Inventory improvement and optimization of pharmacy Automated Dispensing Cabinet (ADC)

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MSc. Health Information Sciences, Iran University of Medical Sciences, 2000

A Thesis Submitted in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

In the School of Health Information Science

University Of Victoria

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To my family Adeleh and Nika, for their endless support

Abstract

Introduction

Emerge of Automated Dispensing Cabinets (ADCs) has helped hospital pharmacies to expand their monitoring and controls beyond pharmacy walls. It has provided opportunities for hospital pharmacies to manage the inventory and associated costs in a more effective way however, there are challenges regarding the optimum level of stocked medications.

Island Health (aka Vancouver Island Health Authority or VIHA) had implemented several ADCs in rural and remote facilities, where there is no in-house pharmacy to support inventory. Tofino Hospital is the first rural hospital of this kind. Remoteness of Tofino, lack of in-house pharmacy and the number of visitors that this touristic town receives each year makes ADC optimization mandatory.

This project applies historical data of demand and supply to find the optimum inventory level for the stocked medication items. This project answers the important question of what is the optimum configuration for each medication item to minimize inventory exhaustion events.

Methods

To conduct a single echelon inventory optimization, historical data from 30/May/2017 to 31/July/2018 analyzed to calculate daily demands and stocking intervals for a group of 113 stocked medication items. Then a standard inventory management formula applied to create a predictive model to calculate the re-order point and safety stock for a selected group of 52 medication items. The calculated variables compared with current settings of each medication.

In addition, system reports examined for incorrect system settings, expired medications and medication items that showed no trace of use during the observation period. The most and least demanded medication items identified. Microsoft Excel and Python used for calculations and visualizing the results.

Conclusion

Comparing results with the current system settings revealed that the ADC were overstocked for the studied group of medication item however; stock-out events were recurring. Measuring responsiveness of supporting pharmacy to system "refill" messages, showed that delays in restocking medication items is the reason for stock-outs. The calculated re-order point and safety stock for each medication item along with other recommendations prepared for supporting pharmacy.

1 Chapter 1: Introduction

Since the 1980's, many hospitals have implemented Automated Dispensing Cabinets (ADCs) in wards and units (Mandrack et al. 2012). ADCs are decentralized, computer-controlled storage systems for medications that are expected to provide better inventory control for pharmacies in hospitals and lessen the burden of the dispensing process for nurses. Several studies have shown the role of ADCs in enhancing patient safety, cost-effectiveness and process improvement (Zaidan et al, 2016).

The implementation of ADCs should always be followed by an "optimization" phase. Several months after implementation, the hospital pharmacy should review and revise the configuration of the ADCs and adjust the level of stocked medication to increase the efficacy and efficiency of the system. However, there is no standard method for the optimization of ADCs (O'Neill, Miller, Cronin, & Hatfield, 2016).

In this project, we will use system transactions and apply standard Inventory Management techniques and appropriate statistical and mathematical methods to find a model to manipulate the configuration and stock levels within the ADCs to increase the effectiveness of the medication use process.

1.1 Automated Dispensing Cabinets (ADCs)

Since the emergence of ADCs in the 1980s, many hospitals have acquired this technology in order to elevate patient safety. Managed by the hospital pharmacy, ADCs provide an opportunity to manage medication inventory in a more effective fashion. Integrated with Electronic Health Records (EHRs) and Unit Dose Bar Code Added (UDBCA) medication systems, ADCs have shown their effectiveness in promoting medication safety by preventing dispensing and administration errors and near misses (Fung & Leung, 2009). They help the pharmacy to adhere to policies and procedures regarding high-risk drugs, narcotics and security measures.

The implementation of ADCs provides the opportunity for pharmacy to extend its services beyond working hours and to increase the accessibility of medications. As a result, the turnaround time for

both initial patient doses and overall medication delivery from pharmacy to patient care units will be decreased (Institute for Safe Medication Practices- Guidance on the Interdisciplinary Safe Use of Automated Dispensing Cabinets, 2008). Effective computer-based documentation via ADCs will allow both pharmacy and nursing teams to improve their workflow. It will also help pharmacy to have tighter control over medication and operational costs.

To meet the aforementioned benefits, ADCs should be configured accurately before implementation and optimized carefully and periodically after implementation. Inaccurate configuration of ADCs can lead to unbalanced medication stocking and create "stock-out" events, which is a risk to patient safety. In addition, the maintenance of the inventory of an ADC with an unbalanced configuration increases the workload of pharmacy. In rural and remote facilities, where there is no in-house pharmacy, the magnitude of this challenge is even greater.

Although uncertainty around medication demand makes the prediction and replenishment of medications a challenging task, applying general inventory control knowledge and Operational Research techniques might assist with the situation. While there are quantitative methods and mathematical models to enhance inventory management, there is a lack of consensus over a standard method for ADC optimization.

1.2 Statement of the problem

To improve patient safety and better inventory management, the Island Health Authority (aka VIHA), located on Vancouver Island, British Columbia, Canada has replaced traditional medication ward-stocks with ADCs in several Rural and Remote (R&R) facilities including Tofino General Hospital (TGH). TGH is a 10 acute bed hospital in Tofino - a seasonal tourist destination 317 Km from Victoria (the capital of the province of British Columbia.)

TGH does not have an in-house pharmacy department, and thus receives pharmacy support services from West Coast General Hospital pharmacy (WCGH) located in Port Alberni (128 Km from TGH). Therefore, technically speaking, over 600 medication items stocked in the TGH ADC belong to the WCGH pharmacy. Although the WCGH pharmacy technicians try to replenish the TGH ADC on a regular basis, system reports show frequent "stock-out" and "critically low inventory" incidents for

several items. Considering the fact that the ADC is the only source of medication in TGH, this could be a major risk to patient safety. The risk of road closures due to harsh weather and snowstorms during cold seasons exacerbate the situation and add to the intensity of the patient safety risk. Over stocking of the ADC increases the risk of expiration and imposes more workload on the WCGH pharmacy. There is also only limited space available for each medication item within an ADC. Maximizing the Service Level through accurate optimization of ADCs will elevate patient safety.

1.3 Project Purpose

The purpose of this project is to apply statistical and mathematical models to discern the optimum inventory configuration (Maximum, Minimum, Safety Stock, and Point of Reorder) for the stocked medications of an implemented ADC in TGH. The objective is to maximize the Service Level and minimize the probability of "stock-out" events. For this purpose, historical anonymized transaction data from the implemented ADC has been collected and analyzed. Appropriate analytical tools and techniques have been applied to forecast medication demand and suggest an adjusted system configuration for implementation purposes.

1.4 Project aim

The goal of this project is to propose a model to improve and optimize the inventory of the implemented ADC in TGH to maximize the Service Level and minimize the risk of stock-out.

1.5 Project Questions

To meet the aim of this project the following questions need to be addressed concerning the ADC implemented at Tofino General Hospital:

- What are the stocked medications?
- What are the historical demand patterns?
- What are the historical restocking patterns?
- What is the Lead Time for restocking each medication?
- What is the Safety Stock level to minimize the stock-out?

1.6 Terms and Definitions

- Lead Time: Total time required Pharmacy to replenish medications in the ADC when replenishment requests are received.
- Stock-out: Event of inventory exhaustion. When the ADC is out of the demanded medication and users are not able to withdraw medications.
- Safety Stock: The quantity of additional medication that is required to mitigate the risk of stock-out.
- Service Level: The percentage of time that the system is able to achieve expected goals. In this project, it is defined as the percentage of time that the ADC is able to fulfill medication requests by nursing.

1.7 Structure of the project

The structure of this report follows this structure:

- Chapter 1 introduces the project, the existing problem and project objectives. A list of variables that should be calculated to conclude the model along with definitions are included in this chapter.
- Chapter 2 reviews the subject of medication inventory management and describes the systematic approach towards reviewing literature. It also contains a summary of the similar optimization projects.
- Chapter 3 includes information regarding setting, project methodology, and materials. In addition, a brief description about data analysis methods and techniques has been provided in this section.
- Chapter 4 presents tables and diagrams about facts, findings and calculation results. In this chapter, a systematic approach is taken to answer each study questions.
- Chapter 5 covers discussions around results. Findings and calculated values are explained in this section. Diagrams and tables are used to facilitate the discussion. Also project limitations and suggestions for further endeavors included in this chapter.

- Chapter 6 concludes this work and covers recommendations to maximize efficiency and effectiveness of inventory management for the studied ADC.

2 Chapter 2: Background and Literature review

Managing medication inventory is one the main tasks of the pharmacy department at each hospital. Despite uncertainties in healthcare, pharmacy should be able to predict periodic demand and order adequate drugs to be able to provide services to patients and units. Inadequate medication inventory will impose serious risks to the process of patient care and impacts The Five Rights of Medication Administration (the Right Medication, the Right Patient, the Right Dose, the Right Time and the Right Route). Appropriate inventory management will help pharmacy to reduce drug waste and prevent medication stock-out events. From a financial perspective, it will reduce healthcare costs and escalate financial performance. (Woo, K., Holleran, C., Blake, G., Gallagher S., Krishnaswamy, T., Piotrowski, K., 2015)

Proper inventory management requires accurate tracing, documentation and reporting systems. A continuous workflow between pharmacy and nursing units is required to maintain the drug inventory at an optimum level to minimize drug availability risk.

2.1 A review of medication distribution systems

This section describes the evolution of medication distribution models in hospitals. There are three major systems for medication distribution in hospitals, Centralized, Decentralized and Hybrid. In a centralized system, pharmacy acts as a central repository for medications and provides services from one location in the hospital. In a Decentralized system, medication inventory is located in each unit and the clinical team have direct access to medications. A hybrid system, allows pharmacy to employ different methods to store and dispense drugs for patients. (Begliomini, 2008)

2.1.1 Floor stock model

Traditionally, hospital pharmacies store extensible drugs in each care unit within medication rooms or other protected areas. These medications are contained in original drug containers (e.g. pill bottles) and are not patient specific. The inventory is not controlled by pharmacy and the medication supply is based on estimated weekly or monthly requests, prepared by nurses on each unit. This means that despite pharmacy's responsibility to dispense medications, nurses are responsible of this work. In fact, in this model the onus of, inventory control, medication dispensing, drug ordering and receiving, is on nurses. In addition, all related documentation is required to be completed by nurses. This gives nurses less time to fulfill direct patient care tasks and has inherent patient safety risks associated with not having these functions assigned to a role specifically focused on them Patient Prescription model

In this model, nurses transcribe prescriptions issued by physicians into the Medication Administration Record (MAR) and generate medication orders for pharmacy. Pharmacists review the orders and dispense an adequate supply of medication for several days.

2.1.2 Cart-fill model

Since the mid-60s', many hospitals have switched to cart-fill system. The cart-fill dispensing model includes Unit Dosed (UD) packages of medications and medication carts. Having UD packages, with the medication name, strength, lot number and expiry date on each package helps with the prevention of dispensing errors and increases patient safety. Pharmacy's role in inventory management and drug dispensing process is bold in this model. Pharmacy only dispenses drugs for a certain period of time (from 24 hours to 7 days) which reduces the released inventory of medications and provides better control over drug expiry management.

This model improves access to medications, nursing workflows related to medication administration and gives nurses more time for direct patient care activities. However, this model imposes extensive workload to pharmacy. Insufficient pharmacy processes, creates workflow issues, especially when pharmacy distributes medications for a shorter period (e.g. 24 hours). This requires Pharmacy staff to unload un-used drugs and stock new medications every 24 hours, which is a labor-intensive task.

2.1.3 Cart-less model

To remove the burden of everyday inventory management, Automated Dispensing Cabinets (ADC) have employed since the 80's. The embedded ADC computer (and developed applications) allows pharmacy to pair ADCs with hospital EHRs, Computerized Provider Order Entry (CPOE) and other pharmacy applications to create a medication profile for patients. This means that nurses only have access to the compartment that contains the prescribed medication for a specific patient. This improves access to medications and potentially augments medication safety. Hypothetically, this system saves time for nurses, however different results have observed in different studies. (Caldwell, 2007) In addition, pharmacy can load the ADC with more medications with less concern around inventory management and expiry control. ADC applications are able to send "refill" messages and expiry warnings to pharmacy as per system configurations.

2.2 Automated Dispensing Cabinets (ADC)

ADCs allow pharmacy to expand the ownership of dispensing medications down to patient care units and extend inventory control and monitoring beyond the pharmacy storage area closer to the bedside.

2.2.1 Definition

Automated Dispensing cabinets (ADCs), also known as Automated Dispensing Machines [Suryandinata, 2017] are decentralized, computer-controlled storage, dispensing and tracking devices for medications as shown in figure 1. (Zaidan, 2016)

Source: https://www.omnicell.com/products/medication_dispensing/automated_medication_dispensing/omnicell_xt_automated_dispensing_cabinets.aspx (Access 01-Oct-2018)

Each ADC includes several drawers that might have different depths. Each drawer is gridded to form separate compartment locations, so pharmacy technicians can store medications in each compartment. ADCs could consist of two type of drawers, *matrix* drawers, which provide access to all medications in the drawer or *lock-lidded* drawers that allow access only to the selected compartment as shown in figure 2. (Pazour, 2016)

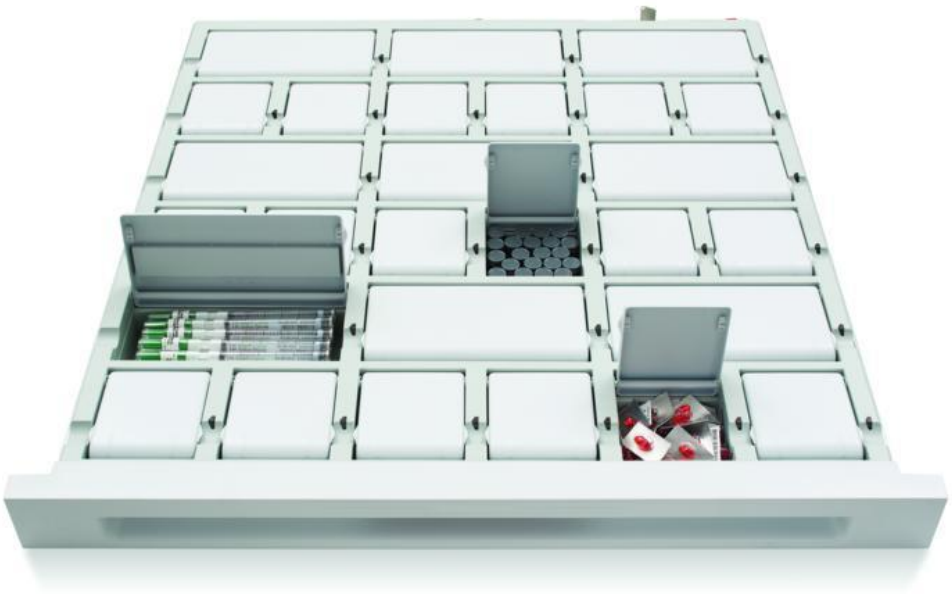


Figure 2: An ADC drawer

Source: http://www.palexmedical.com/es/family.cfm?id=omnicell%2Darmarios%2Dautomatizados%2D#.W7LGZGNRdpg (Access 01-Oct-2018)

Pharmacy is responsible for the configuration, replenishing, maintenance and troubleshooting of ADCs. ADCs are highly configurable, so pharmacy can set the following parameters for each item to keep track of:

- Periodic Automatic Replenishment (PAR): Target quantity to be maintained
- Max: Maximum quantity of medications allowed to be stocked
- Min: Minimum quantity of medications allowed to be stocked

- Re-Order Point (ROP): The level of inventory of a specific medication that triggers a replenishment message

Normally, there is an interface between ADCs and the Pharmacy Information Systems (PIS) and the hospital EHR. This interface facilitates exchanging of HL7 messages between these systems and make it possible for users to see a list of patients and medication orders at the cabinet. The backend server will capture and save all transactions (including null transactions, when users just open and close a drawer, without withdrawing any medications). Pharmacy is able to run different reports to track stocked medications.

2.2.2 Benefits

The effectiveness of ADCs was examined in several studies. Poveda Andres and his colleagues analyzed implementation of ADCs in a hospital in 2003 and concluded, *"Replacement of traditional floor stock with ADCs in the Medical Intensive Care Unit, Surgery Intensive Care Unit and the Emergency Room produces a positive benefit/cost ratio (1.95)."* (Poveda Andres, García Gómez, Hernández Sansalvador & Valladolid Walsh, 2003)

In a pre-post study, Chapuis et al. observed a reduction in medication errors in an intensive care unit, as one the outcomes of utilizing ADCs. They also reported nurses' satisfaction of the new distribution model. (Chapuis et.al, 2010)

Using the medBPM methodology, Baker, Draves and Ramudhin conducted an analysis to compare medication management systems in seven hospitals. The collected data indicated that processes related to medication management and overall patient safety has been elevated due to adding ADCs. For example, as the percent of total medication doses managed through ADCs increases, time to initiate the medication therapy decreases rapidly. Time and motion analysis also revealed a reduction in missing doses, non-value added activities related to missing doses and pharmacy staff workload. (Baker, Draves, Ramudhin, 2010)

Fung and Leung explained how implementation of an automated medication system in the operating rooms at the Toronto General Hospital resolved an under/over stocking of inventory problem (Do automated dispensing machines improve patient safety? - 2009). They also have emphasized other

benefits of ADCs including traceability of drugs and drug waste, improvement of efficiency and control of narcotics and eventually maximizing patient safety.

Due to the expanded control that ADCs provide for pharmacy, it is possible for pharmacy to allow wholesalers to refill cabinets directly. Helmons and his team examined effects of a direct refill program for ADCs and observed that when the process includes prepackaged medications and bar code assisted refill, ADC refill errors significantly decreases. [Helmons, Dalton & Daniels, 2012]

In 2009, a team of researchers designed a cost analysis model to compare a manual drug distribution system with ward-base ADCs. They showed that with ADCs a 400-bed hospital would save $2.7 million in a five-year span. In their study, they also found that other researchers examined the role of ADCs in saving time for nurses, optimizing medication storage areas and overall treatment costs. (Canadian Agency for Drugs and Technologies in Health (CADTH), 2010)

Results of other studies confirms positive impacts of ADCs on costs and staff time. For example, de-Carvalho and his collogues assessed the impact of ADCs in a tertiary hospital retrospectively and observed work time reduction among nurses. They concluded that the initial investment for ADCs would have be paid off in a 5-year period through work time saving. (de-Carvalho, Alvim-Borges, Toscano 2017)

2.2.3 Challenges

Despite mentioned advantages, implementation of ADCs might impose several challenges to pharmacy and engaged units. For example, in a time and motion study in Australia, Roman and her team observed that the medication retrieval process is actually slower although nursing presumption is that ADCs save time. (Roman, Poole, Walker, Smit & Dooley, 2016)

Hamilton and Hope criticize published affirming papers and believe that there is a serious methodological flaw. They state that the efficiency of ADCs should be studied in conjunction with other medication distribution technologies like Unit Dose Bar Code Added packages (UDBCA), Computerized Physician Order Entry (CPOE) and Electronic Medication Administration Records (eMARs). ADCs should be considered (and studied) as a piece of technology in a comprehensive, organizational medication safety enhancement strategy. The high cost of implementation of these

systems, the enormous impact of the change and limited return of investment should be considered before making any decisions. (Canadian Agency for Drugs and Technologies in Health (CADTH, 2010)

In fact, they found evidence that shows an increasing trend in medication errors involving ADCs without supporting technologies. They advise hospitals to follow recommendations that The Institute for Safe Medication Practices Canada (ISMP Canada) published in 2007. This set of recommendations evolved into the publication "Guidance on the Interdisciplinary Safe Use of Automated Dispensing Cabinets" released in 2009. (Institute for Safe Medication Practices- Guidance on the Interdisciplinary Safe Use of Automated Dispensing Cabinets, 2009)

Tsao and his team conducted a systematic review to study the clinical and economic impacts of ADCs in hospitals. They examined medication errors (from a storage and dispensing perspective), nursing time, pharmacy time and costs. Based on their findings they concluded that gaining full benefits of ADCs is "*institution-specific*". In other words, integration with other components of a medication distribution system is a deterministic factor to reap the expected benefits. (Tsao, Lo, Babich, Shah & Bansback, 2014)

2.3 Inventory Management in Pharmacy

In a Pharmacy context, Inventory defined as "*the stock of pharmaceutical products retained to meet future demand*." (Ali, 2011) Managing inventory is one of the most important tasks of pharmacy in order to reduce costs, prevent drug shortages and prevent harm to patients. In addition, effective pharmacy inventory management has a positive impact on the financial operation of the hospital. (Noel. 1984) The main goal of managing inventory is to find the optimal balance point between demand and supply. The aim is to reduce operational costs associated with ordering, receiving, storing, distributing and returning of pharmaceutical products while keeping sufficient supply to meet demand. It is challenging to find this sweet spot without proper planning, organizing and controlling inventory. Proper inventory management helps pharmacy to ensure that ordered medications are available and are not counterfeit, expired or spoiled. (Ali, 2011)

2.3.1 Methods of Inventory Management

To manage inventory effectively, pharmacy may use one or more of the following methods:

2.3.1.1 Visual Method

In this basic method, pharmacy staff look at the medications and count them against a list. The number of counted items are then compared with the Periodic Automatic Replenishment level (PAR-Target quantity to be maintained) and if the item number drops below the target, pharmacy will place a purchasing order. This is a convenient and inexpensive method however it has a high risk of human error and is inefficient especially in larger pharmacies. (Mattingly, 2016)

2.3.1.2 Periodic Method

In this method, pharmacy applies the visual method at regular intervals (Weekly, monthly…). This method is more common for pharmacy supplies rather than medications.

2.3.1.3 Perpetual Method

This method provides pharmacy the opportunity for constant inventory monitoring. This method involves Information Technology and information systems, so pharmacy adds items when the orders are received and subtracts them while dispensing. It provides a real-time inventory on-hand quantity. The disadvantage of this method is a heavy reliance on technology. Careful workaround planning is required during a downtime. This is the most common system in industrialized countries. [Ali, 2011]

2.3.1.4 Hybrid Method

This is a combination of two or all three mentioned methods. Normally when it comes to stock accuracy or controlled substances (e.g. Narcotics) pharmacies apply manual methods to make sure that the documented numbers match what they have counted on the floor. (Mattingly, 2016)

2.3.2 Evaluation of Inventory Management in Pharmacy

To measure how well the inventory has been managed, there are several indicators. Total Inventory Value, Day Supply and Inventory Turnover Rate (ITOR) are some of these measures.

2.3.2.1 Total Inventory Value

Total inventory value is a snapshot of the current (unsold) dollar value. Normally at the end of each accounting period, pharmacy compiles a list of total inventory on-hand and the value of each item.

A simple formula for inventory value calculation is:

$$\text{Begining Inventory (BI)} + Purchases - \text{Cost of Goods Sold (COGS)} = \text{Ending Inventory}$$

Beginning Inventory is the value of inventory at the beginning of the accounting period. Purchases includes added inventory during the same accounting period. COGS represents all the costs of the sold goods. This includes operational costs, storage costs, transportation, labor, etc.

To value inventory there are three common methods:

- First In, First Out (FIFO): in this inventory accounting method, pharmacy will sell/ distribute the oldest (but not expired) pharmaceutical products first and leave the newer stock for the end of accounting period. This is mostly applicable for stocks with a shelf life or expiry date.
- Last In, First Out (LIFO): in a LIFO model, the business may decide to sell/distribute newer stock and keep the older inventory for the end of accounting period. The likelihood that retail pharmacies or hospital pharmacy use this method is minimal.
- Average Cost (AVCO): the average value of each item in stock will be calculated to determine the inventory value.

2.3.2.2 Day Supply

Day supply normally calculates based on the average on-hand quantity and Cost of Goods Sold as:

$$\frac{Average\ on-hand\ inventory}{COGS} * 365\ days$$

2.3.2.3 Inventory Turnover Rate (ITR)

ITR is a calculation that uses average inventory and COGS to measure pharmacy efficiency. This shows how many times a year a pharmacy has turned over the inventory. The lower the number of the Inventory Turnover rate the more there is an indication of "poor sell" or over stocking of goods. The formula for Inventory Turnover Rate is:

$$\frac{COGS}{Average\ inventory} = ITR$$

2.3.2.4 Influencing Factors on Pharmacy Inventory

Several factors might affect pharmacy performance regarding inventory management:

- Pharmacy Type

Different pharmacy types may employ various inventory management techniques. Inventory management methods are different in a retail pharmacy compared with a hospital pharmacy. Even in hospital pharmacies, methods may vary based on facility type, whether it is a Long Term Care facility, or Acute Care or a specialty hospital. In specialty hospitals or Long Term Care facilities, pharmacy keeps only a selected, required group of medications in stock. Supported by historical information, it is easier to predict future needs in these facilities so inventory can be smaller due to the ability to advance order. They might even be able to employ a Just In-Time (JIT) inventory system if they refine their processes. However, serving acute patients, the pharmacy might have to keep a large inventory with a vast variety of medication items on-hand to be able to respond to demand.

- Product Type

The product type plays a major role in medication price and, as a result, in inventory management strategies. Branded drugs are more expensive compared to generic medications. This affects inventory value and other above-mentioned inventory indexes. In addition, given that medications are perishable, pharmacy needs to employ meticulous methods to manage the inventory efficiently.

- Dispensing volume

Larger pharmacies with higher volume of dispensed medications need to order drugs more frequently. They also need to keep more inventory on the shelves but they are able to "Turn" that inventory more quickly.

- Cost of Stock-Out

The nature of pharmacy business (whether it is a private pharmacy, or hospital pharmacy), proximity of other pharmacies or serving community are a few factors that reveal the real cost of being out of stock. It could create customer dissatisfaction, increase operational costs or even impose risks to patient safety and access to timely treatment. Therefore, pharmacies should consider the cost of stock out when they delineate their inventory management strategies.

2.4 Literature review:

To systematically find and review evidence regarding ADC optimization, the researcher conducted a search in several databases using these keywords: Pharmacy, Inventory, Automated Dispensing Cabinet, Automated Medication Dispensing Machine, and Automated Dispensing Device. Results are shown in chart No.2 1.

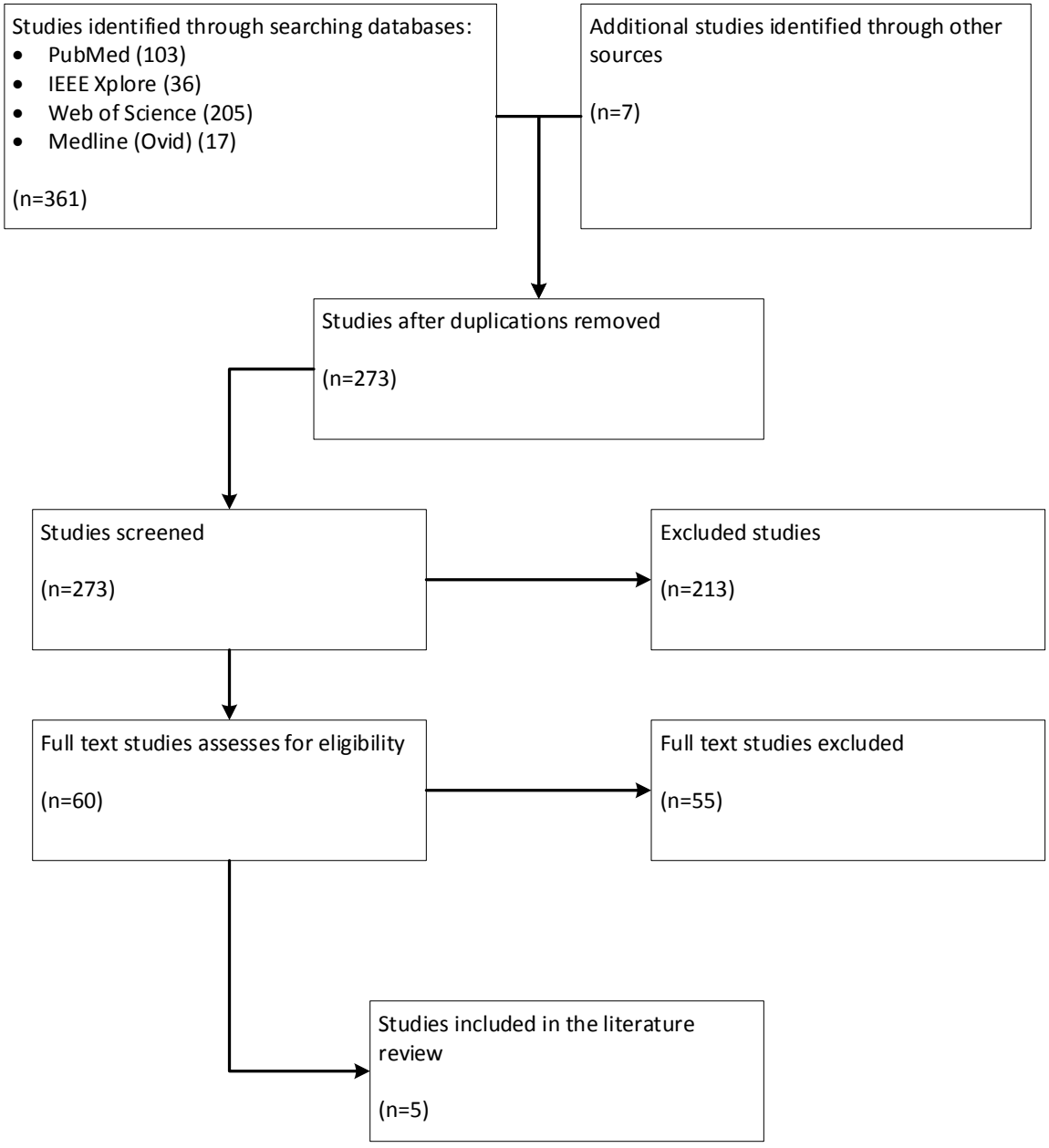


Chart No.2 1- process of systematic literature review

Exclusion reasons for the full text reviewed studies are listed in table No. 1

Domain of study	Number of excluded studies
Implementation report	16
Medication error	14
Workflow improvement	7
Medication turnaround time	4
cost/benefit analysis	3
Technology Governance	2
User satisfaction	1
Other domains	8
Total	55

Table No. 1 Exclusion reasons

2.4.1 Summary of included studies

Findlay, Webb, & Lund, 2015: For two intervention groups of ADCs (6 each), the static inventory values were replaced by a Dynamic Inventory Standards (DIS). DIS was utilizing a computer-based algorithm to readjust maximum (Max) and Periodic Automatic Replenishment (PAR) levels. Also for the intervention group, a Low Inventory Alert (LIA) System implemented to notify the pharmacy technician when the inventory level reached 50%. These solutions were implemented in 2 phases, a separate implementation for each group and concurrent implementation for both groups of ADCs.

Researchers observed a significant reduction in stock outs for both DIS and LIA methods at each group, in phase 1. Also after concurrent implementing both methods in phase 2, an overall reduction of stock outs were recorded (-47.4% in Group A and -52.2% in group B). They also observed a significant reduction in the duration of stock outs (Total: 37.9% in Group A and 35.1% in Group B). No

statistically significant changes observed in inventory "turns" in either phase for group B. There were no reports on results of group A.

Researchers concluded that concurrent implementation of DIS and LIA is a viable solution to reduce stock outs and improve duration of stock outs without imposing capital resources or augmenting labor.

Labuhn, Almeter, McLaughlin, Fields, & Turner, 2017: This is a report on a series of interventions to optimize the pharmacy supply chain (including 133 ADCs) at the University of Kentucky Albert B. Chandler Medical Center. The first implementation was reported as implementation of carousel technology in a central pharmacy that enhanced replenishing ADCs located in health care units. This intervention alone, led to a 56% reduction of stock-outs. During the second intervention, they redesigned and adjusted pharmacy staff workflow, so they could refill ADCs efficiently. Five pharmacy technicians were appointed to restock ADCs 3 times a day. This workflow design enhanced nursing and pharmacy technicians' satisfaction and increased efficiency.

For the last intervention, researchers worked with a team of industrial engineers and process improvement experts to create a stochastic inventory-modeling tool to adjust Minimum Maximum and reorder points of each medication in each ADC. The Research team reviewed historical data and removed medications with zero demand in the previous 6 months from the ADCs (20% to 30% of medications). Regardless of demand level, life-saving medications remained in the ADCs as "standard stock list".

To determine Minimums and Maximums for each medication, the team divided the stock to 3 levels:

- Cycle Stock: "Average demand for a given medication over the replenishment period"
- Buffer stock: "Variances between demand and replenishment period"
- Safety stock: which was added per average daily demand X number of days held

Figure 3 shows the mathematical formula that the research team applied to create a tool to help pharmacy technicians adjust ADCs configurations accordingly:

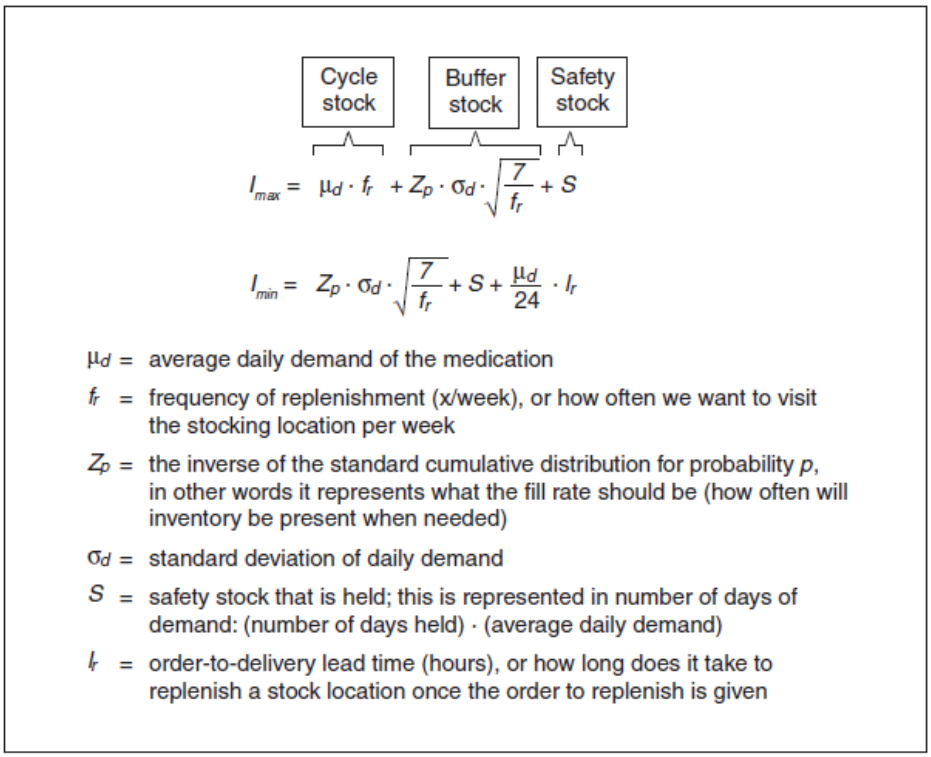


Figure 3: Applied formula by Labuhn, Almeter, McLaughlin, Fields, & Turner, 2017

After applying the optimization tool for inventory fine-tuning on 42 of the ADC stations (32% of 133 implemented ADCs), a total inventory reduction of $220,500 was observed. The team continued monitoring stock-out events and to the time of releasing the research paper, nursing staff had reported no missing medications. Finally, the researchers concluded that the three-phased interventions have enhanced the pharmacy inventory management, reduced the number of stock outs and saved inventory costs.

McCarthy & Ferker, 2016:

To address the issue of prevalent medication stock-out, McCarthy & Ferker launched an optimization project, 6 weeks after activations of 30 ADCs in patient care units in an academic medical center in Chicago. They applied three interventions and explained the results in their paper. The first intervention was to increase PAR level to reduce refill intervals to once a week and adjusted the *"reorder level to one unit higher than maximum usage per transaction day for medications that*

infrequently dispended in large quantities" for more than 3000 medications in 30 ADCs. The results of the first interaction estimated as a $2728 annual savings on pharmacy labor cost. In addition, system reports showed that the weekly average stock-out rate for all ADCs dropped from 3.25% to .5%, 8 months after intervention. This also showed a positive impact on medication turnaround time.

During the second intervention, pharmacy reviewed the "common stocked" medication items and expanded them up to 3% overall. No significant change in restocking rate or stock-out percentage was observed because of this intervention. After consulting with patient care units and pharmacy technicians, they removed infrequently used medications from the ADCs as the third intervention. After reviewing system generated usage reports, 835 medication items (9% of inventory) were removed from ADCs. The result of this phase of optimization estimated a potential $19,660 annual savings through avoiding expiration and operational costs associated with returning unused medications to pharmacy.

Researchers concluded that a lack of a widely accepted method for ADC optimization makes the described approach applicable to most ADC optimization scenarios. Researchers recommended that re-training users and system administrators on reports and the associated interpretation should be followed after each ADC implementation project. In addition, to address the uncertainty around medication prescriptions and usage patterns, they recommended a periodic, ongoing ADC optimization procedure, which needs to be followed up by pharmacy. Researchers believed that the absence of a benchmark for guiding ADC optimization or a target percentage for stock-outs was a limitation for their work.

O'Neil, Miller, Cronin, & Hatfield, 2016 compared two methods of inventory optimization for ADCs. The researchers broke down optimization in four actions:

- Increasing the inventory of frequently used medication in ADCs
- Removing unused medications and reducing the stock
- Adjusting PAR level to decrease stock-out events and restocking rate
- And finally, the physical move of stocked items to make the use of ADC more convenient for users

To conduct this research, eight ADCs located in a perioperative, labor and delivery unit in North Carolina Medical Center was selected and divided in two groups. For each group they a) removed unused medications in past 180 days, b) moved the stocked items to suit nursing and c) adjusted the Par level (however, for each group they applied a different method of adjustment.) For the Day Supply group, the PAR level for each medication was adjusted based on the "*range of three-day minimum and seven-day maximum values based on the daily mean number of vends*" based on the past two months data. The Par level for the second group (Formula group) though was calculated per a standard inventory formula.

A comparison between pre-post intervention data showed that the total number of stocked items was reduced, resulting in $44,981 of savings. The impact of Formula group was relatively higher ($6,688 vs. $4,558 per ADC). Also the vend: fill ratio for Formula group increased (from 4.33 pre-optimization to 5.2 post-optimization) whereas for the Day Supply group the fill ratio decreased from 4.52 to 3.9. Researchers concluded that the significant improvement of the Formula group is related to the accuracy of the applied formula. Researchers could not find a significant difference in stock-out rate before and after optimization in both groups. However, a comparison between the two groups revealed that stock-out rates in the Formula group decreased from 1.14% to 1.11% whereas in the Day Supply group this rate was slightly increased from 0.90% to 1.13%. No statistically significant change in the quantity of expired medications was observed.

Regarding study limitations, researchers pointed to the small size of the study, unbalanced number of available resources for optimization and movement of items within ADCs and limited control over PAR levels and quantities of medication after optimization. The impact of interventions on nursing or pharmacy technicians' workflow was not assessed and user satisfaction was not addressed. They eventually concluded that the standard inventory formula is the preferred method for optimization and has improved inventory cost and vend (fill ratio and stock-out prevalence.)

Radparvar, Tesch, Gull, & Isaac, 2016 conducted a pilot study to develop and implement an algorithm to optimize the inventory of ADCs at the University of Massachusetts Memorial Medical Center, Worcester, WA. The ultimate goal set was to make progress in medication administration efficiency, decrease waste of medication and uplift pharmacy workflow. They selected four ADCs in two different

units and collected data from the previous three months for dispensed medications; vend to fill ratios and percentages of stock-outs. Considering the patient population, they applied a standardized formula to optimize the inventory of pilot ADCs. Results were analyzed three months after intervention and showed changes in endpoint indicators.

These changes where not significant for fill: vend ratio and stock-out percentages (which was interpreted as the suitable stocking of inventory) however, the mean number of medications with loads and unload above two per month dropped by 50%. Although the quantity of stocked medications increased, post intervention analysis showed 23% reduction of the mean number of expired medications.

The results of this pilot study was satisfying enough to apply the developed algorithm for all ADCs within the institution.

3 Methods and Materials

3.1 Setting

Tofino General Hospital (TGH) is located in Tofino (49°08'38"N 125°53'30"W) on the west coast of Vancouver Island, British Columbia, Canada. TGH is a small hospital with 10 acute beds and 5 emergency room stretchers which provides services to almost 3,650 residents of Tofino and her sister town, Ucluelet. It is important to note that Tofino is a popular tourist destination. In the absence of accurate data, Park Canada estimates the number of annual visitors as high as 800,000. 75% of these visits occur between March and October. (Tofino Tourism Master Plan, 2014, p.16)

TGH does not have an in-house pharmacy. However, West Coast General Hospital (WCGH), located in Port Alberni (49°14'2"N 124°48'18"W), provides pharmacy services and supply for TGH. The land distance between Port Alberni and Tofino is 128 Km. Highway No.4 that connects Port Alberni to Tofino crosses through mountains so road closure is common during winter due to harsh weather.

Figure 4 Sutton Pass towards Tofino/Ucluelet, Source: https://www.alberniweather.ca/wp-content/uploads/2012/01/207.jpeg

Considering the high volume of visitors in warmer months and the risk of commuting during the cold seasons, it is extremely important to have proper quantity and a variety of medication stocked in TGH to appropriately respond to needs. On the other hand, WCGH pharmacy needs to have a tight control over shipped medications, particularly controlled substances and narcotics.

3.2 The implemented system

Funded by Island Health (Formerly Vancouver Island Health Authority), a three-tower Omnicell ADC implemented in TGH on June 2017. The backend of the implemented system is an application/database server that supports the cabinet. This server retains all configurations related to the TGH ADC and other 45 implemented ADCs in other healthcare facilities across the region. All configurations related to medication items (i.e. Maximum and Minimum level of inventory, reorder points, PAR levels, etc.) are set at the server level by appropriate Pharmacy resources. Another Interface server manages HL7 based message flow, between the central server and the Island Health Electronic Health Record. Therefore, in a bi-directional relationship, the TGH nurses can see patients' names and medical orders at the cabinet. Similarly, the central server updates the patient record with withdrawn medications, so the order does not show as an "active order" for the withdrawn doses.

The system triggers three refill messages at three different checkpoint levels of inventory: a) Reorder point (ROP) b) critical low and c) zero inventory. Pharmacy sets these checkpoints for each medication item individually, at the time of ADC setup. Each medication item has a unique Item ID in the system. There are different transactions types as shown in table No.2.

