costs				$ 6,709,480.35
JIT/LUM Items	89,485		$ 3,297,765.11	
JIT/LUM Distribution Fees 7.5%			$ 247,332.38	
Total JIT/LUM Costs				$ 3,545,097.49
Labor	**Labor Hours**			
Breakdown/Staging Labor	3,155		$ 88,330.67	
Repackaging Labor	2,275		$ 63,700.00	
Restocking Labor	9,165		$ 256,620.00	
Travel Time Labor	75			
Total Labor hours	14,670			$ 410,761.87
Transportation	**Mileage**			
Mileage Costs	3,822		$ 726.18	
Vehicle Leas		$ 15,000.00	$ -	
Total Transportation Costs				$ 15,726.18
TOTAL				$ 10,665,339.71

Table 11. Palo Alto Medical Center annual costs

Northern California Health Care System Annual Costs

Sacramento Medical center has 60 Beds
Martinez has 120 Bed Community Center and extensive services
Total items ordered was 136,035

Items	Number of Items	Fixed Costs	Variable Costs	Total Costs
Bulk/Conventional items	77,328		$ 1,962,613.01	
Bulk/Conventional Fees 3.5%			$ 68,691.46	
Total Bulk Costs				$ 2,031,304.47
JIT/LUM Items	58,707		$ 2,367,996.44	
JIT/LUM Distribution Fees 7.5%			$ 177,599.73	
Total JIT/LUM Costs				$ 2,545,596.17
Labor	**Labor Hours**			
Breakdown/Staging Labor	2,028			
Repackaging Labor	126			
Restocking Labor	8,904			
Travel Time Labor	600			
Total Labor hours	11,658			$ 326,410.93
Transportation	**Mileage**			
Mileage Costs	35,526		$ 6,750.02	
Vehicle Leas		$ 15,000.00	$ -	
Total Transportation Costs				$ 21,750.02
TOTAL				$ 4,925,061.59

Table 12. Northern California Health System annual costs

Bulk items are fairly close in cost, which indicates the items ordered in bulk are likely similar; however, a difference exists in Palo Alto's costs. Some very large differences occur in the average LUM cost per item. Figure 7 shows that Northern California has the highest LUM cost, then Palo Alto and San Francisco has the least. Thus, it is thought that Northern California is, on average, ordering more expensive supply items than Palo Alto or San Francisco orders on average for LUM. However, when the cost of PHS fees is included, a dramatic difference in the cost per item is seen. Palo Alto has the lowest average costs per item. Palo Alto is 24% less than Northern California, and 10% less than San Francisco. When reviewing the annual costing figures, notice that both Northern California and San Francisco have the largest contributions to LUM. For this reason, the additional costs for LUM verses the conventional method of bulk ordering and the associated labor increase are evaluated.

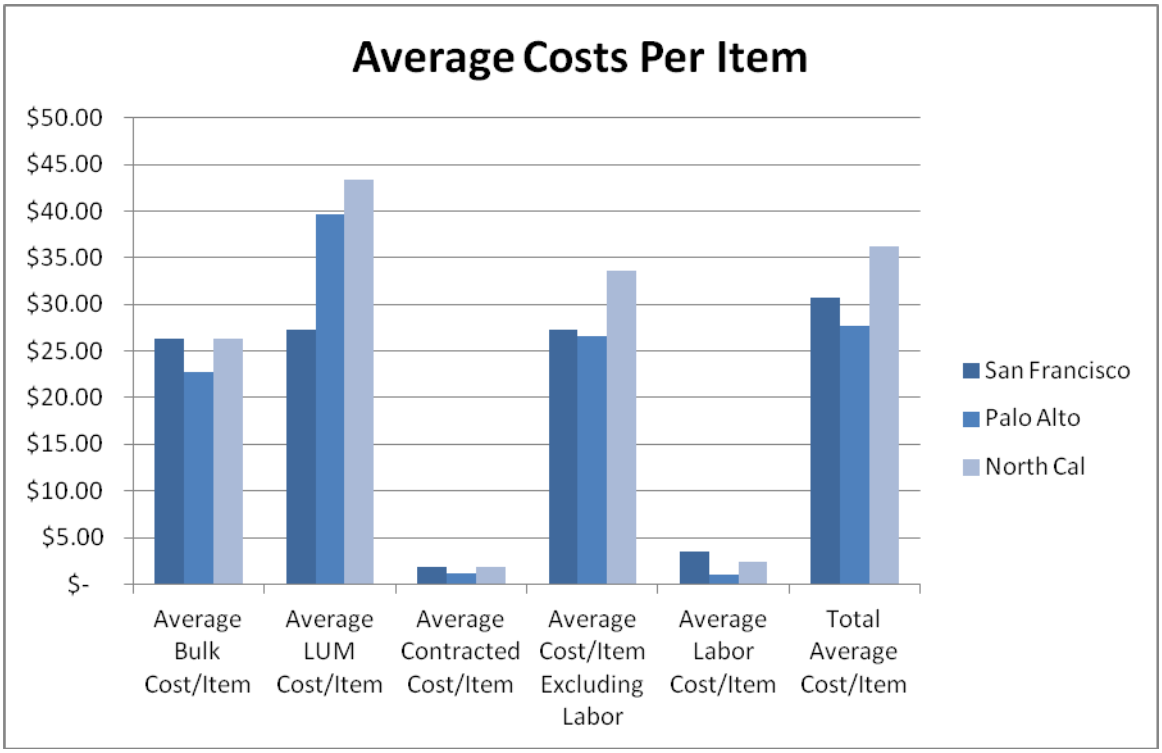

Figure 7. Average cost per item

3. Comparison of JIT/LUM to Conventional/Break Bulk Systems

To analyze the cost differences, two examples were created that show the differences between utilizing only a JIT/LUM ordering system or only a conventional/bulk system. By using the Northern California delivery schedule and annual costing worksheet, a virtual model was created that applied JIT/LUM to all orders, which will help determine what the cost differences will be compared to the current way of doing business. Also, San Francisco was included and virtual model of a fully conventional/bulk delivery process was created to compare it to the current delivery process it is using. Labor was adjusted for appropriately for both San Francisco and Northern California. As Palo Alto uses a hybrid distribution system, it was not included in this analysis. Tables 13 through 15 provide the adjusted results of the delivery schedule and Tables 16 through 18 show the adjusted results of the annual costs.

To compare a standard model of either conventional/bulk delivery or JIT/LUM delivery, it was necessary to create a virtual model of the delivery schedule and compare its associated costs with what is currently happening in VISN 21 health care systems. To create the virtual model, staff was interviewed to ascertain how the time of breaking/staging medical/surgical items would change and the time of repackaging medical/surgical items would take. Once these changes were understood, the following delivery schedules were created.

San Francisco's estimated delivery schedules for the conventional/break bulk example were developed by the authors. The generated numbers were based on the information given through interviewing the staff members at the hospital. It should be noted that breaking bulk/staging times and repackaging times are the only numbers that change. Restocking times do not change whether the health care system is using JIT/LUM or the conventional/bulk distribution process because both processes have been staged prior to the restocking of the items.

San Francisco Medical Center and Outlying Clinics Hub and Spoke Weekly Delivery Schedule Example

All time is labor in minutes

Facility	Breakdown/Staging Time	# Technicians Breakdown/Staging	Total Breakdown/Staging Time	Repackaging Time	# Technicians Repackaging	Total Repackaging Time	Stocking Time	# Technicians Restocking	Total Restocking Time	# Deliveries per week	Travel Time	Miles Traveled	Total Time/Week
San Francisco Medical Center	420	5	2,100	240	5	1,200	2,100	5	10,500	7	0	0	13,800
Down Town San Francisco	0	0	0	30	1	30	60	1	60	1	48	13	138
Clearlake	0	0	0	30	1	30	60	1	60	1	80	52	170
Eureka	0	0	0	30	1	30	60	1	60	1	596	540	686
San Bruno	0	0	0	30	1	30	60	1	60	1	48	29	138
Santa Rosa	0	0	0	30	1	30	60	1	60	1	74	60	164
Ukiah	0	0	0	30	1	30	60	1	60	1	307	167	397
San Francisco TOTALS	420		2,100	420		1,380	2,460		10,860		1,153	861	15,493

The best rout for delivering to Santa Rosa, Clearlake, and Ukiah would be one person driving to all three as they are in the similar direction and time is distributed accordingly.
Note that in this example we adjust for items now being ordered as Bulk verses the real scenario were the majority were LUM.

Table 13. San Francisco hub and spoke weekly delivery schedule example

The authors developed the Northern California's delivery schedules (shown in Table 14) for the JIT/LUM based off the information obtained through interviewing the logistics management staff at the hospital. It should be noted that breaking bulk/staging times and repackaging times are the only numbers that change. Restocking times do not change whether the health care system is using JIT/LUM or the conventional/bulk distribution process because both processes have been staged prior to the restocking of the items.

North California Health Care System JIT/LUM Weekly Delivery Schedule Example

All time is labor in minutes

Facility	Breakdown/Staging Time	# Technicians Breakdown/Staging	Total Breakdown/Staging Time	Repackaging Time	# Technicians Repackaging	Total Repackaging Time	Stocking Time	# Technicians Restocking	Total Restocking Time	# Deliveries per week	Travel Time	Miles Traveled	Total Time/Week
Sacramento Medical Center	200	4	800	0	0	0	1,800	4	7,200	5	0	0	8,000
McClellan Outpatient Clinic	0	0	0	0	0	0	60	1	59	1	0	0	59
Mare Island Outpatient Clinic	0	0	0	0	0	0	30	1	29	1	0	0	29
Fairfield Outpatient Clinic	0	0	0	0	0	0	30	1	29	1	0	0	29
Oakland Outpatient Clinic	0	0	0	0	0	0	60	1	60	2	0	0	60
Martinez Outpatient Clinic	420	2	840	0	0	0	1,680	2	1,678	7	0	0	2,518
Redding Outpatient Clinic	300	1	300	0	0	0	1,200	1	1,199	5	0	0	1,499
Chico Outpatient Clinic	0	0	0	15	0	0	20	1	20	1	0	0	20
Northern California TOTALS	920		1,940	15		0	4,880		10,274		0	0	12,214

Note in this example we have adjusted for all items to be LUM items verses the real scenario were there was a mixture of LUM and Bulk items.