Key	Transaction type
A	Inactive Access
B	Bedside
C	Cycle Count
D	Discrepancy
E	Emergency

F	Dispensing Error
G	Pick
I	Issue
K	Destock
L	Receive
M	Modify Bin
N	Null
O	Supplemental Restock
P	Chargeable Procedure
Q	Discrepancy Resolution
R	Return
S	Restock
T	Transfer
U	Return to Rx
V	Event
W	Waste
X	Expired
Z	Reconciliation Reason

Table 2: System Transaction Types

3.3 Data Gathering Method

The system is able to create a vast variety of reports as needed. The system administrator also is able to design and create custom reports and run them as per ad hoc requirements. To conduct this project, two type of reports extracted from 30 May 2017 to 31 July 2018 in order to capture the volatility of medication demands.

1. Transactions by item procedures report

This report shows daily transactions regarding stocked medication items. The following data fields from this report used for daily demand and restocking patterns:

Report field	Description
item_id	Medication item ID
rx_name	Medication item name
omni_bin	Bin number
xact_dati	Date and time of transaction
xfer_type	Transaction type
qty	Transaction quantity
qty_onhand	Quantity on hand after transaction

2. Par Vs Usage report

   This report shows configurations of each medication item and compares usage (demand) data with system settings. The data fields that used for this project are:

Data field	Description
item_id	Medication item ID
rx_disp	Medication item name
item_used	whether or not the item has been issued
par	Periodic Automatic Replenishment
qty_onhand	Quantity on hand per report date and time
ro	Re-order Point

cl	Safety Stock
totalqty	Total quantity of issued medication items during the report period
minqty	Minimum quantity of issued medication item
maxqty	Maximum quantity of issued medication items
countday	Number of days that medication item were being issued
avgqty	Total quantity of issued medication items during the report period divided by number of days that medication item were being issued
lowdays	Number of days that quantity on hand has been below re-order point
zerodays	Number of days that quantity on hand has been equal to 0

Approval for the use of these reports obtained from ethical committee of the University of Victoria and Island Health Pharmacy Director (information steward within Island Health). No personal information (either patients or staff) were included.

3.4 Data Analysis Methods and Tools

Before describing data analysis methods and tools, it is important to explain Re-Order Point (ROP) calculation methods in various scenarios.

A summary of ROP calculations scenarios

Re-order point calculations vary based on different scenarios (Paul, 2016):

3.4.1 Constant Demand- Constant Lead Time

Constant Demand – Constant Lead_Time is when both demand and lead-time are constant as depicted in figure 5. Because of the predictability of demand and lead-time, the ROP could be considered equal to demand during lead-time (LTD) as shown in formula [1]:

[1] ROP= d x LT or ROP=LTD

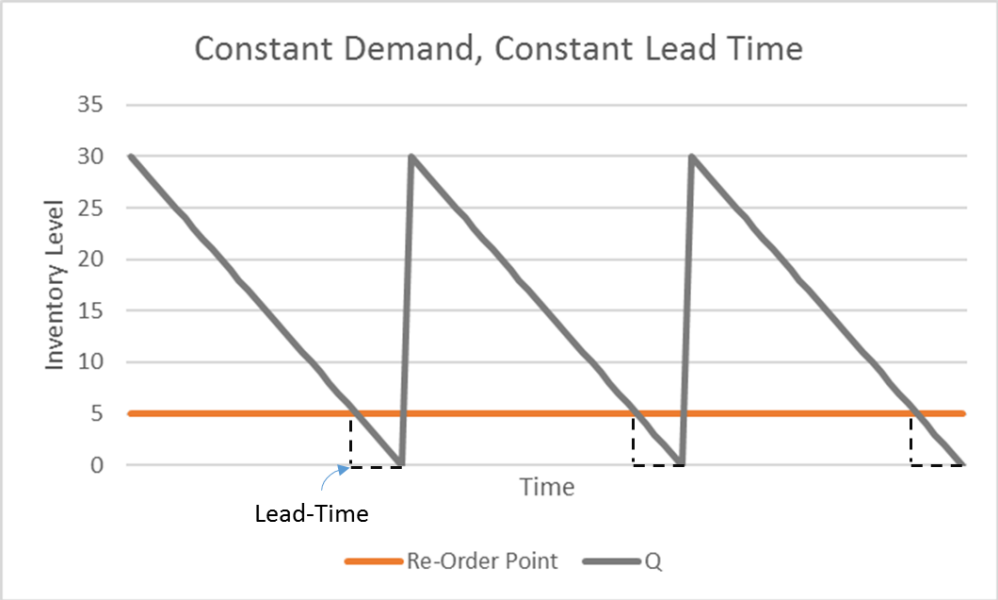


Figure 5- Constant Lead time and demand

3.4.2 Variable Demand-Constant Lead Time:

In this scenario, the depletion rate of the inventory level during LT is variable however; the lead-time for replenishment is constant. Because of uncertainty around demand during lead-time, normally an extra inventory on hand or Safety Stock (SS) is added to the estimated demand for the period of the lead-time (Figure 5). In this scenario, the ROP is equal to LTD and SS, so as shown in formula [2]:

[2] ROP=LTD+SS

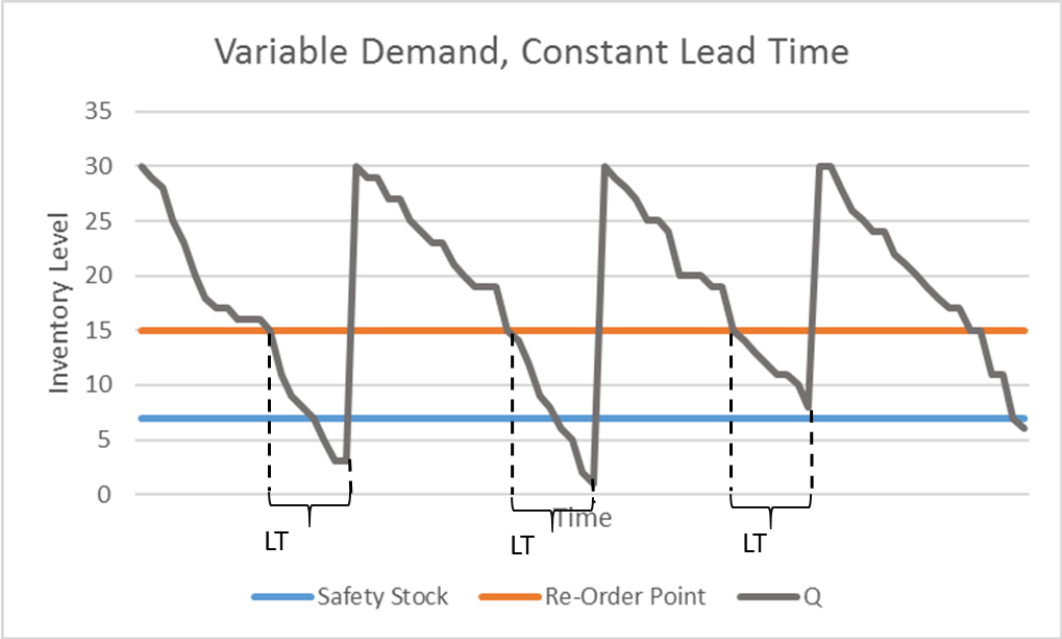


Figure 5: Constant lead-time and variable demand

Due to the volatility of demand during the lead-time, the average and standard deviation of the lead-time demand (LTD) is used for calculations of the Safety Stock. The assumption is that the LTD follows a normal distribution so the Service Level (SL) would be the probability of the amount that we need (LTD) is equal to or less than the amount that we have on hand (ROP). (Bussom, 2018)

In other words:

SL=Prob (LTD≤ROP)

Or SL=1-Prob (stock-out)

To calculate the Safety Stock (SS), we need to have the sum of the lead-time demand variances as:

(Daily variance) x (number of days of lead-time) = $\boldsymbol{\sigma_{d^2}}$LT

Standard deviation= $\sqrt{\boldsymbol{\sigma_{d^2}}\mathbf{LT}}$ = $\boldsymbol{\sigma_d\sqrt{LT}}$

Safety Stock is the product of standard deviation of daily demand, times the number of standard deviations corresponding to the service level probability so as in formula [3]:

[3] SS= z $\boldsymbol{\sigma_d\sqrt{LT}}$

To visualize the formula please see figure 6.

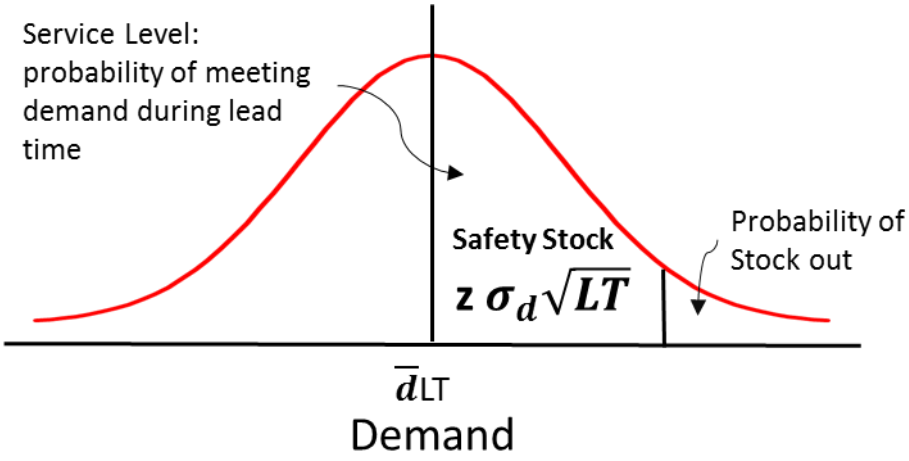


Figure 6: Lead time demand when demand is variable and lead-time is constant

The mathematical expression for calculating ROP is as formula [4]:

[4] ROP= $\overline{\boldsymbol{d}}$LT + $\boldsymbol{\sigma_d\sqrt{LT}}$

Where:

$\overline{\boldsymbol{d}}$LT = average daily demand during lead time

$\boldsymbol{\sigma_d\sqrt{LT}}$= Safety Stock

3.4.3 Variable Lead Time -Constant Demand:

When demand is constant but lead-time is variable the aforementioned formula will be changed to formula [5]:

[5] ROP=d$\overline{\boldsymbol{LT}}$+ zd$\boldsymbol{\sigma_{LT}}$

Where:

d$\overline{\boldsymbol{LT}}$ = demand during average lead time

$\boldsymbol{z}$= number of stand deviations corresponding to the service level probability

$\boldsymbol{\sigma_{LT}}$= standard deviation of lead time

3.4.4 Variable demand- variable Lead Time:

This is a common scenario in the real world (Figure 7). In this case, both demand and lead-time are variable, so the ROP formula will be as formula 6:

$$[6]\ \boldsymbol{ROP} = \overline{\boldsymbol{d}}\ \boldsymbol{x}\ \overline{\boldsymbol{LT}} + \boldsymbol{z}\sqrt{\overline{\boldsymbol{LT}}\ \boldsymbol{\sigma_d}^{\boldsymbol{2}} + \overline{\boldsymbol{d}}^{\boldsymbol{2}}\boldsymbol{\sigma_{LT}}^{\boldsymbol{2}}}$$

Where:

$\overline{\boldsymbol{d}}$= Average demand rate

$\overline{\boldsymbol{LT}}$= Average Lead Time

$\boldsymbol{\sigma_d}$= Standard deviation of demand rate

$\boldsymbol{\sigma_{LT}}$=Standard deviation of lead-time

$\boldsymbol{z}$= number of stand deviations corresponding to the service level probability

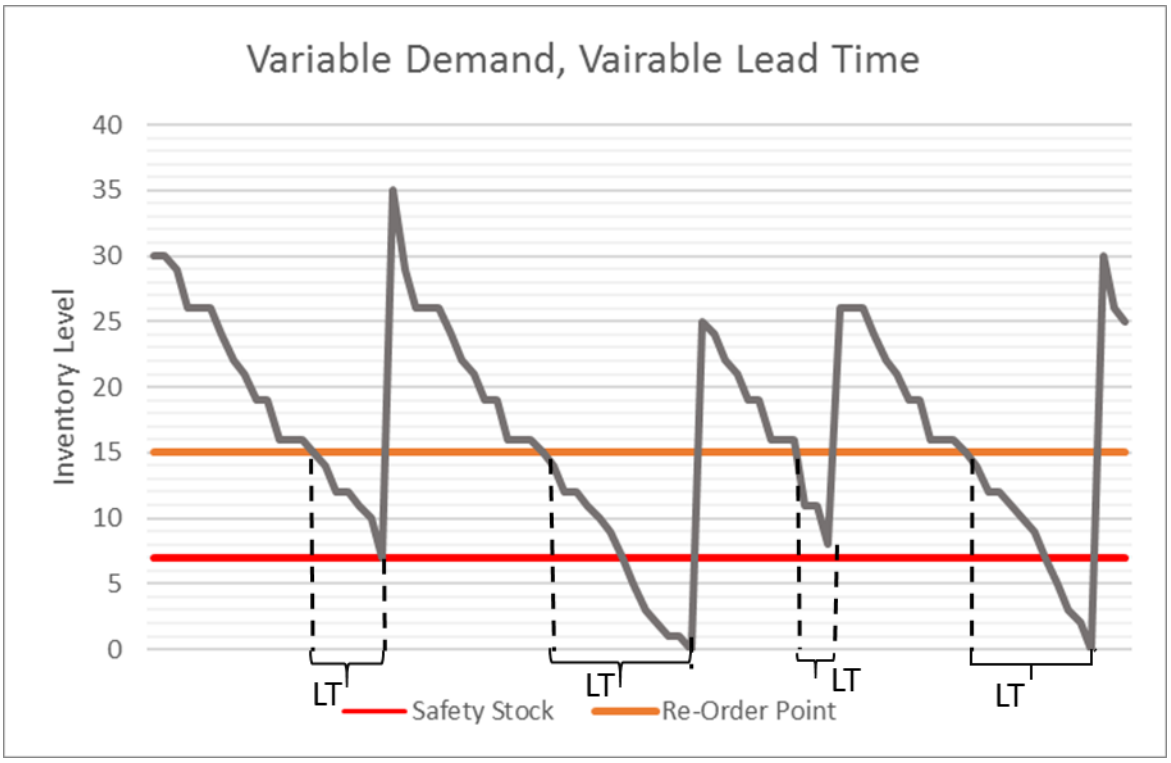


Figure 7: Variable lead-time and variable demand

3.4.5 Data analysis methods and materials

Due to the common healthcare uncertainties, a stochastic optimization approach was taken for data analysis. Considering the scope of the project and because of the lack of integrated upstream data, a single echelon optimization model was designed to predict the TGH ADC configuration in order to maximize the service level. After calculating average daily demands and lead-time for each medication item, the demand during lead-time is calculated. Having produced variables on hand, supply chain optimization techniques and the statistical model are applied to forecast the best values for Reorder Point and Safety Stock configuration to avoid medication stock-outs. Microsoft Excel and Anaconda Python are used as tools for plotting diagrams and developing models.

Table 3 summarizes methods and resources that have been used to answer the project questions:

Project Question	Applied techniques	Source of data
Stocked medications	A list of stocked medications extracted from appropriate reports.	Par Vs Usage report
Historical demand pattern	Daily transactions for "issued" medications calculated.	Par Vs Usage report Transactions by item procedure
Historical restocking pattern	Daily transactions for "Restock and Supplemental Restock" medications calculated	Transactions by item procedure
Lead Time calculations	Replenishment data calculated for Lead Time (LT: the time between ordering and replenishment) and Lead Time Demand (LTD: the amount of medications demanded during LT)	Transactions by item procedure

Reorder Point and Safety Stock calculations	The daily demands and related standard deviations calculated for a selected group of medications. The Service Level set as 99%, which means in 99% of times the ordered medication would be available for nurses to withdraw from the ADC. The Reorder Point (ROP) and Safety Stock (SS) levels calculated using formula [6]: $$[6]\ \boldsymbol{ROP = \overline{d}\ x\ \overline{LT} + z\sqrt{\overline{LT}\ \sigma_d{}^2 + \overline{d}^2 \sigma_{LT}{}^2}}$$	

Table3- Summary of data analysis methods and materials

4 Chapter 4: Results

4.1 Question 1: What are the stocked medications?

To obtain a list of stocked medication items a "Par Vs Usage" report was run and a list of 672 stocked medications were received. Of these medications, 22.92% (n=154) showed no record of consumption during the observation period (T= 428 days).

Diagram 4.1 depicts the percentage of demanded medication items. Un-demanded medication items have been listed in table 4.1.

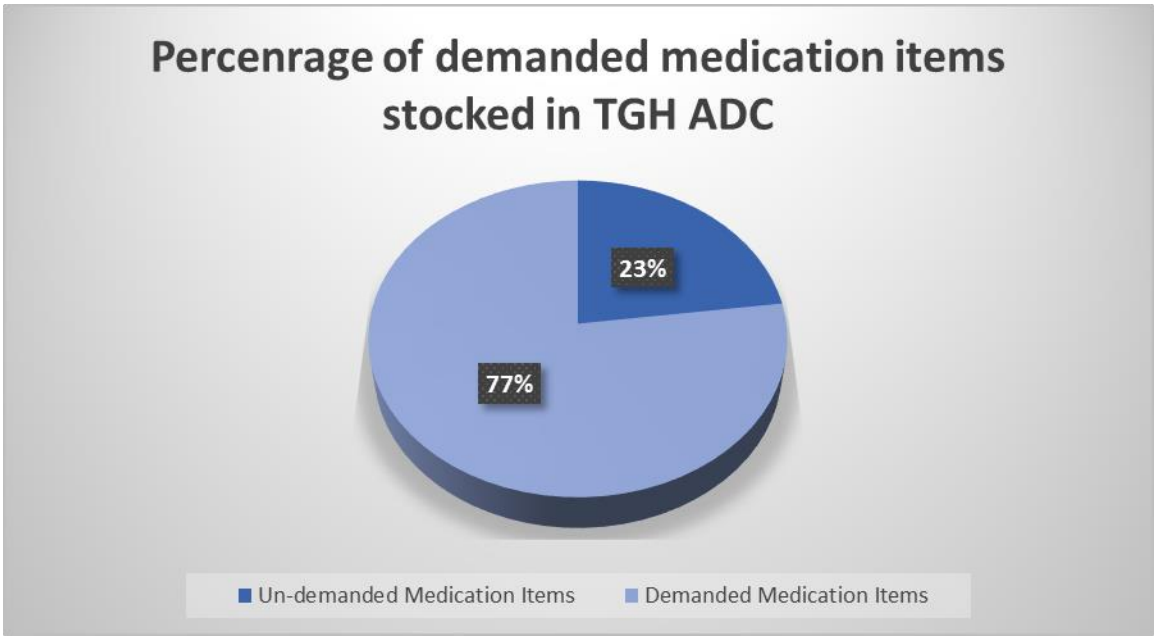


Diagram 4.1: percentage of un-demanded medication items

Table 4.1- quantity on hand for un-demanded medication items

Item ID	Medication item	PAR	Quantity on hand	Reorder Point	Safety Stock
300077	atropine 0.6mg/1mL 1mL Inj	80	80	65	60
299810	HYDROmorphone 8mg Tab	50	50	25	10

301979	tacrolimus 1mg Cap	0	45	0	0
301823	morphine ER 100mg Cap	25	25	15	5
305479	tacrolimus 0.5mg Cap	0	22	0	0
303658	erythromycin 250mg Tab	20	21	10	5
299716	cloxacillin 2g Inj	30	20	12	6
303666	codeine CR 50mg Tab	25	20	15	5
310795	nabilone 0.5mg Cap	25	20	15	10
299699	clarithromycin 250mg Tab	20	20	10	5
299713	cloxacillin 250mg Cap	20	20	10	5
299800	HYDROmorphone CR 24mg Cap	20	20	10	6
300374	divalproex sodium EC 250mg Tab	20	20	10	5
300602	isoproterenol 0.2mg/1mL 1mL Inj	20	20	10	4
300605	isosorbide 10mg Tab	20	20	10	5
303348	clonazePAM 2mg Tab	20	20	10	5
744937	tobramycin PF 40mg/1mL 2mL Inj	20	20	10	5
1196752	nozzles - lidocaine (plastic, disposable) 1ea Device	10	20	5	3
300767	methocarbamol 500mg Tab	10	20	5	2
300867	NIFEdipine 5mg Cap	20	19	10	5
299717	cloxacillin 500mg Cap	30	15	10	5
300167	carBAMazepine chew 100mg Tab	15	15	10	6
892747	docusate sodium UD 100mg/25mL 25mL Syrup	10	15	5	3
1263414	cascara sagrada UD 5mL Soln	20	13	10	4
300569	indomethacin 100mg Supp	10	11	5	2
1265414	benzydamine 0.15% oral UD 15mL Rinse	10	10	6	3
1267418	ranitidine UD 150mg/10mL 10mL Soln	10	10	8	5
1335423	melatonin SL 5mg Tab	10	10	5	3
299638	amikacin 250mg/1mL 2mL Inj	10	10	4	2

299723	codeine 30mg/1mL 1mL Inj	10	10	5	2
299757	ethambutol 100mg Tab	10	10	5	2
299803	HYDROmorphone CR 30mg Cap	10	10	5	2
300002	acebutolol 100mg Tab	10	10	5	3
300147	calcitriol 0.25mcg Cap	10	10	5	2
300282	deferoxamine 500mg Inj	10	10	9	9
300290	desmopressin 4mcg/1mL 1mL Inj	10	10	4	2
300313	diclofenac sodium SR 100mg Tab	10	10	5	2
300404	triamterene-hydrochlorothiazide 50-25 mg 1tab Tab	10	10	5	2
300416	ePHEDrine 50mg/1mL 1mL Inj	10	10	4	2
300543	hydrALAZINE 20mg/1mL 1mL Inj	10	10	5	2
300600	isoniazid 300mg Tab	10	10	5	2
300655	levothyroxine 88mcg Tab	10	10	5	2
300689	lithium carbonate 150mg Cap	10	10	5	2
300690	lithium carbonate 300mg Cap	10	10	5	2
300749	methotrimeprazine 25mg/1mL 1mL Inj	10	10	4	2
300826	nadolol 40mg Tab	10	10	5	2
300939	phenylephrine 10mg/1mL 1mL Inj	10	10	4	2
300945	phenytoin Chew 50mg Tab	10	10	5	2
300983	conjugated estrogens 0.625mg tab	10	10	5	3
301001	prochlorperazine 10mg Supp	10	10	5	0
301027	pyrazinamide 500mg Tab	10	10	5	2
301054	rifampin 150mg Cap	10	10	5	2
301055	rifampin 300mg cap	10	10	5	2
301142	terazosin 1mg Tab	10	10	5	2
301154	theophylline SR 200mg Tab	10	10	5	2
301261	pyridoxine 25mg Tab	10	10	5	2

301306	misoprostol 100mcg Tab	10	10	8	4
301784	cefuroxime 250mg Tab	10	10	5	2
302008	bromocriptine 2.5mg Tab	10	10	5	2
307710	pramipexole 0.25mg Tab	10	10	5	2
307756	rOPINIRole 1mg Tab	10	10	5	2
308254	pravastatin 20mg Tab	10	10	5	2
339017	entacapone 200mg Tab	10	10	5	2
464860	nitrofurantoin macrocrystals 50mg Cap	10	10	5	2
838927	fentaNYL 100mcg Patch	10	10	5	3
892841	dabigatran 150mg Cap	10	10	5	2
912384	oxyCODONE CR 10mg Tab	10	10	5	3
912386	oxyCODONE CR 40mg Tab	10	10	5	3
974381	acyclovir 50mg/1mL 20mL Inj	10	10	6	4
300842	naproxen 500mg Supp	5	10	2	0
299649	ampicillin 250mg Inj	10	9	4	2
300312	diclofenac sodium 100mg Supp	10	9	5	2
300376	DOBUTamine 12.5mg/1mL 20mL Inj	10	9	4	2
300772	methyldopa 250mg Tab	10	9	5	2
300256	cyclopentolate 1% ophthalmic 1ea Minim	10	8	4	2
303952	sodium bicarbonate 325mg Tab	10	8	5	2
300849	neostigmine 1mg/1mL 10mL Inj	10	7	4	2
301214	tropicamide 1% ophthalmic solution 1ea Minim	10	7	5	3
302153	methylene blue 10mg/1mL 5mL Inj	5	7	4	4
1269415	loperamide UD 2mg/10mL 10mL Soln	10	6	5	3
300045	aminophylline 25mg/1ml 10mL Inj	10	6	4	2
301040	quiNINE 300mg Cap	10	6	5	2
301341	cefotaxime 1g Inj	10	6	4	2

302066	pancrelipase EC (Cotazym ECS 20) 1cap Cap	10	6	5	2
1160773	cotrimoxazole SS 400-80 mg 8tab Vial	6	6	2	1
299848	metroNIDAZOLE (BCCDC) 250mg/1tab 28tab Vial	6	6	3	2
299849	metroNIDAZOLE (BCCDC) 250mg/1tab 8tab Vial	6	6	3	2
302204	vasopressin 20unit/1mL 1mL Inj	6	6	2	1
310618	Pico-Salax 1pkt Packet	6	6	4	2
980380	doxycycline (BCCDC) 100mg/1cap 14cap Vial	6	6	3	2
980381	doxycycline (BCCDC) 100mg/1cap 20cap Vial	6	6	3	2
300326	digoxin 0.0625mg Tab	5	6	4	3
301016	propylthiouracil 50mg Tab	5	6	4	2
301021	propranolol 1mg/1mL 1mL Inj	5	5	2	1
588919	fondaparinux 7.5 mg/0.6 mL 7.5mg/0.6mL 0.6mL Inj	5	5	4	2
838926	fentaNYL 75mcg Patch	5	5	3	2
300991	procainamide 100mg/1mL 10mL Inj	4	5	2	1
301025	protamine 10mg/1mL 5mL Inj	4	5	2	2
299772	fluconazole 2mg/1mL 100mL Inj	6	4	3	1
892543	ASA 325mg Supp	6	4	3	1
1160767	methocarbamol 500mg/1tab 4tab Vial	4	4	2	1
1160772	cloxacillin 250mg/1cap 8cap Vial	4	4	2	1
300475	folic acid 5mg/1mL 10mL Inj	4	4	3	3
302420	heparin 50unit/1mL 500mL Inj	4	4	3	2
304032	eptifibatide bolus 2mg/1mL 10mL Inj	4	4	2	1
980385	azithromycin (BCCDC) 250mg/1tab 8tab Vial	4	4	2	1
300033	alprostadil 500mcg/1mL 1mL Inj	2	4	1	0
300940	phenylephrine 10% ophthalmic 1ea Minim	5	3	2	1
301937	pralidoxime 1g Inj	3	3	2	2
300080	atropine 1% ophthalmic 5mL Soln	1	3	0	0

1163394	clarithromycin 25mg/1mL 55mL Susp	2	2	1	0
299715	cloxacillin 25mg/1mL 100mL Susp	2	2	1	1
299925	permethrin 1% topical 59mL Rinse	2	2	1	0
300985	conjugated estrogens 25mg Inj	2	2	1	0
301260	pyridoxine 100mg/1mL 30mL Inj	2	2	1	0
301289	zinc oxide 15% topical 50g Cream	2	2	1	0
301615	zinc sulfate-hydrocortisone 0.5-0.5% rectal 15g Oint	2	2	1	0
301617	zinc sulfate topical 0.5% rectal 30g Oint	2	2	1	0
301701	petrolatum compound ophthalmic 3.5g Oint	2	2	1	0
301740	nystatin topical 100000unit/1g 15g Cream	2	2	1	0
302006	bovine liquid extract topical 27mg/1mL 5mL Soln	2	2	1	1
302032	calcitonin salmon 200IntUn/2mL 2mL Inj	2	2	1	1
304033	eptifibatide 0.75mg/1mL 100mL Inj	2	2	1	0
310170	streptomycin 1g Inj	2	2	1	0
462776	dibucaine/esculin/framycetin/HC 15g Oint	2	2	1	0
470928	cefuroxime 25mg/1mL 70mL Susp	2	2	1	0
550919	flupentixol decanoate 20mg/1mL 1mL Inj	2	2	1	0
574923	lipid emulsion 20% 250mL Inj	2	2	1	0
716930	dinoprostone vaginal 0.5mg/2.5mL 2.5mL Gel	2	2	1	0
891933	KY Jelly 113g Gel	2	2	1	1
676926	triamcinolone/nystatin/neomycin/gramicidin topic 15g Cream	2	1	1	0
1160766	ferrous sulfate 30mg/1mL 100mL Soln	1	1	0	0
300113	betaxolol 0.25% ophthalmic 5mL Susp	1	1	0	0
300117	betamethasone 0.1% scalp 75mL Lotion	1	1	0	0
300818	sodium chloride 0.9% 30mL Spray	1	1	0	0
300943	phenytoin 25mg/1mL 1mL Susp	1	1	0	0

300986	conjugated estrogens 0.625 mg/g vaginal 14g Cream	1	1	0	0
301197	triamcinolone 0.1% dental 7.5g Paste	1	1	0	0
302044	paradichlorobenzene 11mL Drops	1	1	0	0
302057	clove oil topical 8mL Liquid	1	1	0	0
302075	cyanide antidote kit 1ea Inj	1	1	0	0
302189	pamidronate 9mg/1mL 10mL Inj	1	1	0	0
303725	silver sulfADIAZINE 1% topical 500g Cream	1	1	0	0
303748	prednisoLONE acetate 1% ophthalmic 5mL Susp	1	1	0	0
304354	fomepizole 1000mg/1mL 1.5mL Inj	1	1	0	0
876923	potassium phosphate in D5W 15mmol/255mL 255mL Inj	1	1	0	0
892071	leucovorin 10mg/1mL 50mL Inj	1	1	0	0
892272	metroNIDAZOLE 10% vaginal 60g Cream	1	1	0	0
1202784	oseltamivir 30mg/1cap 2cap Vial	0	0	0	0
1204762	oseltamivir 45mg/1cap 2cap Vial	0	0	0	0
1204763	oseltamivir 75mg/1cap 2cap Vial	0	0	0	0
299927	PHENobarbital 120mg/1mL 1mL Inj	0	0	0	0
892184	oseltamivir 30mg Cap	0	0	0	0
892185	oseltamivir 45mg Cap	0	0	0	0

4.1.1 Finding 1

Reorder Point of 13 demanded medication items was set as zero. Table 4.2 shows these medication items.

Item-ID	Medication Item	PAR	Reorder-Point	Safety Stock
307771	oseltamivir 75mg Cap	0	0	0
1160763	valproic acid oral 50mg/1mL 100mL Syrup	1	0	0

300224	clobetasol 0.05% topical 15g Cream	1	0	0
304351	fluticasone-salmeterol 250-50 mcg 28dose Diskus	1	0	0
446774	cholecalciferol 400 IntUnit/drop 2.5mL Drops	1	0	0
1160761	metoclopramide 1mg/1mL 100mL Syrup	0	0	0
301282	xylometazoline 0.1% nasal 20mL Spray	1	0	0
299711	clotrimazole 1% vaginal 50g Cream	1	0	0
299706	clindamycin 15mg/1mL 100mL Soln	1	0	0
304346	fluticasone-salmeterol 250-25 mcg 120puff Inhaler	1	0	0
302207	tetanus immne globulin human 250unit/1mL 1mL Inj	1	0	0
308274	budesonide-formoterol 200-6 mcg 60dose Inhaler	1	0	0
302166	mycophenolate mofetil 250mg Cap	0	0	0

Table 4.2: Demanded medication items with ROP =0

4.1.2 Finding 2

Safety Stock of 43 demanded medication items was set as zero.

Table 4.3 shows these medication items.

Item-ID	Medication Item	PAR	Reorder Point	Safety Stock
307771	oseltamivir 75mg Cap	0	0	0
1160763	valproic acid oral 50mg/1mL 100mL Syrup	1	0	0
300224	clobetasol 0.05% topical 15g Cream	1	0	0
304351	fluticasone-salmeterol 250-50 mcg 28dose Diskus	1	0	0
446774	cholecalciferol 400 IntUnit/drop 2.5mL Drops	1	0	0
1160761	metoclopramide 1mg/1mL 100mL Syrup	0	0	0

301282	xylometazoline 0.1% nasal 20mL Spray	1	0	0
299711	clotrimazole 1% vaginal 50g Cream	1	0	0
299706	clindamycin 15mg/1mL 100mL Soln	1	0	0
304346	fluticasone-salmeterol 250-25 mcg 120puff Inhaler	1	0	0
302207	tetanus immne globulin human 250unit/1mL 1mL Inj	1	0	0
308274	budesonide-formoterol 200-6 mcg 60dose Inhaler	1	0	0
302166	mycophenolate mofetil 250mg Cap	0	0	0
300526	hydrocortisone sodium succinate 500mg Inj	2	1	0
300951	phentolamine 10mg/1mL 1mL Inj	2	1	0
299823	ketoconazole 2% topical 30g Cream	2	1	0
300929	permethrin 5% topical 30g Cream	2	1	0
706923	fusidic acid 2% topical 30g Cream	2	1	0
706924	fusidic acid 2% topical 30g Oint	2	1	0
304571	fentaNYL 50mcg/1mL 10mL Inj	2	1	0
300672	lidocaine 4% topical 50mL Soln	2	1	0
1160762	ora-sweet SYRUP 100mL Syrup	2	1	0
582919	diclofenac 0.1% ophthalmic 5mL Soln	2	1	0
1052742	tiotropium handihaler 1ea Device	2	1	0
299957	tobramycin 0.3% ophthalmic 5mL Soln	2	1	0
300644	latanoprost ophthalmic 0.005% 2.5mL Soln	2	1	0
301773	HIV Kit 1ea Kit	2	1	0
1223395	polymyxin-gramicidin ophthalmic-otic 15mL Soln	2	1	0
301540	fluticasone 125 mcg 60puff Inhaler	2	1	0
309110	triamcinolone acetonide 40mg/1mL 1mL Inj	2	1	0
301145	terbinafine 1% topical 30g Cream	2	1	0

299747	enoxaparin 100mg/1mL 3mL Inj	2	1	0
299697	ciprofloxacin 0.3% ophthalmic 5mL Soln	2	1	0
301561	fluticasone 250 mcg 60puff Inhaler	2	1	0
299911	ondansetron 0.8mg/1mL 50mL Soln	2	1	0
299656	azithromycin (BCCDC) 250mg/1tab 4tab Vial	2	1	0
300968	polyvinyl alcohol 1.4% ophthalmic 15mL Soln	2	1	0
300097	beclomethasone nasal 50 mcg 200spray Spray	2	1	0
300673	lidocaine 2% 30g Gel	2	1	0
300333	dihydroergotamine 1mg/1mL 1mL Inj	3	1	0
301768	tuberculin PPD 5unit/0.1mL 1mL Inj	3	1	0
918396	glycerin pediatric 1supp Supp	12	3	0
918394	glycerin adult 1supp Supp	12	3	0

Table 4.3: Demanded Medication items with SS=0

4.1.3 Finding 3

The report revealed a stocked-out event for 122 on demanded medication items. Medications were reported as "stocked out" for 1 to 8 days. Table 4.4 lists 10 medication items with highest number of stock-out days.

Item-ID	Medication Item	PAR	Reorder-Point	Safety Stock	Total Demand	# of Stock-outs
301227	ursodiol 250mg Tab	30	15	6	417	8
308274	budesonide-formoterol 200-6 mcg 60dose Inhaler	1	0	0	7	6
498921	dexamethasone 0.1mg/1mL 100mL Soln	2	1	1	17	6

299911	ondansetron 0.8mg/1mL 50mL Soln	2	1	0	15	5
301215	calcium carbonate 500mg Tab	50	30	20	896	5
304346	fluticasone-salmeterol 250-25 mcg 120puff Inhaler	1	0	0	4	4
301150	tetracaine 0.5% ophthalmic solution 1ea Minim	10	5	2	82	4
300709	losartan 50mg Tab	10	5	2	110	4
892375	cholecalciferol 1000IntUn Tab	30	15	10	552	4
299794	HYDROmorphone 1mg Tab	75	50	15	1009	4

Table 4.4: Medication items with highest number of stock-out days

4.1.4 Finding 4

After calculating the Stock-out rate (number of days with zero quantity on hand divided by total demand days), it revealed that 39 medication items have more than 10% stock-out rate. Diagram 4.2 shows these medication items and the percentage of stock-out rate for each.

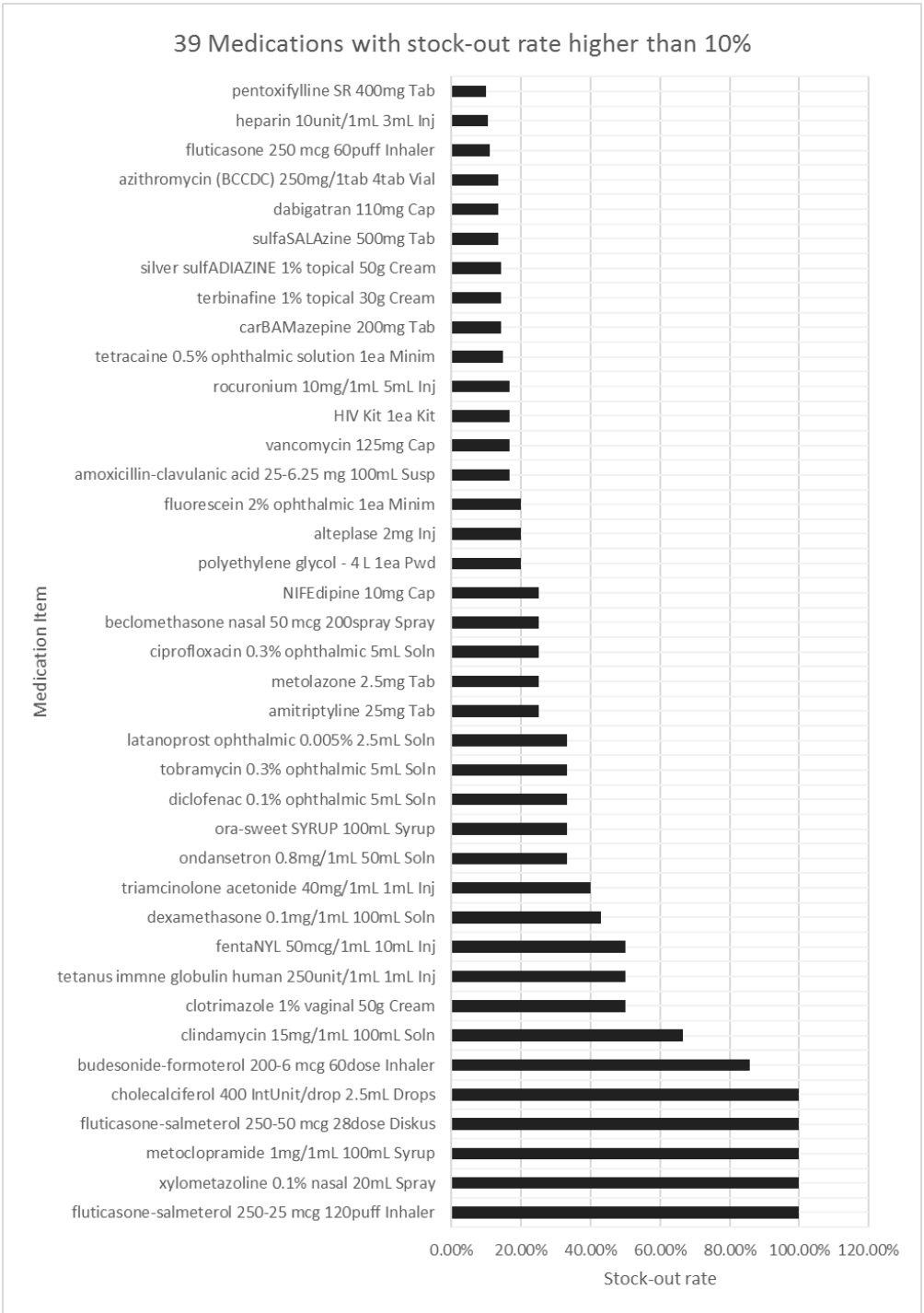


Diagram 4.2: Medication items with stock out ratio above 10%

4.1.5 Finding 5

300 medication items showed "Expired" transactions. The quantity of expired items ranged from 1 to 98. Diagram 4.3 shows items with more than 30 expired medications.

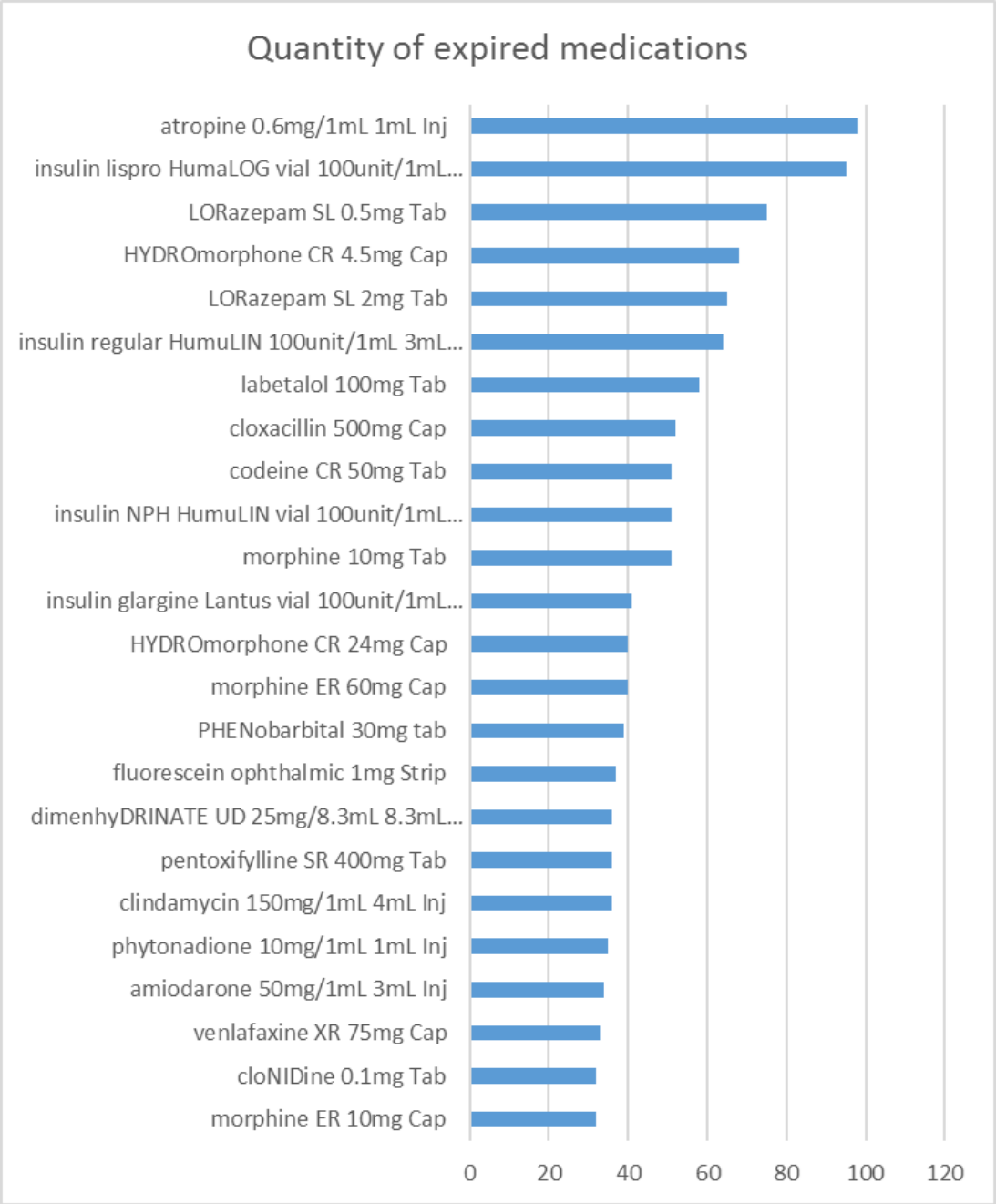


Diagram 4.3: Expired medications

4.2 Question 2: What are the historical demand patterns?

4.2.1 -The most demanded medications

To understand the historical demand patterns, a Par vs. Usage report run from 30 May 2017 (go-live date) to 31 July 2018. (T=428 days) and examined. This report revealed the total quantity of issued medications; however, to calculate the average quantity of issued medication items the system uses the "count-days" field. Count-days is the number of days that each specific medication item has been issued therefore it could be different for each medication item. The Par vs. Usage reports also shows

the maximum and minimum number of issued medication items during the report period. Diagram 4.4 shows the 25 most demanded (issues) medication items during the observation period.

Diagram 4.4: The most demanded medication items

To normalize the average daily demand of each medication item, the researcher divided the total issued quantity by total days of observation rather than number of days that the issue event happened. Diagram 4.5 compares the average daily demands, in both methods for the 25 most issued medication items.

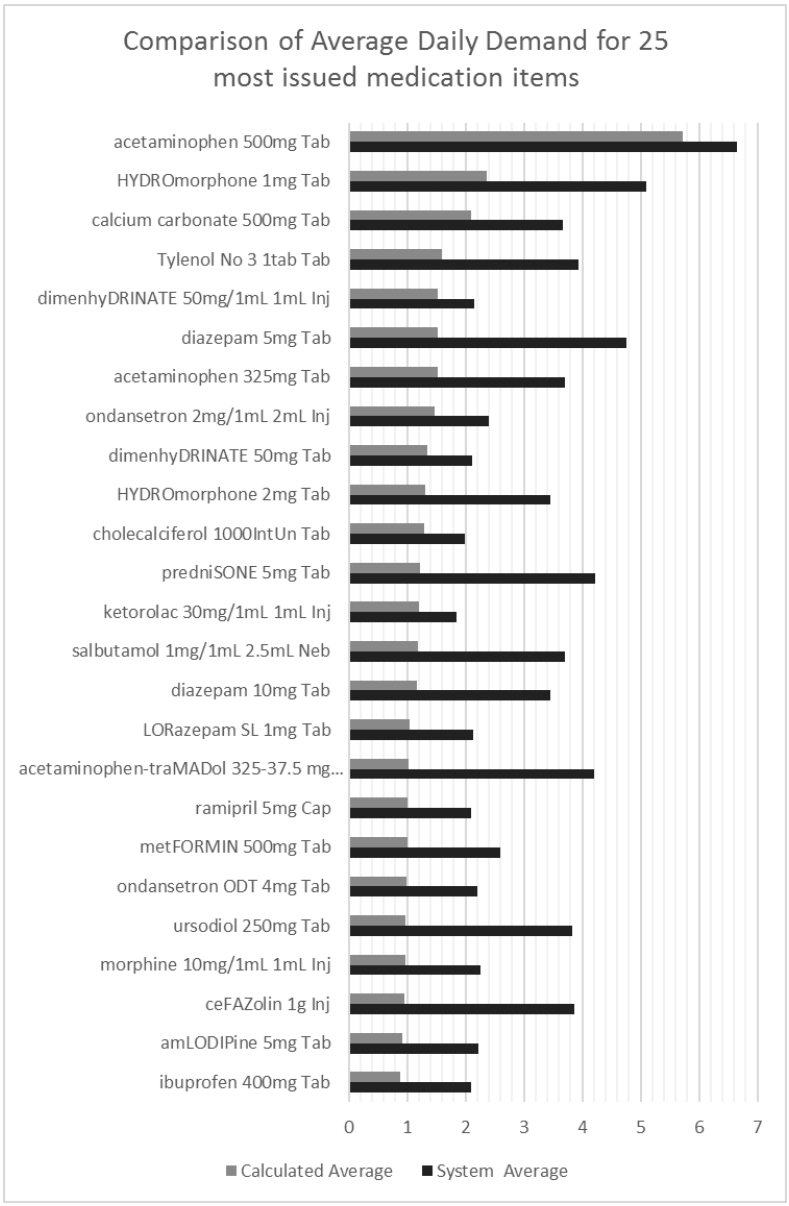


Diagram 4.5: A comparison between normalized and non-normalized Average Daily Demands

4.2.2 The least demanded medication items

Par vs. Usage reports also showed a list of the least demanded medication items. Table 4.5 shows a list of 25 least demanded medication items with related settings for each item. The normalized daily demand for each item is as low as 0.002 per day.

Item-ID	Medication Item	PAR	Reorder-Point	Safety Stock	Total Demand
1160763	valproic acid oral 50mg/1mL 100mL Syrup	1	0	0	1
300224	clobetasol 0.05% topical 15g Cream	1	0	0	1
918396	glycerin pediatric 1supp Supp	12	3	0	1
301768	tuberculin PPD 5unit/0.1mL 1mL Inj	3	1	0	1
299677	cefuroxime 1.5g Inj	10	4	2	1
300100	benztropine 1mg/1mL 2mL Inj	10	4	2	1
300331	digoxin 0.25mg/1mL 2mL Inj	10	4	2	1
1271414	cotrimoxazole 400-80 mg oral UD 10mL Susp	12	6	4	1
300526	hydrocortisone sodium succinate 500mg Inj	2	1	0	1
300951	phentolamine 10mg/1mL 1mL Inj	2	1	0	1
894447	lidocaine 0.4% 250mL Inj	4	2	2	1
300632	labetalol 5mg/1mL 20mL Inj	6	3	2	1
300066	ASA EC 325mg Tab	10	5	2	1
300136	buPROPion SR 100mg Tab	10	5	2	1
300350	dimenhyDRINATE 100mg Supp	10	5	2	1
300712	loxapine 25mg Tab	10	5	2	1

301039	quiNINE 200mg Cap	10	5	2	1
301113	spironolactone 100mg Tab	10	5	2	1
301234	venlafaxine XR 37.5mg Cap	10	5	2	1
301243	verapamil 80mg Tab	10	5	2	1
304874	indapamide 2.5mg Tab	10	5	2	1
524919	finasteride 5mg Tab	10	5	3	1
866927	dalteparin 7500 IntUnit/0.3 mL 1ea Inj	10	5	3	1
299947	SUFentanil 50mcg/1mL 1mL Inj	20	10	5	1
300630	labetalol 100mg Tab	20	10	5	1

Table 4.5: The least demanded medication items

4.3 Question3: What are the historical restocking patterns?

The "Transactions by Item Procedure" report shows the daily transaction of each medication item during the study period. This report includes all transactions of the ADC, regarding issuing or withdrawing a medication. Diagram 4.6 shows daily transactions of ciprofloxacin 500mg Tab during the observation period. The configured ROP and safety stock for this medication item was set as 10 and 5. Appendix 1 contains demand patterns of 103 medication items along with their configured ROP and Safety Stock levels.

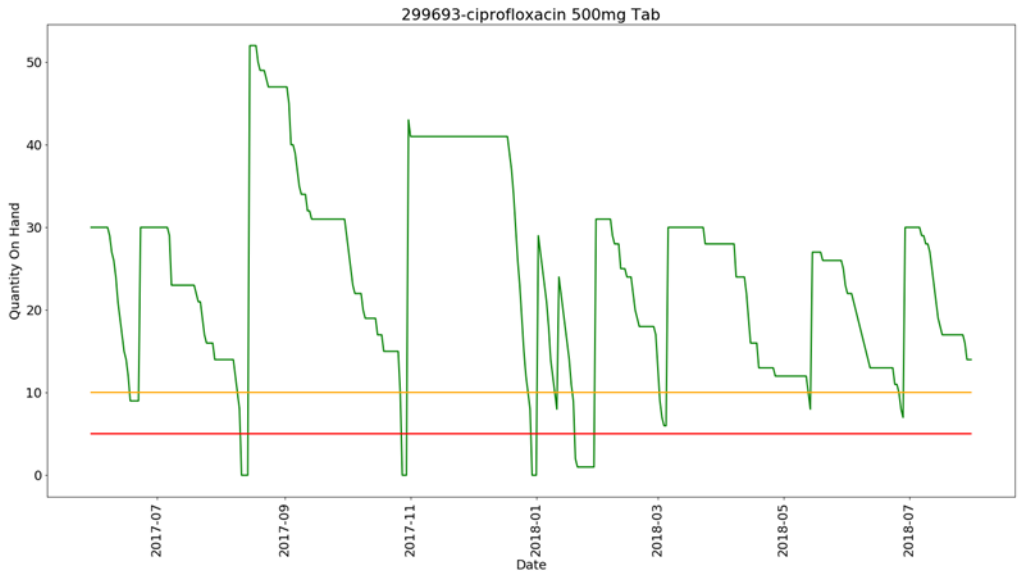


Diagram 4.6: Daily transactions of ciprofloxacin 500mg Tab

4.4 Question 4: What is the Lead Time for restocking medications?

To calculate the lead-time, the "Transactions by Item Procedure" report was examined for replenishment transactions. Comparing the configured Reorder Point (extracted from Par Vs Usage report) and "quantity on hand" for each medication item, the date that ADC sent a reorder message was subtracted from the date that the "restock" transaction had been recorded. The average and standard deviation of the calculated lead-time for a selected group of 52 medications stocked in single bins are listed in table 4.6 under question 5. These two variables were required to calculate the Safety Stock and Reorder Point for each medication item.

4.5 Question5: What is the Safety Stock level to minimize the stock-out?

Table 4.6 lists the Safety Stock and Reorder Point of 52 medication items, for 99% confidence interval.

Table 4.6 Safety Stock and Reorder Point for 99% Service Level

Item ID	Medication Item	Average daily demand	Standard deviation of daily demand	Average lead time (in days)	Standard deviation of lead time, σLT	Service level (% of demand met)	Z-value	Average demand during lead time	Standard deviation of demand during lead time,	Suggested SS	Suggested ROP
299644	amoxicillin 500mg Cap	0.42	1.52	3.80	1.23	99.00%	2.33	1.580373832	3.01	7	9
299664	ceFAZolin 1g Inj	0.96	2.28	2.85	1.46	99.00%	2.33	2.72645579	4.10	10	12
299670	cefTRIAXone 1g Inj	0.41	0.70	2.43	0.79	99.00%	2.33	1.00433912	1.14	3	4
299672	cefTRIAXone 2g Inj	0.47	0.75	2.94	1.70	99.00%	2.33	1.39654725	1.51	4	5
299683	cephalexin 500mg Tab	0.56	1.21	4.46	6.94	99.00%	2.33	2.49137311	4.64	11	13
299693	ciprofloxacin 500mg Tab	0.61	1.09	4.67	2.74	99.00%	2.33	2.82398754	2.88	7	10
299701	amoxicillin-clavulanic acid 500-125mg 1tab Tab	0.26	0.91	8.50	10.77	99.00%	2.33	2.24415888	3.89	9	11
299731	cotrimoxazole DS 800-160 mg 1tab Tab	0.20	0.81	4.00	2.71	99.00%	2.33	0.80373832	1.72	4	5
299870	morphine ER 15mg Cap	0.19	0.60	2.60	1.67	99.00%	2.33	0.49205607	1.02	2	3
299993	ondansetron ODT 4mg Tab	0.98	1.59	3.42	1.59	99.00%	2.33	3.3607866	3.33	8	11
300007	acetaminophen 325mg Tab	1.52	2.51	3.50	3.11	99.00%	2.33	5.32359813	6.66	16	21
300013	acetaminophen 500mg Tab	5.71	5.35	2.72	1.23	99.00%	2.33	15.5573728	11.28	26	42
300075	atorvastatin 20mg Tab	0.26	0.58	2.70	1.06	99.00%	2.33	0.70023364	0.99	2	3
300219	citalopram 20mg Tab	0.32	0.57	3.20	1.55	99.00%	2.33	1.02429907	1.14	3	4
300255	cyclobenzaprine 10mg Tab	0.22	0.83	2.67	1.75	99.00%	2.33	0.57943925	1.40	3	4
300353	dimenhyDRINATE 50mg Tab	1.34	1.60	8.18	5.34	99.00%	2.33	10.9919286	8.51	20	31
300355	dimenhyDRINATE 50mg/1mL 1mL Inj	1.53	1.50	2.53	1.51	99.00%	2.33	3.86510903	3.31	8	12
300361	diphenhydrAMINE 25mg Cap	0.65	1.52	9.33	7.68	99.00%	2.33	6.105919	6.84	16	22
300379	docusate sodium 100mg Cap	0.24	0.58	2.75	1.50	99.00%	2.33	0.65537383	1.03	2	3

300419	EPINEPHrine 1mg/1mL 1mL Inj	0.14	0.62	1.25	0.96	99.00%	2.33	0.16939252	0.71	2	2
300485	furosemide 10mg/1mL 4mL Inj	0.20	0.66	14.00	15.07	99.00%	2.33	2.78037383	3.89	9	12
300511	haloperidol 5mg/1mL 1mL Inj	0.23	0.87	14.50	21.02	99.00%	2.33	3.35397196	5.89	14	17
300550	hyoscine butylbromide 20mg/1mL 1mL Inj	0.22	0.55	3.67	2.07	99.00%	2.33	0.80529595	1.14	3	3
300551	ibuprofen 200mg Tab	0.68	1.62	2.70	1.06	99.00%	2.33	1.83574766	2.75	6	8
300553	ibuprofen 300mg Tab	0.78	1.45	3.73	2.96	99.00%	2.33	2.91339564	3.64	8	11
300618	potassium chloride SR 600mg Tab	0.74	1.64	4.19	3.45	99.00%	2.33	3.11127336	4.22	10	13
300701	loratadine 10mg Tab	0.14	0.48	4.25	2.55	99.00%	2.33	0.58586449	1.05	2	3
300706	LORazepam 4mg/1mL 1mL Inj	0.19	0.53	22.11	18.79	99.00%	2.33	4.13291796	4.30	10	14
300709	losartan 50mg Tab	0.26	0.64	2.46	1.39	99.00%	2.33	0.63263839	1.07	2	3
300777	metoclopramide 5mg/1mL 2mL Inj	0.34	0.74	7.40	5.98	99.00%	2.33	2.54158879	2.88	7	9
300918	pantoprazole 40mg Inj	0.39	0.90	15.80	15.45	99.00%	2.33	6.0911215	6.95	16	22
301051	ranitidine 25mg/1mL 2mL Inj	0.09	0.40	3.67	0.58	99.00%	2.33	0.33411215	0.76	2	2
301252	thiamine 100mg Tab	0.65	1.05	2.47	1.54	99.00%	2.33	1.61251845	1.94	5	6
301264	ascorbic acid 500mg Tab	0.74	0.96	3.29	1.69	99.00%	2.33	2.43980209	2.15	5	7
301572	ranitidine 150mg Tab	0.78	1.18	3.50	1.90	99.00%	2.33	2.71495327	2.65	6	9
301623	ASA EC 81mg Tab	0.54	0.86	2.13	0.99	99.00%	2.33	1.15186916	1.37	3	4
301826	ondansetron 2mg/1mL 2mL Inj	1.47	1.84	3.67	2.42	99.00%	2.33	5.40576324	5.02	12	17
302056	clopidogrel 75mg Tab	0.29	0.89	10.50	11.74	99.00%	2.33	3.04205607	4.46	10	13
302164	multivitamin 10mL Inj	0.18	0.44	2.93	1.44	99.00%	2.33	0.53371162	0.79	2	2
302500	diphenhydrAMINE 50mg/1mL 1mL Inj	0.20	0.52	3.25	1.71	99.00%	2.33	0.66063084	1.01	2	3
304712	gabapentin 100mg Cap	0.43	1.44	0.83	0.75	99.00%	2.33	0.35436137	1.36	3	4
304713	gabapentin 300mg Cap	0.54	1.36	2.25	1.71	99.00%	2.33	1.20385514	2.24	5	6
305174	perindopril 4mg Tab	0.07	0.31	1.50	1.00	99.00%	2.33	0.09813084	0.39	1	1
306314	ondansetron 4mg Tab	0.80	1.44	3.44	1.63	99.00%	2.33	2.76285047	2.97	7	10

306485	atorvastatin 40mg Tab	0.39	0.86	4.24	4.25	99.00%	2.33	1.67234744	2.44	6	7
464907	magnesium elemental 100mg Tab	0.67	1.31	8.00	5.37	99.00%	2.33	5.34579439	5.15	12	17
502922	melatonin SL 3mg Tab	0.11	0.48	3.80	1.30	99.00%	2.33	0.39953271	0.95	2	3
892033	metoprolol 50mg Tab	0.36	0.95	5.00	3.70	99.00%	2.33	1.82242991	2.52	6	8
892225	QUEtiapine 25mg Tab	0.24	0.82	16.83	27.72	99.00%	2.33	4.05101246	7.47	17	21
892420	clindamycin 150mg/1mL 4mL Inj	0.32	0.92	6.50	9.04	99.00%	2.33	2.05023364	3.69	9	11
1160770	acetaminophen 500mg/1tab 8tab Vial	0.12	0.38	13.13	9.92	99.00%	2.33	1.59462617	1.83	4	6
1250771	pantoprazole magnesium EC (new) 40mg Tab	1.97	1.44	3.66	2.48	99.00%	2.33	7.20998832	5.62	13	20

5 Chapter 5- Discussion

Collected data shows anomalies and a lack of following best practice regarding stocking, replenishment and configuration of medication items. In addition, studying workflows, both from a pharmacy and a nursing perspective, indicate potential related barriers to following best practice with respect these activities.

5.1 Stocked Medications

5.1.1 Un-demanded medications

As shown in diagram 4.1, 23% of the stocked medications were not used during the observation period. Reviewing the "Transaction by Item Procedure" report revealed that many of these medications were expiring during the observation period. During this period, pharmacy technicians were checking and controlling these items and replacing them with new inventory. In addition, for controlled substances (i.e. Narcotic medications) nurses were required to perform cycle counts as per pharmacy policies and procedures. In other words, keeping this inventory in the ADC is imposing cost and increasing workload both for pharmacy and nursing.

In other similar studies for ADC inventory optimization (McCarthy & Ferker, 2016) (O'Neil, Miller, Cronin, & Hatfield, 2016) and (Labuhn, Almeter, McLaughlin, Fields, & Turner, 2017), it has been suggested to remove the unused medication items except for emergency items. However due to the remoteness of Tofino and geographical distance between the supporting pharmacy and the hospital, it is not prudent to remove these medication items from the TGH ADC.

To address this problem, pharmacy could consider following measures:

- Perform a meticulous analysis to remove those medications that could be substituted by other medications or doses without imposing any risks to patient health (i.e. generic medications rather than branded). This will make room for other highly demanded medications. With larger inventory for those medications, Reorder Point and Safety Stock cutoff points could be adjusted to a higher volume. This will affect the number of weekly visits positively and eventually reduces pharmacy workload.

- Minimize the inventory level based on the number of pharmacy staff weekly visits or average Lead Time for total medication items.
- Adjust the Safety Stock and Reorder point accordingly.

5.1.2 Inappropriate configurations

Examining the "Par. Vs Usage" report showed suboptimal configuration of PAR, Reorder Point and Safety Stock levels for several medications. For example, the "refill" message for medication items listed in table 4.2 would not be sent to pharmacy because the Reorder Point was set as zero for these items. In addition, 43 items listed in table 4.3 have no safety stock configured for; meaning no reminder replenishment message for pharmacy had been fired for them.

Cross-examining these items with the "Transactions by Item Procedures" report shows a trace of demand (and restocking) for these medications. Without accurate configuration of medications, pharmacy is not able to manage the inventory properly and stock-out events are inevitable. This poses a serious risk to patient medication safety and interrupts the process of care. Pharmacy should periodically examine the demand pattern and re-adjust the configuration and settings for each medication item.

5.1.3 Stock-out events

The "Par Vs Usage" report is a valuable reference to understand the frequency of stock-out events and to study the relationship between the medication settings and the demand associated with each item. As an example, more than 27% percent of 122 medication items with stock-out events have a Safety Stock as low as zero or one. Without an appropriate Safety Stock setting, pharmacy is not able to replenish items appropriately.

Citing the frequency of stock-out events on "Par Vs Usage" as the only source of information could be misleading. Cross-referencing this report with other system reports, (e.g. Daily Transactions by Item Procedure) showed that in real world scenarios, the inventory might hit zero due to several reasons, including:

- Destocking medications by pharmacy technicians
- Switching bins or drawers

- Bin modification

To have a more realistic picture of this issue, each single medication should be examined individually. One appropriate source could be the daily transactions Reports

5.1.4 Stock-out rate and non-unit dose items

The "Par Vs Usage" report shows "Count-days" for each medication item. Count-days is the number of days that system has recorded an issue transaction for each item. This variable has been used to calculate the stock-out rates. Diagram 4.2 shows a list of 39 items with stock-out rate higher than 10%. Cross-referencing these items with the daily transaction reports opens a new window to these results. Item packaging is another factor that should be considered for inventory optimization. In other words, settings and workflows regrading usage and replenishment of the medication items with non-Unit Dose format is different from Unit Dose format medication items. Medication items with non-Unit Dose format could be:

- Inhalers
- Creams
- Solutions
- Syrups
- Powders
- Drops
- Sprays
- Specific kits (HIV, Emergency…)

Pharmacy needs to develop policies around stocking, replenishment and usage workflows of these type of medications.

5.1.5 Expired medications

Expiration of a medication is an indicator of poor inventory management, yet it is inevitable. Having expired medications in the ADC could be assessed as a potential risk to medication safety. There is always a chance for user error to administer expired medications. It imposes more inventory cost and takes the required space required for storing other demanded medication items.

A deeper look into the system configuration for the expired medications revealed an interesting fact. As shown in table 5.1, the quantity-issued for medications with the highest expiry quantity is as low as zero while the quantity on hand for these items is equal to or close to PAR level. In other words, even though in the past 428 days none of these medications where in demand, pharmacy has not adjusted the system configuration for these items and still stocks them to the PAR level on a regular basis. A list of all medication items with a history of expiration included in Appendix 2.

Item_ID	Medication Item	PAR	qty_onhand	Reorder point	Safety Stock	qty_issued	Expired
300077	atropine 0.6mg/1mL 1mL Inj	80	80	65	60	0	98
299717	cloxacillin 500mg Cap	30	15	10	5	0	52
303666	codeine CR 50mg Tab	25	20	15	5	0	51
299800	HYDROmorphone CR 24mg Cap	20	20	10	6	0	40
300689	lithium carbonate 150mg Cap	10	10	5	2	0	27
299810	HYDROmorphone 8mg Tab	50	50	25	10	0	25
301823	morphine ER 100mg Cap	25	25	15	5	0	25
300602	isoproterenol 0.2mg/1mL 1mL Inj	20	20	10	4	0	25
876923	potassium phosphate in D5W 15mmol/255mL 255mL Inj	1	1	0	0	0	21
299713	cloxacillin 250mg Cap	20	20	10	5	0	20
300374	divalproex sodium EC 250mg Tab	20	20	10	5	0	20
300605	isosorbide 10mg Tab	20	20	10	5	0	20
303348	clonazePAM 2mg Tab	20	20	10	5	0	20
1263414	cascara sagrada UD 5mL Soln	20	13	10	4	0	20
299638	amikacin 250mg/1mL 2mL Inj	10	10	4	2	0	20
300147	calcitriol 0.25mcg Cap	10	10	5	2	0	20
300655	levothyroxine 88mcg Tab	10	10	5	2	0	20
300945	phenytoin Chew 50mg Tab	10	10	5	2	0	20
301054	rifampin 150mg Cap	10	10	5	2	0	20
301214	tropicamide 1% ophthalmic solution 1ea Minim	10	7	5	3	0	20
300045	aminophylline 25mg/1ml 10mL Inj	10	6	4	2	0	20
301040	quiNINE 300mg Cap	10	6	5	2	0	20
912384	oxyCODONE CR 10mg Tab	10	10	5	3	0	19
300940	phenylephrine 10% ophthalmic 1ea Minim	5	3	2	1	0	16
300983	conjugated estrogens 0.625mg tab	10	10	5	3	0	15
301001	prochlorperazine 10mg Supp	10	10	5	0	0	15
302066	pancrelipase EC (Cotazym ECS 20) 1cap Cap	10	6	5	2	0	14
892543	ASA 325mg Supp	6	4	3	1	0	12
300867	NIFEdipine 5mg Cap	20	19	10	5	0	11
300767	methocarbamol 500mg Tab	10	20	5	2	0	10
1265414	benzydamine 0.15% oral UD 15mL Rinse	10	10	6	3	0	10
299757	ethambutol 100mg Tab	10	10	5	2	0	10
299803	HYDROmorphone CR 30mg Cap	10	10	5	2	0	10
300282	deferoxamine 500mg Inj	10	10	9	9	0	10
300313	diclofenac sodium SR 100mg Tab	10	10	5	2	0	10
300404	triamterene-hydrochlorothiazide 50-25 mg 1tab Tab	10	10	5	2	0	10
300826	nadolol 40mg Tab	10	10	5	2	0	10
301027	pyrazinamide 500mg Tab	10	10	5	2	0	10
301055	rifampin 300mg cap	10	10	5	2	0	10
301142	terazosin 1mg Tab	10	10	5	2	0	10
301784	cefuroxime 250mg Tab	10	10	5	2	0	10
302008	bromocriptine 2.5mg Tab	10	10	5	2	0	10
307756	rOPINIRole 1mg Tab	10	10	5	2	0	10
339017	entacapone 200mg Tab	10	10	5	2	0	10
464860	nitrofurantoin macrocrystals 50mg Cap	10	10	5	2	0	10
892841	dabigatran 150mg Cap	10	10	5	2	0	10
300772	methyldopa 250mg Tab	10	9	5	2	0	10
303952	sodium bicarbonate 325mg Tab	10	8	5	2	0	10
1269415	loperamide UD 2mg/10mL 10mL Soln	10	6	5	3	0	10
892185	oseltamivir 45mg Cap	0	0	0	0	0	10
303658	erythromycin 250mg Tab	20	21	10	5	0	9

Table 5.1: list of medications with the highest expired quantity.

5.1.6 Demand patterns

While calculating daily demand patterns for each medication item is necessary to calculate Safety Stock and Reorder Point, it also helps to understand which medication items should be stocked more to fulfill the daily demands. Examining the "Par Vs Usage" report, the most demanded medications are shown in Diagram 4.4. It seems that Hydromorphone 1mg Tab is the second demanded medication (n=1009) after Acetaminophen 500Mg Tab (n=2446). This could be concerning for pharmacy, as Hydromorphone is a controlled substance.

After cross examining the "Par Vs Usage" report with other reports, it's been discovered that the total count days for each medication item is the summation of all days that the item has been issued, so it was different for each item. To normalize the demand rates, the total number of issued medications were divided by the total number of observation days (T=428 days). After normalizing the data, a significant difference observed. This could provide a baseline for comparing demand patterns for other rural and remote sites that are utilizing ADCs for medication distribution.

Regarding the least demanded items listed in Table 4.5, during the observation period, the total demand for these items were as low as one. As expected, no constant demand pattern observed.

5.1.7 Restocking patterns

Several important facts found after reviewing replenishment patterns:

- The intervals between pharmacy technician visits for replenishment purposes were variable.
- Pharmacy staff were not restocking medication items as per configured PAR values. For example, the PAR level for ciprofloxacin 500mg Tab was set as 30, however the quantity on hand values after each restocking event was ranging from 52 to 25 as shown in diagram 4.6. One reason for understocking could be drug shortage in upstream entities
- Pharmacy has not been responsive to reorder messages that the ADC was sending when the inventory level of certain medication was hitting the Re-Order Point or Safety Stock points. As a result, stock out events were happening frequently for several medication items. While it is not practical to travel to the site to refill the cabinet for each single medication item, pharmacy could readjust medication items configurations to increase the ROP and Safety

Stock cutoff numbers. It might be one of the reasons for overstocking medications to postpone stock-out events.

- After reviewing replenishment patterns, it seems that over time pharmacy has gained better experience and understanding about restocking frequency as stock out events are less frequent toward the end of the observation period.

5.1.8 Lead Time

As mentioned above, examining reports and measuring intervals between replenishments showed that the lead-time for each item is different. As an example the lead-time for ciprofloxacin 500 mg Tab was fluctuating between 2 to 11 days. The variable demand rate, justifies the variable lead-time; however, as said before pharmacy's responsiveness to replenishment requests were low.

5.1.9 Calculated Safety Stock level

After proving that Demand (d) and Lead Time (LT) are not constant, the average for each variable and 52 medications were calculated and formula [6] applied to calculate the reorder points and Safety stock values for each medication item. To minimize the risk of stock-outs, the maximum service level (confidence interval) was set as 99%. Table 4.6 shows the calculated Safety Stock and Reorder Points for each medication item.

$$[6]\ \boldsymbol{ROP = \overline{d}\ x\ \overline{LT} + z\sqrt{\overline{LT}\ \sigma_d^{\,2} + \overline{d}^{\,2}\sigma_{LT}^{\,2}}}$$

Diagram 5.1 shows a comparison between calculated values and the current configuration of Reorder Points for each medication item. After examining the diagram, it seems that the ADC at TGH was overloaded for the selected group of medications. Also as shown in Diagram 5.2, in most cases the calculations show a lower level of Safety Stock compared to the current system setting. This affirms the point that the cabinet was overloaded and that a late response to refill requests explains most of the stock-out events.

Diagram 5.1: A comparison between suggested Re-order points and configured Re-order Points

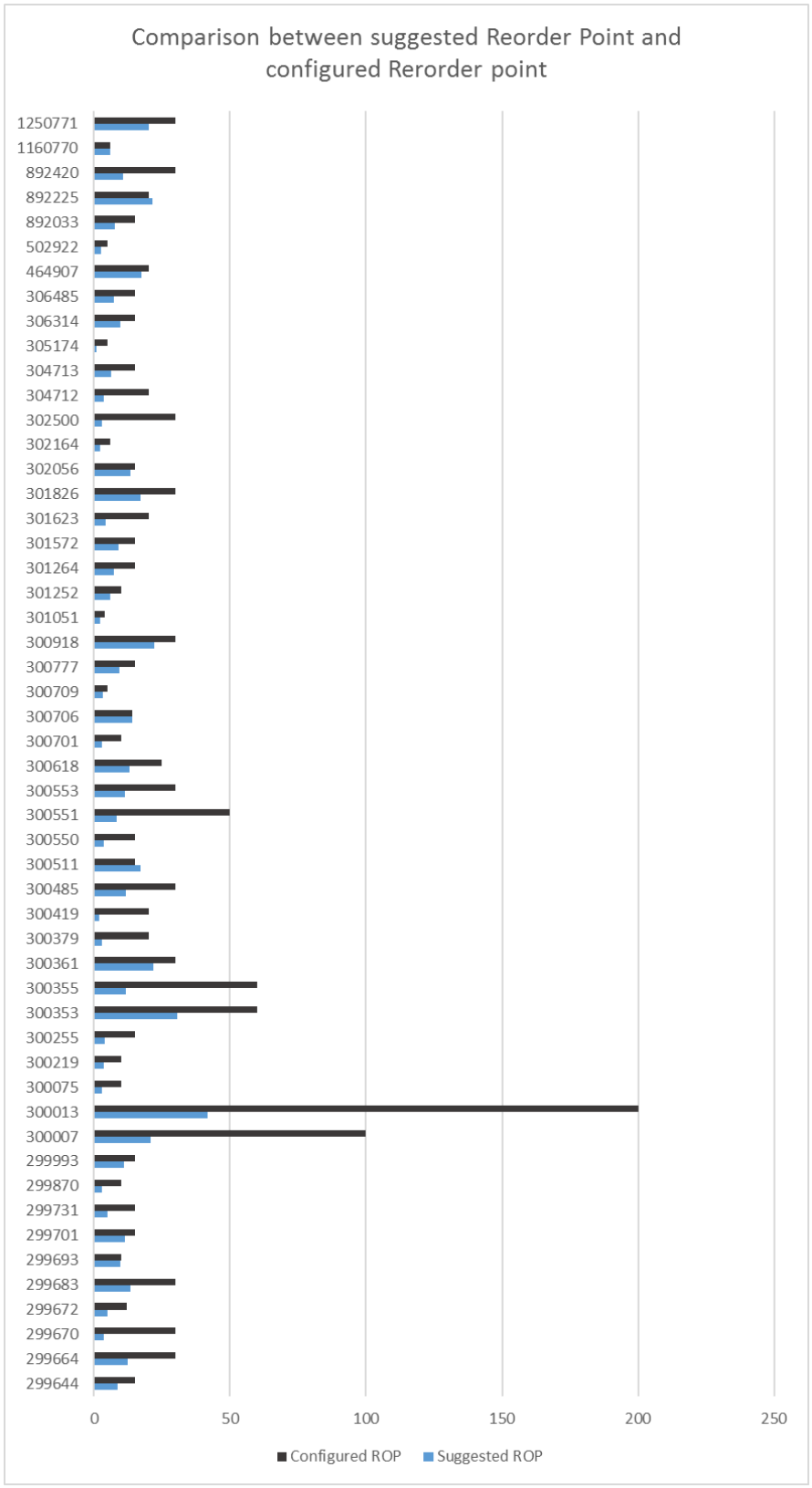
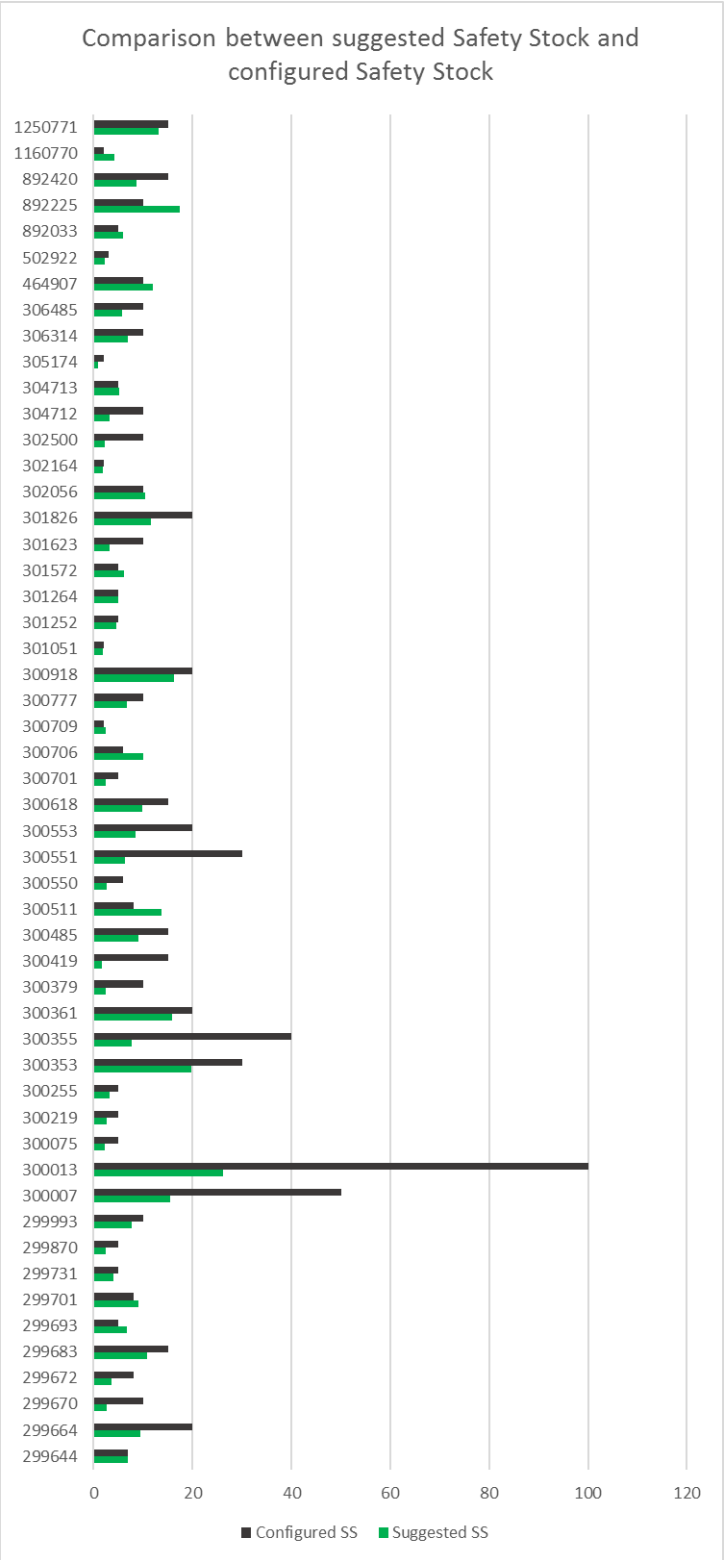


Diagram 5.2: A comparison between suggested Safety Stock and configured Safety Stock



5.2 Project limitations

This project is a case study, meaning the findings and suggestions are only applicable to this specific case. During this project, several limitations influenced the outcome of the project. The first limitation was due to Microsoft Excel's capability to handle large amounts of data. To tackle this issue, the researcher had to apply Python and Anaconda languages to be able to analyze the large-scale data set. Learning Python and Anaconda syntax was a time consuming process.

Real life situations and scenarios affected data cleanliness. As an example, in the case of changing a broken drawer, or assigning a new bin to a medication item, they had to destock and restock medications. In these scenarios, system generated transactions were misleading and provided wrong inventory levels. These types of transactions should be spotted, interpreted and excluded manually to avoid skewing results.

System reports were not showing total quantity on hand for items that were stocked in several bins. In other words, the reported "quantity on hand" for each bin was calculated independently from other bins. Due to the size of data and the number of assigned bins for each medication (in some cases up to 14), reorder point and Safety Stock only calculated for medications within a single bin.

5.3 Suggestions for future work:

As for future direction, it was worthwhile to conduct a time series analysis to refine the model based on findings. Fluctuations of supporting population in Tofino during warmer seasons might lead pharmacy to apply even more effective inventory management methods. In addition, including operational and net costs of medication items and measuring savings could be an appealing incentive for pharmacy in order to apply this model to other facilities. It might be beneficial to apply other statistical methods (i.e. correlation tests) or data analytic methods like data mining and examine the results. Conducting the same study to optimize ADC inventory in other rural and remote facilities and comparing results might help with refining the model and achieving better results.

6 Chapter 6- Conclusion

In this project, we conducted a single echelon optimization project and suggested a mathematical model for inventory management of an Automated Dispensing Cabinet in Tofino General Hospital. For this purpose, two system reports were run from the 30th of May 2017 to the 31st of July 2018 to provide data to gage the average daily demand lead-time for each medication item. Finally, the optimum Safety Stock and Reorder point for more than 50 medication items was calculated and compared with current settings. In addition, to gather information about similar projects, several main databases were searched systematically and related literature was reviewed.