Table 14. Northern California JIT weekly delivery schedule example

The authors developed the Northern California's delivery schedules (shown in Table 15) for the conventional/bulk example based off the information obtained through

interviewing the logistics management staff at the hospital. It should be noted that breaking bulk/staging times and repackaging times are the only numbers that change. Restocking times do not change whether the health care system is using JIT/LUM or the conventional/bulk distribution process because both processes have been staged prior to the restocking of the items.

North California Health Care Systeml Bulk Weekly Delivery Schedule Example

All time is labor in minutes

Facility	Breakdown/Staging Time	# Technicians Breakdown/Staging	Total Breakdown/Staging Time	Repackaging Time	# Technicians Repackaging	Total Repackaging Time	Stocking Time	# Technicians Restocking	Total Restocking Time	# Deliveries per week	Travel Time	Miles Traveled	Total Time/Week
Sacramento Medical Center	300	4	1,200	0	0	0	1,800	4	7,200	5	0	0	8,400
McClellan Outpatient Clinic	0	0	0	60	1	60	60	1	59	1	50	26	169
Mare Island Outpatient Clinic	0	0	0	30	1	30	30	1	29	1	66	49	125
Fairfield Outpatient Clinic	0	0	0	0	0	0	30	1	29	1	106	102	135
Oakland Outpatient Clinic	0	0	0	40	1	40	60	1	60	2	332	368	432
Martinez Outpatient Clinic	560	2	1,120	30	2	60	1,680	2	1,678	7	0	0	2,858
Redding Outpatient Clinic	300	1	300	0	0	0	1,200	1	1,199	5	0	0	1,499
Chico Outpatient Clinic	0	0	0	15	1	15	20	1	20	1	138	138	173
Northern California TOTALS	1,160		2,620	175		205	4,880		10,274		692	683	13,791

Note in this example we have adjusted for all items to be Bulk items verses the real scenario were there was a mixture of LUM and Bulk items.

Table 15. Northern California bulk weekly delivery schedule example

After deriving the delivery schedule, the authors used that information to calculate the annual costs for Northern California and San Francisco health care systems. Tables 16 through 18 show the results. Notice that the items on the annual costs examples have changed to reflect the virtual models delivery process. In addition, the transportation costs have changed to reflect the virtual models delivery process.

Northern California Health Care System Annual Costs Example

In this example of North California we adjust all conventional/bulk items to JIT/LUM and adjust labor appropriately

Sacramento Medical center has 60 Beds
Martinez has 120 Bed Community Center and extensive services
Total items ordered was 136,035

Items	Number of Items	Fixed Costs	Variable Costs	Total Costs
Bulk/Conventional items	~~77,328~~		$ -	
Bulk/Conventional Fees 3.5%			$ -	
Total Bulk Costs				$ -
JIT/LUM Items	136,035		$ 4,330,609.45	
JIT/LUM Distribution Fees 7.5%			$ 324,795.71	
Total JIT/LUM Costs				$ 4,655,405.16
Labor	**Labor Hours**			
Breakdown/Staging Labor	1,681			
Repackaging Labor	0			
Restocking Labor	8,904			
Travel Time Labor	0			
Total Labor hours	10,585			$ 296,393.07
Transportation	**Mileage**			
Mileage Costs	0		$ -	
Vehicle Leas		~~$ 15,000.00~~	$ -	
Total Transportation Costs				$ -
TOTAL				$ 4,951,798.23

Table 16. Northern California annual costs example of all JIT/LUM

Northern California Health Care System Annual Costs

In this example of North California we adjust all items to conventional/bulk and adjust labor appropriately

Sacramento Medical center has 60 Beds
Martinez has 120 Bed Community Center and extensive services
Total items ordered was 136,035

Items	Number of Items	Fixed Costs	Variable Costs	Total Costs
Bulk/Conventional items	136,035		$ 4,330,609.45	
Bulk/Conventional Fees 3.5%			$ 151,571.33	
Total Bulk Costs				$ 4,482,180.78
JIT/LUM Items	~~58,707~~		$ -	
JIT/LUM Distribution Fees 7.5%			$ -	
Total JIT/LUM Costs				$ -
Labor	**Labor Hours**			
Breakdown/Staging Labor	2,271			
Repackaging Labor	178			
Restocking Labor	8,904			
Travel Time Labor	600			
Total Labor hours	11,952			$ 334,661.60
Transportation	**Mileage**			
Mileage Costs	35,526		$ 6,750.02	
Vehicle Leas		$ 15,000.00	$ -	
Total Transportation Costs				$ 21,750.02
TOTAL				$ 4,838,592.40

Table 17. Northern California annual costs example of all bulk items

San Francisco Medical Center and its Outlying Clinics Annual Costs Example

In this example of San Francisco we adjust allJIT/ LUM items as conventional/bulk and adjust labor appropriately

124 Beds with 120 Nursing Beds
Total items ordered was 82,999

Items	Number of Items	Fixed Costs	Variable Costs	Total Costs
Bulk/Conventional items	82,999		$ 2,106,537.96	
Bulk/Conventional Fees 3.5%			$ 73,728.83	
Total Bulk Costs				$ 2,180,266.79
JIT/LUM Items	~~79,047~~		$ -	
JIT/LUM Distribution Fees 7.5%			$ -	
Total JIT/LUM Costs				$ -
Labor	**Labor Hours**			
Breakdown/Staging Labor	1820		$ 50,960.00	
Repackaging Labor	1,196		$ 33,488.00	
Restocking Labor	9,412		$ 263,536.00	
Travel Time Labor	999			
Total Labor hours	13,427			$ 375,963.47
Transportation	**Mileage**			
Mileage Costs	44,767		$ 8,505.69	
Vehicle Leas		$ 15,000.00	$ -	
Total Transportation Costs				$ 23,505.69
TOTAL				$ 2,556,230.26

Table 18. San Francisco annual costs example of all bulk items

After making the adjustments, the authors compared the cost information side by side to find the cost variance in the costs and labor hours. Again, cost variance refers to the comparison of actual costs incurred to a set of standard costs (Hilton & Platt, 2011, p. 441). Northern California is examined first and next San Francisco.

4. Northern California Health System Cost-Variance Analysis

The cost-variance of the different costs of contract fees, labor hours and transportation was examined to compare the current costs and the JIT costs. In Table 19, note that the cost of the contract has an unfavorable cost variance of $78,504.52, which is a -32% change. However, a favorable cost-variance in the labor hour costs of $30,017.87 occurred, which is a 9% change. Also, a favorable cost-variance in the transportation of $21,750.02 occurred, as it would no longer be used; thereby, eliminating all transportation costs. The overall cost-variance is an unfavorable variance of $26,736.64, which is a -4% change that indicates it is more costly to utilize a JIT/LUM distribution system for Northern California.

Northern California Cost Variance Analysis of Current Costs Vs. JIT Costs				
	Current Costs	JIT/LUM Costs	Variance	% Change
Contract Fee	$ 246,291.19	$ 324,795.71	$ (78,504.52)	-32%
Labor Hours	11,657.53	10,585.47	1,072.07	9%
Labor	$ 326,410.93	$ 296,393.07	$ 30,017.87	9%
Transportation	$ 21,750.02	$ -	$ 21,750.02	100%
TOTAL	$ 594,452.14	$ 621,188.78	$ (26,736.64)	-4%

Table 19. Northern California cost variance analysis of current costs vs. JIT costs

When looking at the cost-variances in Table 19, it is important to remember that North California Health Care System orders 43% of its current medical/surgical supplies through JIT/LUM, which are ordered through the Martinez clinics. To adjust for this situation, the Northern California costing and labor information was adjusted to indicate how it would look if all items were ordered as bulk. Again, this was based off interviewing staff members to make the estimates. Table 20 shows the result for Northern California Health Care System cost-variances.

Northern California Cost Variance Analysis of Bulk Costs Vs. JIT Costs				
	Bulk Cost	JIT/LUM Costs	Variance	% Change
Contract Fee	$ 151,571.33	$ 324,795.71	$(173,224.38)	-114%
Labor Hours	11,952.20	10,585.47	1,366.73	11%
Labor	$ 334,661.60	$ 296,393.07	$ 38,268.53	11%
Transportation	$ 21,750.02	$ -	$ 21,750.02	100%
TOTAL	$ 507,982.95	$ 621,188.78	$(113,205.83)	-22%

Table 20. Northern California cost variance analysis of bulk costs vs. JIT costs

As indicated, the cost variance changes dramatically with an unfavorable variance change from $78,504.52 to almost $100,000 more at $173,224.38. No change occurred to transportation. However, the favorable variance in labor should be noted. Overall, a negative cost-variance of $113,205.83 occurs, which indicates it is much more costly to use JIT/LUM under the current contract conditions.

5. San Francisco Medical Center Cost-Variance Analysis

The same type of approach was taken for San Francisco as for Northern California to examine the cost-variances; however, with San Francisco, not all items were changed to JIT/LUM as a low percentage (less than 5%) of items were ordered as bulk. Table 21 shows the results.

San Francisco Cost Variance Analsysis of Current Costs Vs. Bulk Costs				
	Current Costs	Bulk Costs	Variance	% Change
Contract Fee	$ 153,977.89	$ 73,728.83	$ 80,249.07	52%
Labor Hours	10,322.00	13,427.27	(3,105.27)	-30%
Labor	$ 289,016.00	$ 375,963.47	$ (86,947.47)	-30%
Transportation	$ -	$ 23,505.69	$ (23,505.69)	-100%
TOTAL	$ 442,993.89	$ 473,197.99	$ (30,204.09)	-7%

Table 21. San Francisco cost variance analysis of current costs vs. bulk costs

As indicated on the comparison, a favorable cost-variance in the contract fee of $80,249.07 occurred. However, an unfavorable cost-variance in labor of $86,947.47 did occur, which outweighs the favorable variance in contracting fees. An additional unfavorable cost-variance of $23,505.09 for transportation occurred, which yields an overall unfavorable cost-variance of $30,204.09. It could be concluded that it is better for San Francisco to utilize a JIT/LUM distribution system.