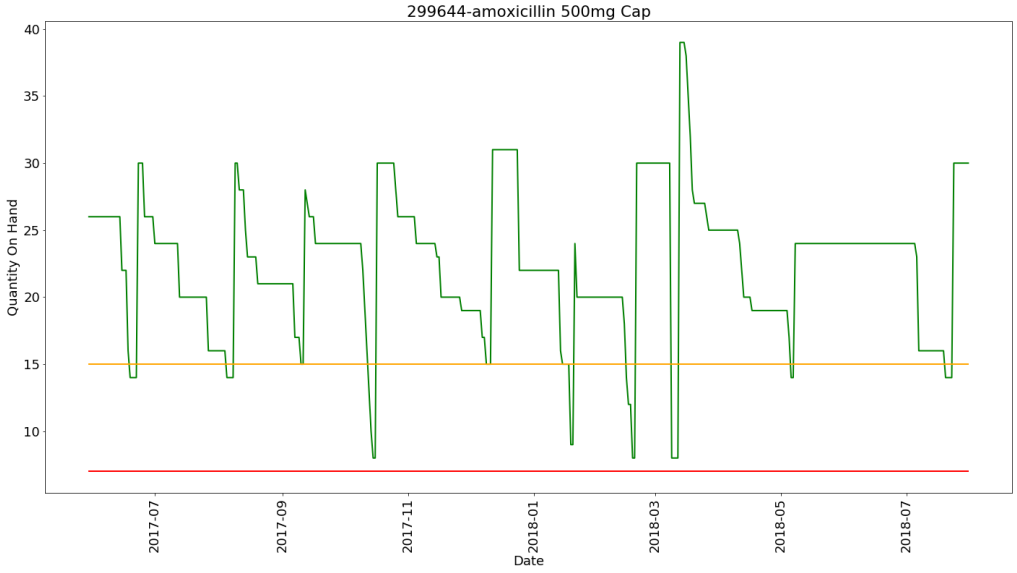
The outcome of this project is the following recommendations to West Coast General Hospital Pharmacy as the supporting pharmacy for Tofino:

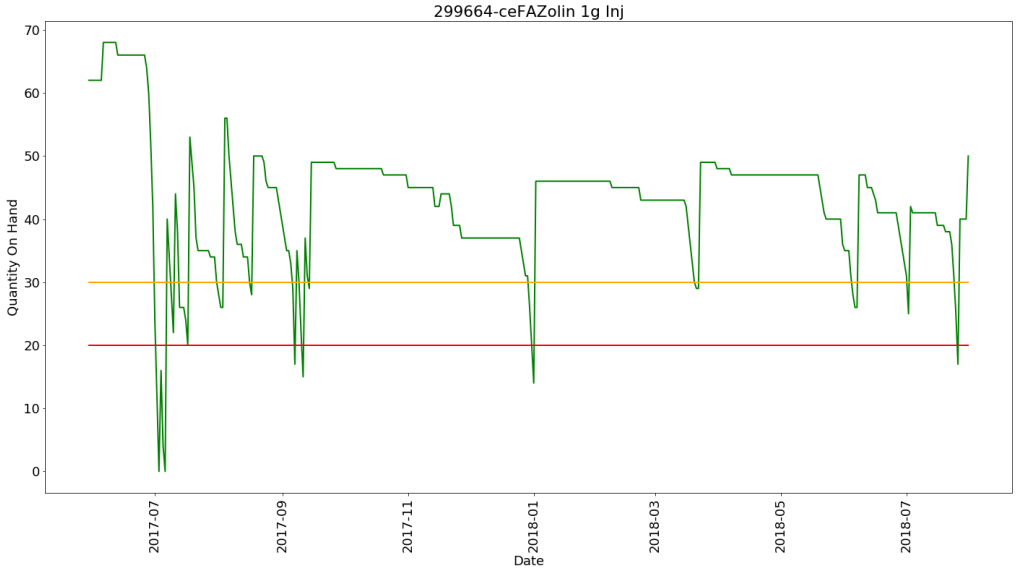
- Re-adjust Par, Reorder Point and Safety Stock levels for medication items that are currently set to zero should be readjusted to avoid stock outs.
- Reduce PAR, Reorder Point and Safety Stock levels for un-demanded medications to a minimum and align the frequencies of pharmacy visits with the inventory level of these medications. This will make room for medications that need more inventory level.
- Use generic medications rather than branded ones. Investigate to see if these medications could be substituted with other similar, but more frequently used medications. For items with minimum demand, stock medications with longer expiration dates. This would reduce pharmacy's long-term workload. Establish a regular replenishment schedule and top up medications as per system reports. A constant lead-time would help with more effective inventory management and prevent stock-outs.
- Apply more effective inventory management techniques to prevent or reduce medication expiration. Re-adjusting system configuration for expired items (especially those without any history of demand) creates an opportunity to save costs, decrease pharmacy workload and increase efficacy of the ADC. If possible, use generic medications rather than branded ones for medications with a history of expiration. Implement the suggested model, re-adjust system configuration as per calculated values and evaluate results for fine-tuning. Establishing a data-driven approach for inventory management could enhance medication

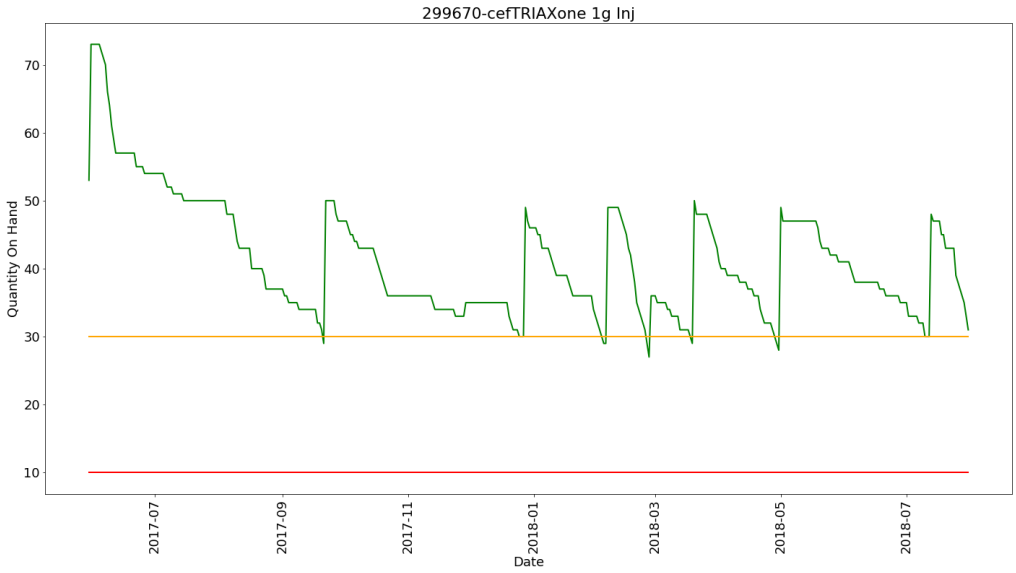
safety. Short-term and long-term assessments and re-adjusting medication settings per observed results could minimize the risk of stock-out and medication expiration.

Appendix 1

Demand patterns of 103 medication items along with their configured ROP and Safety Stock levels






299670-cefTRIAXone 1g Inj
Quantity On Hand
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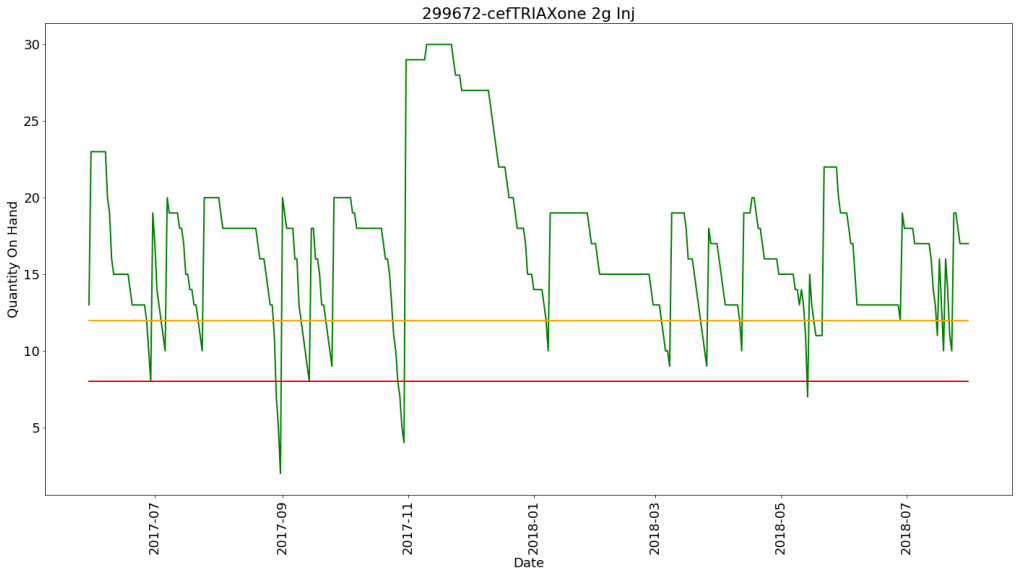
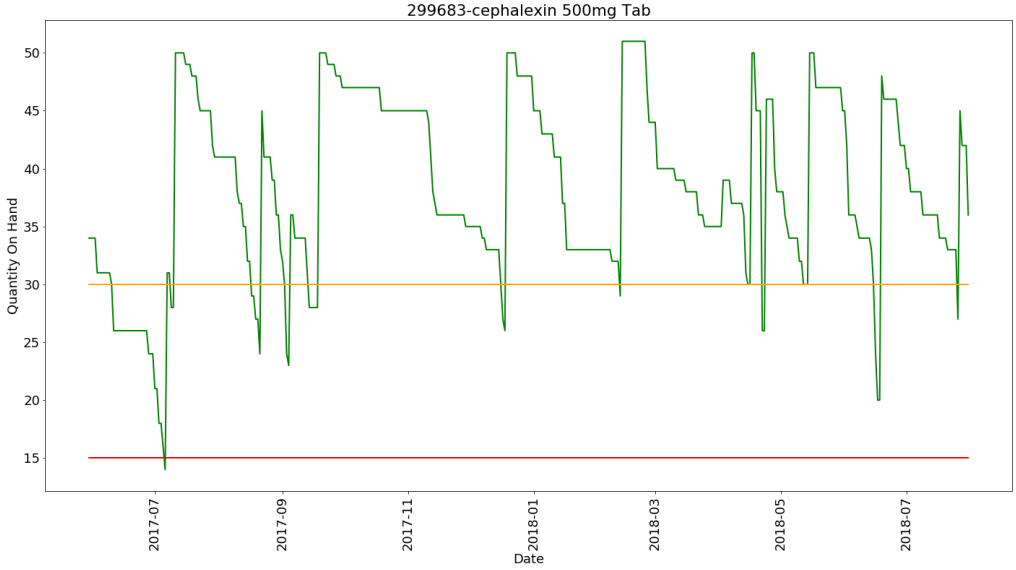
60
50
40
30
20
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299672-cefTRIAXone 2g Inj
Quantity On Hand
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299683-cephalexin 500mg Tab
Quantity On Hand
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40
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25
20
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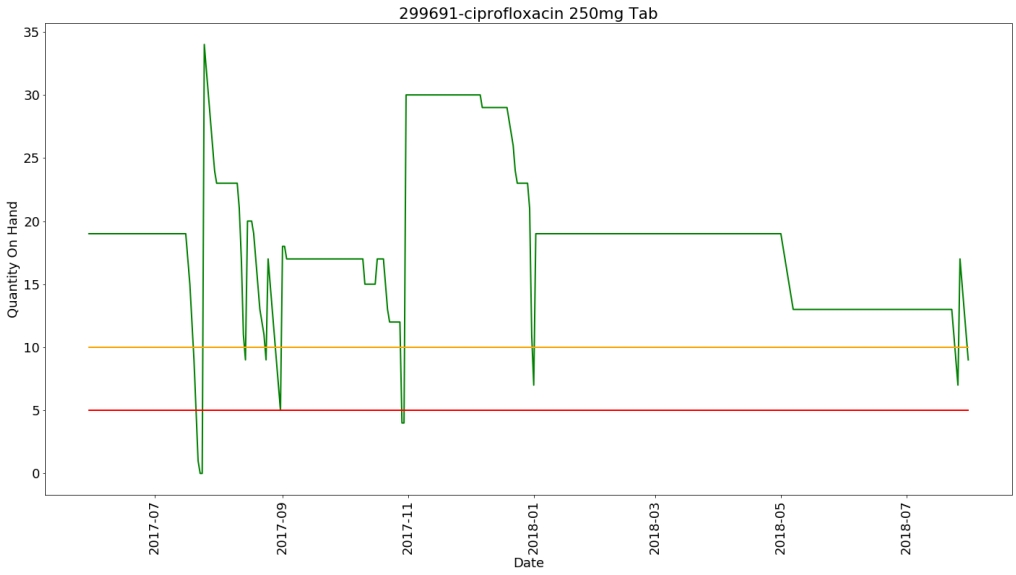
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299691-ciprofloxacin 250mg Tab
Quantity On Hand
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30
25
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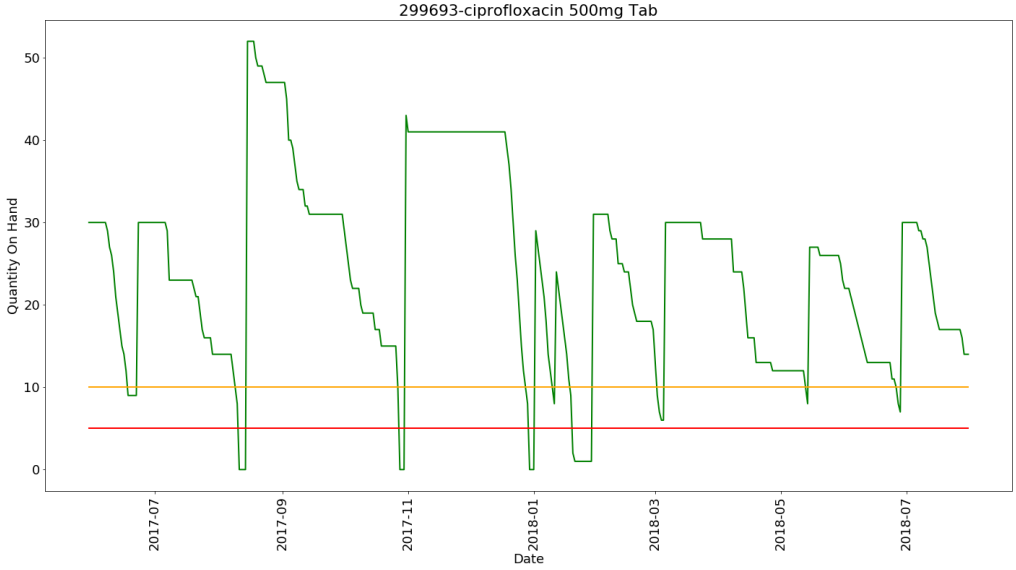
15
10
5
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299693-ciprofloxacin 500mg Tab
Quantity On Hand
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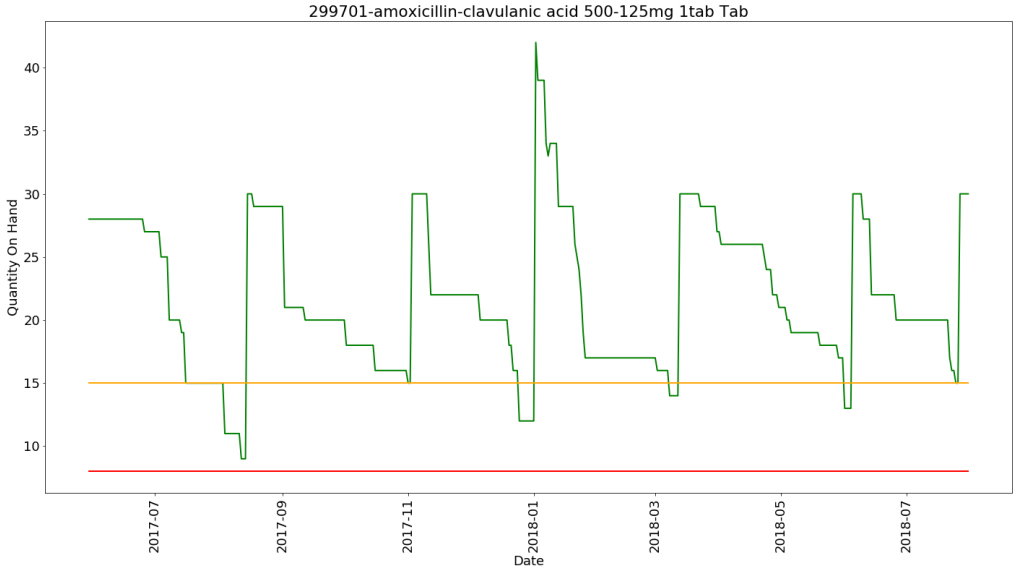
20
30
40
50
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299701-amoxicillin-clavulanic acid 500-125mg 1tab Tab
Quantity On Hand
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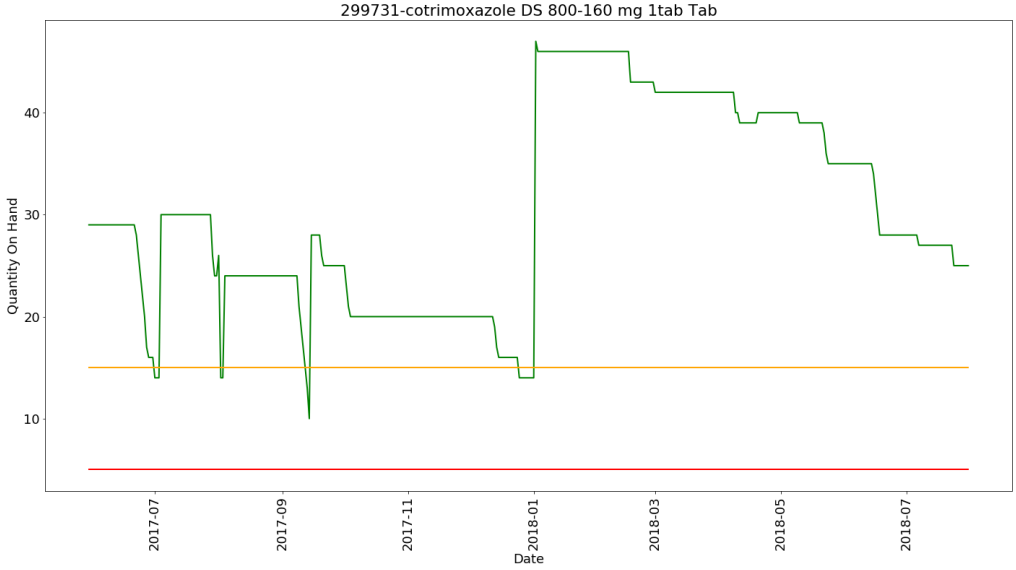
15
20
25
30
35
40
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299731-cotrimoxazole DS 800-160 mg 1tab Tab
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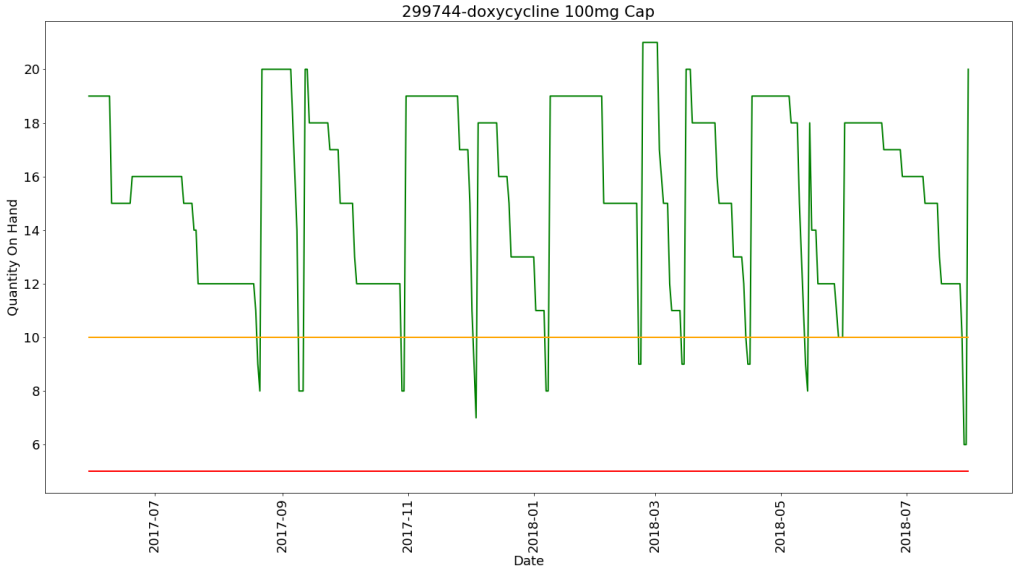
20
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299744-doxycycline 100mg Cap
Quantity On Hand
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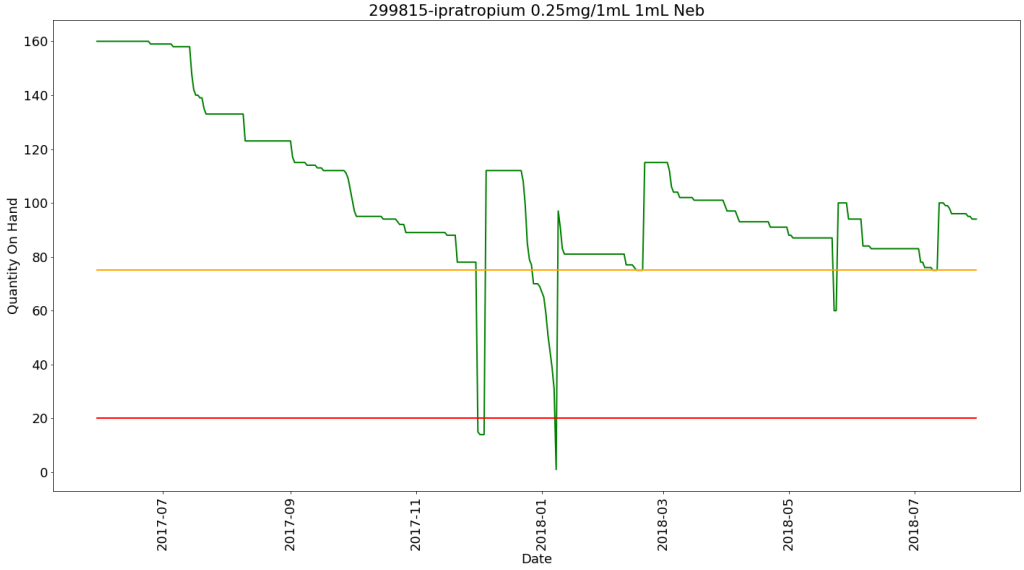
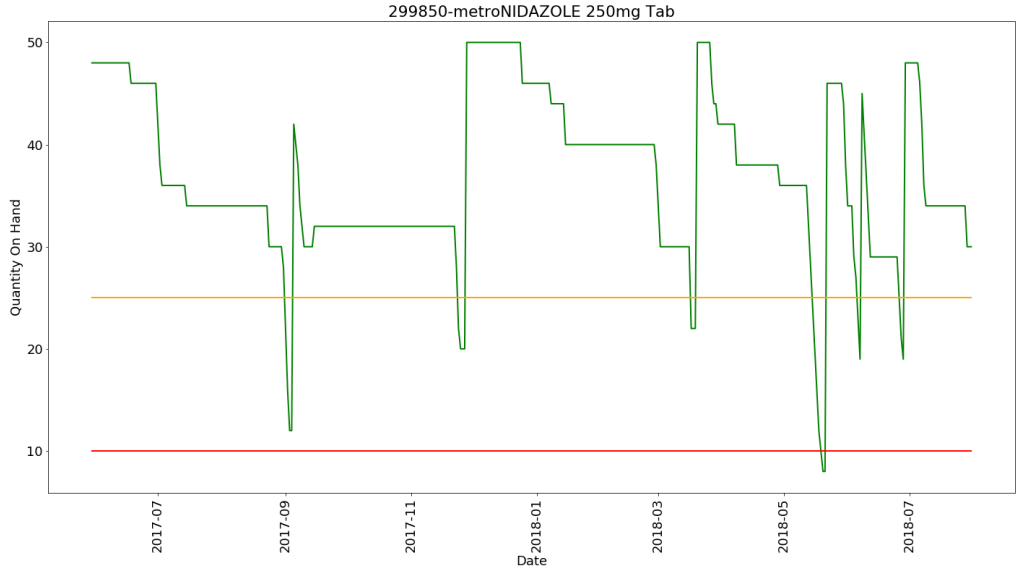
6
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299815-ipratropium 0.25mg/1mL 1mL Neb
Quantity On Hand
0
20
40
60
80
100
120
140
160
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299850-metroNIDAZOLE 250mg Tab
Quantity On Hand
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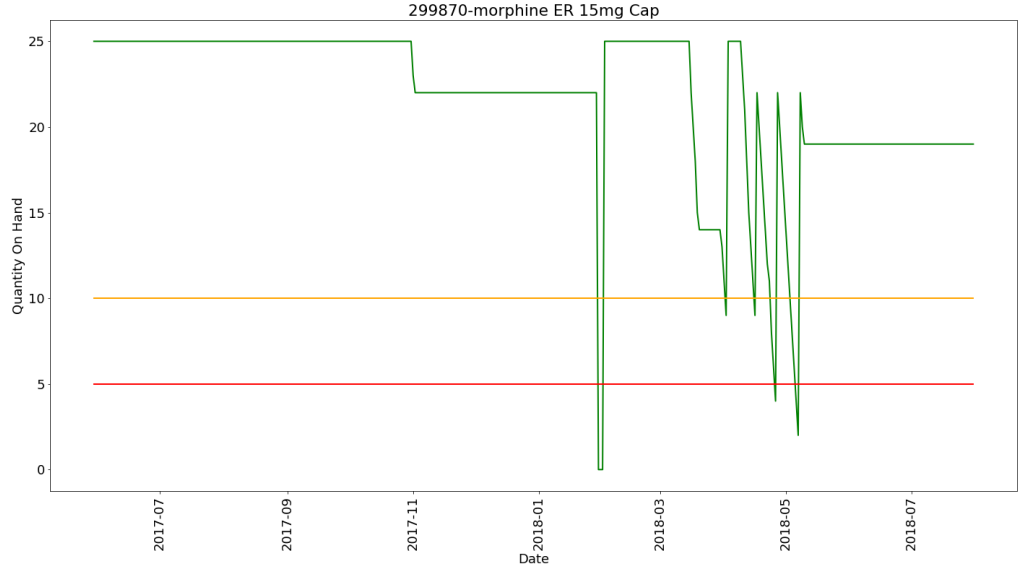
20
30
40
50
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299870-morphine ER 15mg Cap
Quantity On Hand
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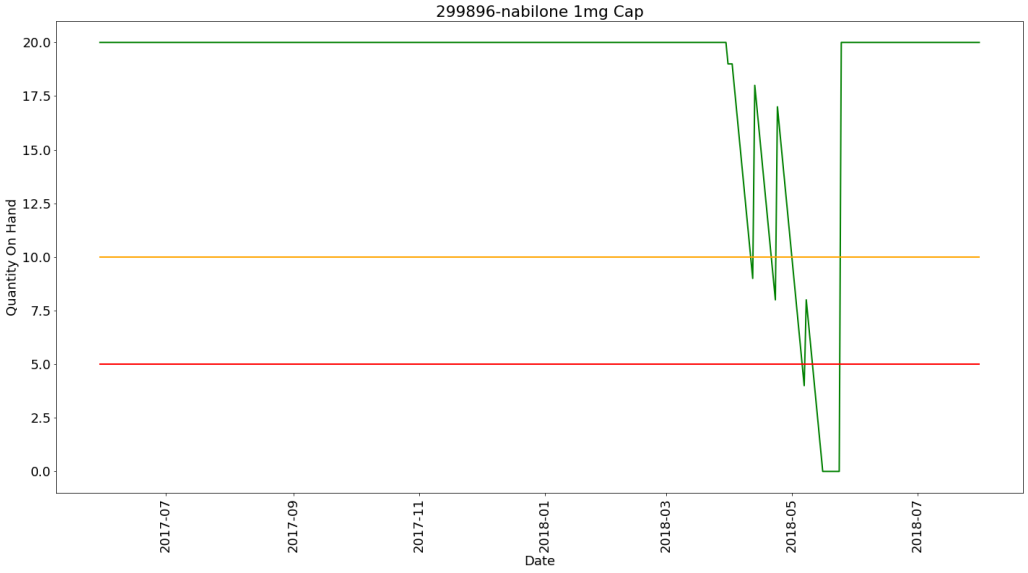
15
10
5
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299896-nabilone 1mg Cap
Quantity On Hand
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17.5
15.0
12.5
10.0
7.5
5.0
2.5
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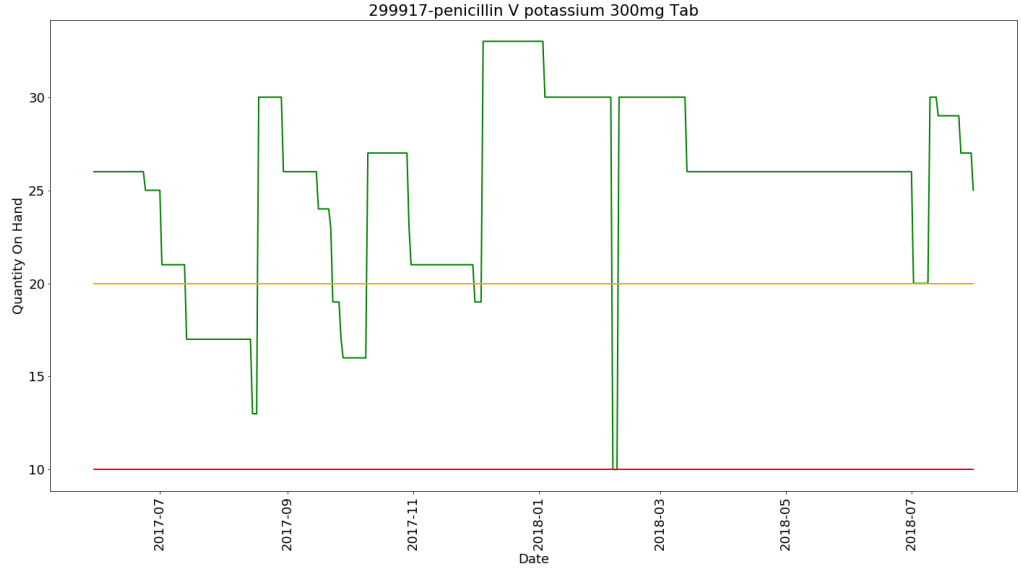
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299917-penicillin V potassium 300mg Tab
Quantity On Hand
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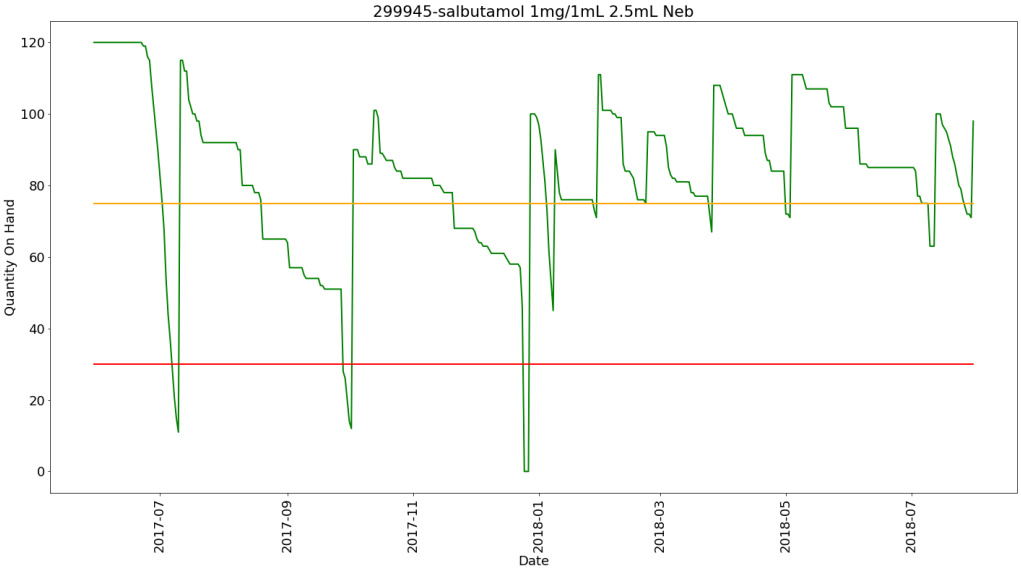
25
20
15
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299945-salbutamol 1mg/1mL 2.5mL Neb
Quantity On Hand
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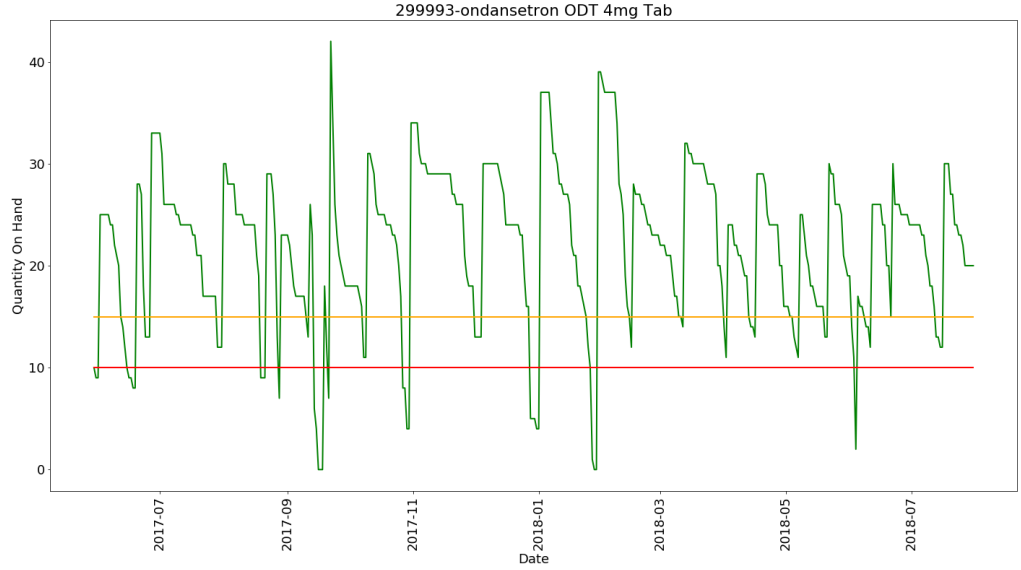
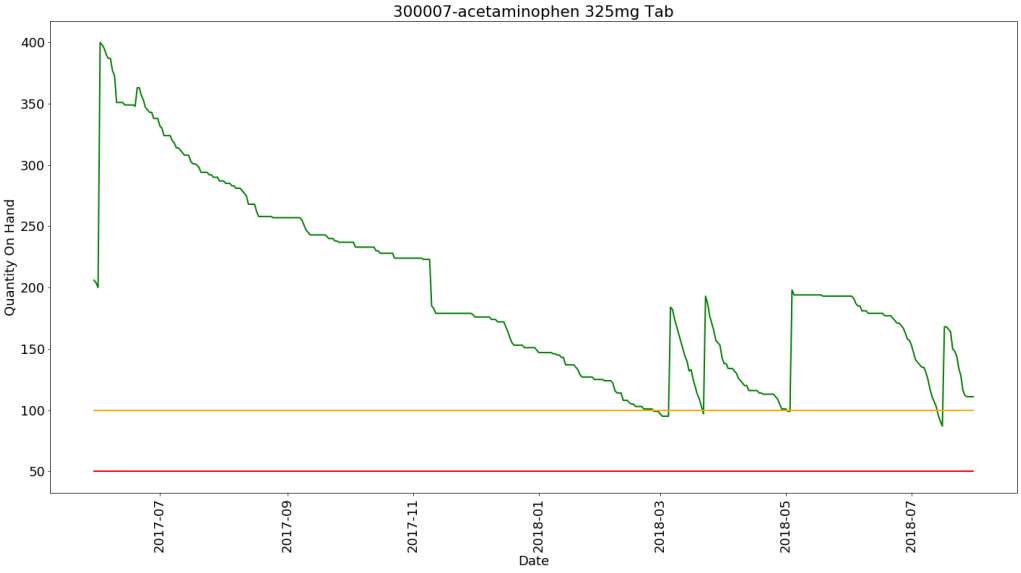
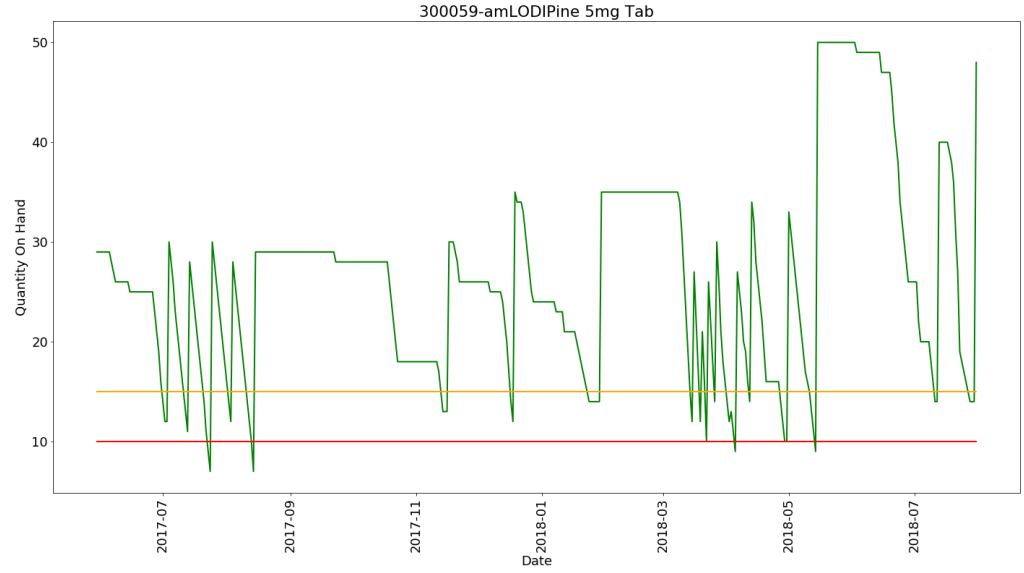
100
80
60
40
20
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


299993-ondansetron ODT 4mg Tab
Quantity On Hand
0
10
20
30
40
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


300007-acetaminophen 325mg Tab
Quantity On Hand
50
100
150
200
250
300
350
400
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


300013-acetaminophen 500mg Tab
Quantity On Hand
500
400
300
200
100
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


300059-amLODIPine 5mg Tab
Quantity On Hand
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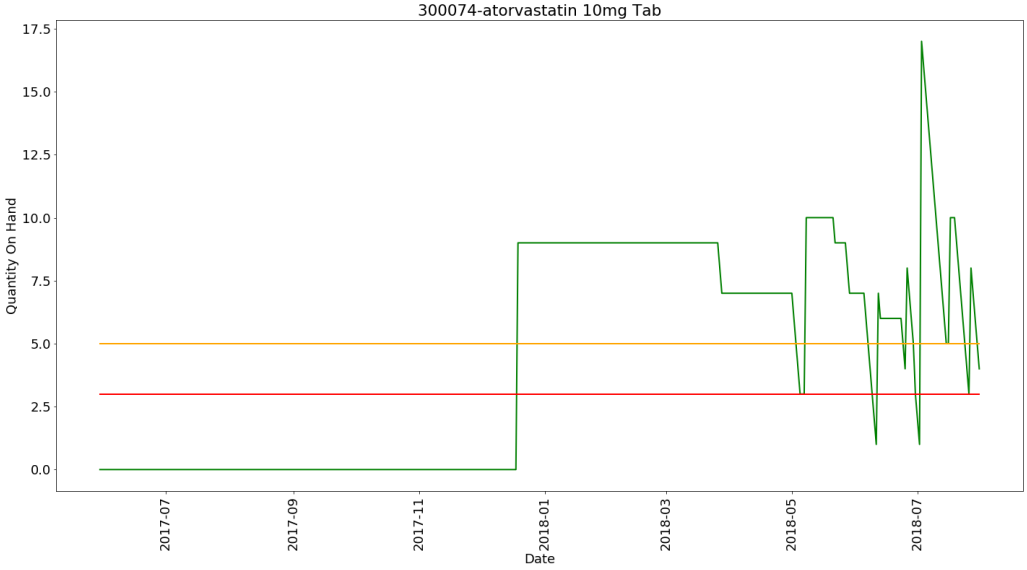
40
30
20
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


300074-atorvastatin 10mg Tab
Quantity On Hand
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15.0
12.5
10.0
7.5
5.0
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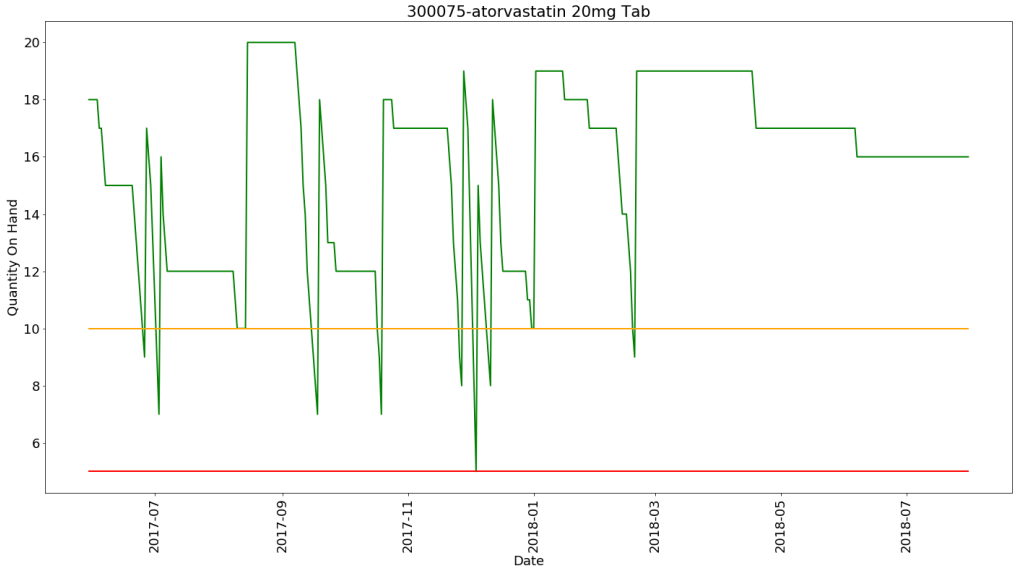
0.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


300075-atorvastatin 20mg Tab
Quantity On Hand
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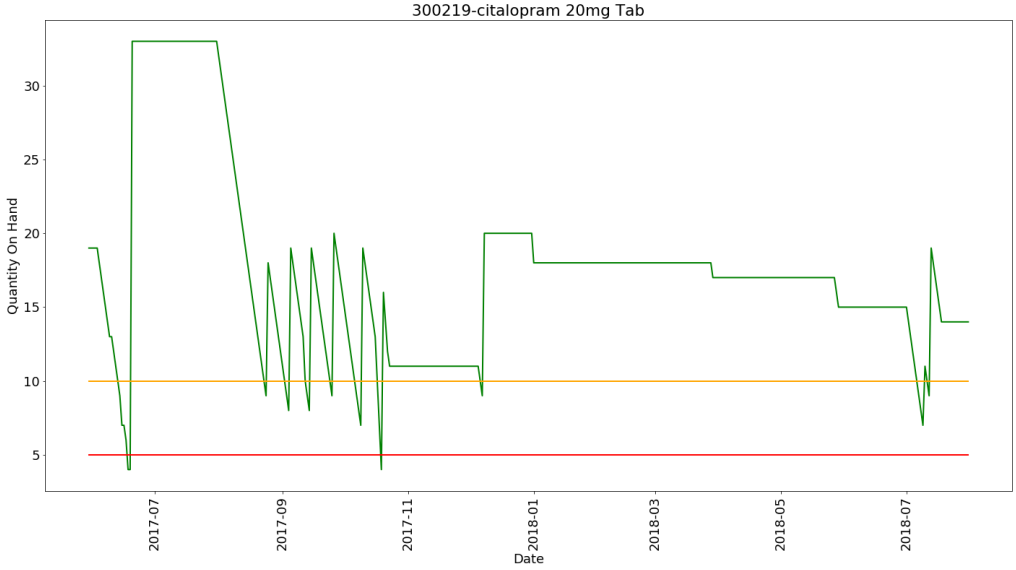
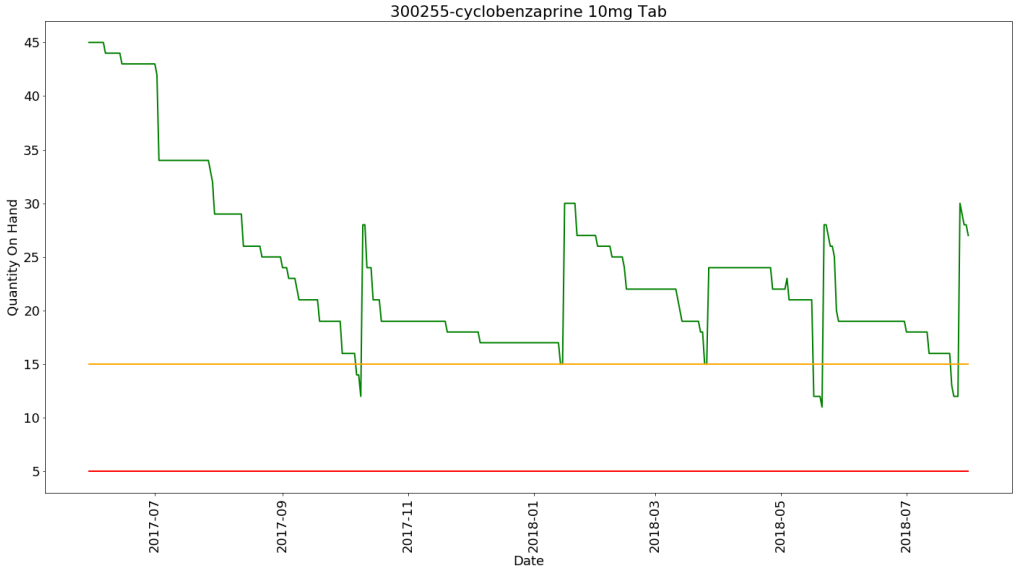
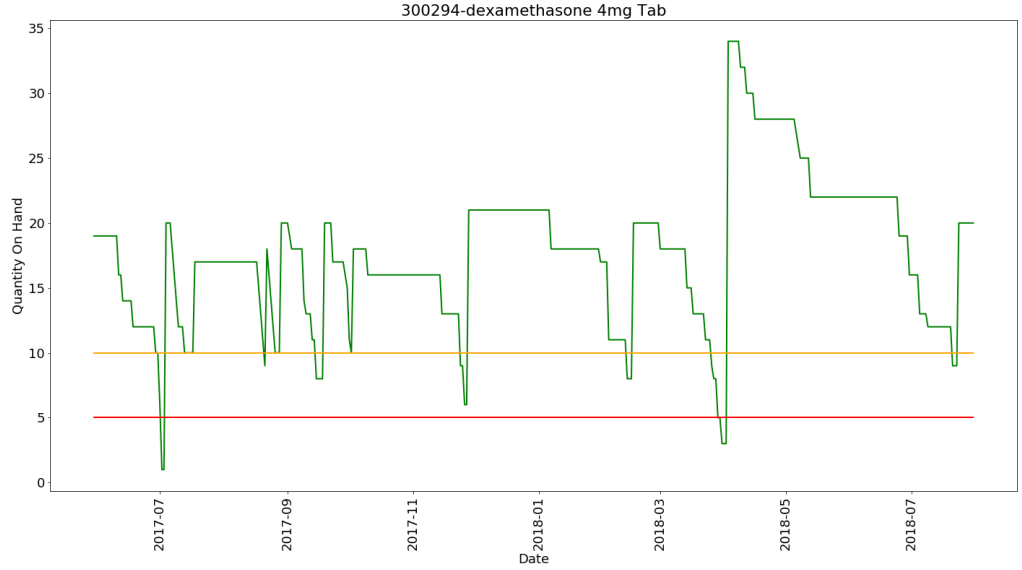
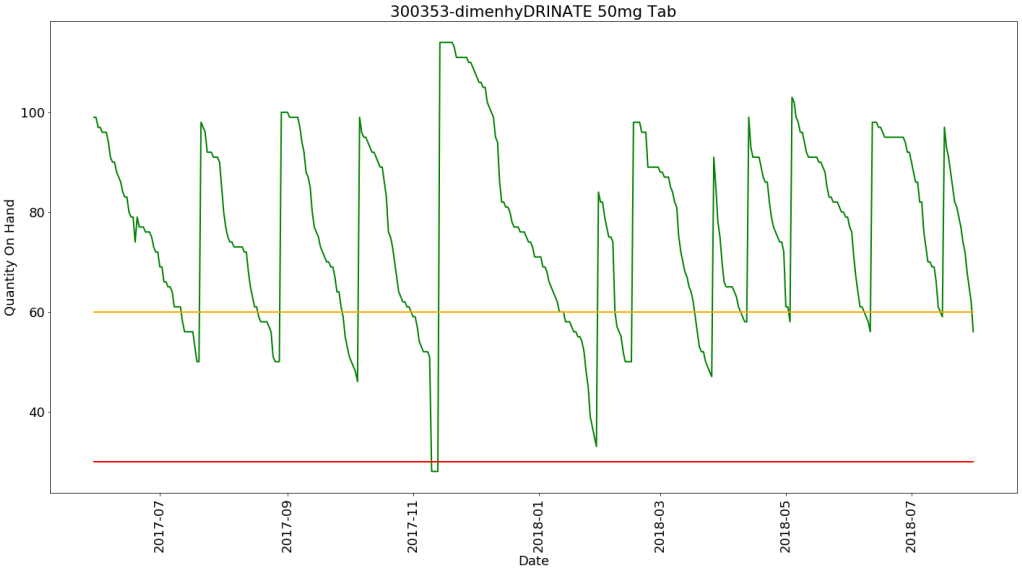
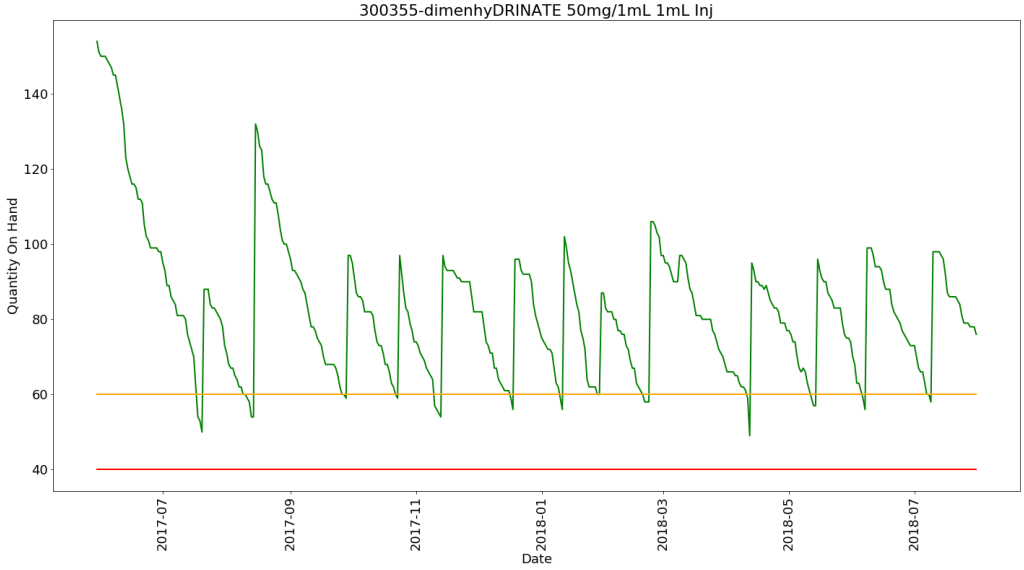
18
16
14
12
10
8
6
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

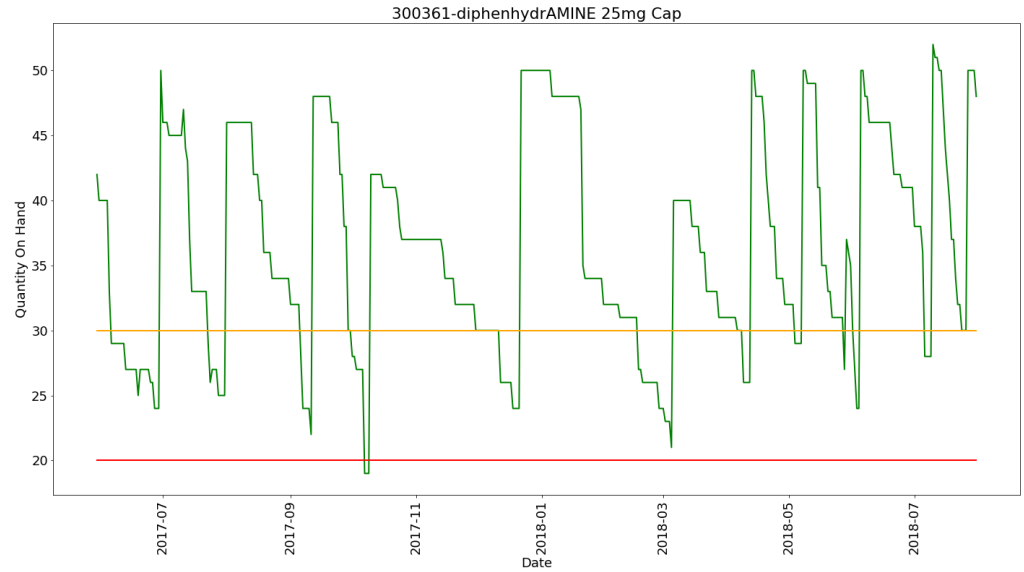

300219-citalopram 20mg Tab
Quantity On Hand
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

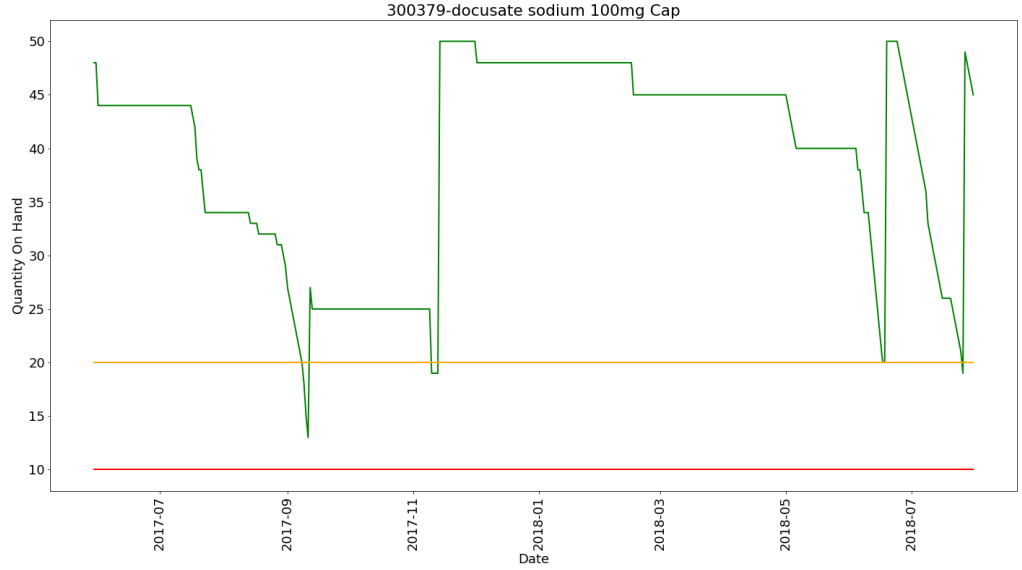

300255-cyclobenzaprine 10mg Tab
Quantity On Hand
45
40
35
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


300294-dexamethasone 4mg Tab
Quantity On Hand
0
5
10
15
20
25
30
35
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

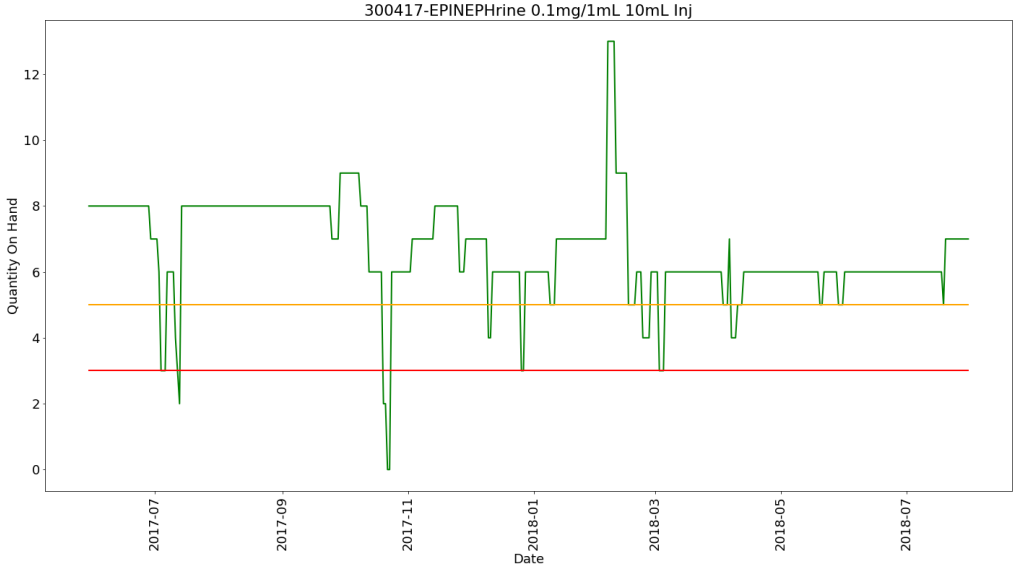

300353-dimenhyDRINATE 50mg Tab
Quantity On Hand
40
60
80
100
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

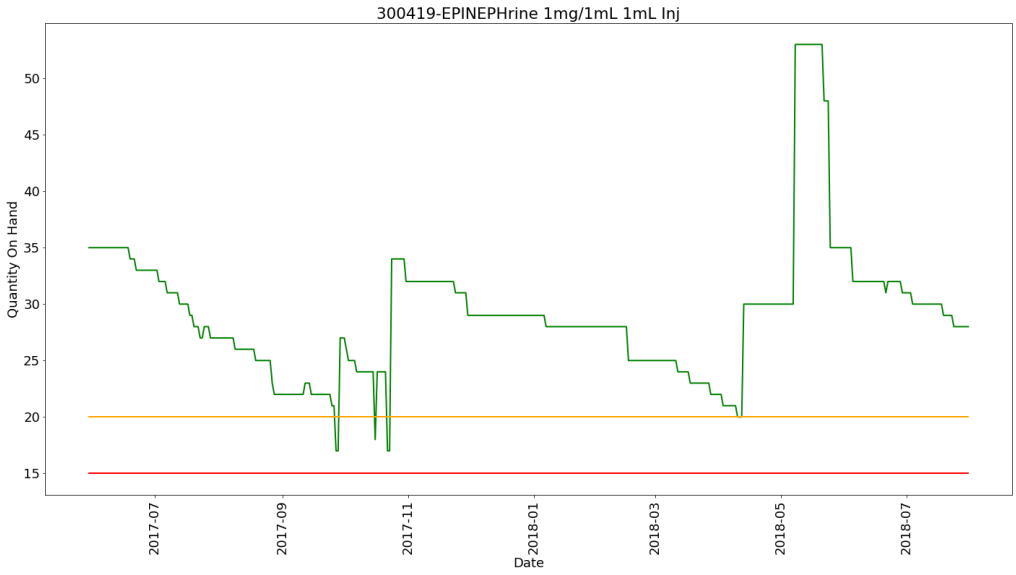

300355-dimenhyDRINATE 50mg/1mL 1mL Inj
Quantity On Hand
140
120
100
80
60
40
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

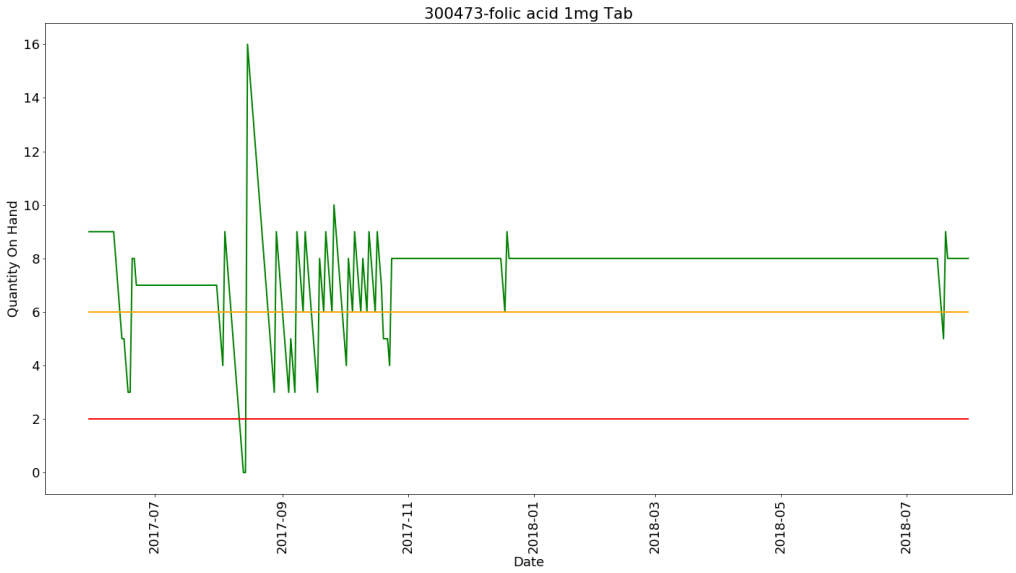

300361-diphenhydrAMINE 25mg Cap
Quantity On Hand
50
45
40
35
30
25
20
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

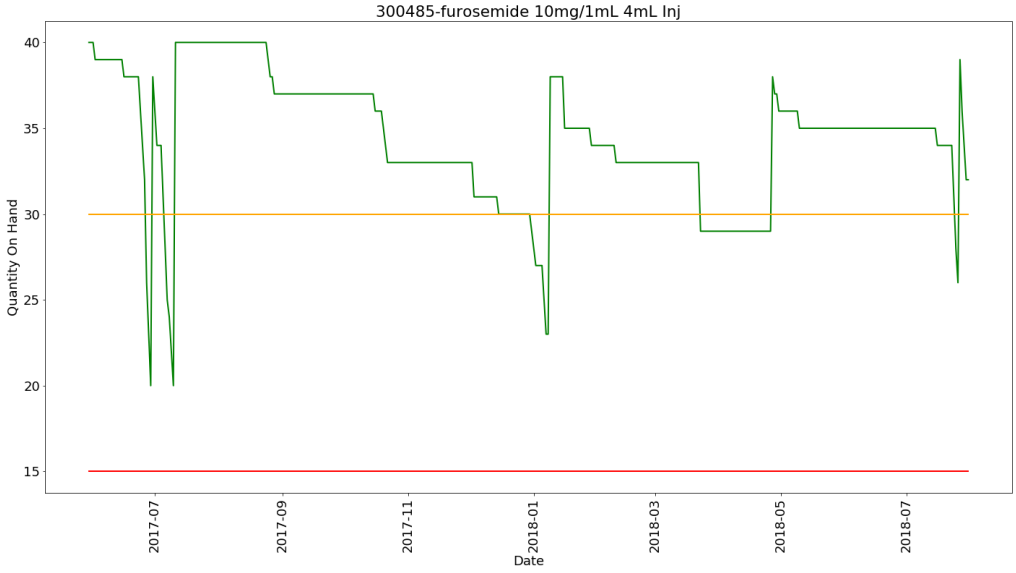

300379-docusate sodium 100mg Cap
Quantity On Hand
50
45
40
35
30
25
20
15
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

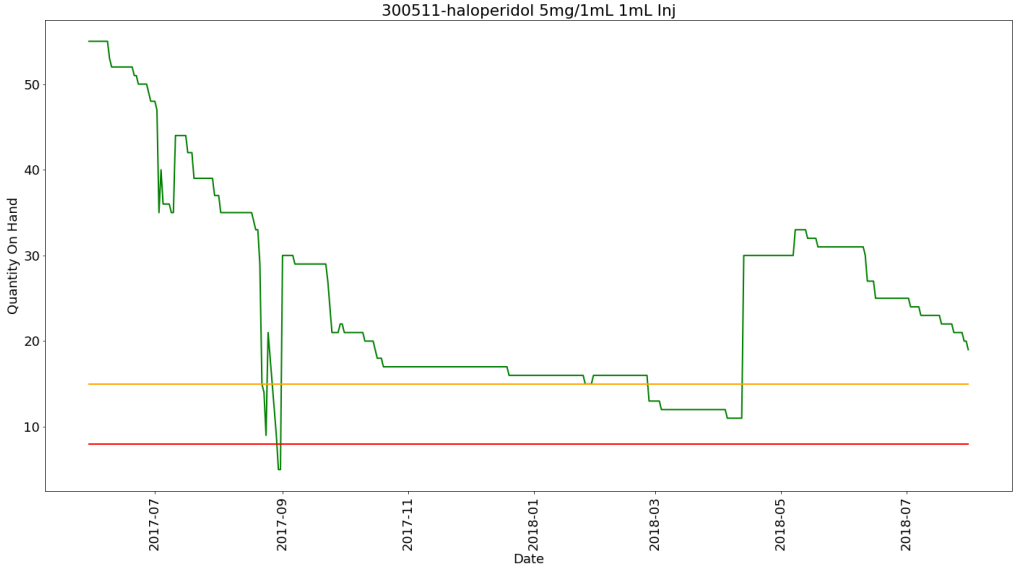

300382-domperidone 10mg Tab
Quantity On Hand
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

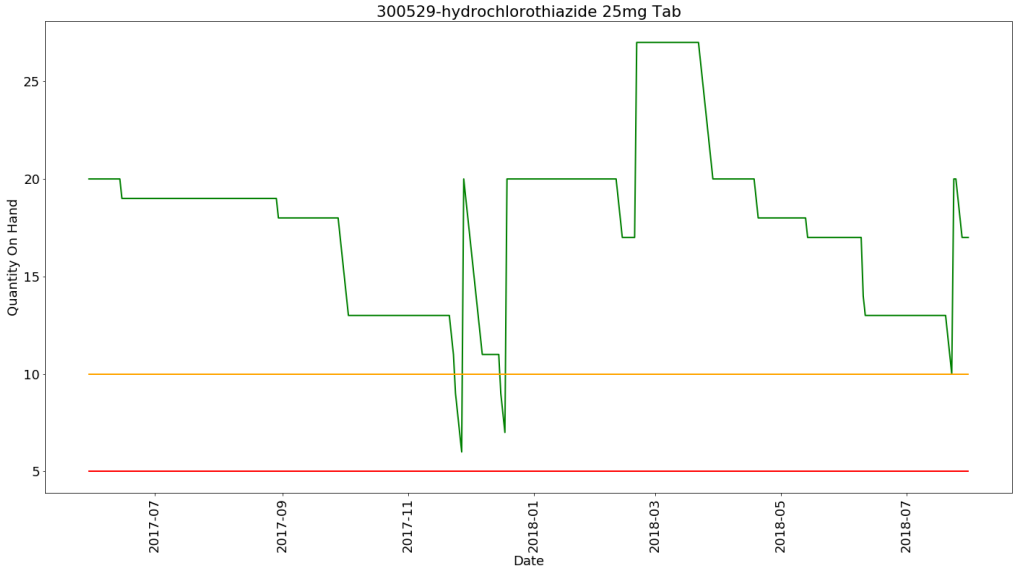

300417-EPINEPHrine 0.1mg/1mL 10mL Inj
Quantity On Hand
0
2
4
6
8
10
12
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

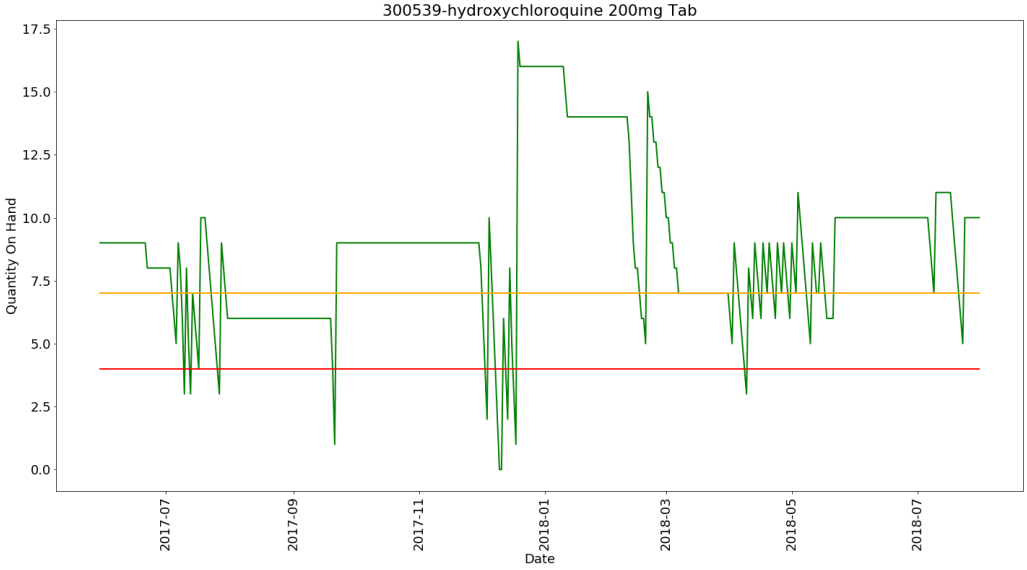

300419-EPINEPHrine 1mg/1mL 1mL Inj
Quantity On Hand
15
20
25
30
35
40
45
50
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

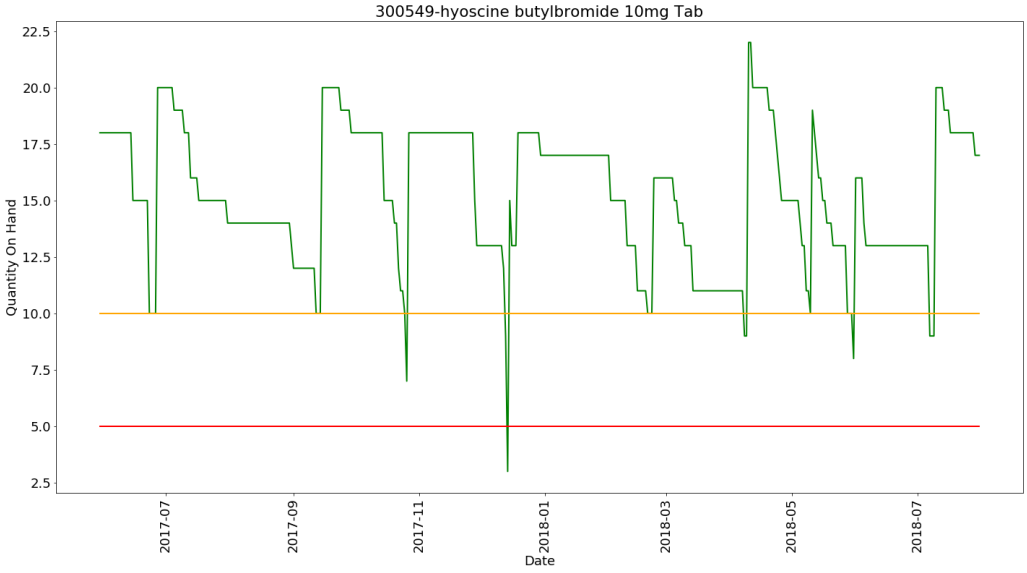

300473-folic acid 1mg Tab
Quantity On Hand
0
2
4
6
8
10
12
14
16
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

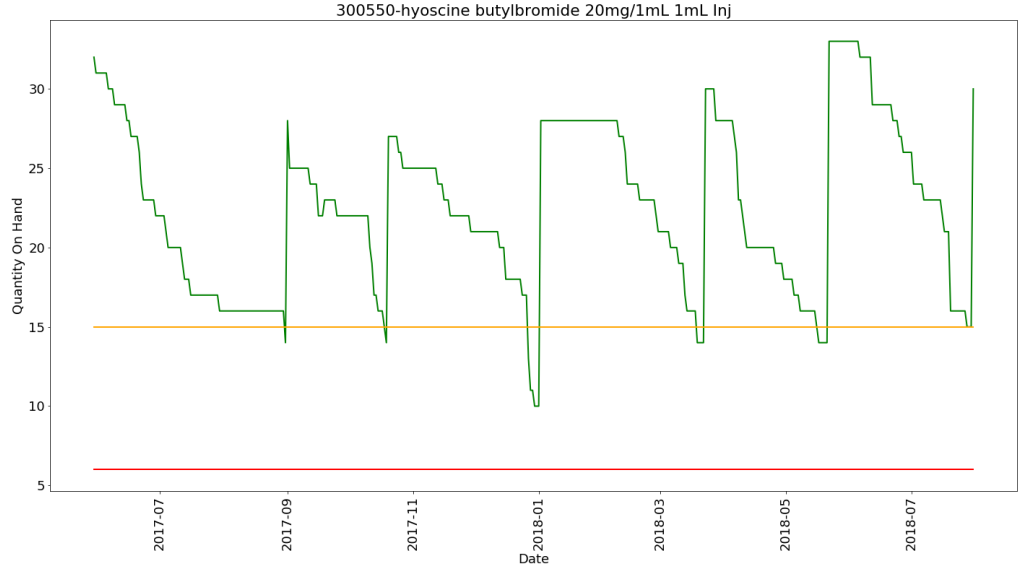

300485-furosemide 10mg/1mL 4mL Inj
Quantity On Hand
15
20
25
30
35
40
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


300511-haloperidol 5mg/1mL 1mL Inj
Quantity On Hand
50
40
30
20
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

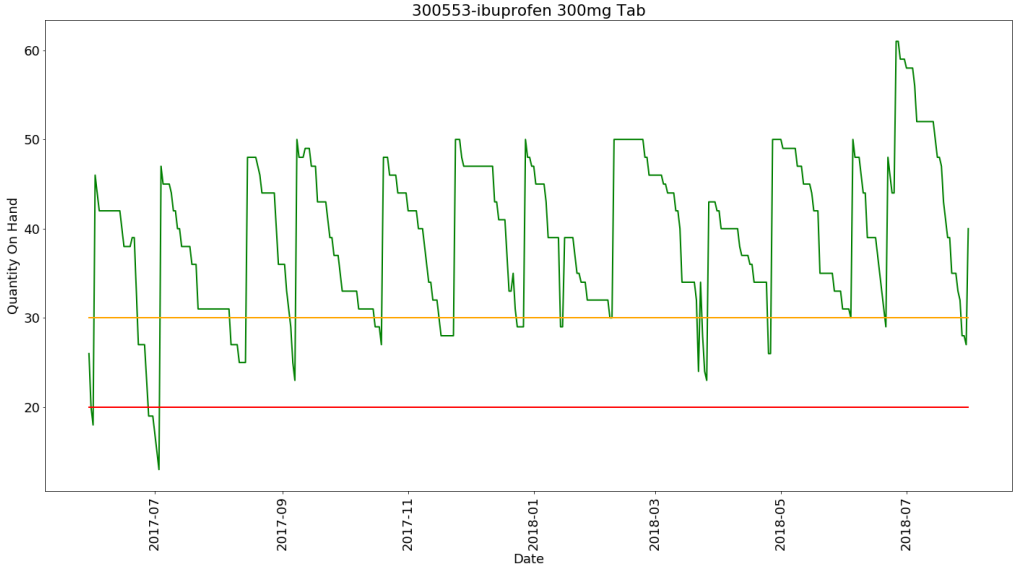

300529-hydrochlorothiazide 25mg Tab
Quantity On Hand
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

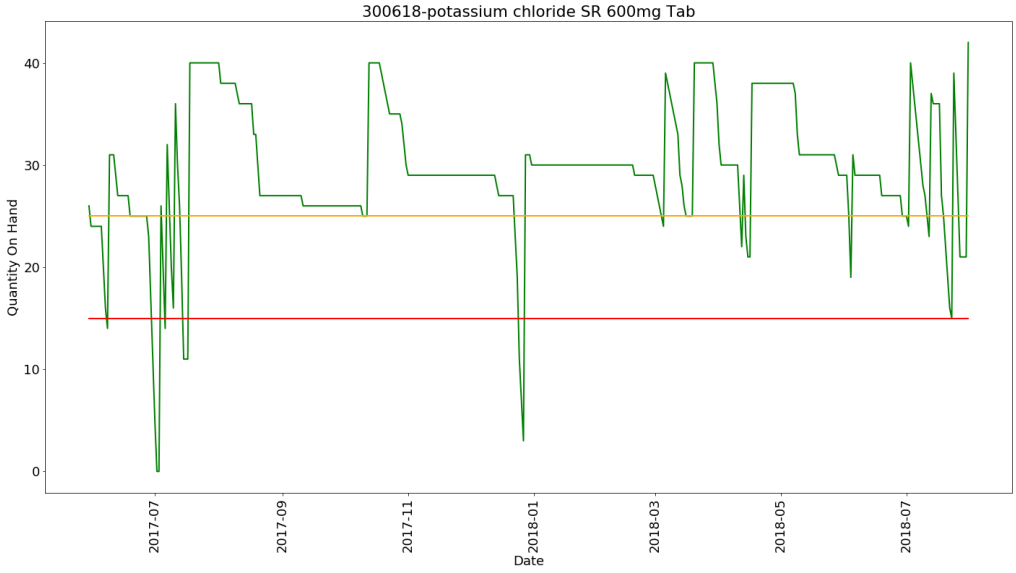

300539-hydroxychloroquine 200mg Tab
Quantity On Hand
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

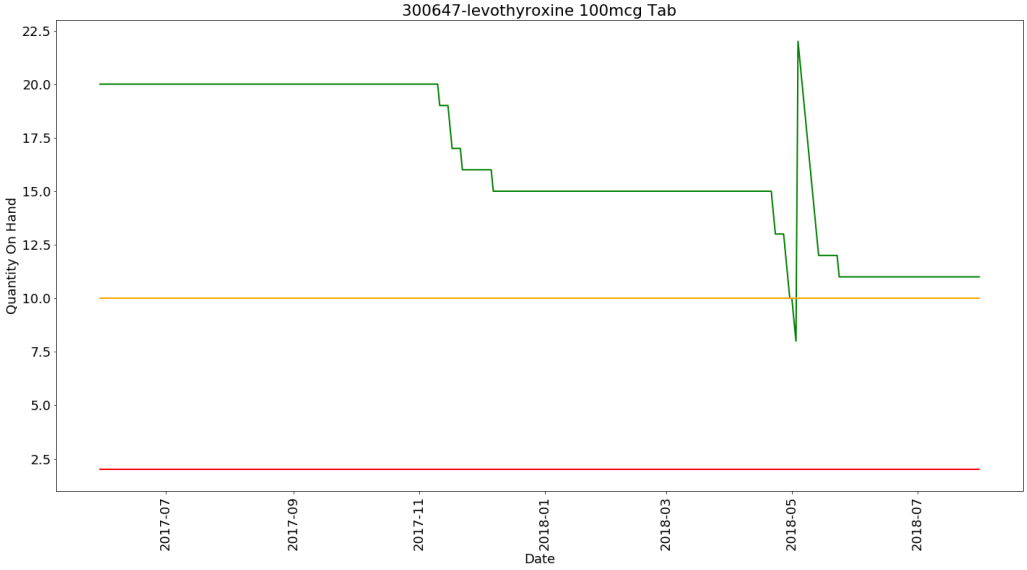

300549-hyoscine butylbromide 10mg Tab
Quantity On Hand
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

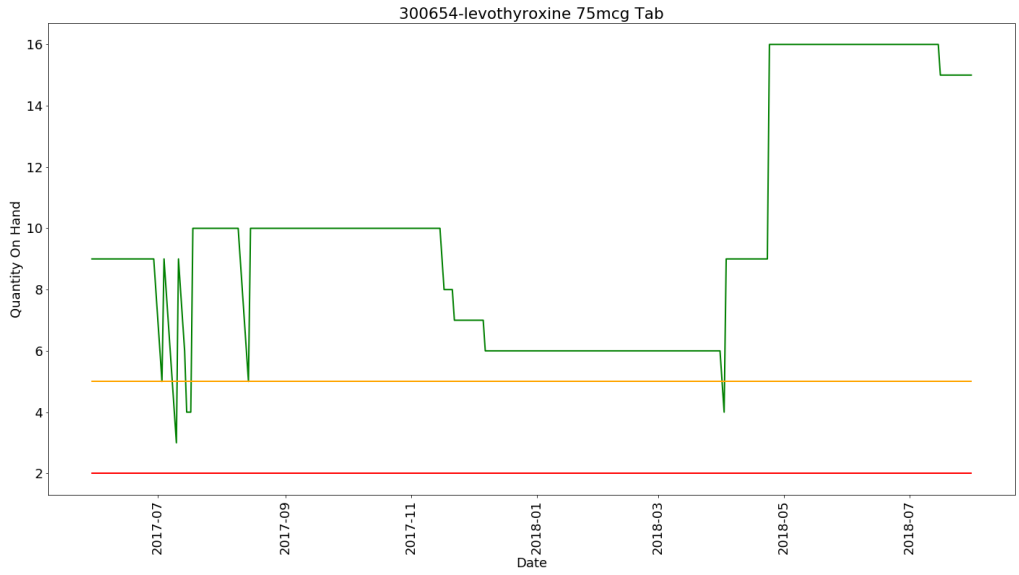

300550-hyoscine butylbromide 20mg/1mL 1mL Inj
Quantity On Hand
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

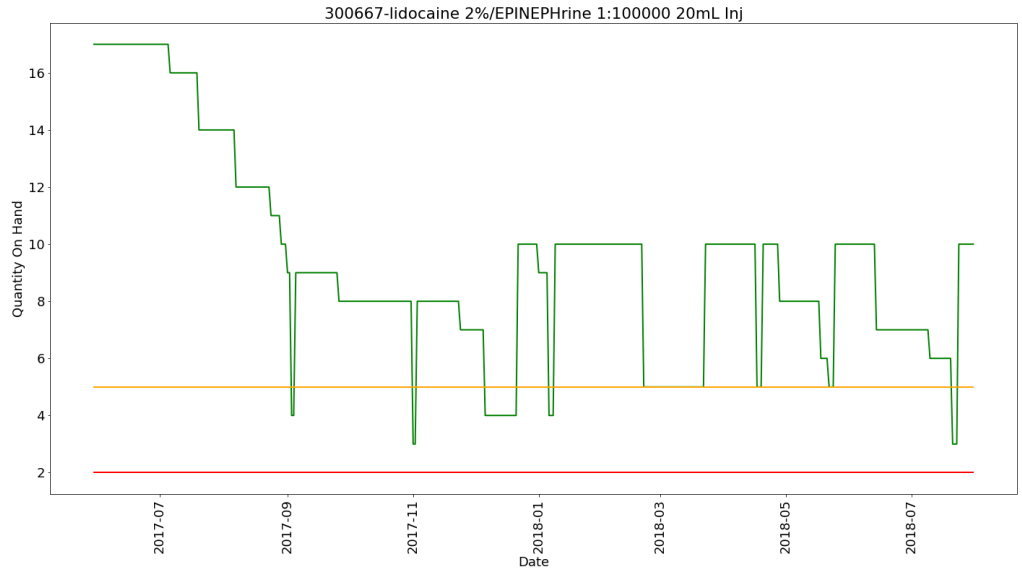

300551-ibuprofen 200mg Tab
Quantity On Hand
100
90
80
70
60
50
40
30
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

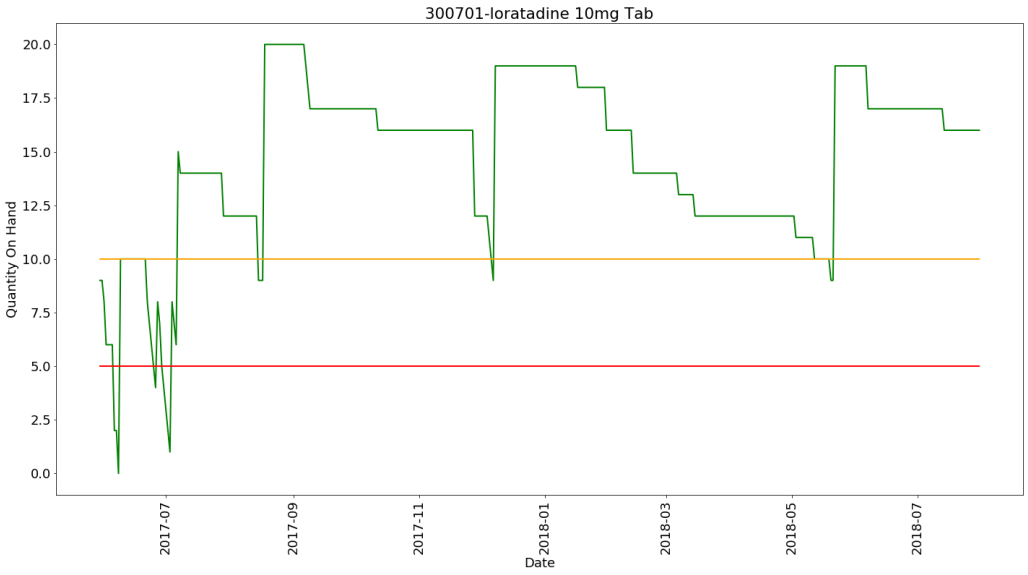

300553-ibuprofen 300mg Tab
Quantity On Hand
60
50
40
30
20
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

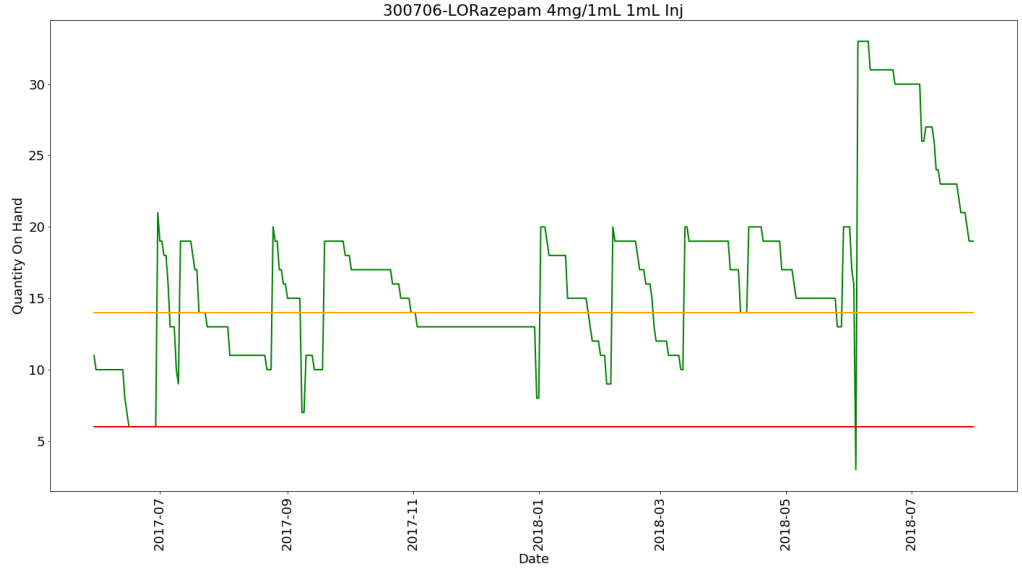

300618-potassium chloride SR 600mg Tab
Quantity On Hand
40
30
20
10
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