Although the San Francisco model currently shows an unfavorable cost-variance, it is important to consider that it is necessary to travel rather large distances from the San Francisco Medical Center to the outlying clinics. The travel rapidly increases both vehicle transportation and labor costs. With this in mind, San Francisco could utilize both systems, do JIT/LUM to the outlying clinics and move to a conventional/bulk system at the medical center.

6. Cost Recommendations

Under the current prime vendor contract and the situation of VISN 21, it is noted that using both JIT/LUM and conventional/bulk distribution processes may have the

potential to yield the least costs depending on the circumstances of the health care system. When both distribution processes are being utilized, great cost savings could be achieved as noted in the cost variance analysis. All three health care systems are currently utilizing some form of both JIT/LUM and conventional/bulk distribution processes; however, San Francisco is using a very small portion of the conventional/bulk distribution process.

As the contract is currently set up, and according to how the delivery processes are currently ran, it is very feasible to use a hybrid delivery process that mixes the type of contract being utilized by VISN 21 as a whole. All three individual health care systems can mix their distribution processes as well. For example, the cost variance analysis indicates that San Francisco contract costs could possibly be reduced by moving to a hybrid distribution system in which the medical center receives items in bulk at the 3.5% rate. It may save a substantial portion of money. In addition, the branch clinics could continue to utilize the JIT/LUM distribution process at the 7.0% rate and save on travel costs with the accompanying labor costs. Of course, this analysis does not include the cost of the space required in San Francisco to achieve this result.

Based on the cost variances, two major cost drivers are very important, the contracted rate being charged for the supplies and the travel between the clinics with its accompanying labor. Understanding these two factors gives a good indication of how VISN 21 and its health care systems should utilize the prime vendor contract with PHS. If transportation costs to the outlying clinics are higher than the JIT/LUM fees, then JIT/LUM may be a better choice over the conventional/bulk option. If transportation costs to the outlying clinics are less than the JIT/LUM fees, then utilizing the conventional/bulk option may be the better choice for the outlying clinics.

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V. DISCUSSION AND CONCLUSIONS

A. DISCUSSION

Based on the inventory analysis, the Sacramento hospital and Oakland clinic had the smallest variability in monthly orders, while the San Francisco hospital and San Bruno had the highest. The current safety stock and days of supply on-hand were not in alignment with each health care system's goals. The hospitals were carrying more inventory than needed, whereas the clinics did not have enough. The authors' recommendation is to set a service level of 99.75%, which would provide efficient and constant levels of stock protection. Decreasing the supplies on hand to a 99.75% service level at the hospitals and increasing them at the clinics would allow the facilities to keep their inventory stock levels at very efficient levels while providing outstanding logistical services to the customers. The service level approach is superior to the DOS approach. While seemingly uniform, given differences between facilities in terms of demand variability and lead time, the DOS approach will lead to very different protection levels at the different facilities, and although not demonstrated with the data, very different protection levels between stock-keeping units within a facility occur. The service level approach will allow the control of costs and stable protection levels across facilities and stock-keeping units.

The previous sections indicated that no "one-fit" distribution model exists for all three health care systems. In actuality, all three healthcare systems are currently utilizing some form of JIT/LUM and conventional/bulk ordering options. SFVA only orders a very small portion of conventional/bulk inventory in comparison to the VANCHCS and VAPAHCS systems. Both ordering options have the potential to yield the lower costs individually depending on the inventory management and distribution processes used within the healthcare system. The current PHS contract is set up to allow all three healthcare systems autonomy to decide the mix of JIT/LUM and conventional/bulk orders within their systems. Also, great cost savings could be achieved when utilizing a mix of both ordering options together, as noted in the cost variance analysis.

Two of the major cost drivers were the ordering rates being charged and the transportation costs to make deliveries to the outlying clinics, with their accompanying labor costs. Understanding these two factors gives a good indication of how the medical system should utilize the prime vendor contract. If transportation costs remain high, then utilizing JIT/LUM is better than utilizing the bulk system or if transportation costs are less than the JIT/LUM, then utilizing the bulk system is the better choice.

In addition to the recommendations made in the analysis portions, additional benefits have been identified in the systems that should be recognized. These benefits are the use of the Omnicell cabinets, benefits of JIT and the uses of hub and spoke systems. A discussion of each benefit follows. Additionally, it is pertinent to discuss a few areas for future study.

B. OMNICELL BENEFITS TO THE ORGANIZATION

Inventory management staff can utilize information collected by Omnicells to generate appropriate inventory policies. In-depth reporting and data analysis tools enable materials and item managers to equip themselves with information necessary to make better-informed decisions about supply usage and to improve the overall performance of the supply chain management system.

C. BENEFITS OF JIT

When JIT/LUM was implemented at San Francisco, the space needed to store inventory decreased from 9,500 to 6,500 square feet, which opened space to be reutilized for providing care to patients. The hospital's overall productivity increased by allowing employees to focus on its original tasks, such as nurses (and other healthcare providers) caring for patients instead of handling unnecessary inventory.

One of the goals of JIT is to match demand with supply accurately. The costs associated with unused inventory are minimized and holding costs of overstocking inventory can also be eliminated. Smaller orders and higher frequency of deliveries allow a hospital to respond to price fluctuations quickly, and switch to less expensive and/or better quality products. Wilson, Cunningham, and Westbrook documented three hospitals

that reduced inventories anywhere between 40–80% (Wilson, Cunningham, & Westbrook, 1992). Rivard-Royer reported that hospitals reduced full time equivalents (FTEs) by 45% (Rivard-Roy, Landry, & Beaulieu, 2002). Nathan and Trinkaus noted two hospitals with item fill rates over 99%, compared with a conventional average of 92% (Nathan & Trinkaus, 1996).

Although implementing JIT can be very beneficial, it is necessary to be aware of certain risks because of the nature of how hospitals work. The major concern is the unpredictability of hospital work volume. A low level of inventory can create risk when the demand unexpectedly increases. Since the hospital services provided can mean the difference between life and death, inventory levels need to be carefully managed to avoid running out of supplies. One way to avoid stock out is to keep some amount of safety inventory, as all three health care systems currently do. However, if the goal is to reduce costs due to future budgetary constraints, the current levels of safety stock should be further evaluated as a possible solution to cutting costs.

D. USES OF HUB AND SPOKE DISTRIBUTION SYSTEMS

Maria Weiskott describes a hub and spoke model as, "The distribution model's hub is the location that holds inventory for a large region, with each spoke leading to a smaller distribution center, which houses inventory for a smaller region. Proximity to the customer is the driver here, with the goal being to supply a maximum amount of customers in a minimum amount of time" (Weiskott, 1999), which is essentially how Northern California works.

Some suggest that the goal of supplying the maximum amount of clinics in the least amount of time can be accomplished without the hub and spoke distribution system. However, Weiskott said,

> Hub and spoke still has its applications, but it worked particularly well when distribution was considered an autonomous function. Today, however, a strategy of total supply chain management is replacing distribution as a singular function. Several fundamentals are making this evolution possible. (Weiskott, 1999)

In this analysis, it has been shown that in certain circumstances, the hub and spoke distribution process may have greater applicability than JIT. However, caution should be used because in the circumstances with the distribution systems in this analysis, JIT/LUM are one in the same, which is not always the case with all organizations.

E. EXTENSIONS

A standard cost for labor hours for supply technicians provided by the VA was used. It could be beneficial to do a cost variance analysis between the systems using the actual rates of the employees involved in the processes of the delivery of medical and surgical supplies.

Another factor to consider would be an analysis of the quantity purchased (orders) versus the quantity used (demand). This safety stock analysis was based on orders as a surrogate for demand for the purposes of demonstration. However, a systematic analysis should use demand to provide more accurate safety-stock recommendations.

If VISN 21 decides in the future to move to a bulk system, it should utilize a modeling and simulation for travel times to each clinic so that only one van could go to multiple places in one run. Mare Island Clinic and Fairfield Clinic are currently doing something similar, as logistics management staff delivers to both places in one run.

Due to the nature of medical logistics, frequent stock outs could have negative results in life or death situations. The logistics management staff focuses heavily on ensuring a good amount of safety stock is on hand, but the limit to this stock rests with each individual health care system, which is resulting in too much inventory on hand. VISN 21 should look into its incentive programs to improve its inventory management processes. Rewards should be given for meeting goals and maintaining certain levels of supply on hand, as well as reprimands for overstocking and stock outs. Only focusing on the negative outcomes will continue to lead to overstocking, spoilage, and obsolescence.

After seeing the advantages and disadvantages of each distribution model within VISN 21, it may prove to very beneficial to conduct a future analysis of a hybrid (JIT and hub and spoke mix) distribution model tailored for each individual health care system. However, more data would be required.

F. CONCLUSION

Each of the three health systems in the VISN 21 network was described. Many differences exist between the three in how they operate and how they utilize the contract with PHS.

The authors found that the safety stock on hand varies from facility to facility. In addition, they have provided recommendations to achieve an appropriate service level that could be maintained at a constant level across items and across facilities. The alcohol pads example can act as a sample model that shows the methodology applicable to other medical/surgical items.

The authors also analyzed the costs to place orders under JIT/LUM and conventional/bulk orders, as well as created a virtual model based off information received from interviewing staff. These models show that cost benefits do exist to utilizing a mix of JIT and the hub and spoke processes. They also gave some recommendations to further the distribution system to maximize service levels and decrease costs. Some of the suggestions include further research in the area of medical/surgical inventory.

It is the authors' hope that this project can act as a model for VISN 21 to further its progress of its inventory management processes in addition to being able to continue to build a renowned process. They also hope that the case study in Appendix B can serve the professors well in teaching inventory management principles to their students.

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APPENDIX A.

A. VISN 21 FLOW CHARTS

The following charts are the physical inventory and the informational data flow charts provided by the VISN 21 staff.

1. Physical Inventory Flow Charts

Physical inventory flow charts shown in Figures 8 through 11 show the inventory management tasks and the times that it takes to accomplish each task in the process. The flow charts vary in complexity and completion times depending on the inventory processes each facility uses.

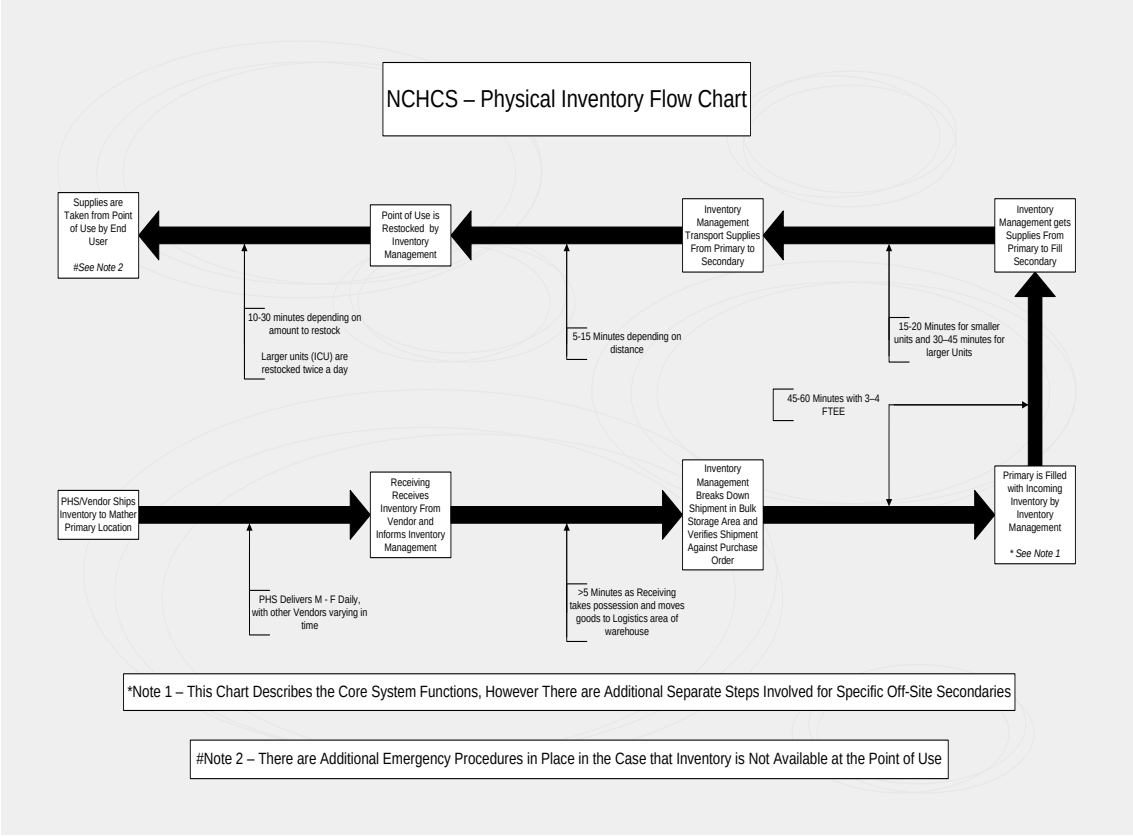

Figure 8. Northern California physical inventory flow chart

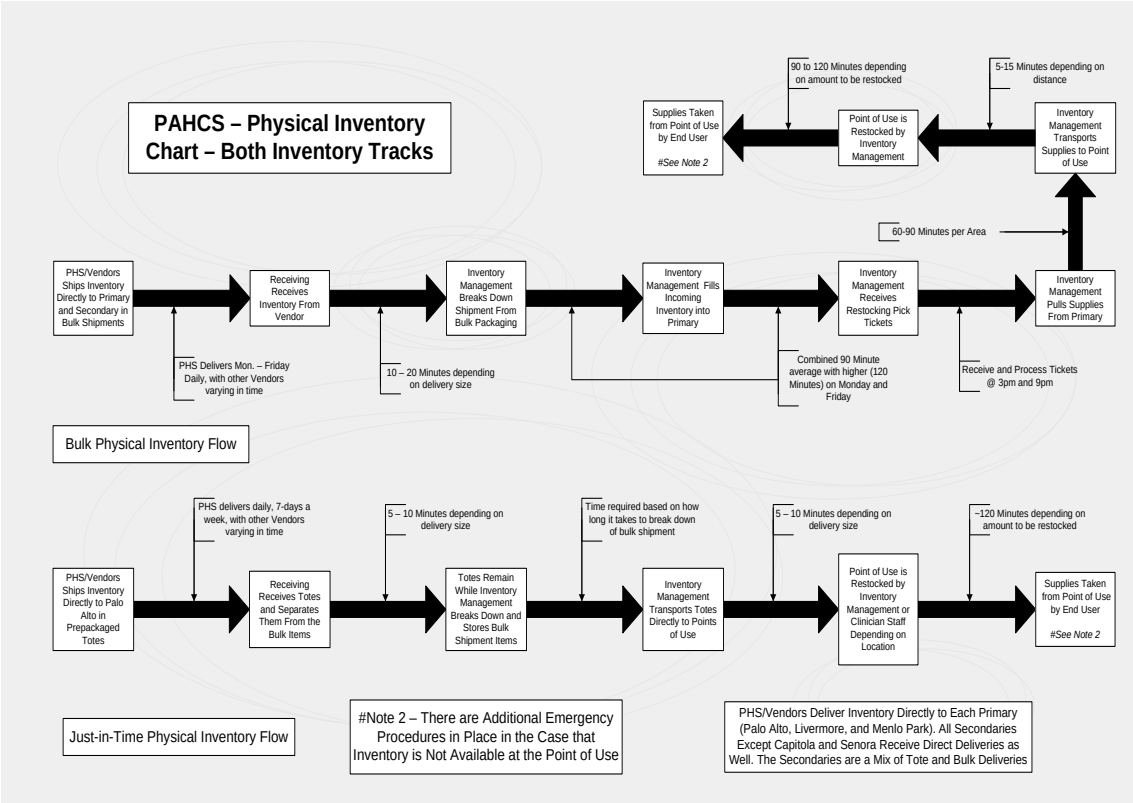

Figure 9. Palo Alto physical inventory flow chart

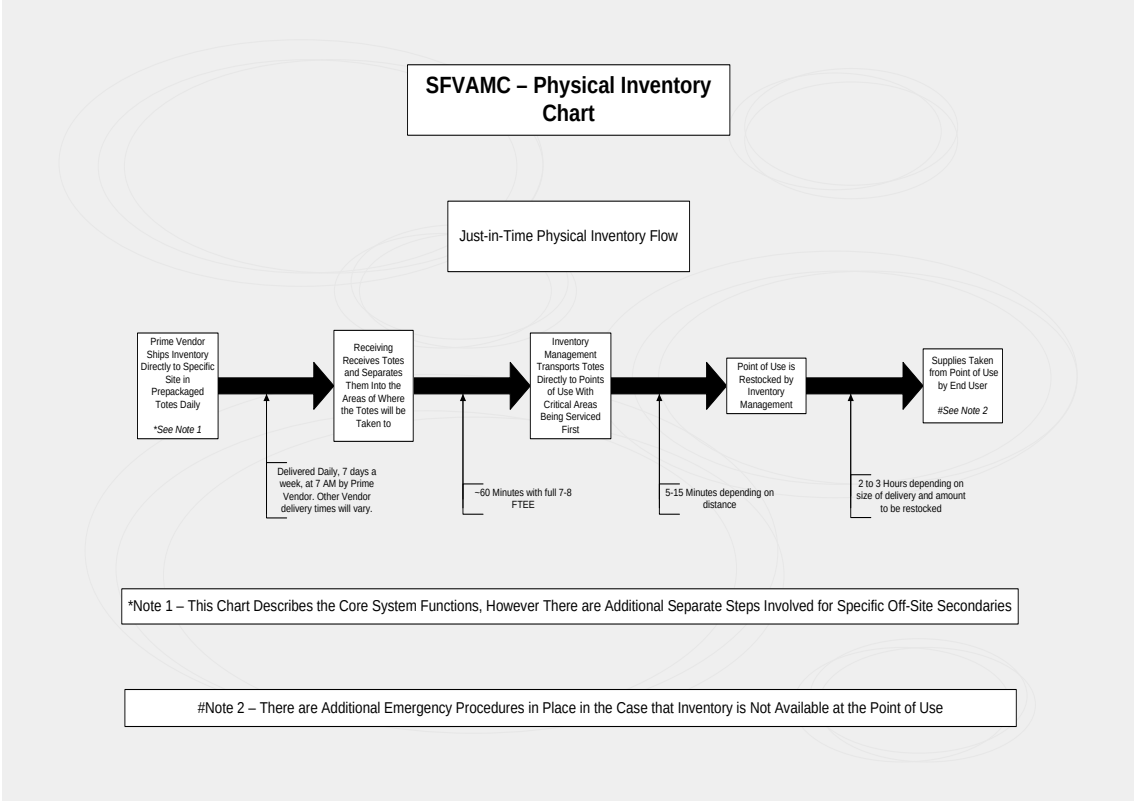

Figure 10. San Francisco physical inventory flow chart

2. Information Data Flow Charts

Information data flow charts shown in Figures 11 through 13 show the ordering data flow from the logistics management staff to the prime vendor, PHS. The flow charts vary in complexity and completion times depending on the inventory processes each facility uses.