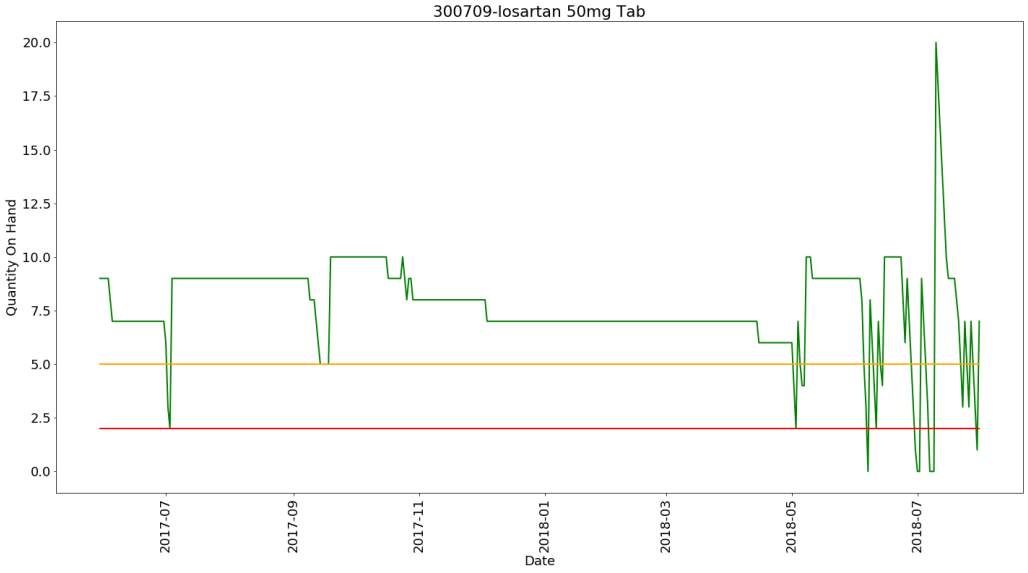

300647-levothyroxine 100mcg Tab
Quantity On Hand
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

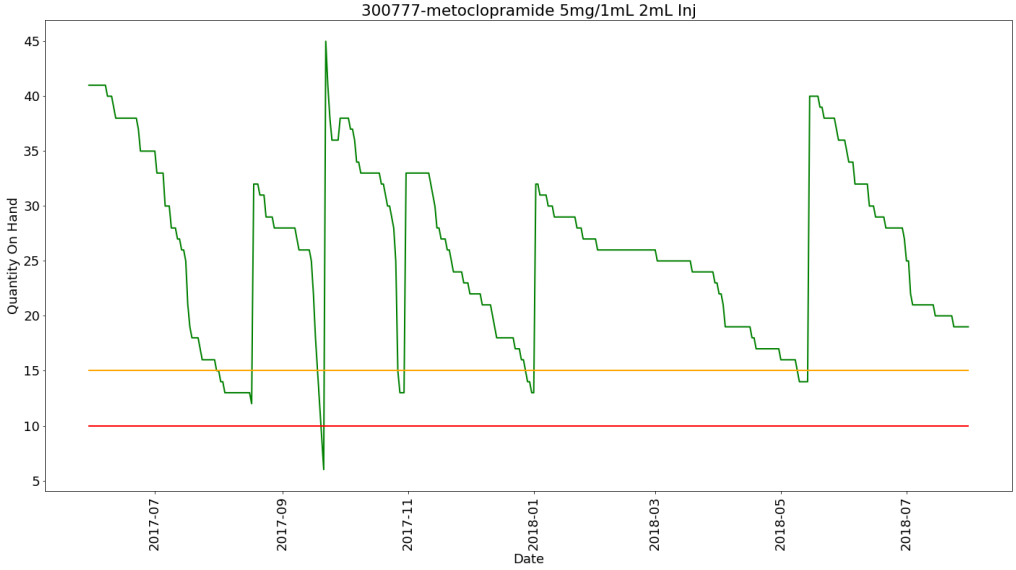

300654-levothyroxine 75mcg Tab
Quantity On Hand
16
14
12
10
8
6
4
2
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

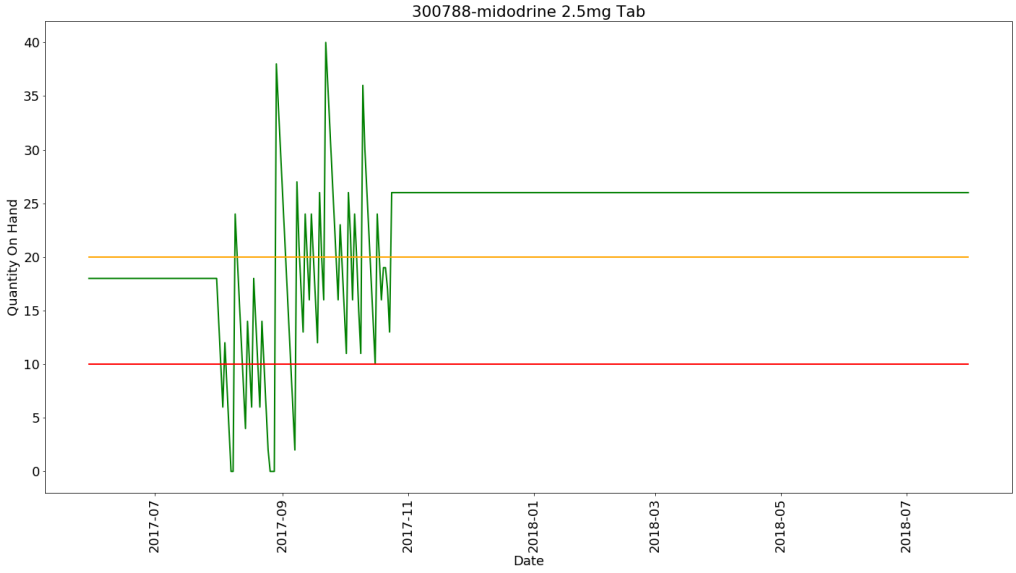

300667-lidocaine 2%/EPINEPHrine 1:100000 20mL Inj
Quantity On Hand
16
14
12
10
8
6
4
2
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

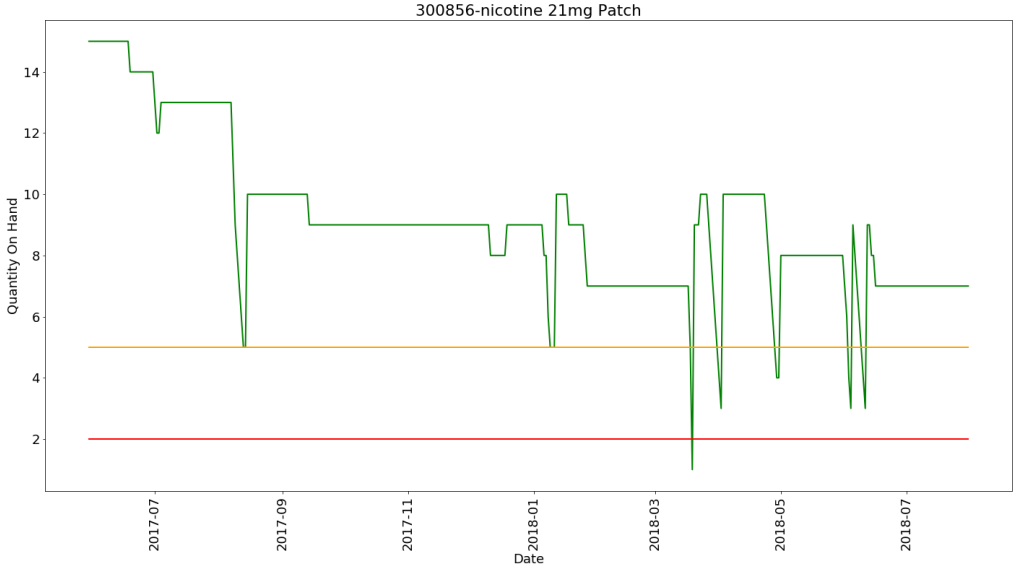

300701-loratadine 10mg Tab
Quantity On Hand
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

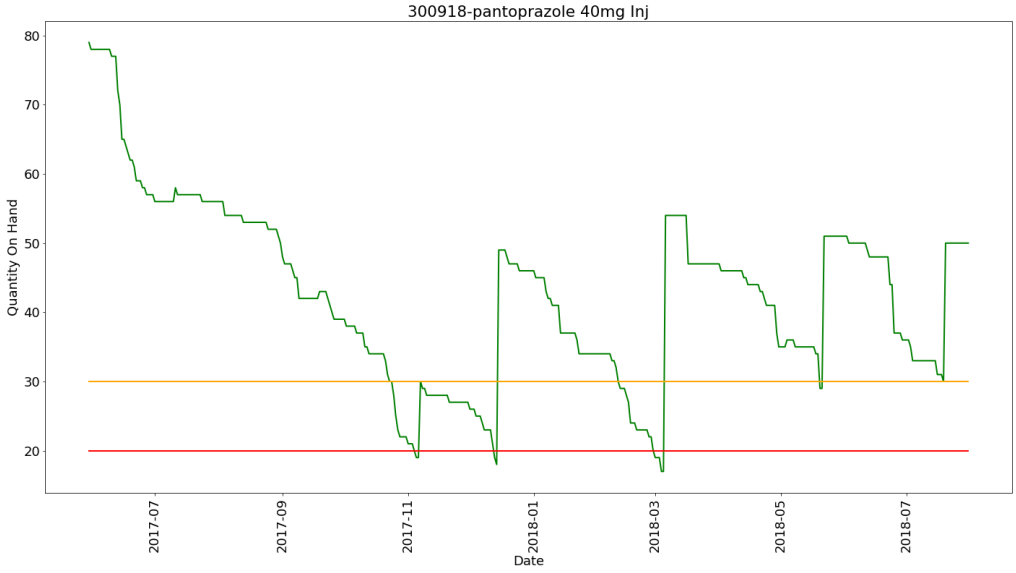

300706-LORazepam 4mg/1mL 1mL Inj
Quantity On Hand
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

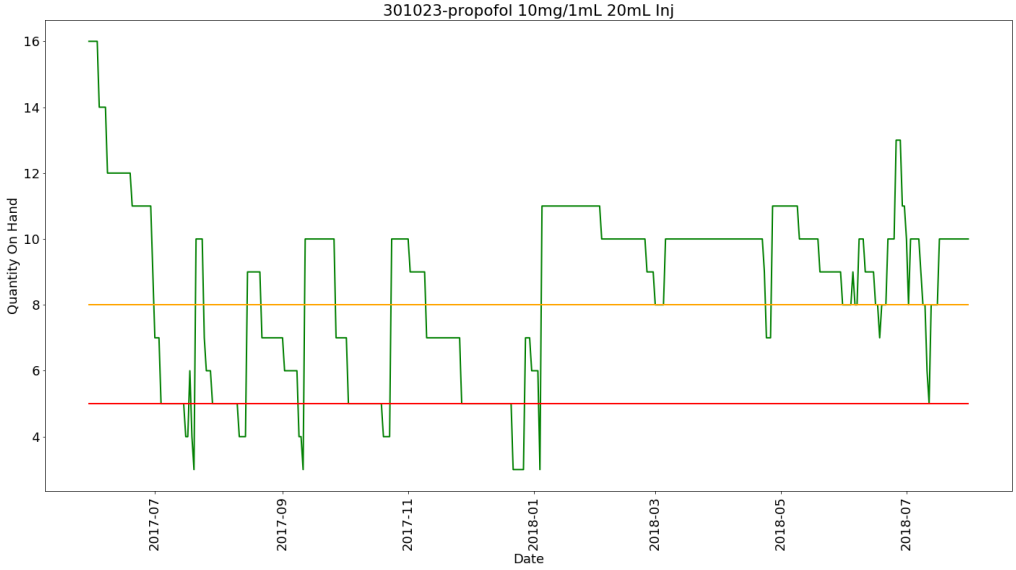

300709-losartan 50mg Tab
Quantity On Hand
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

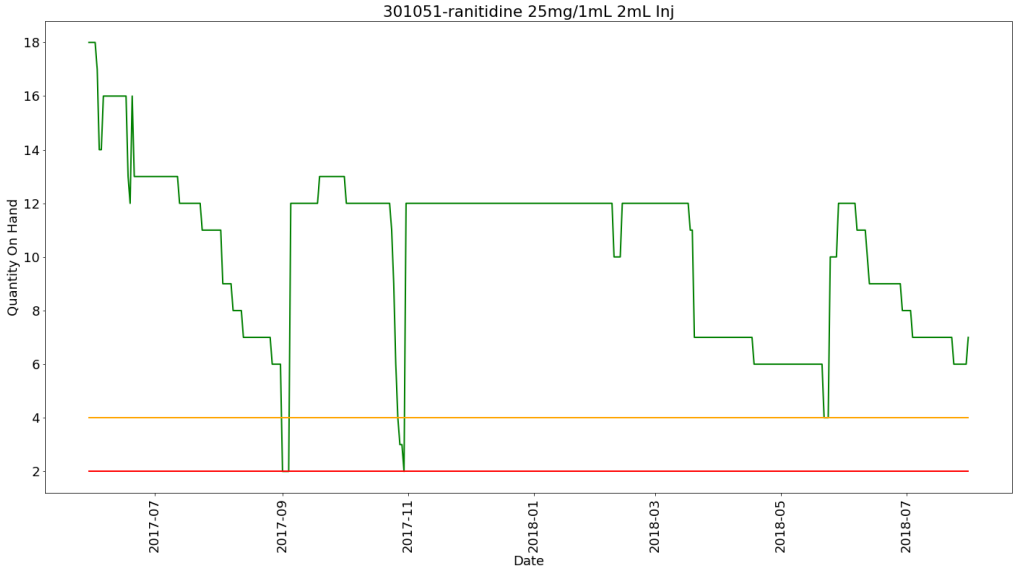

300777-metoclopramide 5mg/1mL 2mL Inj
Quantity On Hand
Date
45
40
35
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07

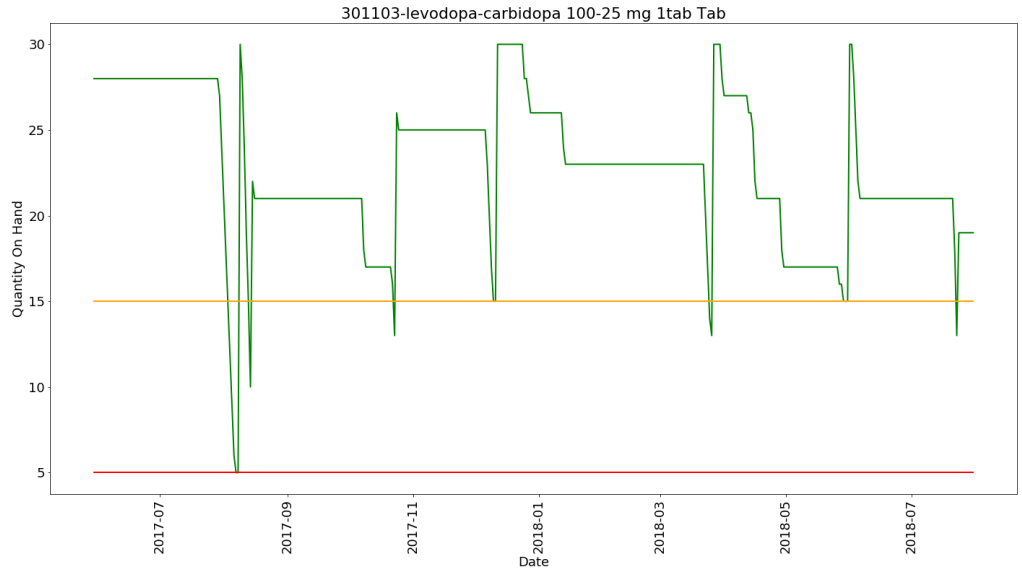

300788-midodrine 2.5mg Tab
Quantity On Hand
Date
40
35
30
25
20
15
10
5
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07

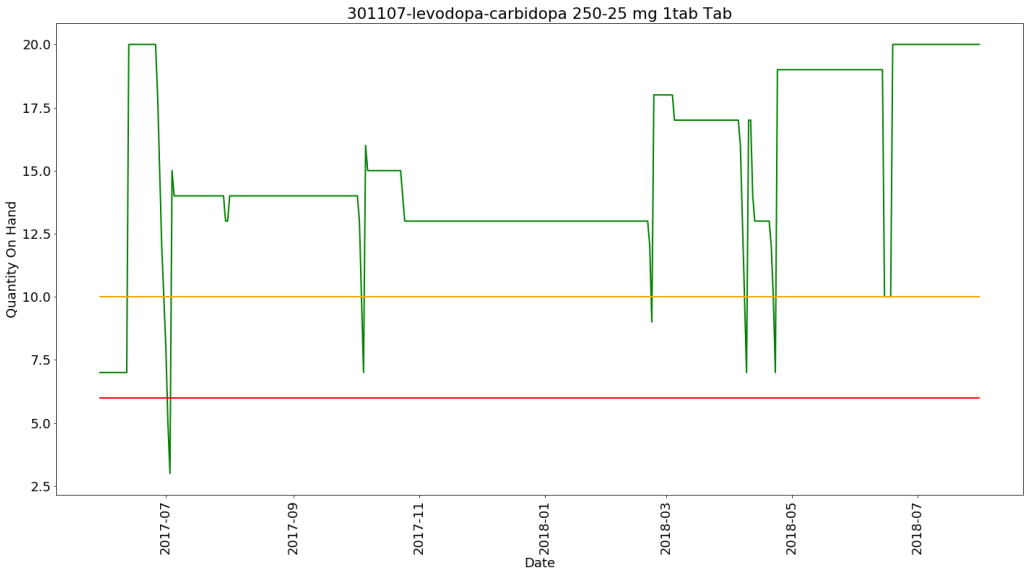

300856-nicotine 21mg Patch
Quantity On Hand
14
12
10
8
6
4
2
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

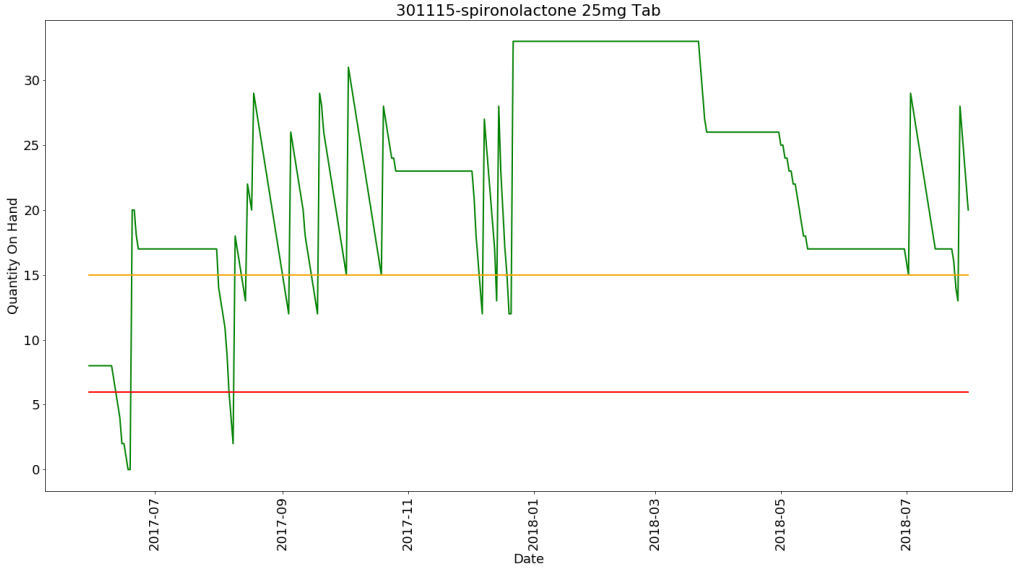

300918-pantoprazole 40mg Inj
Quantity On Hand
80
70
60
50
40
30
20
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

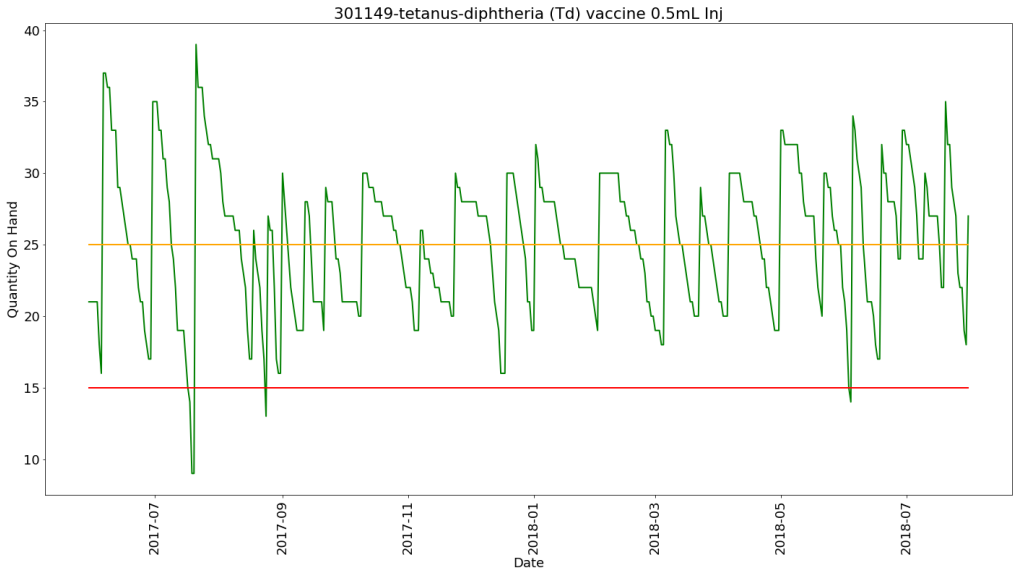

301023-propofol 10mg/1mL 20mL Inj
Quantity On Hand
16
14
12
10
8
6
4
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

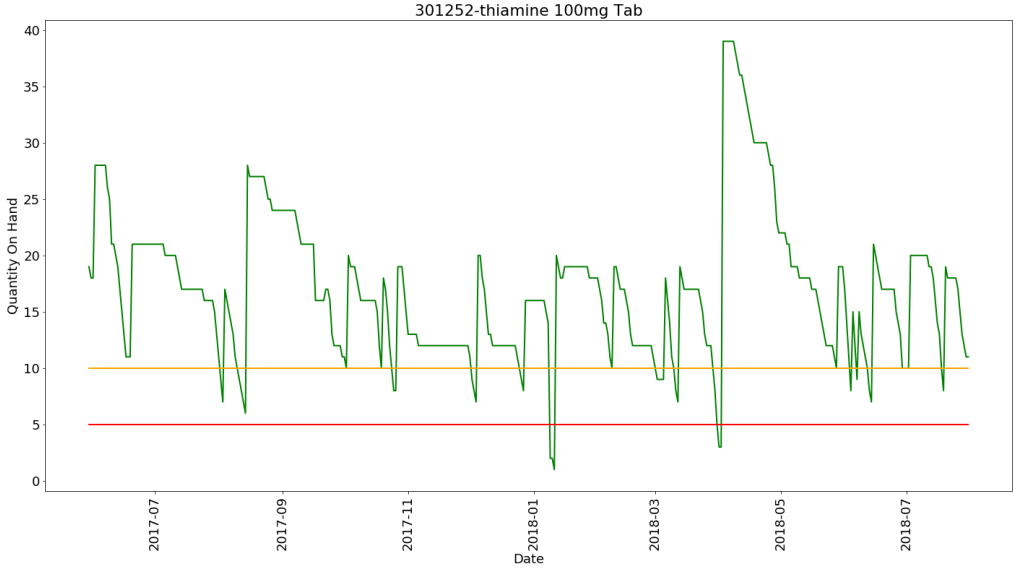

301051-ranitidine 25mg/1mL 2mL Inj
Quantity On Hand
18
16
14
12
10
8
6
4
2
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

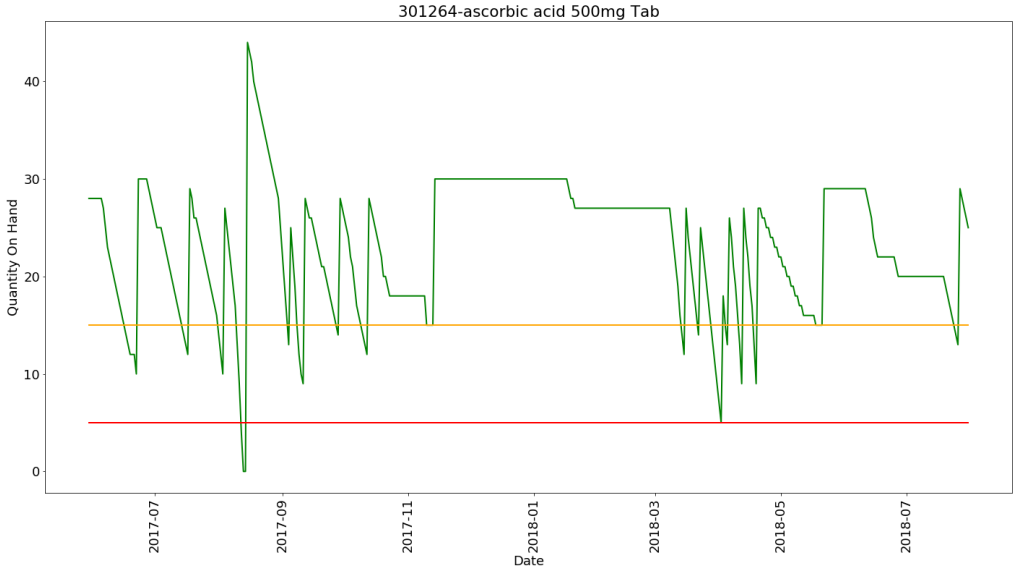

301103-levodopa-carbidopa 100-25 mg 1tab Tab
Quantity On Hand
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

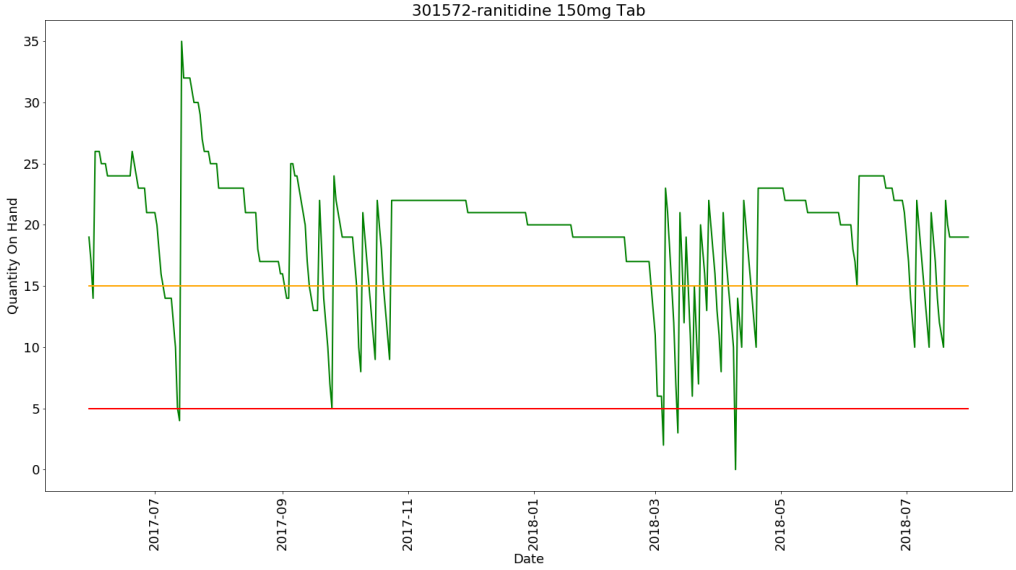

301107-levodopa-carbidopa 250-25 mg 1tab Tab
Quantity On Hand
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

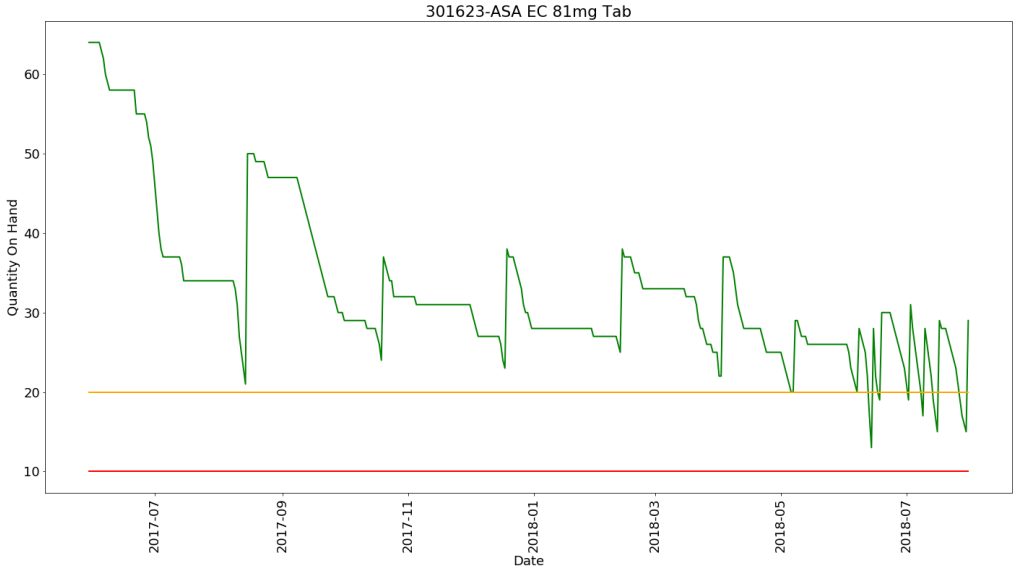

301115-spironolactone 25mg Tab
Quantity On Hand
0
5
10
15
20
25
30
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

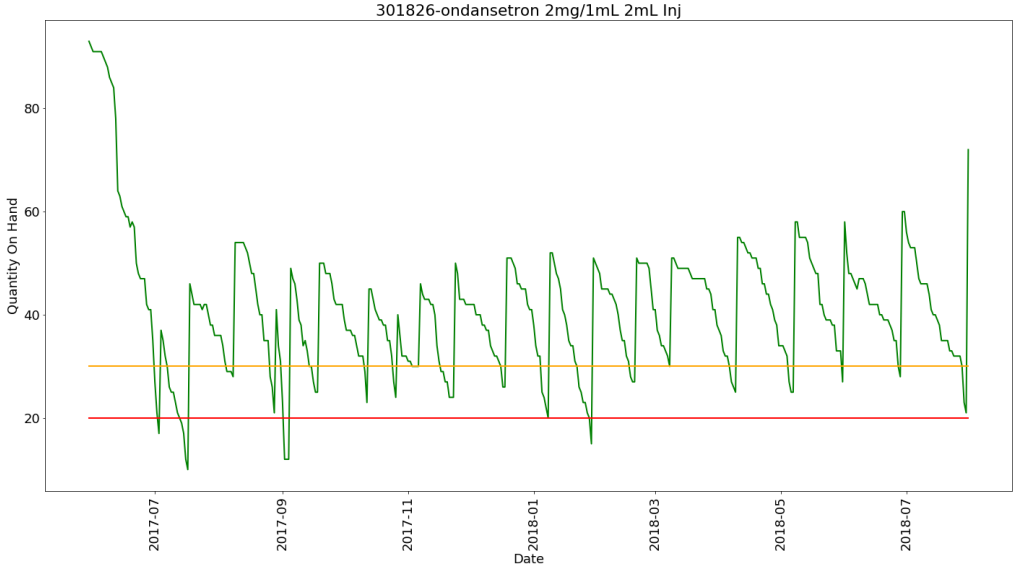

301149-tetanus-diphtheria (Td) vaccine 0.5mL Inj
Quantity On Hand
10
15
20
25
30
35
40
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

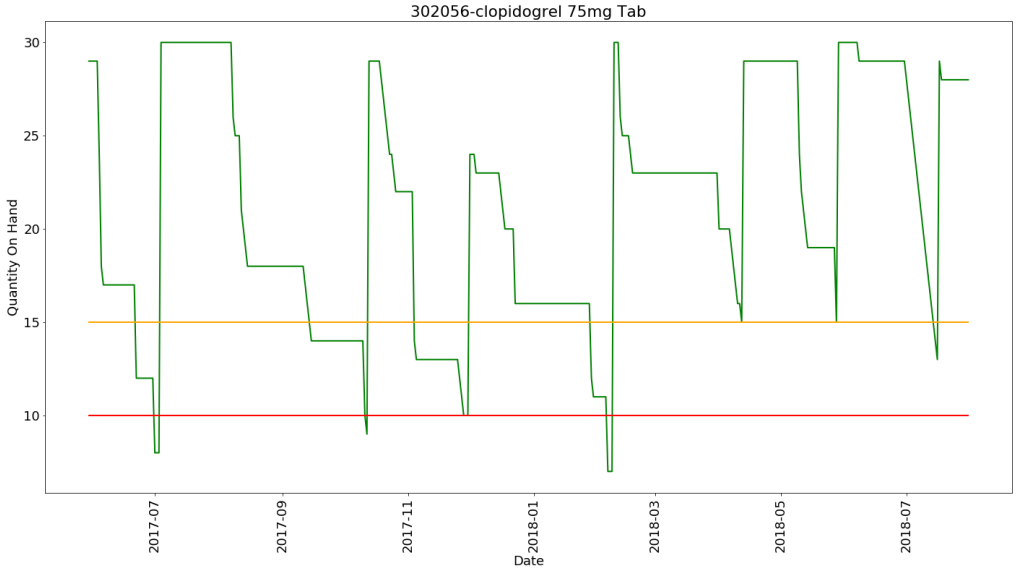

301252-thiamine 100mg Tab
Quantity On Hand
0
5
10
15
20
25
30
35
40
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

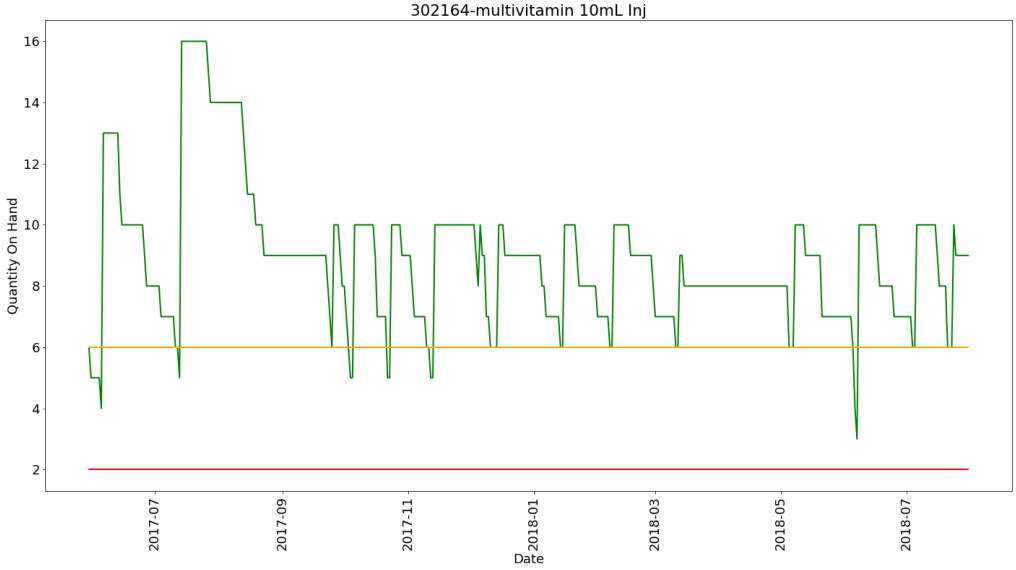

301264-ascorbic acid 500mg Tab
Quantity On Hand
0
10
20
30
40
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

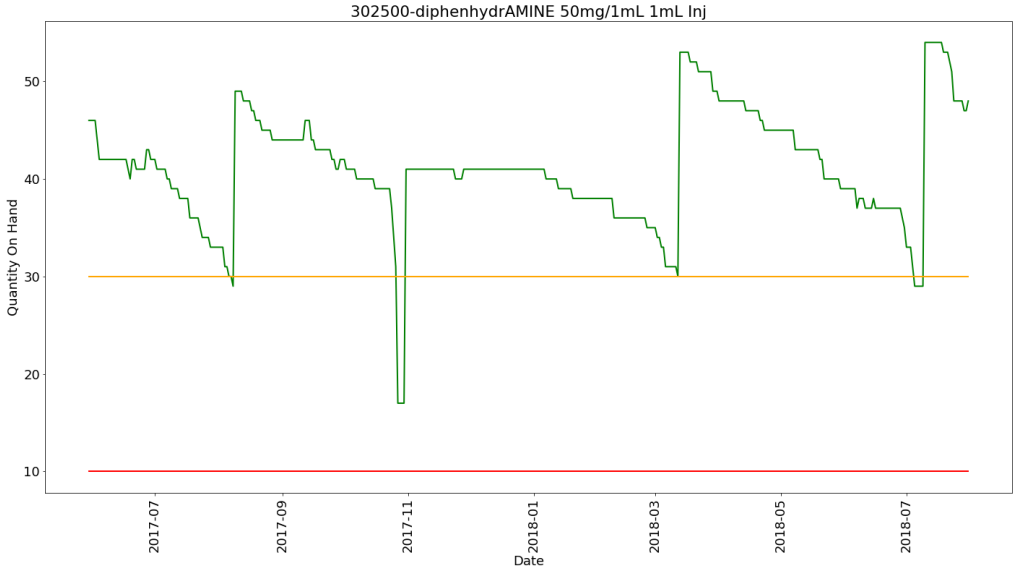

301572-ranitidine 150mg Tab
Quantity On Hand
0
5
10
15
20
25
30
35
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

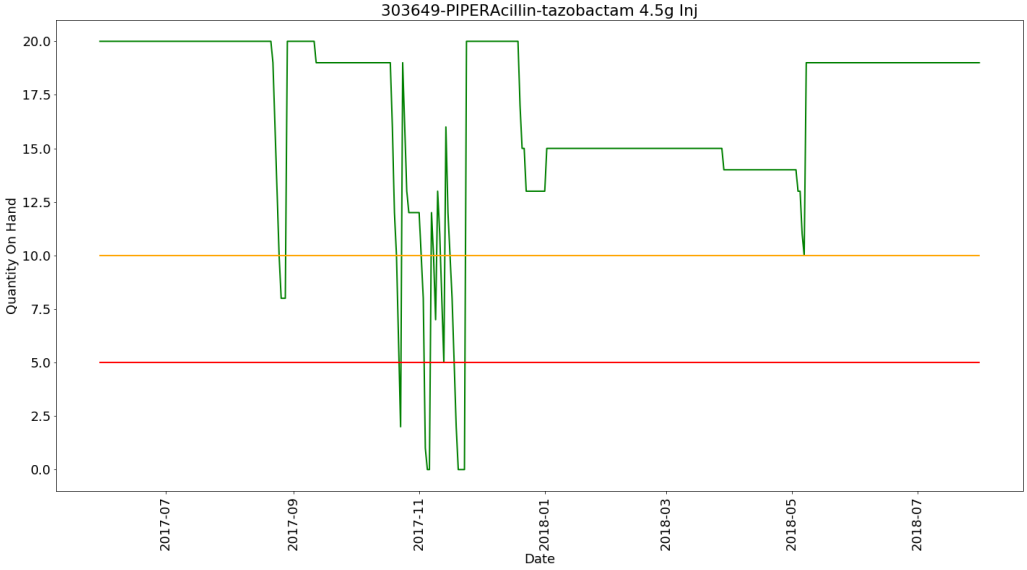

301623-ASA EC 81mg Tab
Quantity On Hand
10
20
30
40
50
60
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

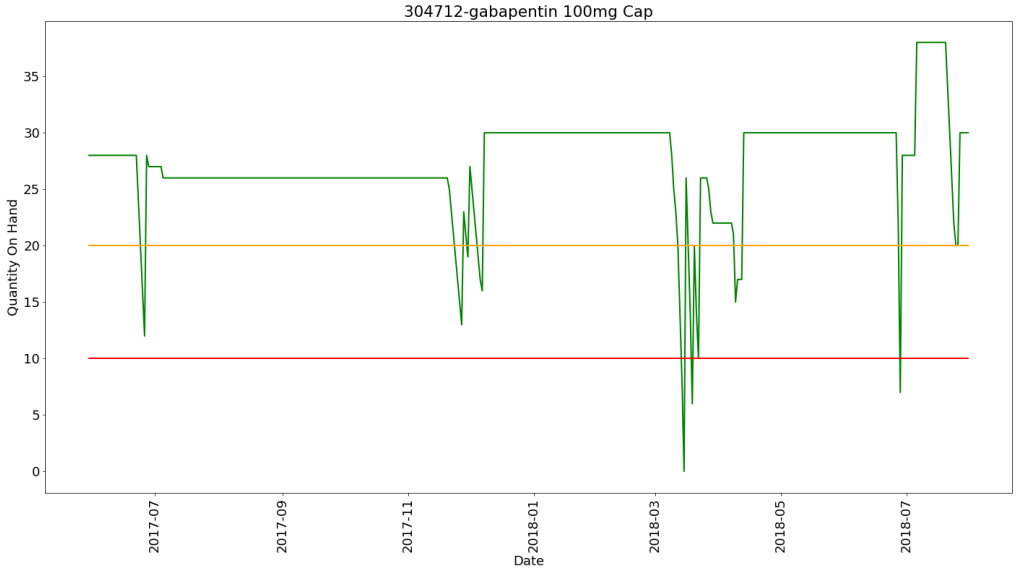

301826-ondansetron 2mg/1mL 2mL Inj
Quantity On Hand
80
60
40
20
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

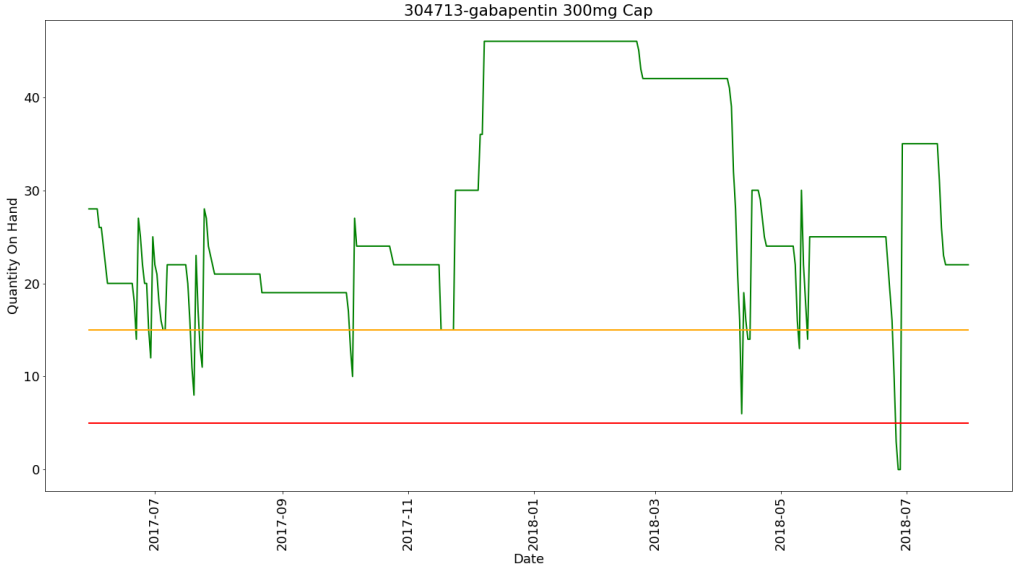

302056-clopidogrel 75mg Tab
Quantity On Hand
30
25
20
15
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

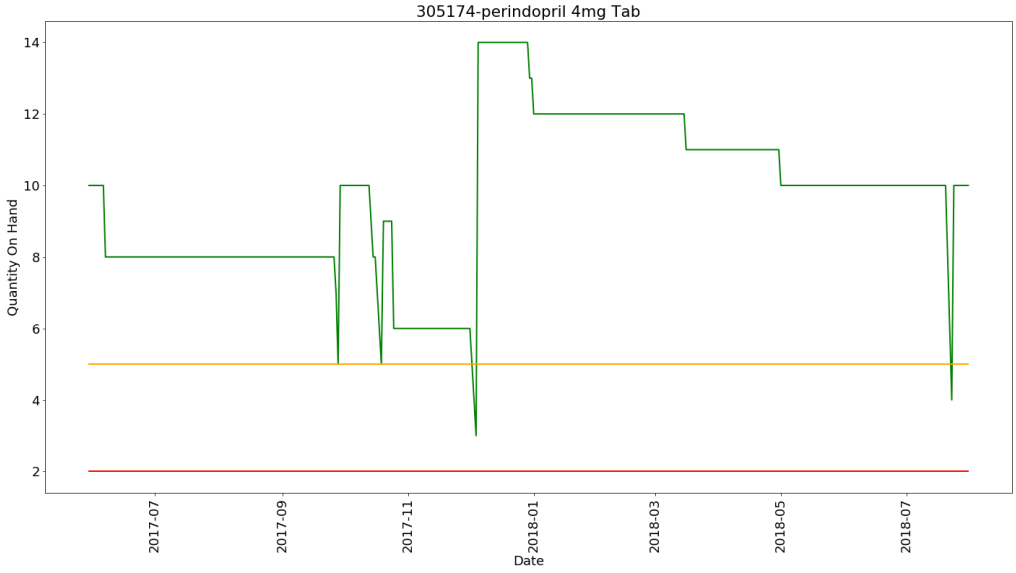

302164-multivitamin 10mL Inj
Quantity On Hand
16
14
12
10
8
6
4
2
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

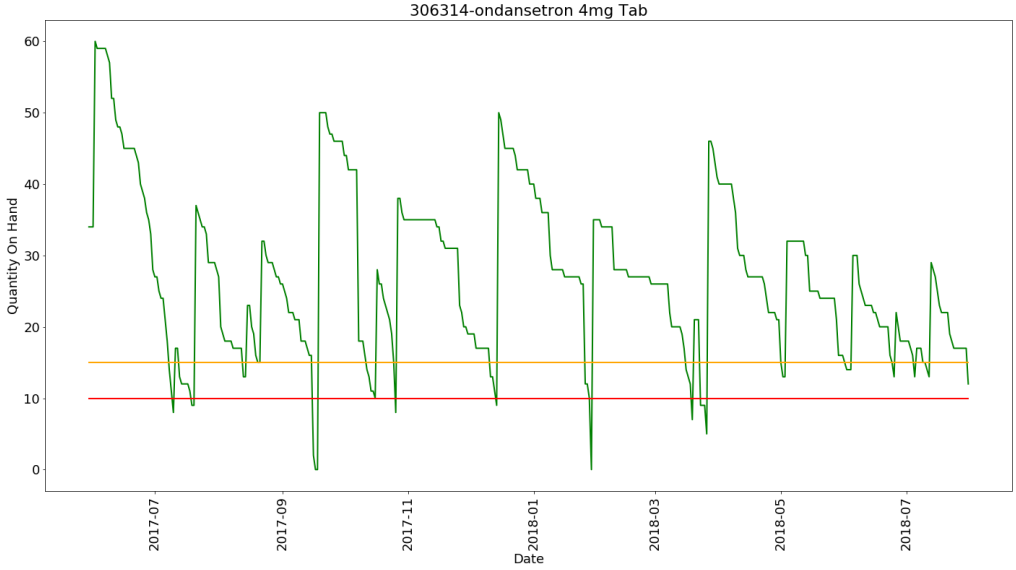

302500-diphenhydrAMINE 50mg/1mL 1mL Inj
Quantity On Hand
50
40
30
20
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

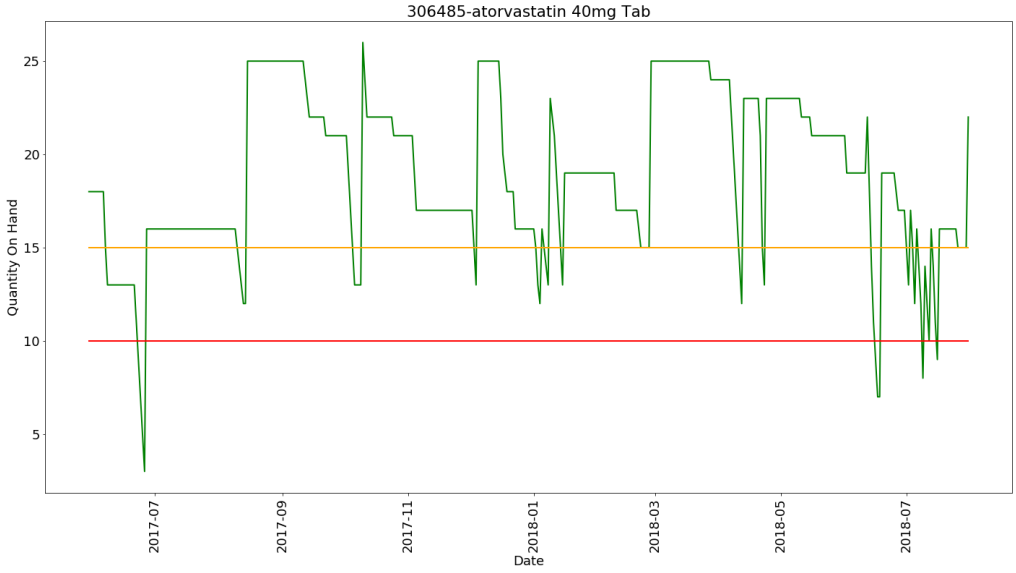

303649-PIPERAcillin-tazobactam 4.5g Inj
Quantity On Hand
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

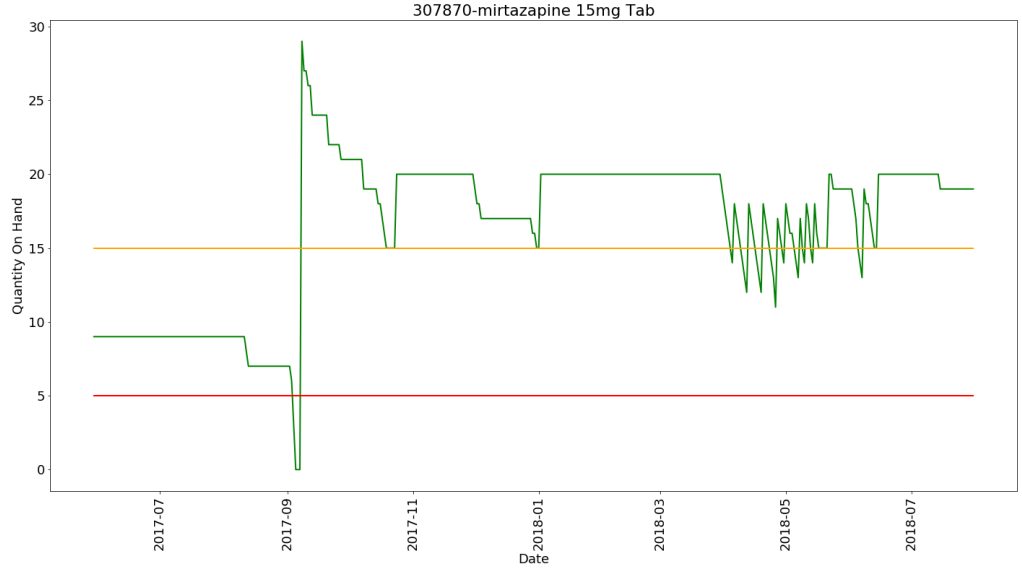

304712-gabapentin 100mg Cap
Quantity On Hand
35
30
25
20
15
10
5
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

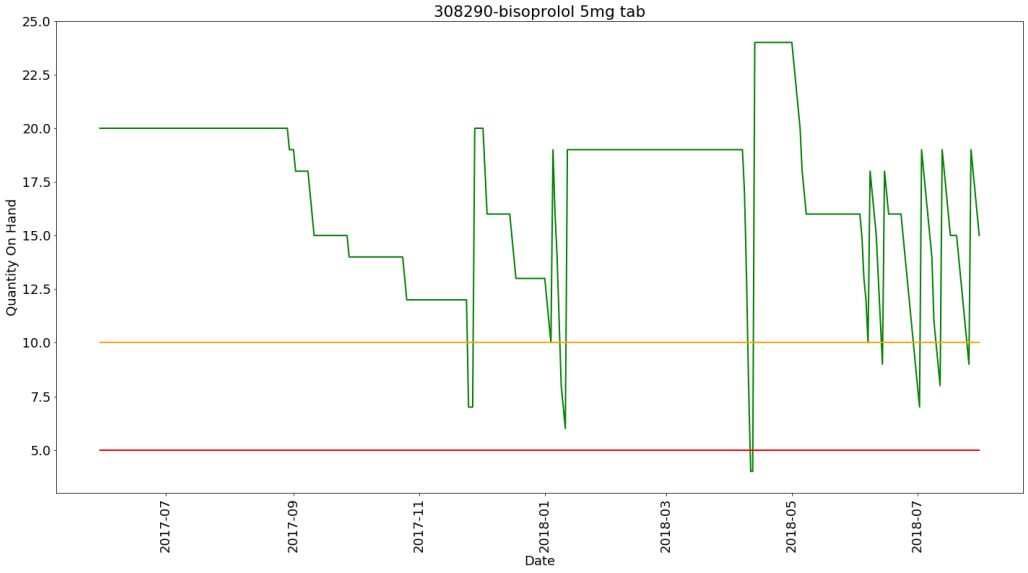

304713-gabapentin 300mg Cap
Quantity On Hand
0
10
20
30
40
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

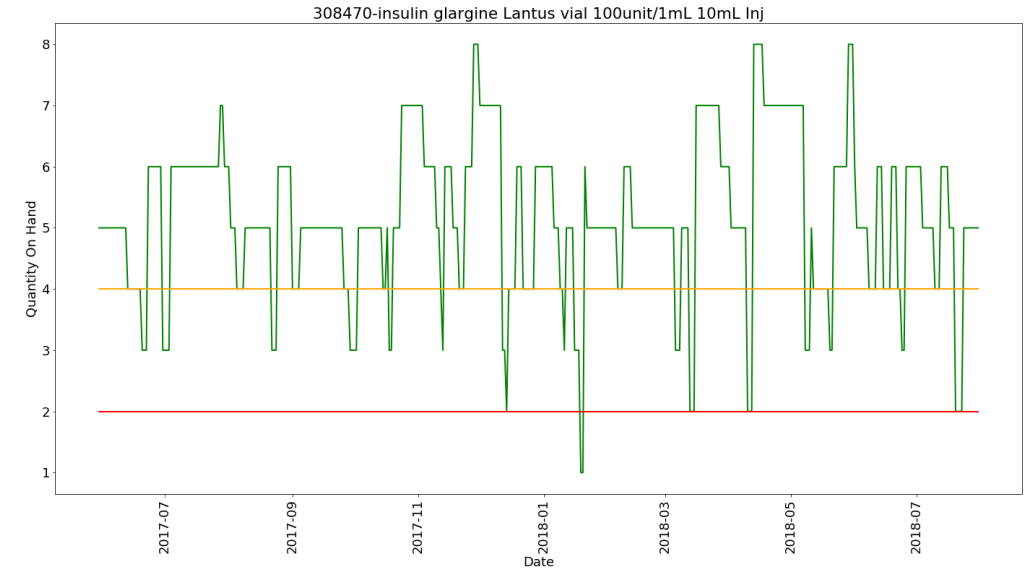

305174-perindopril 4mg Tab
Quantity On Hand
2
4
6
8
10
12
14
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

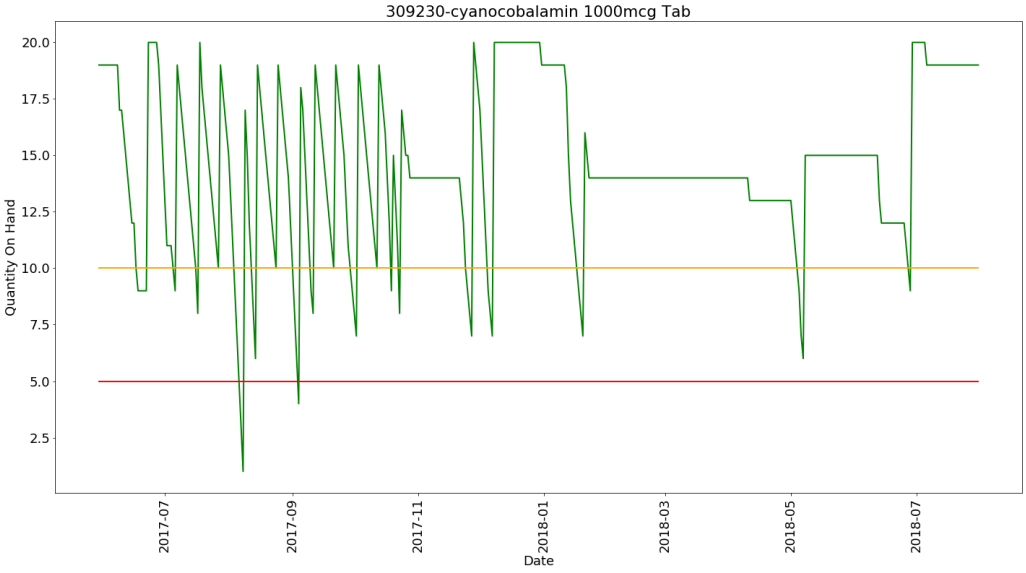

306314-ondansetron 4mg Tab
Quantity On Hand
0
10
20
30
40
50
60
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

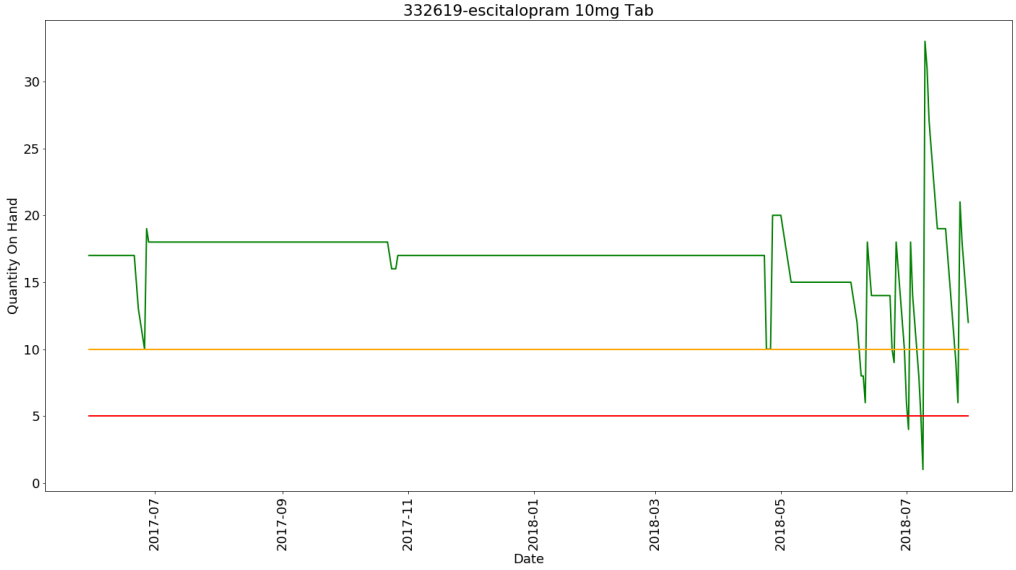

306485-atorvastatin 40mg Tab
Quantity On Hand
5
10
15
20
25
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

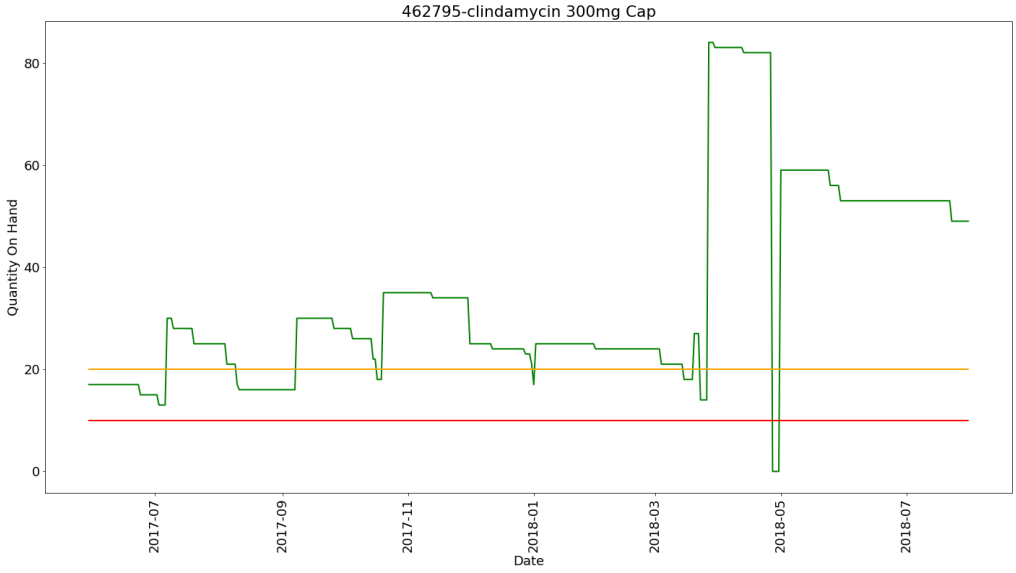

307870-mirtazapine 15mg Tab
Quantity On Hand
30
25
20
15
10
5
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

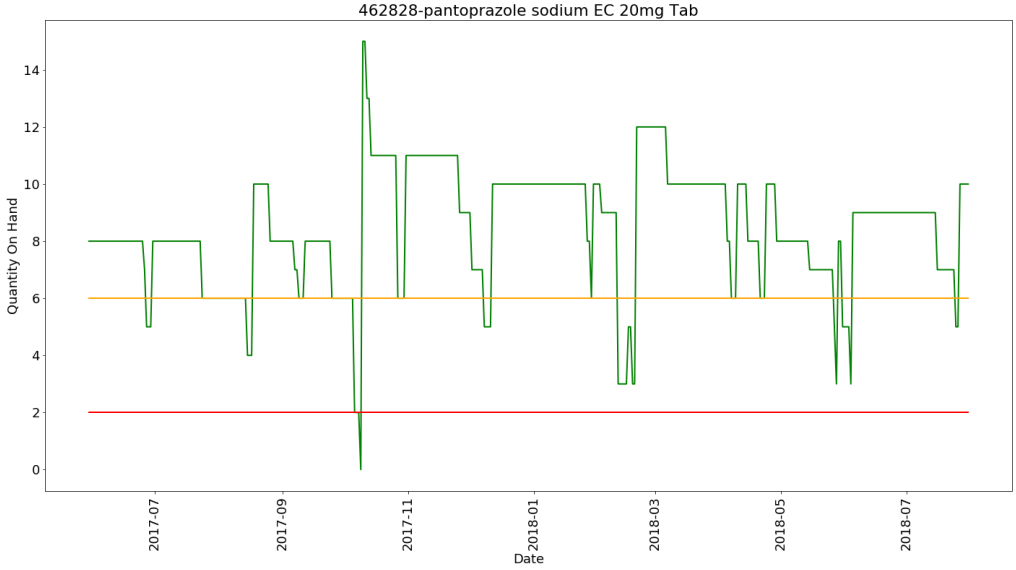

308290-bisoprolol 5mg tab
Quantity On Hand
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

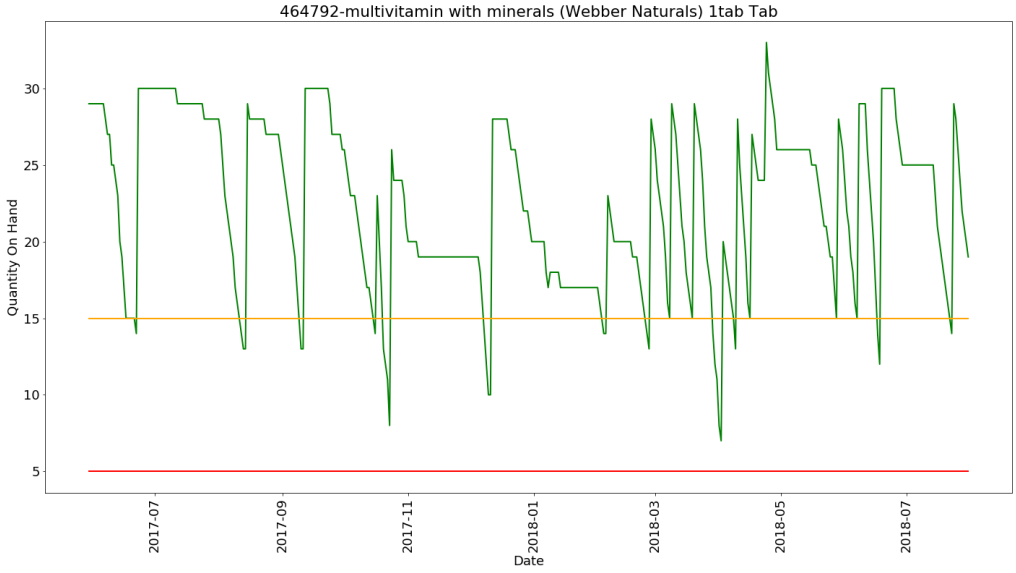

308470-insulin glargine Lantus vial 100unit/1mL 10mL Inj
Quantity On Hand
8
7
6
5
4
3
2
1
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

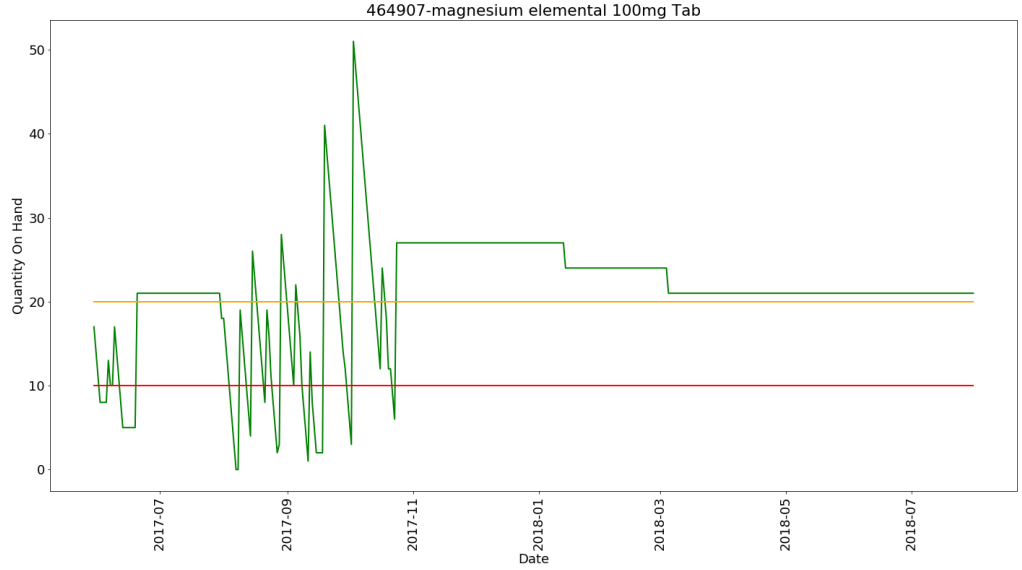

309230-cyanocobalamin 1000mcg Tab
Quantity On Hand
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

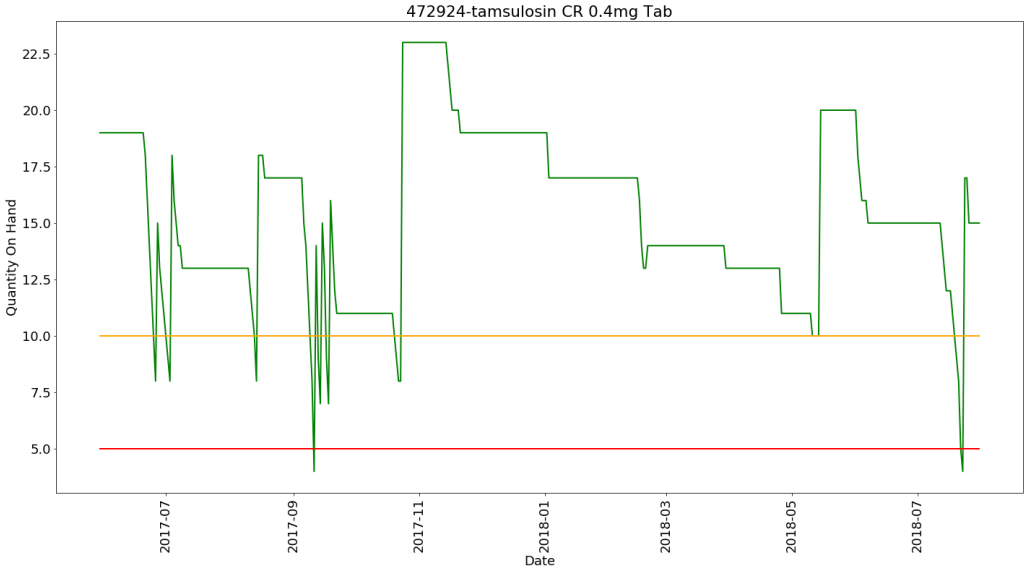

332619-escitalopram 10mg Tab
Quantity On Hand
0
5
10
15
20
25
30
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

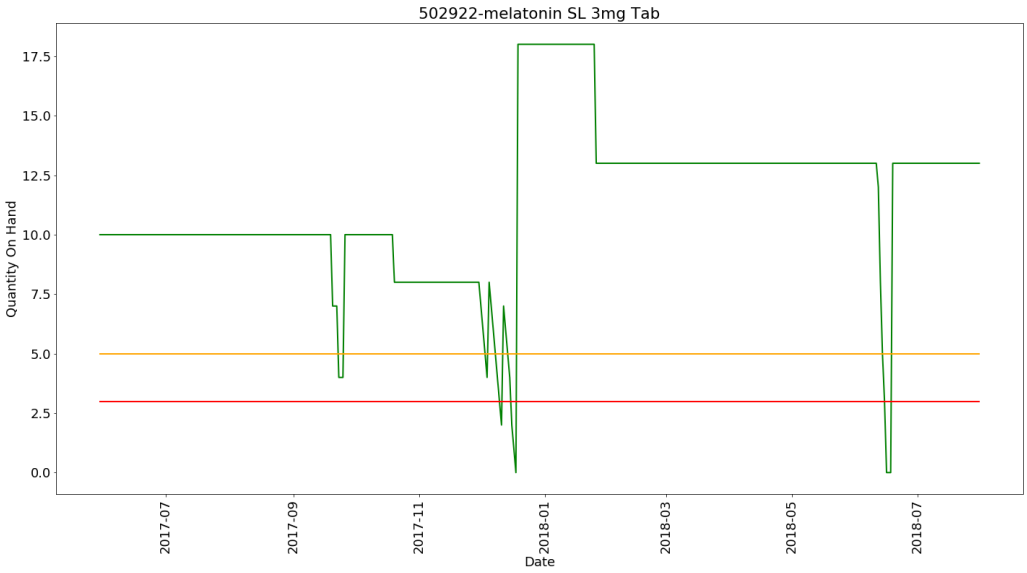

462795-clindamycin 300mg Cap
Quantity On Hand
0
20
40
60
80
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

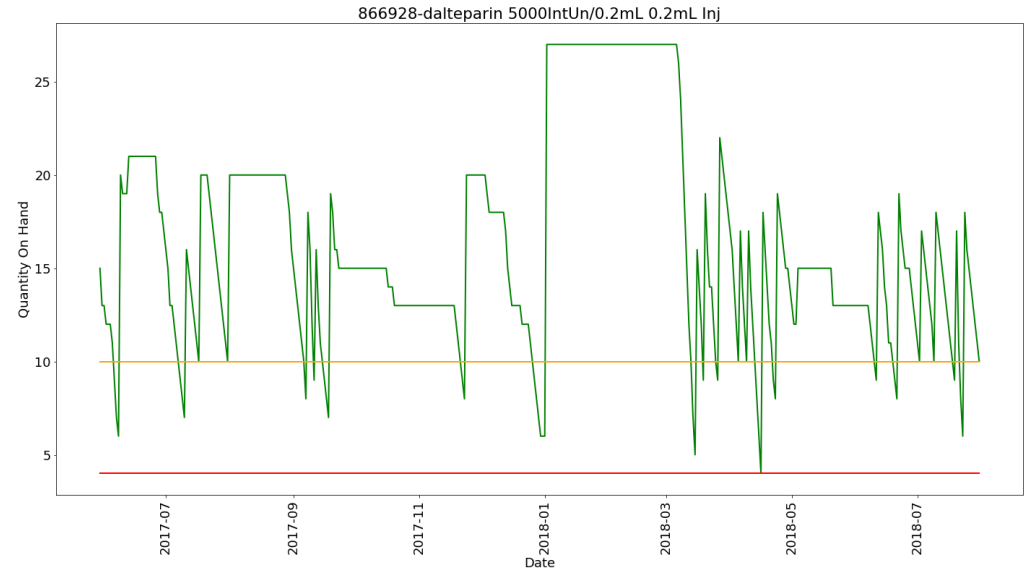

462828-pantoprazole sodium EC 20mg Tab
Quantity On Hand
0
2
4
6
8
10
12
14
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

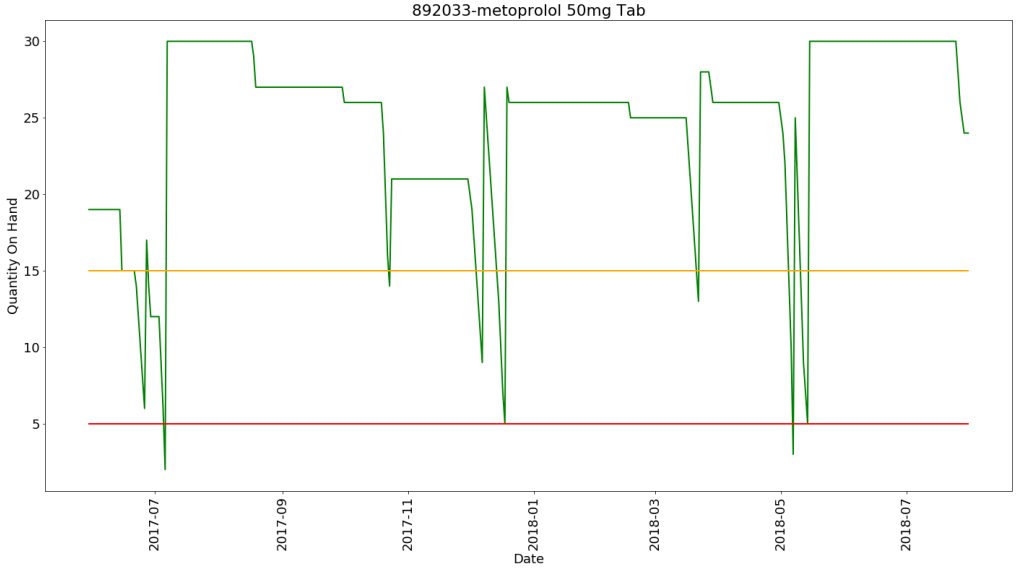

464792-multivitamin with minerals (Webber Naturals) 1tab Tab
Quantity On Hand
5
10
15
20
25
30
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

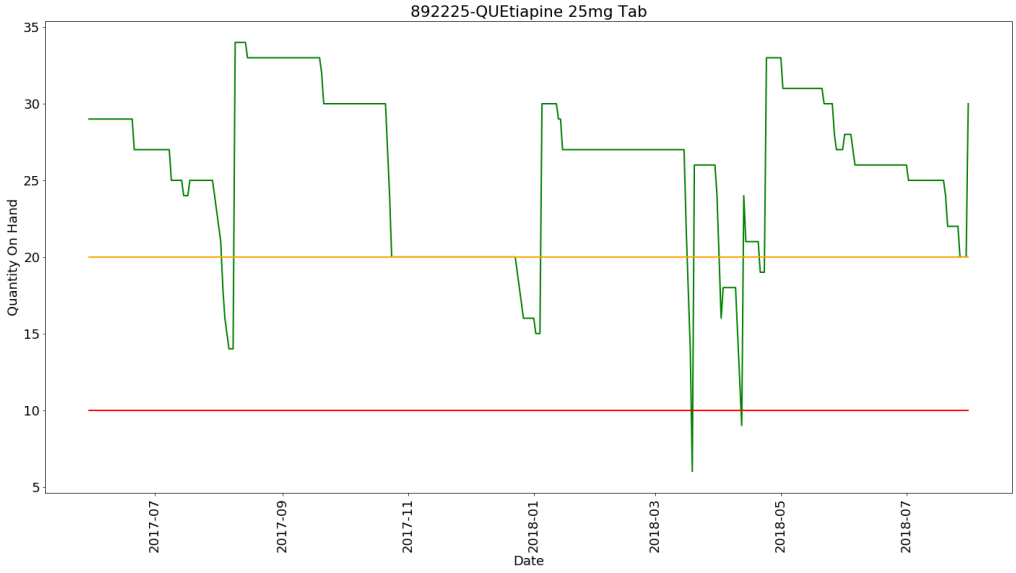

464907-magnesium elemental 100mg Tab
Quantity On Hand
0
10
20
30
40
50
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

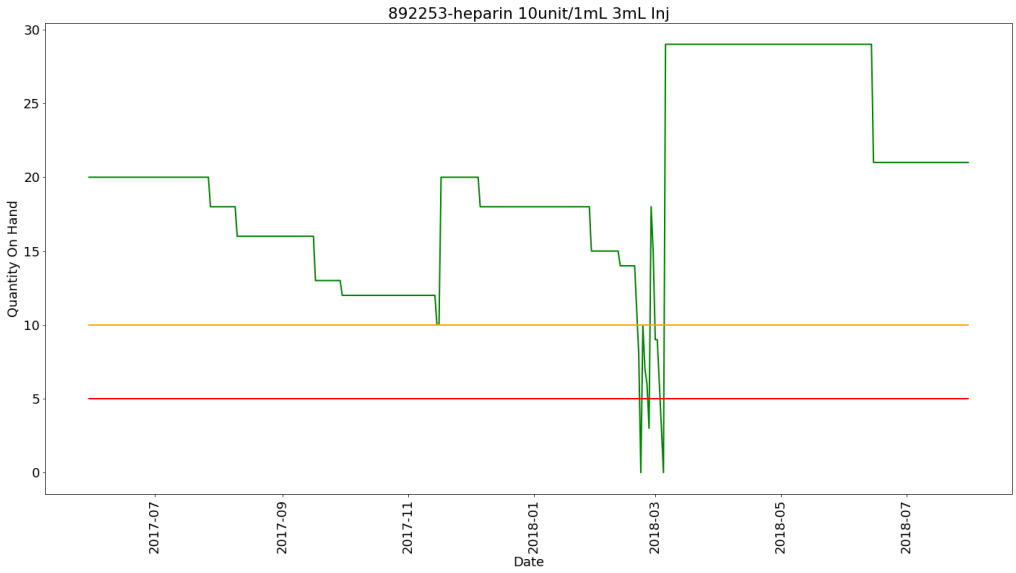

472924-tamsulosin CR 0.4mg Tab
Quantity On Hand
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

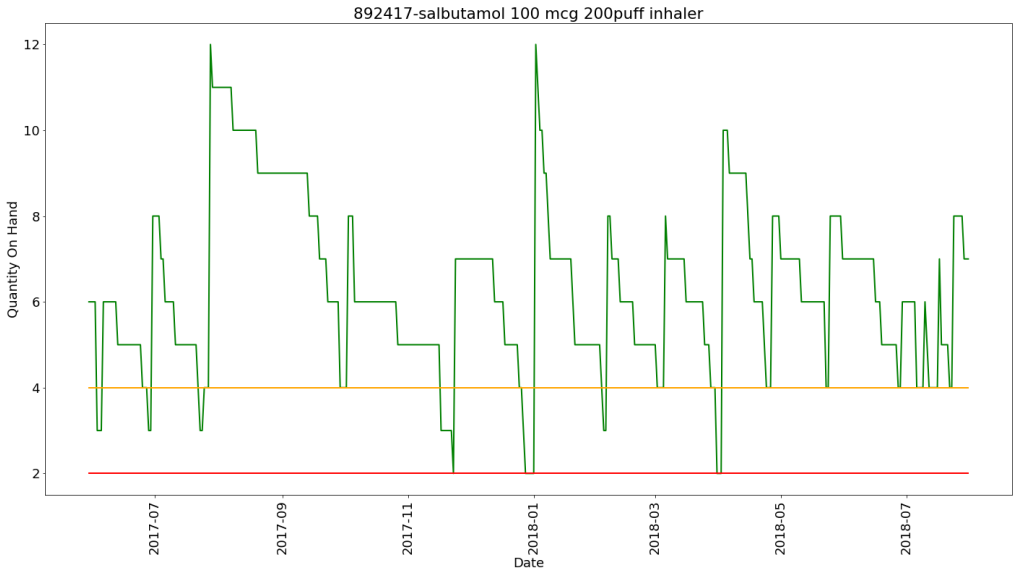

502922-melatonin SL 3mg Tab
Quantity On Hand
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

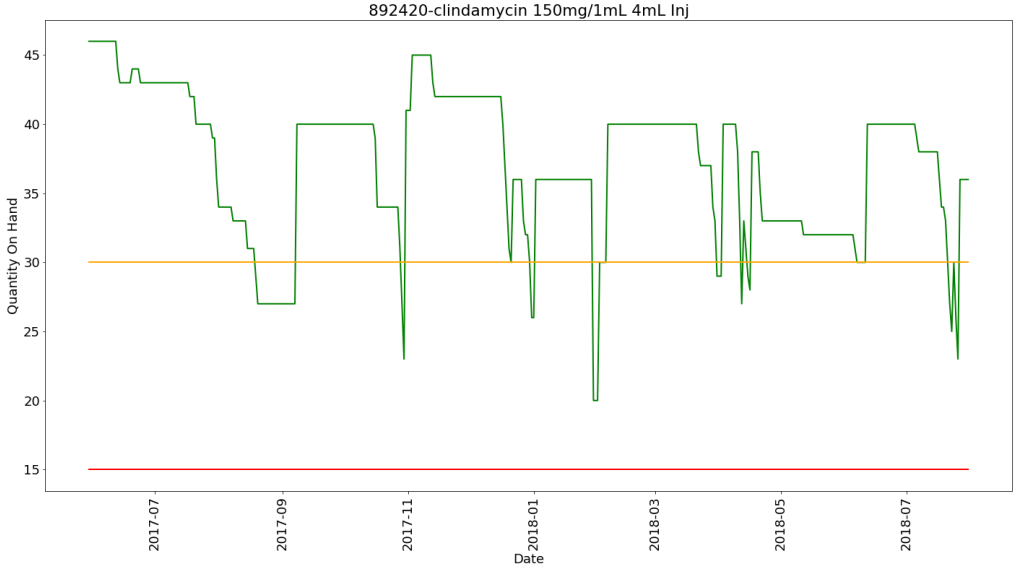

866928-dalteparin 5000IntUn/0.2mL 0.2mL Inj
Quantity On Hand
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