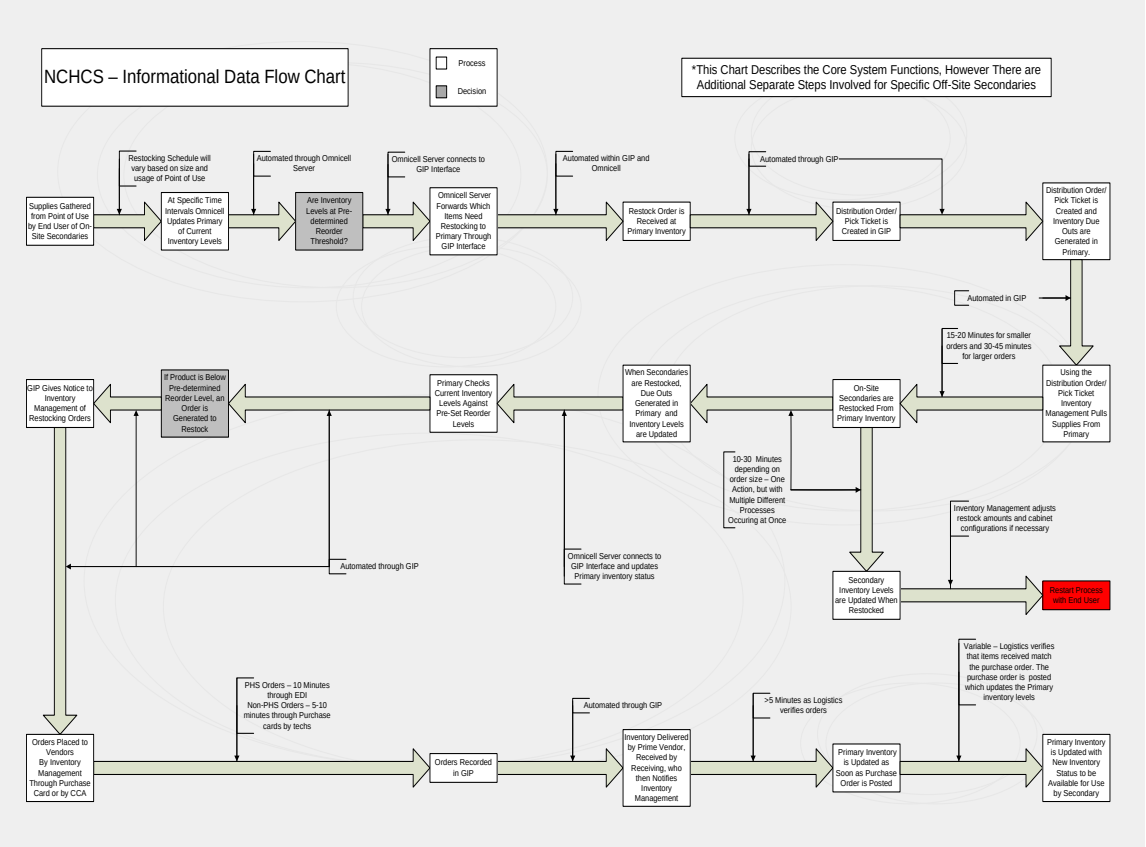

Figure 11. Northern California information data flow chart

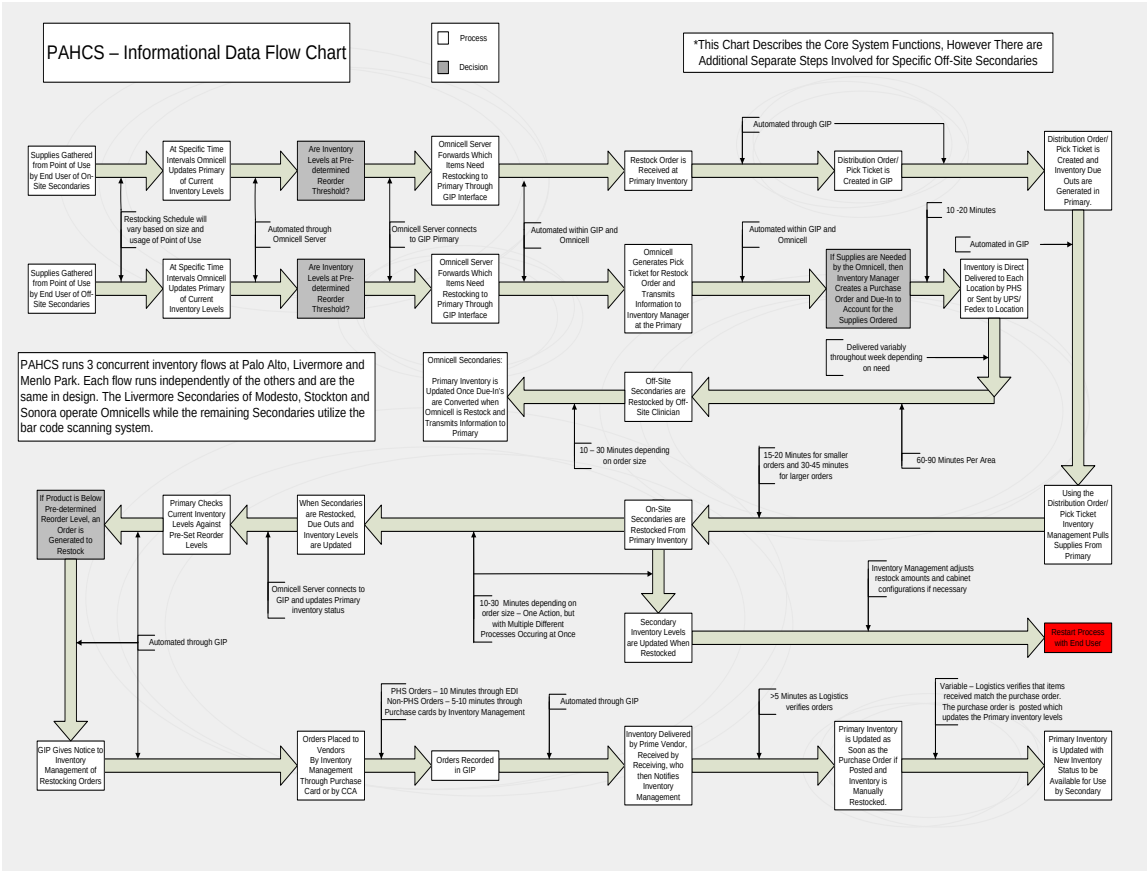

Figure 12. Palo Alto information data flow chart

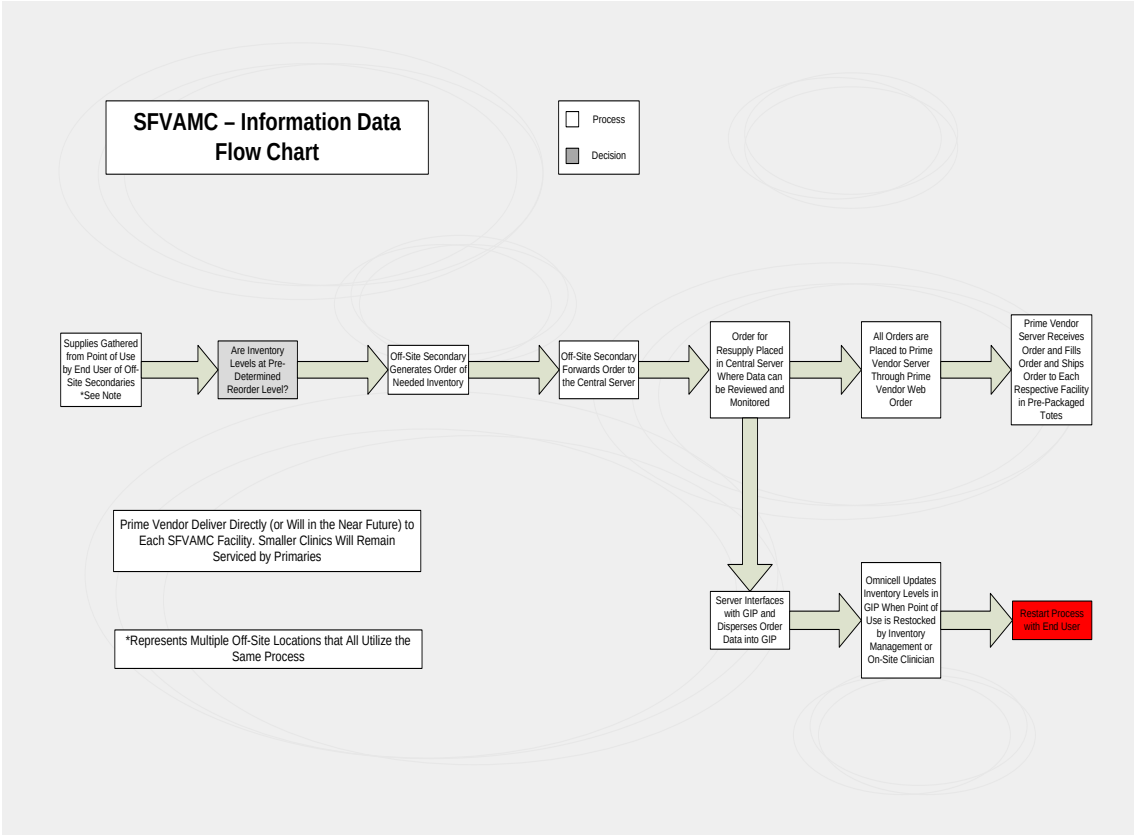

Figure 13. San Francisco information data flow chart

APPENDIX B. THE CASE STUDY

A. INTRODUCTION

A recently appointed Chief Logistics Officer (CLO) at Veterans Administration Sierra Pacific Network (VISN 21) has been reviewing the performance of the distributions systems within his network. He has three health systems closely located geographically using three different types of distribution systems. The CLO wants to reduce overhead costs, provide a standard process for medical and surgical supplies, reduce the value (level of stock) on hand, shorten the supply chain, leverage contractor support, free up FTEs to divert to other duties, and to reduce space requirements for managing inventory. His goal is to determine if it is possible standardize to one supply system throughout all of VISN 21. If so, which system should he use? To start working towards this goal, the CLO's primary focus is on the medical and surgical consumable supplies only due to their associated costs and space.

VISN 21 has seven medical centers/health systems under its control. Of those seven, the CLO is focusing on three: VA Northern California Health Care System (Northern California), San Francisco VA Medical Center, and VA Palo Alto Health Care System (Palo Alto). Most of the medical/surgical supplies are stored in an electronic shelving system called Omnicell. VISN 21 has a contract with one prime vendor, Professional Hospital Supply Inc. (PHS).

B. VISN 21 CONTRACT

VISN 21 contracted Professional Hospital Supply Inc. (PHS) to provide the majority of its medical and surgical supplies. Roughly 90% of its supplies are purchased through PHS. The remaining items are procured through a government purchase card. PHS allows the hospitals to order items in bulk, as well as low-unit-of-measure. No backorders occur as all orders are kill or fill; i.e., if PHS has the item on hand, the order is filled; otherwise, the order is canceled.

The current contract contains the following provisions.

- Distribution fees:
  - Conventional Delivery Method or Bulk: 3.5%
  - Just-in-Time Delivery Method or Low-Unit-of-Measure (LUM): 7.5%
  - Note that distribution fees for LUM must be quoted as a stand-alone fee. Fees must not be incremental to the conventional/bulk delivery fee. (Richards, 2010)
- Fill Rates:
  - Conventional: 95% deliveries per week
  - Just-In-Time: 98% deliveries per week
- Emergency Deliveries:
  - Four monthly deliveries per account at no additional cost. Thereafter: $125 per delivery.

C. PROFESSIONAL HOSPITAL SUPPLY, INC. (PHS)

Founded in 1981, PHS is one of the nation's oldest regional suppliers of medical and surgical supplies. PHS utilizes a Custom Packaging Information System (CPIS), which helps meet requirements in a timely and accurate manner especially with low-unit-of-measure items. CPIS consists of a comprehensive set of tools that maintain hospitals custom kit specifications, monitor hospital usage, and control each production run. PHS can track hospital usage patterns and schedule the appropriate production runs to ensure uninterrupted service. PHS tracks all their raw material component requirements, and maintains and factors historical lead-times into the production model. The system utilizes Electronic Data Interchange (EDI) and auto fax technology to work efficiently with its supplier partners (Professional Hospital Supply, Inc., 2011).

1. PHS Packaging

PHS delivers medical and surgical supplies to VISN 21 in two packaging options.

- Bin Packaging: This is a low-unit-of-measure (LUM) system. Medical materials in bulk packages are broken down to an "each" unit-of-measure for distribution. Each ward/clinic is assigned a plastic bin in which PHS employees place the ordered items. The bins are then delivered to the loading docks of the requesting facilities, staged for item managers, and

delivered to the wards/clinics. All facilities in the San Francisco system, a few facilities in the Sacramento (Northern California), and all the outlying facilities in the Palo Alto system use this option.

- Bulk Delivery: Items will be ordered from PHS in bulk (boxed and placed on a palate) and then delivered to the central warehouse of the hospital/health system where the boxes are then broken down and the supplies are then delivered to each ward/clinic as needed.

2. PHS Delivery

PHS operates its own fleet of trucks, which consists of full size semi-trucks to smaller size delivery vans. PHS delivery drivers are responsible for the hospital shipment all the way to its designated delivery point, whether there is a receiving dock or a stock station on the hospital floor or not. However, ownership of the supplies is transferred to the hospital once a case or cart is stocked at the PHS facility. Deliveries are available 24 hours a day, 365 days a year. For VISN 21 health systems, deliveries arrive at various times throughout the day ranging from 0700 to 1700.

3. Ordering with PHS

Customers can order electronically, by phone, or fax, 24 hours a day, 365 days a year. The majority of the orders are placed electronically through electronic data interchange (EDI) in conjunction with the Omnicell systems at the hospitals/clinics. The Omnicell system is discussed later.

D. SUPPLY, PROCESSING, AND DISTRIBUTION DEPARTMENT (SPD)

Supply, Processing, and Distribution (SPD), also referred to as the primary, is a centrally managed section of the medical center responsible for receiving, storage, and distribution of medical and surgical supplies. SPD is a sterile environment and all incoming medical and surgical supplies are removed from shipping boxes before entering storage. The goal of San Francisco, Palo Alto, and Sacramento hospital SPDs is to maintain three days of safety stock on hand.

All VA facilities utilize Omnicell for providing secured, automatic dispensing of supplies in medical departments. Access to supplies is limited to employees provided passwords. These cabinets not only allow for tracking usage and ordering of supplies, but also reduce the consumption and loss of products.

Palo Alto and Sacramento facilities utilize GIP system to generate orders; whereby San Francisco hospital uses Omnicells. GIP is a Veterans Affairs electronic system used to manage inventory within SPD areas. The primary inventory is the SPD inventory, and the secondary inventories are the points of distribution (wards/clinics). Stock levels are established to maintain constant availability of items. These levels are as follows.

- Normal stock levels—represent the largest amounts of items to be maintained in the primary (SPD shelves).
- Secondary stock levels—represent the amounts of items to be maintained in the Omnicells.

GIP has the ability to auto-generate orders. In other words, the computer automatically reviews preset inventory levels against current amounts on-hand and identifies those items below the preset levels so that they may be requisitioned. Primary and secondary inventories are reviewed on a regular basis utilizing GIP-generated reports.

- History of Distribution Report—shows the total dollar amount of supplies distributed to each secondary. This information is useful in computing quarterly and annual budget reports and compiling a Cost Distribution Report (CDR).
- Inactive Item Report—gives a list of items for a specific period of time that have been inactive, which allows a determination to be made as to whether an item should continue to be stocked.
- Usage Demand Analysis Report—used to evaluate item usage and show an increase/decrease in usage; thereby, indicating a need to change stock levels.

Computerized bar code labels identify each item within the inventory. The medical supply technicians use bar code readers to scan the labels to identify the items

and then enter the actual amounts. After scanning the inventory, the information is uploaded into GIP, and a picking ticket is generated. The picking ticket identifies the items and amounts required to be restocked to.

E. OMNICELL

Omnicell is a computer automated supply cabinet-based system whose purpose is to increase overall efficiency and productivity of health care facilities by providing a convenient, secure, and flexible system for managing health care supplies. The system allows quick and easy access to supplies, improves data capture, reduces consumption and inventory, and enhances inventory and information management.

Cabinets are placed throughout the hospital and are accessed only by authorized users to pull inventory. Once an item is removed from the Omnicells, medical personnel input the transactions directly on the Omnicell computers or by pressing "take" buttons located on the appropriate cabinets bin. These systems keep continuous inventory records and automatically can place orders based on the established reorder and order-up-to points. By applying accountability to staff using the inventory, Omnicell can assist in reducing shrinkage and increase cost capture.

Another claimed benefit of Omnicell is that it allows for visibility into the entire hospital's inventory. For common consumables, a shortage in one ward can be mitigated with inventory from another ward until the next replenishment arrives. This advantage of added visibility from Omnicell increases the resiliency of the hospital supply chain under emergency demand situations.

A unique feature of Omnicell systems includes a server application that facilitates day-to-day operational management of multiple systems in a single or across multiple facilities. A materials manager in charge of a hospital and outlying clinics has full visibility of usage trends in all facilities. Standard and customized reports can be generated from a centralized database to provide complete information on supply inventory and product use. As with the case of VISN 21, Omnicells' distribution information system is integrated with the VA's own electronic supply system, which reduces manual data entry between different systems and departments.

Currently, no standardized ordering process exists within the VISN 21 health care systems. As such, the process is different at each of the three health care systems. The San Francisco health care system places orders directly from its Omnicells at all facilities. The Palo Alto health care system places orders directly from its Omnicells only at building seven on the Palo Alto campus and at its outlying clinics. The primary facility on the campus places manual orders to PHS via the GIP ordering system. The VA Northern California Health Care System does not place any orders to PHS via its Omnicells.

1. Benefits of Omnicell Systems

- Achieve real-time, usage-based perpetual inventory management for medical supplies located throughout the health care facility.
- Reduce stock outs and the associated time spent filling last-minute requests from nursing.
- Lower overall costs by reducing inventory levels and increasing inventory turns.

F. NORTHERN CALIFORNIA HEALTH CARE SYSTEM

The VA Northern California Health Care System (Northern California) is part of the Veterans Integrated Service Networks (VISN). Northern California has a network of 12 clinics in seven areas thought the northern California region. The Northern California network provides a plethora of services from dental, mental health, pharmacy, physical medicine and rehabilitation, women's health, surgery, and social work services. The Sacramento VA Medical Center is the hub of Northern California operations; it is a 60-bed state-of-the-art inpatient facility offering a full range of comprehensive health care services (VA Northern California Health Care System, 2011).

1. Distribution System

Like all VISN 21 networks, Northern California utilizes PHS as the primary vendor for their medical and surgical supplies. Most of the PHS shipments come to the main facility in Sacramento in bulk, are broken down, and then distributed out to the clinics and other sites.

Northern California strives to maintain three days of safety stock on hand to meet the demands of the clinics and prevent stock outs. It also has a sterile processing and distribution room and almost all inventories are stocked in Omnicell cabinets in the individual clinics for which the supplies are intended to be used.

2. Deliveries

To deliver all medical/surgical supplies to the medical center and the outlying clinics in Northern California, a modified hub and spoke delivery system is used. Sacramento Medical Center acts as the main hub and receives orders directly to its warehouse from PHS in bulk, Monday through Friday. The process begins first thing in the morning; first, the delivery is broken down and the supplies are pulled per order requests and then staged for item managers to deliver the supplies to individual wards and clinics throughout the medical center and its campus. In addition, the Sacramento Medical Center supplies are also broken down to fill order requests to be delivered to the following outpatient clinics via a VA supply technician: McClellan Clinic, Mare Island Clinic, Fairfield Clinic and the Oakland Clinic.

McClellan Outpatient Clinic supplies are to be delivered to McClellan every Wednesday. Mare Island Outpatient Clinic supplies are to be delivered to the Mare Island Clinic every Sunday. Currently, a supply technician will go to Mare Island and to the Fairfield Outpatient Clinic on the same run every Sunday. Oakland Outpatient Clinic supplies are delivered every Monday and Wednesday.

Martinez Outpatient Clinic receives the medical/surgical supplies every day from PHS in LUM. The Redding Outpatient Clinic supplies come from PHS directly Monday through Friday in bulk. In addition, the Redding Clinic breaks down the bulk orders and then forwards some of them on to the Chico Outpatient Clinic. Chico supplies are delivered every other week on Wednesday.

Table 23 lists the time that it takes for the weekly delivery schedules under the data section, in addition to the driving times to and from the clinics.

G. SAN FRANCISCO HEALTH CARE SYSTEM

San Francisco Veterans Affairs Medical Center (SFVA) is a level one facility that provides services to more than 310,000 veterans living in an 8-county area of Northern California. The facility also manages six outlying clinics and a veteran's nursing home.

1. Distribution System

The SFVA medical center and its outlying clinics utilize a form of just in time inventory (JIT) distribution system. SF hospital strives to keep three days of safety stock inventory on hand. The safety inventories of medical/surgical supplies are stored in the SPD. San Francisco Hospital's inventory cost was reduced by approximately 20% when it originally implemented JIT with the use of Omnicell. All supplies are housed in the Omnicell cabinets excluding those in SPD.

The hospital utilizes PHS as the prime vendor for medical/surgical items. When using JIT, PHS delivers medical/surgical supplies in low units of measure rather than bulk quantities. Orders are delivered daily to the SFVA medical center and on a weekly basis to the clinics. If the ordered quantity for the clinics is too small for truck delivery, the items are shipped via UPS.

For the distribution of supplies to the departments, the hospital and the clinics use Omnicell cabinets. The SFVA health care system has 150 Omnicells. Medical/surgical items are delivered and placed in Omnicells every day before 1400 by the logistics personnel. In addition to storage, Omnicells are also used for placing electronic orders directly to PHS. Each day at 1400, the Omnicell computer generates orders via the hospital's main Omnicell server and sends the orders to PHS. This automated system simplifies the ordering process and accelerates the supply replenishment process. The item managers in the hospital's inventory management department and designated personnel in the clinics set up the orders up to levels

H. PALO ALTO HEALTH CARE SYSTEM

The VA Palo Alto Health Care system (VAPAHCS) consists of three inpatient facilities located at Palo Alto, Menlo Park, and Livermore, in addition to seven outpatient

clinics in San Jose, Capitola, Monterey, Stockton, Modesto, Sonora, and Fremont. With nearly 900 beds, including three nursing homes and a 100-bed homeless domiciliary to serve more than 85,000 enrolled veterans, these facilities provide some of the world's finest medical care and cutting-edge technology (DoVA, 2011).

1. Distribution System

VAPAHCS has a multi-echelon system utilizing two distribution processes; a hub and spoke model (centrally located stock) and just- in- time (low- unit- of- measure) supply chain distribution systems. The Palo Alto campus utilizes the hub and spoke distribution system, with the exception of building 7. Building 7, along with the other nine outlying facilities, utilize the JIT distribution system.

VAPAHCS also strives to maintain three days of safety stock on hand to meet the demands of the clinics and prevent stock outs. All medical and surgical supply inventories are stocked in SPD and the Omnicell cabinets throughout the system.

2. Deliveries

Supply operations are conducted Monday–Friday. All supplies are ordered from the prime vendor, PHS. The main Palo Alto facility receives bulk and low unit of measure shipments from PHS. Daily at 1400, the Omnicells send pick orders to the Omnicell website. The logistics management personnel in the primary pull the new pick orders from the website and convert these orders into the GIP system to replenish supplies from PHS. Orders are received the next day and the process is restarted. Bulk shipments are broken down and placed in the primary storage area or SPD, from which all the secondary areas, such as the hospital wards and ancillary health care facilities on the main campus, replenish their supplies. All supplies in the secondary areas are stored in Omnicells.

Building 7 and the outlying facilities utilize the JIT distribution system. Once a week supplies are replenished through the Omnicell electronic ordering process. When

Omnicell is downloading the pick orders for the next day, instead of going to the primary, these orders are sent directly to PHS. PHS breaks down these orders into low units of measure and places them into bins and deliver the next day.

I. COMPARING COSTS

To compare a standard model of either conventional/bulk delivery or JIT/LUM delivery, a virtual model of the delivery schedule has been created to compare its associated costs with what is currently happening in VISN 21 health care systems. Staff members were interviewed to create the virtual to ascertain how the time of breaking/staging medical/surgical items would change and the time it would take to repackage medical/surgical items. Once these changes were understood, the delivery schedules were created and listed in the costing data.

J. DATA

1. Inventory Data

To suggest a systematic approach to setting the value of S for all inventory items, only a single item has been given. A single item is sufficient to make the demonstration and illustrate the differences between policies. The analysis is based on the demand data provided for Alcohol Pads. These pads are ordered from PHS in boxes of 200 each and are a commonly used item amongst all facilities.

Facility	C	QTY/UM	σ_M	σ_d	D	d	h	LT
Sacramento hospital	$1.60	200	29.79	5.44	420.94	14.03	$0.009	2.00
Palo Alto hospital	$1.60	200	45.84	8.37	670.64	22.35	$0.009	2.00
San Francisco hospital	$1.66	200	61.08	11.15	408.88	13.63	$0.010	1.00
San Bruno clinic	$1.66	200	3.37	0.62	22.74	0.76	$0.010	2.00
Oakland clinic	$1.60	200	1.21	0.22	8.16	0.27	$0.009	3.57
San Jose clinic	$1.60	200	1.79	0.33	12.05	0.40	$0.009	2.00

Table 22. Current inventory variables for alcohol pads

2. Terminology of Variables

- C — price of an item
- QTY/UM — quantity per unit of measure. The amount of items in each packaged item
- σ_M — standard deviation of average monthly demand
- σ_d — standard deviation of average daily demand
- D — average monthly demand
- d — average daily demand h—monthly holding cost per item
- LT — replenishment lead time (in days)

3. Cost Data

To understand the costs for the different distribution systems better, the following tables are provided. Table 23, the weekly delivery schedule, gives the different parts of the processes in labor minutes. It also provides the distance between the hospital and the clinics. Cost of transportation is at $0.19 per mile. In addition to the delivery schedule, Tables 24 through 26 give the costs associated with the delivery processes.

To help compare the costs of the delivery processes, estimates of labor time and transportation costs have been given for Northern California and San Francisco. These estimates are given to conduct post-hoc analyses of costs that would occur if the individual health systems were to move either to a strictly conventional/bulk delivery process or to a strictly LUM/JIT delivery process. Tables 27, 29 and 31 give the estimated times and travel distances for the processes and Tables 28, 30 and 32 provide the estimated costs.

Weekly Delivery Schedules

All time is labor in minutes

Facility	Breakdown/Staging Time	# Technicians Breakdown/Staging	Total Breakdown/Staging Time	Repackaging Time	# Technicians Repackaging	Total Repackaging Time	Stocking Time	# Technicians Restocking	Total Restocking Time	# Deliveries per week	Travel Time	Miles Traveled	Total Time/Week
Sacramento Medical Center	300	4	1,200	0	0	0	1,800	4	7,200	5	0	0	8,400
McClellan Outpatient Clinic	0	0	0	60	1	60	60	1	59	1	50	26	169
Mare Island Outpatient Clinic	0	0	0	30	1	30	30	1	29	1	66	49	125
Fairfield Outpatient Clinic	0	0	0	0	0	0	30	1	29	1	106	102	135
Oakland Outpatient Clinic	0	0	0	40	1	40	60	1	60	2	332	368	432
Martinez Outpatient Clinic	420	2	840	0	0	0	1,680	2	1,678	7	0	0	2,518
Redding Outpatient Clinic	300	1	300	0	0	0	1,200	1	1,199	5	0	0	1,499
Chico Outpatient Clinic	0	0	0	15	1	15	20	1	20	1	138	138	173
Northern California TOTALS	1,020		2,340	145		145	4,880		10,274		692	683	13,451
San Francisco Medical Center	210	5	1,050	0	0	0	2,100	5	10,500	7	0	0	11,550
Down Town San Francisco	0	0	0	0	0	0	60	1	60	1	0	0	60
Clearlake	0	0	0	0	0	0	60	1	60	1	0	0	60
Eureka	0	0	0	0	0	0	60	1	60	1	0	0	60
San Bruno	0	0	0	0	0	0	60	1	60	1	0	0	60
Santa Rosa	0	0	0	0	0	0	60	1	60	1	0	0	60
Ukiah	0	0	0	0	0	0	60	1	60	1	0	0	60
San Francisco TOTALS	210		1,050	0		0	2,460		10,860		0	0	11,910
Palo Alto Medical Center Bulk	450	7	3,150	375	7	2,625	600	7	4,200	5	0	0	9,975
Palo Alto Building 7 LUM	70	7	490	0	0	0	840	7	5,880	7	0	0	6,370
Menlo Park	0	0	0	0	0	0	60	1	60	1	0	0	60
Livermore	0	0	0	0	0	0	60	1	60	1	0	0	60
San Jose	0	0	0	0	0	0	60	1	60	1	0	0	60
Capitola	0	0	0	0	0	0	60	1	60	1	0	0	60
Monterey	0	0	0	0	0	0	30	1	15	0.5	87	74	102
Stockton	0	0	0	0	0	0	60	1	60	0	0	0	60
Modesto	0	0	0	0	0	0	60	1	60	0	0	0	60
Sonora	0	0	0	0	0	0	60	1	60	0	0	0	60
Fremont	0	0	0	0	0	0	60	1	60	0	0	0	60
Palo Alto Totals	520		3,640	375		2,625	1,950		10,575		87	74	16,927

Notes:

Mare Island and Fairfield are done in the same run Mare Islands distance is shown from the Fairfield Clinic.

Clinics that list zero in time/technicians is because breakdown and restocking time are combined and only put under restocking.

Times are cut in half for Monterey Clinic because it receives one order every other week along with a technician drives down to restock cabinets

Table 23. Weekly delivery schedules for the case study

San Francisco Medical Center and its Outlying Clinics Annual Costs

124 Beds with 120 Nursing Beds
Total items ordered was 82,999

Items	**Number of Items**	**Fixed Costs**	**Variable Costs**	**Total Costs**
Bulk/Conventional items	3,952		$ 100,311.33	
Bulk/Conventional Fees 3.5%			$ 3,510.90	
Total Bulk Costs				$ 103,822.23
JIT/LUM Items	79,047		$ 2,006,226.63	
JIT/LUM Distribution Fees 7.5%			$ 150,467.00	
Total JIT/LUM Costs				$ 2,156,693.63
Labor	**Labor Hours**			
Breakdown/Staging Labor	910		$ 25,480.00	
Repackaging Labor	0		$ -	
Restocking Labor	9,412		$ 263,536.00	
Travel Time Labor	0			
Total Labor hours	10,322			$ 289,016.00
Transportation	**Mileage**			
Mileage Costs	0		$ -	
Vehicle Leas		$ -	$ -	
Total Transportation Costs				$ -
TOTAL				$ 2,549,531.86

Table 24. San Francisco Medical Center annual costs for the case study

Palo Alto Health Care System Annual Costs

897 Beds total items ordered was 385,354

Items	Number of Items	Fixed Costs	Variable Costs	Total Costs
Bulk/Conventional items	295,869		$ 6,482,589.71	
Bulk/Conventional Fees 3.5%			$ 226,890.64	
Total Bulk/Conventional Costs				$ 6,709,480.35
JIT/LUM Items	89,485		$ 3,297,765.11	
JIT/LUM Distribution Fees 7.5%			$ 247,332.38	
Total JIT/LUM Costs				$ 3,545,097.49
Labor	**Labor Hours**			
Breakdown/Staging Labor	3,155		$ 88,330.67	
Repackaging Labor	2,275		$ 63,700.00	
Restocking Labor	9,165		$ 256,620.00	
Travel Time Labor	75			
Total Labor hours	14,670			$ 410,761.87
Transportation	**Mileage**			
Mileage Costs	3,822		$ 726.18	
Vehicle Leas		$ 15,000.00	$ -	
Total Transportation Costs				$ 15,726.18
TOTAL				$ 10,665,339.71

Table 25. Palo Alto Medical Center annual costs for the case study

Northern California Health Care System Annual Costs

Sacramento Medical center has 60 Beds
Martinez has 120 Bed Community Center and extensive services
Total items ordered was 136,035

Items	Number of Items	Fixed Costs	Variable Costs	Total Costs
Bulk/Conventional items	77,328		$ 1,962,613.01	
Bulk/Conventional Fees 3.5%			$ 68,691.46	
Total Bulk Costs				$ 2,031,304.47
JIT/LUM Items	58,707		$ 2,367,996.44	
JIT/LUM Distribution Fees 7.5%			$ 177,599.73	
Total JIT/LUM Costs				$ 2,545,596.17
Labor	**Labor Hours**			
Breakdown/Staging Labor	2,028			
Repackaging Labor	126			
Restocking Labor	8,904			
Travel Time Labor	600			
Total Labor hours	11,658			$ 326,410.93
Transportation	**Mileage**			
Mileage Costs	35,526		$ 6,750.02	
Vehicle Leas		$ 15,000.00	$ -	
Total Transportation Costs				$ 21,750.02
TOTAL				$ 4,925,061.59

Table 26. Northern California Health System annual costs for the case study

North California Health Care System JIT/LUM Weekly Delivery Schedule Example

All time is labor in minutes

Facility	Breakdown/Staging Time	# Technicians Breakdown/Staging	Total Breakdown/Staging Time	Repackaging Time	# Technicians Repackaging	Total Repackaging Time	Stocking Time	# Technicians Restocking	Total Restocking Time	# Deliveries per week	Travel Time	Miles Traveled	Total Time/Week
Sacramento Medical Center	200	4	800	0	0	0	1,800	4	7,200	5	0	0	8,000
McClellan Outpatient Clinic	0	0	0	0	0	0	60	1	59	1	0	0	59
Mare Island Outpatient Clinic	0	0	0	0	0	0	30	1	29	1	0	0	29
Fairfield Outpatient Clinic	0	0	0	0	0	0	30	1	29	1	0	0	29
Oakland Outpatient Clinic	0	0	0	0	0	0	60	1	60	2	0	0	60
Martinez Outpatient Clinic	420	2	840	0	0	0	1,680	2	1,678	7	0	0	2,518
Redding Outpatient Clinic	300	1	300	0	0	0	1,200	1	1,199	5	0	0	1,499
Chico Outpatient Clinic	0	0	0	15	0	0	20	1	20	1	0	0	20
Northern California TOTALS	920		1,940	15		0	4,880		10,274		0	0	12,214

Note in this example we have adjusted for all items to be LUM items verses the real scenario were there was a mixture of LUM and Bulk items.

Table 27. Northern California example of LUM delivery schedule for the case study

Northern California Health Care System Annual Costs Example

In this example of North California we adjust all conventional/bulk items to JIT/LUM and adjust labor appropriately

Sacramento Medical center has 60 Beds
Martinez has 120 Bed Community Center and extensive services
Total items ordered was 136,035

Items	**Number of Items**	**Fixed Costs**	**Variable Costs**	**Total Costs**
Bulk/Conventional items	~~77,328~~		$ -	
Bulk/Conventional Fees 3.5%			$ -	
Total Bulk Costs				$ -
JIT/LUM Items	136,035		$ 4,330,609.45	
JIT/LUM Distribution Fees 7.5%			$ 324,795.71	
Total JIT/LUM Costs				$ 4,655,405.16
Labor	**Labor Hours**			
Breakdown/Staging Labor	1,681			
Repackaging Labor	0			
Restocking Labor	8,904			
Travel Time Labor	0			
Total Labor hours	10,585			$ 296,393.07
Transportation	**Mileage**			
Mileage Costs	0		$ -	
Vehicle Leas		~~$ 15,000.00~~	$ -	
Total Transportation Costs				$ -
TOTAL				$ 4,951,798.23

Table 28. Northern California annual costs example of all LUM for the case study

North California Health Care Systeml Bulk Weekly Delivery Schedule Example

All time is labor in minutes

Facility	Breakdown/Staging Time	# Technicians Breakdown/Staging	Total Breakdown/Staging Time	Repackaging Time	# Technicians Repackaging	Total Repackaging Time	Stocking Time	# Technicians Restocking	Total Restocking Time	# Deliveries per week	Travel Time	Miles Traveled	Total Time/Week
Sacramento Medical Center	300	4	1,200	0	0	0	1,800	4	7,200	5	0	0	8,400
McClellan Outpatient Clinic	0	0	0	60	1	60	60	1	59	1	50	26	169
Mare Island Outpatient Clinic	0	0	0	30	1	30	30	1	29	1	66	49	125
Fairfield Outpatient Clinic	0	0	0	0	0	0	30	1	29	1	106	102	135
Oakland Outpatient Clinic	0	0	0	40	1	40	60	1	60	2	332	368	432
Martinez Outpatient Clinic	560	2	1,120	30	2	60	1,680	2	1,678	7	0	0	2,858
Redding Outpatient Clinic	300	1	300	0	0	0	1,200	1	1,199	5	0	0	1,499
Chico Outpatient Clinic	0	0	0	15	1	15	20	1	20	1	138	138	173
Northern California TOTALS	1,160		2,620	175		205	4,880		10,274		692	683	13,791

Note in this example we have adjusted for all items to be Bulk items verses the real scenario were there was a mixture of LUM and Bulk items.

Table 29. Northern California example of bulk delivery schedule for the case study

Northern California Health Care System Annual Costs

In this example of North California we adjust all items to conventional/bulk and adjust labor appropriately

Sacramento Medical center has 60 Beds
Martinez has 120 Bed Community Center and extensive services
Total items ordered was 136,035

Items	**Number of Items**	**Fixed Costs**	**Variable Costs**	**Total Costs**
Bulk/Conventional items	136,035		$ 4,330,609.45	
Bulk/Conventional Fees 3.5%			$ 151,571.33	
Total Bulk Costs				$ 4,482,180.78
JIT/LUM Items	~~58,707~~		$ -	
JIT/LUM Distribution Fees 7.5%			$ -	
Total JIT/LUM Costs				$ -
Labor	**Labor Hours**			
Breakdown/Staging Labor	2,271			
Repackaging Labor	178			
Restocking Labor	8,904			
Travel Time Labor	600			
Total Labor hours	11,952			$ 334,661.60
Transportation	**Mileage**			
Mileage Costs	35,526		$ 6,750.02	
Vehicle Leas		$ 15,000.00	$ -	
Total Transportation Costs				$ 21,750.02
TOTAL				$ 4,838,592.40

Table 30. Northern California annual costs example of all bulk items for the case study

San Francisco Medical Center and Outlying Clinics Hub and Spoke Weekly Delivery Schedule Example

All time is labor in minutes

Facility	Breakdown/Staging Time	# Technicians Breakdown/Staging	Total Breakdown/Staging Time	Repackaging Time	# Technicians Repackaging	Total Repackaging Time	Stocking Time	# Technicians Restocking	Total Restocking Time	# Deliveries per week	Travel Time	Miles Traveled	Total Time/Week
San Francisco Medical Center	420	5	2,100	240	5	1,200	2,100	5	10,500	7	0	0	13,800
Down Town San Francisco	0	0	0	30	1	30	60	1	60	1	48	13	138
Clearlake	0	0	0	30	1	30	60	1	60	1	80	52	170
Eureka	0	0	0	30	1	30	60	1	60	1	596	540	686
San Bruno	0	0	0	30	1	30	60	1	60	1	48	29	138
Santa Rosa	0	0	0	30	1	30	60	1	60	1	74	60	164
Ukiah	0	0	0	30	1	30	60	1	60	1	307	167	397
San Francisco TOTALS	420		2,100	420		1,380	2,460		10,860		1,153	861	15,493

The best rout for delivering to Santa Rosa, Clearlake, and Ukiah would be one person driving to all three as they are in the similar direction and time is distributed accordingly.
Note that in this example we adjust for items now being ordered as Bulk verses the real scenario were the majority were LUM.

Table 31. San Francisco example of bulk delivery schedule for the case study

San Francisco Medical Center and its Outlying Clinics Annual Costs Example

In this example of San Francisco we adjust allJIT/ LUM items as conventional/bulk and adjust labor appropriately

124 Beds with 120 Nursing Beds
Total items ordered was 82,999

Items	**Number of Items**	**Fixed Costs**	**Variable Costs**	**Total Costs**
Bulk/Conventional items	82,999		$ 2,106,537.96	
Bulk/Conventional Fees 3.5%			$ 73,728.83	
Total Bulk Costs				$ 2,180,266.79
JIT/LUM Items	~~79,047~~		$ -	
JIT/LUM Distribution Fees 7.5%			$ -	
Total JIT/LUM Costs				$ -
Labor	**Labor Hours**			
Breakdown/Staging Labor	1820		$ 50,960.00	
Repackaging Labor	1,196		$ 33,488.00	
Restocking Labor	9,412		$ 263,536.00	
Travel Time Labor	999			
Total Labor hours	13,427			$ 375,963.47
Transportation	**Mileage**			
Mileage Costs	44,767		$ 8,505.69	
Vehicle Leas		$ 15,000.00	$ -	
Total Transportation Costs				$ 23,505.69
TOTAL				$ 2,556,230.26

Table 32. San Francisco annual costs example of all bulk items for the case study

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