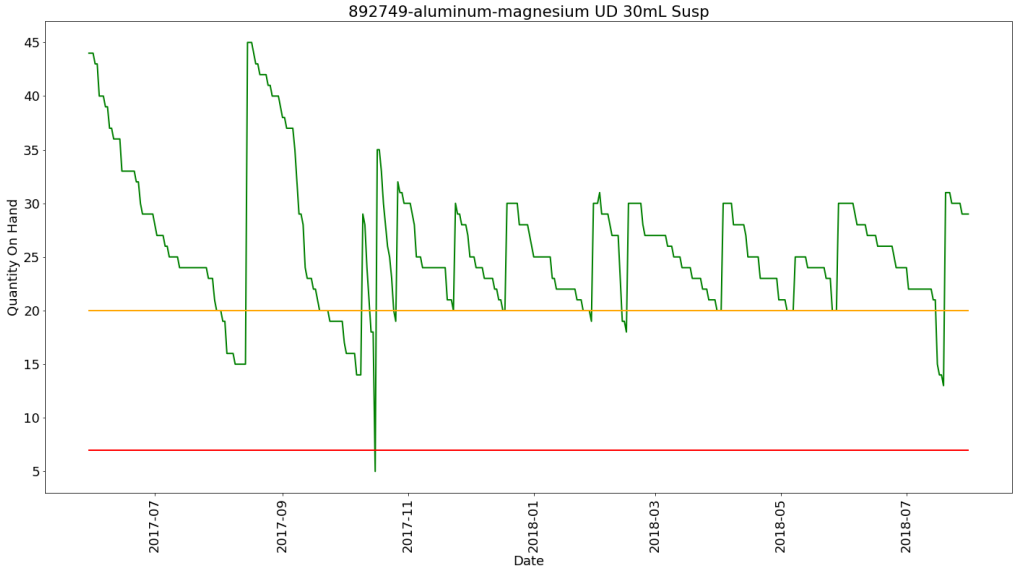

892033-metoprolol 50mg Tab
Quantity On Hand
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

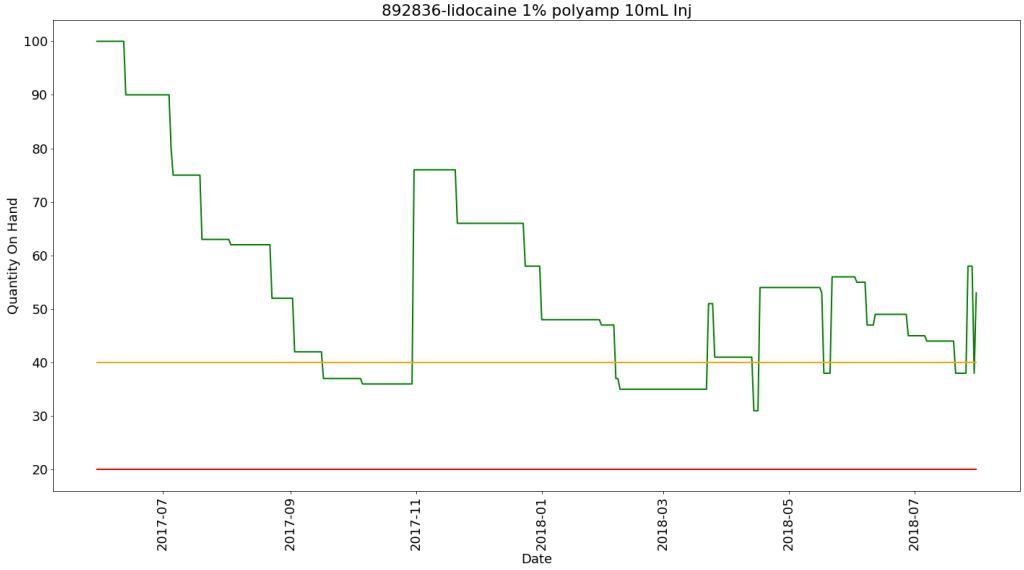

892225-QUEtiapine 25mg Tab
Quantity On Hand
35
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

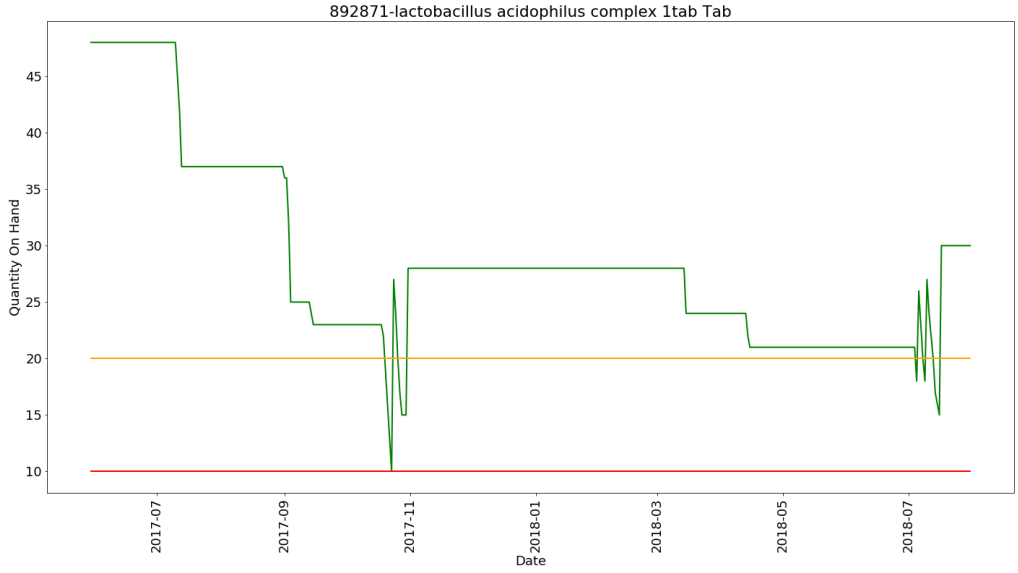

892253-heparin 10unit/1mL 3mL Inj
Quantity On Hand
Date
0
5
10
15
20
25
30
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07

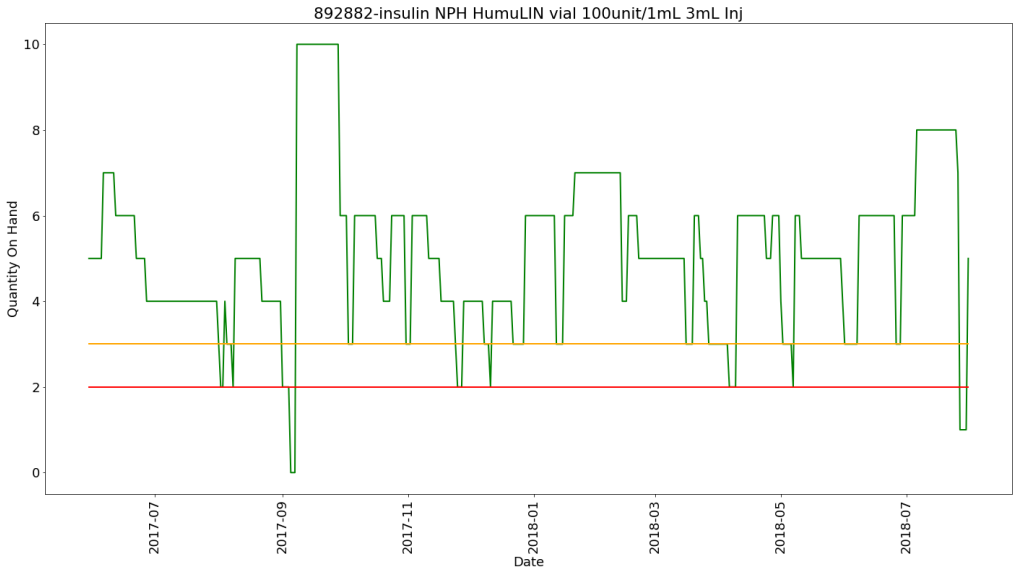

892417-salbutamol 100 mcg 200puff inhaler
Quantity On Hand
Date
2
4
6
8
10
12
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07

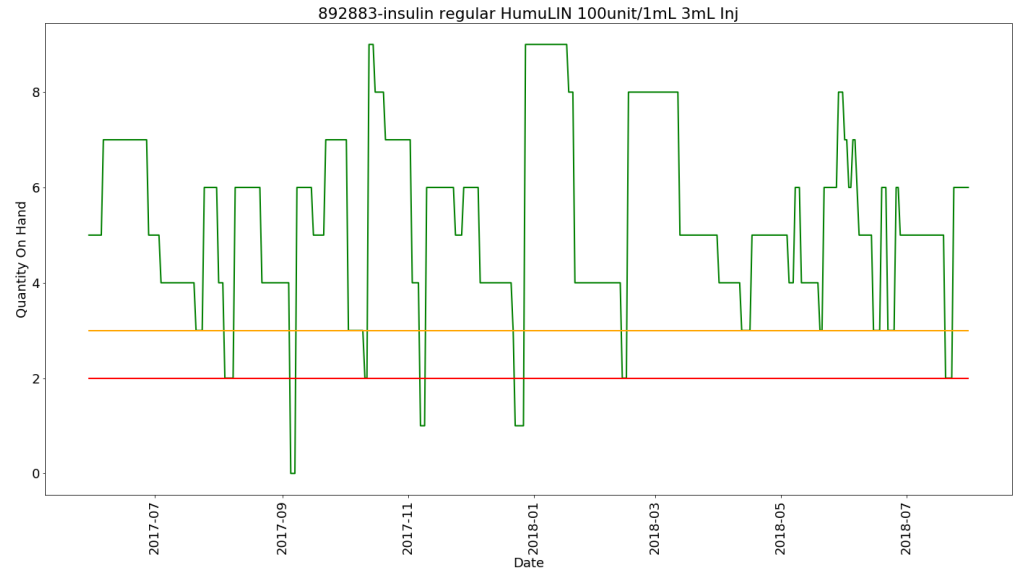

892420-clindamycin 150mg/1mL 4mL Inj
Quantity On Hand
45
40
35
30
25
20
15
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

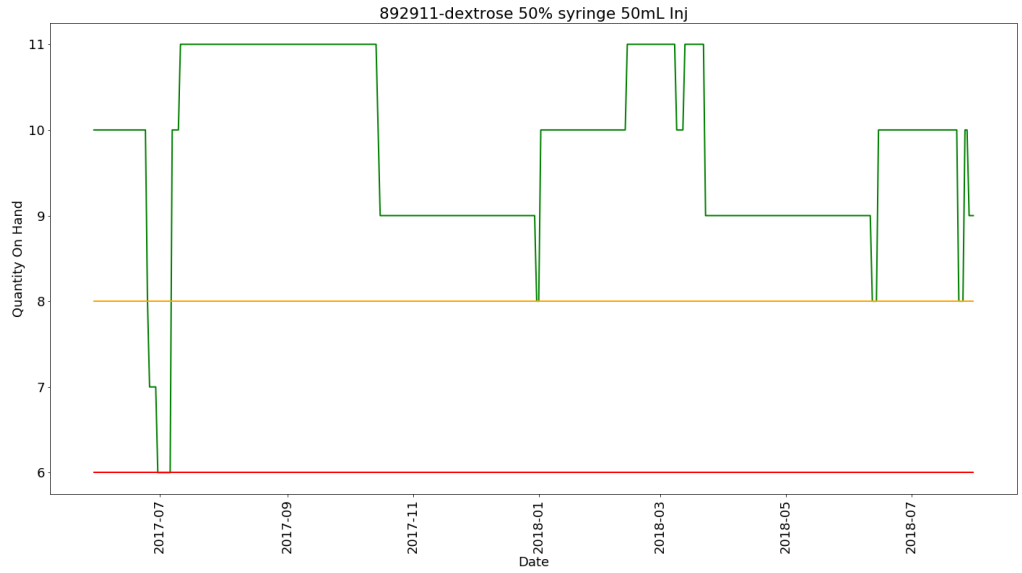

892749-aluminum-magnesium UD 30mL Susp
Quantity On Hand
45
40
35
30
25
20
15
10
5
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

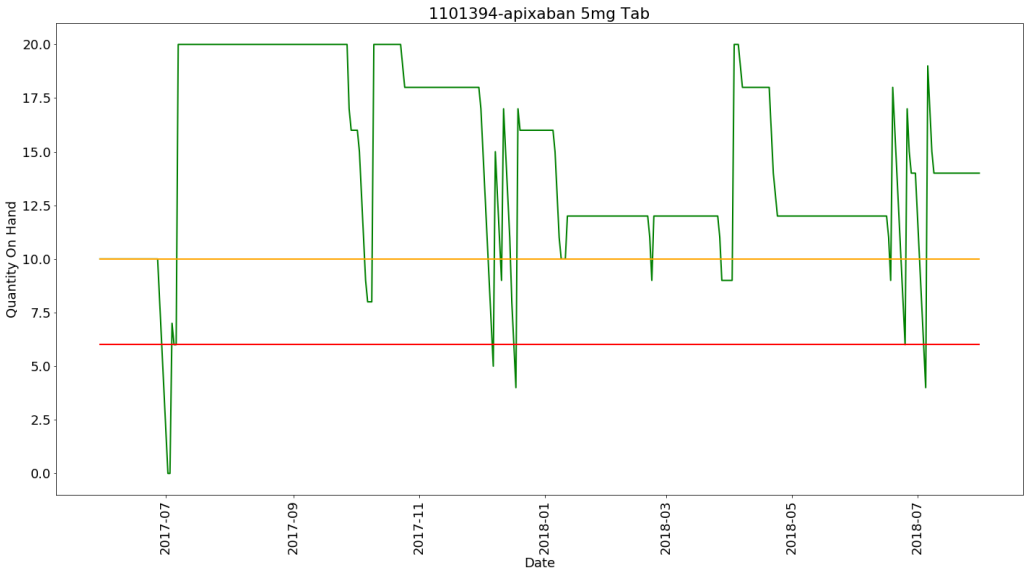

892836-lidocaine 1% polyamp 10mL Inj
Quantity On Hand
100
90
80
70
60
50
40
30
20
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

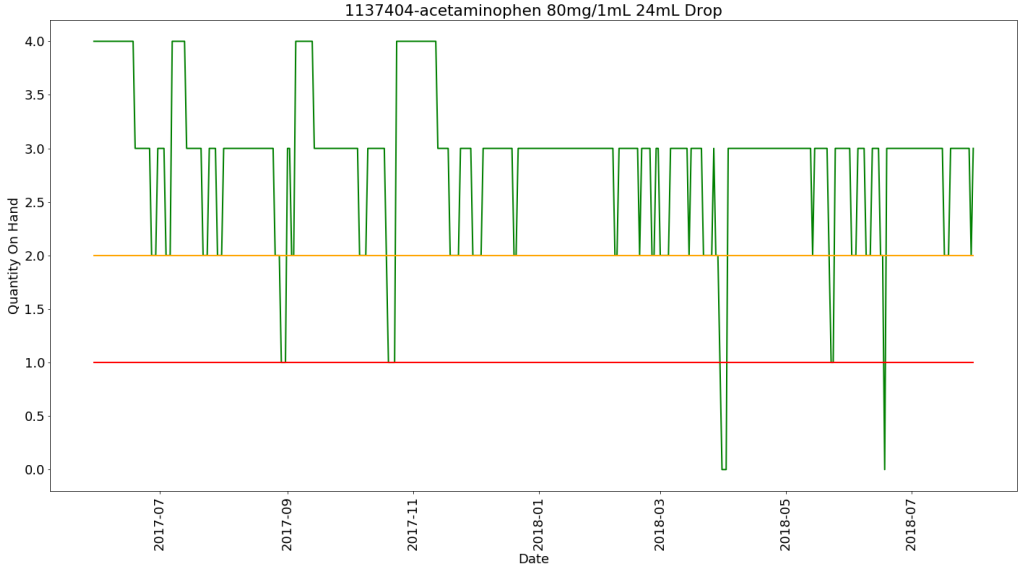

892871-lactobacillus acidophilus complex 1tab Tab
Quantity On Hand
45
40
35
30
25
20
15
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

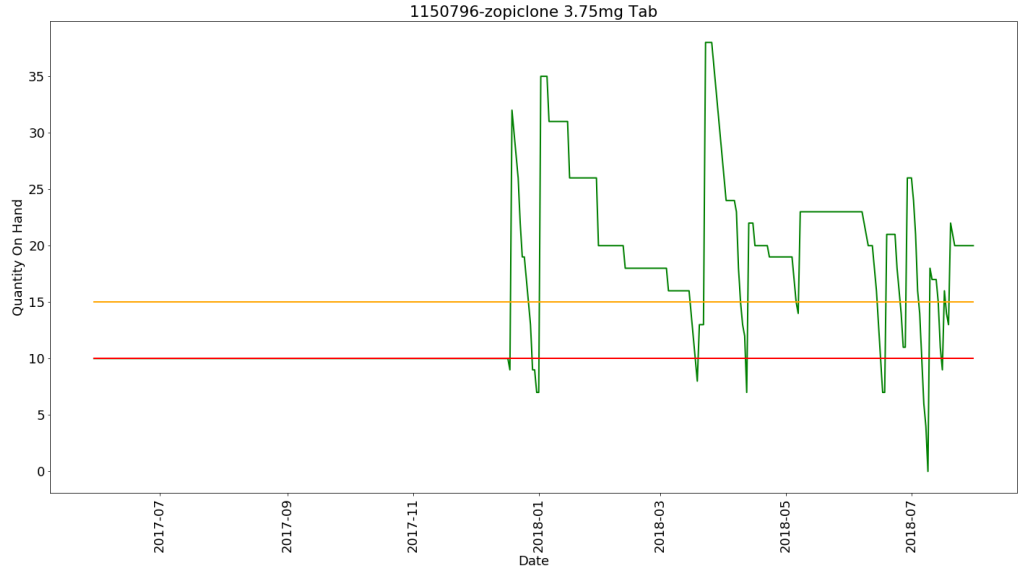

892882-insulin NPH HumuLIN vial 100unit/1mL 3mL Inj
Quantity On Hand
0
2
4
6
8
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

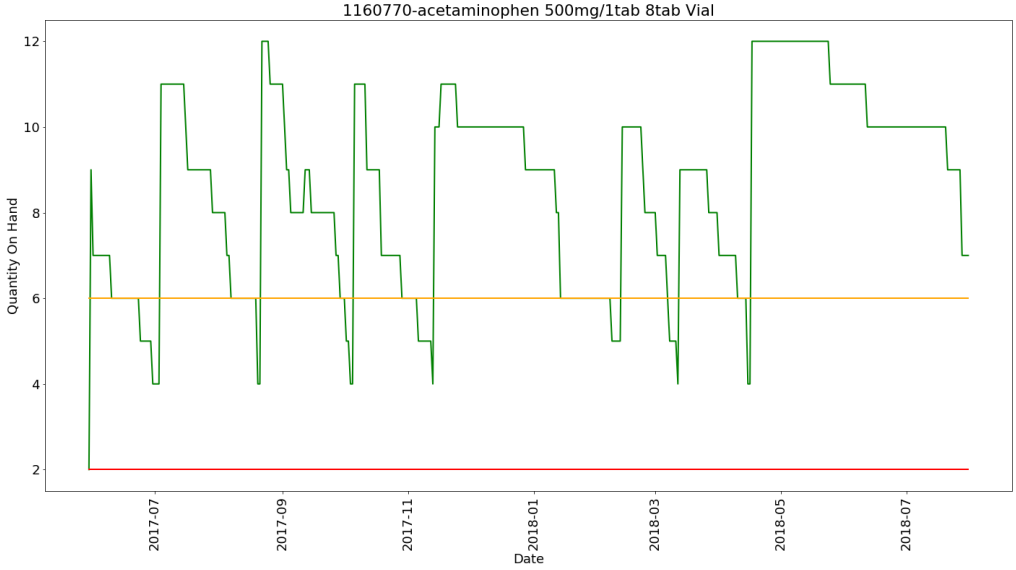

892883-insulin regular HumuLIN 100unit/1mL 3mL Inj
Quantity On Hand
0
2
4
6
8
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

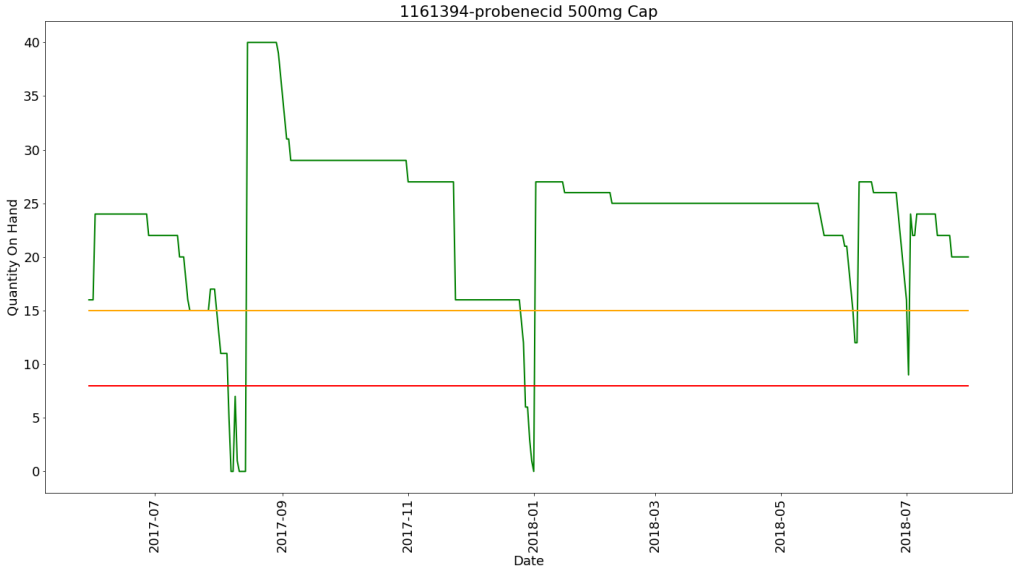

892911-dextrose 50% syringe 50mL Inj
Quantity On Hand
11
10
9
8
7
6
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

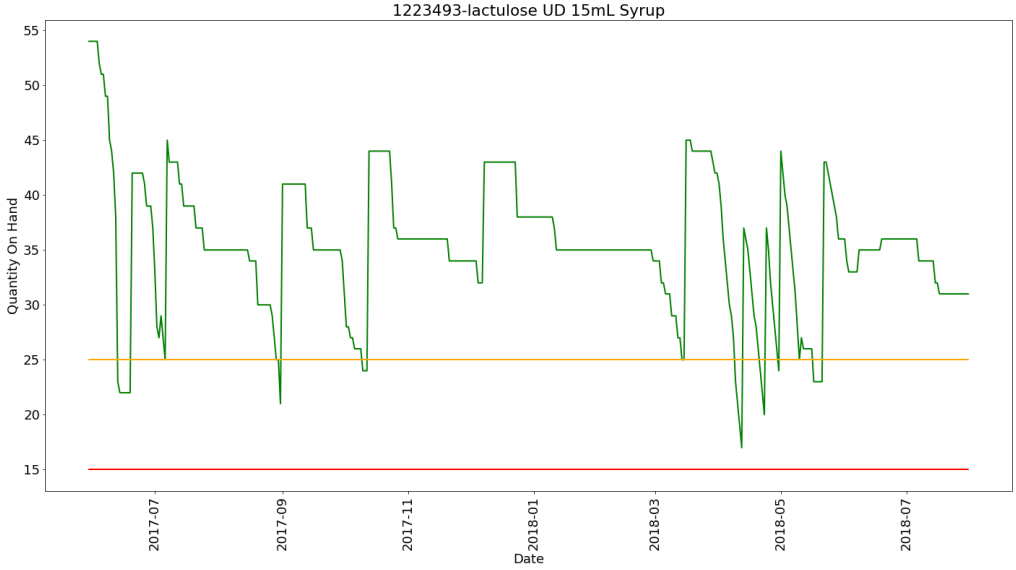

1101394-apixaban 5mg Tab
Quantity On Hand
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

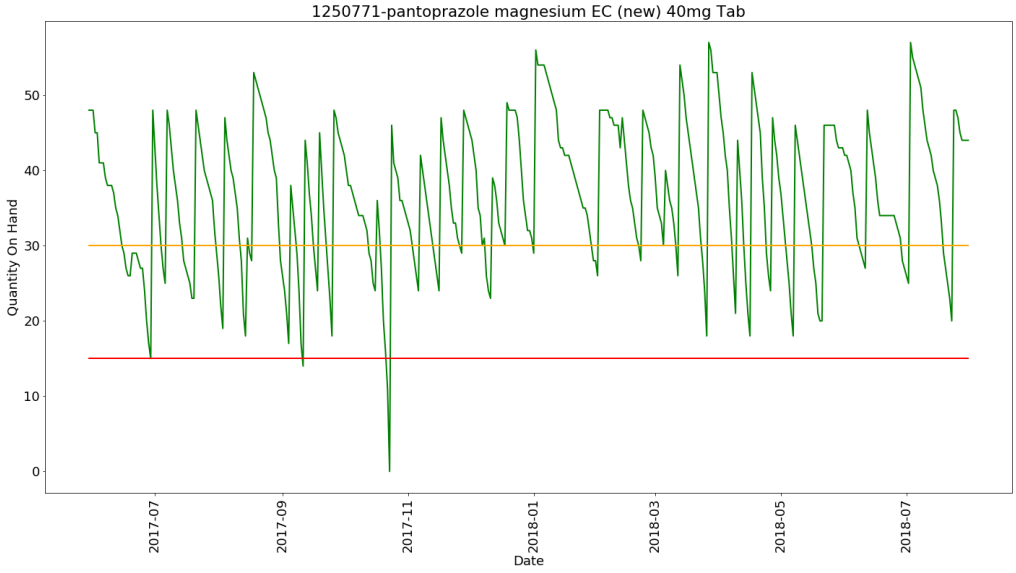

1137404-acetaminophen 80mg/1mL 24mL Drop
Quantity On Hand
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

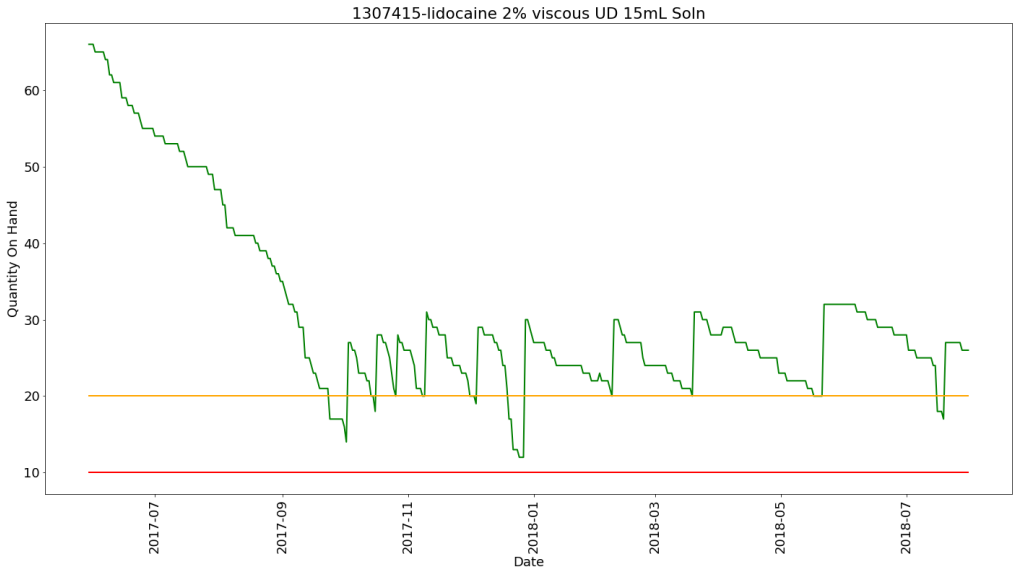

1150796-zopiclone 3.75mg Tab
Quantity On Hand
35
30
25
20
15
10
5
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


1160770-acetaminophen 500mg/1tab 8tab Vial
Quantity On Hand
12
10
8
6
4
2
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


1161394-probenecid 500mg Cap
Quantity On Hand
40
35
30
25
20
15
10
5
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


1223493-lactulose UD 15mL Syrup
Quantity On Hand
55
50
45
40
35
30
25
20
15
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


1250771-pantoprazole magnesium EC (new) 40mg Tab
Quantity On Hand
50
40
30
20
10
0
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date


1307415-lidocaine 2% viscous UD 15mL Soln
Quantity On Hand
60
50
40
30
20
10
2017-07
2017-09
2017-11
2018-01
2018-03
2018-05
2018-07
Date

Appendix 2

Medication items stocked in TGH ADC with a history of expiration from 30/may/2017 to 31/July 2018

Item_ID	rx_disp	PAR	qty_onhand	Reorder point	Safety Stock	qty_issued	Expired
300077	atropine 0.6mg/1mL 1mL Inj	80	80	65	60	0	98
892884	insulin lispro HumaLOG vial 100unit/1mL 3mL Inj	10	9	5	3	53	95
300699	LORazepam SL 0.5mg Tab	25	25	20	10	113	75
1209395	HYDROmorphone CR 4.5mg Cap	25	20	10	5	36	68
300705	LORazepam SL 2mg Tab	25	24	20	10	68	65
892883	insulin regular HumuLIN 100unit/1mL 3mL Inj	6	4	3	2	20	64
300630	labetalol 100mg Tab	20	16	10	5	1	58
299717	cloxacillin 500mg Cap	30	15	10	5	0	52
299860	morphine 10mg Tab	50	34	25	10	64	51
303666	codeine CR 50mg Tab	25	20	15	5	0	51
892882	insulin NPH HumuLIN vial 100unit/1mL 3mL Inj	6	5	3	2	27	51
308470	insulin glargine Lantus vial 100unit/1mL 10mL Inj	6	5	4	2	41	41
299892	morphine ER 60mg Cap	20	20	10	5	28	40
299800	HYDROmorphone CR 24mg Cap	20	20	10	6	0	40
299929	PHENobarbital 30mg tab	25	25	20	15	6	39
300461	fluorescein ophthalmic 1mg Strip	20	0	10	6	38	37
892420	clindamycin 150mg/1mL 4mL Inj	40	36	30	15	135	36
300924	pentoxifylline SR 400mg Tab	15	10	7	3	15	36
1273415	dimenhyDRINATE UD 25mg/8.3mL 8.3mL Soln	10	8	5	2	10	36
301276	phytonadione 10mg/1mL 1mL Inj	20	18	10	5	9	35
300053	amiodarone 50mg/1mL 3mL Inj	20	20	15	10	40	34
301236	venlafaxine XR 75mg Cap	20	20	10	5	50	33
299866	morphine ER 10mg Cap	50	23	20	10	68	32
300233	cloNIDine 0.1mg Tab	20	13	10	5	15	32
299913	oxyCODONE 5mg Tab	50	48	25	10	20	30
300544	hydrALAZINE 25mg Tab	30	29	15	5	22	30
299970	vancomycin 125mg Cap	20	20	15	10	20	30
300235	clonazePAM 0.5mg Tab	60	19	15	10	58	29
300977	predniSONE 1mg Tab	30	10	20	10	100	29
303662	moxifloxacin 400mg Tab	20	20	10	5	39	27
301785	cefuroxime 500mg Tab	20	20	10	5	2	27
299972	vancomycin 500mg Inj	15	14	10	5	43	27
300689	lithium carbonate 150mg Cap	10	10	5	2	0	27

300778	metolazone 2.5mg Tab	30	40	15	10	10	26
301254	cyanocobalamin 1000mcg/1mL 1mL Inj	10	7	4	2	4	26
299810	HYDROmorphone 8mg Tab	50	50	25	10	0	25
301823	morphine ER 100mg Cap	25	25	15	5	0	25
300602	isoproterenol 0.2mg/1mL 1mL Inj	20	20	10	4	0	25
302341	bupivacaine-EPINEPHrine 0.25%-1:200000 20mL Inj	20	0	10	4	6	24
1015380	heparin 10000unit/1mL 0.5mL Inj	20	20	10	5	3	24
1273414	dextromethorphan UD 15mg/5mL 5mL Syrup	15	15	15	5	16	24
1261419	acetaminophen UD 500mg/15.6mL 15.6mL Syrup	30	22	15	10	73	23
299918	penicillin G sodium 5MilUn Inj	30	24	15	7	12	23
940384	codeine UD 30 mg/6mL 1ea Soln	10	7	5	3	2	23
299870	morphine ER 15mg Cap	25	19	10	5	81	22
300913	oxytocin 10unit/1mL 1mL Inj	20	21	8	4	8	22
299729	cotrimoxazole SS 400-80 mg 1tab Tab	30	27	15	5	14	21
301217	Tylenol No 2 1tab tab	25	25	15	5	6	21
301277	phytonadione 2mg/1mL 0.5mL Inj	5	5	4	2	8	21
876923	potassium phosphate in D5W 15mmol/255mL 255mL Inj	1	1	0	0	0	21
299722	codeine 30mg Tab	50	41	25	15	56	20
300829	naloxone 0.4mg/1mL 1mL Inj	40	40	20	10	42	20
299917	penicillin V potassium 300mg Tab	30	25	20	10	57	20
320619	pregabalin 25mg Cap	30	31	20	10	21	20
300921	PARoxetine 20mg Tab	20	11	10	5	29	20
304338	candesartan 8mg Tab	20	16	10	5	14	20
300733	medroxyPROGESTERone 5mg Tab	20	18	10	5	6	20
299713	cloxacillin 250mg Cap	20	20	10	5	0	20
300374	divalproex sodium EC 250mg Tab	20	20	10	5	0	20
300605	isosorbide 10mg Tab	20	20	10	5	0	20
303348	clonazePAM 2mg Tab	20	20	10	5	0	20
1263414	cascara sagrada UD 5mL Soln	20	13	10	4	0	20
300561	imipramine 25mg Tab	10	10	5	2	5	20
1269416	metoclopramide UD 10mg/10mL 10mL Syrup	10	10	7	5	3	20
299677	cefuroxime 1.5g Inj	10	9	4	2	1	20
301243	verapamil 80mg Tab	10	9	5	2	1	20
299638	amikacin 250mg/1mL 2mL Inj	10	10	4	2	0	20
300147	calcitriol 0.25mcg Cap	10	10	5	2	0	20
300655	levothyroxine 88mcg Tab	10	10	5	2	0	20
300945	phenytoin Chew 50mg Tab	10	10	5	2	0	20
301054	rifampin 150mg Cap	10	10	5	2	0	20
301214	tropicamide 1% ophthalmic solution 1ea Minim	10	7	5	3	0	20
300045	aminophylline 25mg/1ml 10mL Inj	10	6	4	2	0	20
301040	quiNINE 300mg Cap	10	6	5	2	0	20
301107	levodopa-carbidopa 250-25 mg 1tab Tab	20	20	10	6	64	19
299973	warfarin 1mg Tab	20	19	10	5	2	19
309370	cefOXitin 1g Inj	20	20	10	4	1	19
301113	spironolactone 100mg Tab	10	10	5	2	1	19
912384	oxyCODONE CR 10mg Tab	10	10	5	3	0	19
300506	haloperidol 1mg Tab	20	20	10	5	16	18
299703	clindamycin 150mg Cap	20	11	10	5	11	18

300509	haloperidol 2mg Tab	20	20	10	5	2	18
464832	acetaminophen-oxyCODONE 325-5 mg 1tab Tab	50	39	25	10	86	17
332619	escitalopram 10mg Tab	20	13	10	5	114	17
301012	propafenone 150mg Tab	10	7	5	2	3	17
305313	KCl in SWFI 10mmoL/100mL 100mL Inj	20	19	16	10	12	16
299977	warfarin 2.5mg Tab	20	20	10	5	4	16
300713	loxapine 5mg Tab	20	20	10	5	4	16
1010742	EPINEPHrine 2.5mg/2.5mL 2.5mL Neb	6	5	3	1	25	16
300940	phenylephrine 10% ophthalmic 1ea Minim	5	3	2	1	0	16
299712	cloxacillin 1g Inj	30	15	12	6	5	15
299883	morphine ER 30mg Cap	25	12	10	5	44	15
300006	acetaZOLAMIDE 250mg Tab	20	20	10	5	28	15
300540	hydrOXYzine 25mg Cap	20	19	10	5	6	15
303683	mirtazapine 30mg Tab	15	10	8	2	78	15
300898	OLANZapine 5mg Tab	15	15	10	2	36	15
300983	conjugated estrogens 0.625mg tab	10	10	5	3	0	15
301001	prochlorperazine 10mg Supp	10	10	5	0	0	15
303533	calcium carbonate 1250mg Tab	30	35	20	6	63	14
300419	EPINEPHrine 1mg/1mL 1mL Inj	30	27	20	15	58	14
299981	warfarin 4mg Tab	20	17	10	5	16	14
300492	glucagon kit 1mg Inj	20	20	18	12	7	14
300440	ferrous sulfate 300mg Tab	20	17	10	5	4	14
302066	pancrelipase EC (Cotazym ECS 20) 1cap Cap	10	6	5	2	0	14
306315	ondansetron 8mg Tab	20	14	10	5	54	13
1273421	magnesium glucoheptonate UD 1500mg/15mL 15mL Soln	20	17	10	3	30	13
299648	ampicillin 1g Inj	20	20	10	4	10	13
300244	pancrelipase 1cap Cap	20	22	10	5	7	13
300855	nicotine polacrilex (Nicorette) 2mg Gum	20	26	10	5	4	13
300327	digoxin 0.125mg Tab	15	14	10	5	5	13
1161394	probenecid 500mg Cap	30	20	15	8	101	12
300052	amiodarone 200mg Tab	20	12	10	5	28	12
300897	OLANZapine 2.5mg Tab	15	15	10	5	4	12
1077387	magnesium sulfate 0.2g/1mL 10mL Inj	15	13	10	5	2	12
300009	acetaminophen 325mg Supp	12	11	6	2	7	12
892543	ASA 325mg Supp	6	4	3	1	0	12
300120	bisacodyl 10mg Supp	20	13	10	4	2	11
300867	NIFEdipine 5mg Cap	20	19	10	5	0	11
300329	digoxin 0.25mg Tab	10	10	5	2	23	11
1273419	prednisoLONE UD 15 mg/15 mL 1ea Soln	10	12	8	5	5	11
300083	atropine syringe 0.1mg/1mL 10mL Inj	6	7	5	3	4	11
838923	fentaNYL 50mcg Patch	5	5	3	2	4	11
299661	budesonide 0.25mg/1mL 2mL Neb	60	50	40	20	22	10
300701	loratadine 10mg Tab	20	16	10	5	59	10
301102	levodopa-carbidopa 100-10 mg 1tab Tab	20	20	10	6	21	10
300449	flumazenil 0.1mg/1mL 5mL Inj	20	20	10	7	2	10
299947	SUFentanil 50mcg/1mL 1mL Inj	20	29	10	5	1	10
1271414	cotrimoxazole 400-80 mg oral UD 10mL Susp	12	0	6	4	1	10
301019	propranolol LA 80mg Cap	10	10	5	2	18	10

612924	scopolamine 0.4mg/1mL 1mL Inj	10	5	4	2	13	10
300386	donepezil 5mg Tab	10	5	5	2	11	10
300314	diclofenac sodium EC 25mg Tab	10	6	5	2	4	10
300649	levothyroxine 125mcg Tab	10	8	5	2	2	10
300331	digoxin 0.25mg/1mL 2mL Inj	10	5	4	2	1	10
300066	ASA EC 325mg Tab	10	9	5	2	1	10
300712	loxapine 25mg Tab	10	9	5	2	1	10
301234	venlafaxine XR 37.5mg Cap	10	10	5	2	1	10
300151	calcium chloride 100mg/1mL 10mL Inj	10	11	9	8	1	10
300767	methocarbamol 500mg Tab	10	20	5	2	0	10
1265414	benzydamine 0.15% oral UD 15mL Rinse	10	10	6	3	0	10
299757	ethambutol 100mg Tab	10	10	5	2	0	10
299803	HYDROmorphone CR 30mg Cap	10	10	5	2	0	10
300282	deferoxamine 500mg Inj	10	10	9	9	0	10
300313	diclofenac sodium SR 100mg Tab	10	10	5	2	0	10
300404	triamterene-hydrochlorothiazide 50-25 mg 1tab Tab	10	10	5	2	0	10
300826	nadolol 40mg Tab	10	10	5	2	0	10
301027	pyrazinamide 500mg Tab	10	10	5	2	0	10
301055	rifampin 300mg cap	10	10	5	2	0	10
301142	terazosin 1mg Tab	10	10	5	2	0	10
301784	cefuroxime 250mg Tab	10	10	5	2	0	10
302008	bromocriptine 2.5mg Tab	10	10	5	2	0	10
307756	rOPINIRole 1mg Tab	10	10	5	2	0	10
339017	entacapone 200mg Tab	10	10	5	2	0	10
464860	nitrofurantoin macrocrystals 50mg Cap	10	10	5	2	0	10
892841	dabigatran 150mg Cap	10	10	5	2	0	10
300772	methyldopa 250mg Tab	10	9	5	2	0	10
303952	sodium bicarbonate 325mg Tab	10	8	5	2	0	10
1269415	loperamide UD 2mg/10mL 10mL Soln	10	6	5	3	0	10
892185	oseltamivir 45mg Cap	0	0	0	0	0	10
300831	naloxone 1mg/1mL 2mL Inj	40	30	10	5	11	9
302060	colchicine 0.6mg Tab	20	24	10	5	43	9
301071	rocuronium 10mg/1mL 5mL Inj	20	15	10	5	26	9
300653	levothyroxine 50mcg Tab	20	20	10	5	13	9
303658	erythromycin 250mg Tab	20	21	10	5	0	9
300459	fluorescein 2% ophthalmic 1ea Minim	10	7	5	3	16	9
301896	gliclazide 80mg Tab	10	10	5	2	11	9
892911	dextrose 50% syringe 50mL Inj	10	9	8	6	8	9
300028	ALPRAZolam 0.25mg Tab	10	5	5	2	6	9
301030	QUEtiapine 100mg Tab	10	7	5	2	4	9
1273418	guaiFENesin UD 200mg/10mL 10mL Soln	10	10	10	4	4	9
300417	EPINEPHrine 0.1mg/1mL 10mL Inj	6	6	5	3	31	9
892184	oseltamivir 30mg Cap	0	0	0	0	0	9
300703	LORazepam SL 1mg Tab	100	67	50	25	443	8
305559	tranexamic acid 500mg Tab	20	22	10	5	11	8
300783	metoprolol 1mg/1mL 5mL Inj	15	10	6	3	9	8
300153	calcium chloride syringe 100mg/1mL 10mL Inj	15	12	10	9	1	8
306366	losartan 100mg Tab	10	7	5	2	14	8

300144	calcium gluconate 100mg/1mL 10mL Inj	10	10	9	8	8	8
300116	betamethasone 6mg/1mL 1mL Inj	10	11	4	2	4	8
300158	captopril 12.5mg Tab	10	10	5	2	2	8
838927	fentaNYL 100mcg Patch	10	10	5	3	0	8
1160768	ranitidine 150mg/1tab 6tab Vial	6	3	2	1	4	8
301021	propranolol 1mg/1mL 1mL Inj	5	5	2	1	0	8
301025	protamine 10mg/1mL 5mL Inj	4	5	2	2	0	8
301189	traZODone 50mg Tab	30	26	15	5	34	7
300510	haloperidol 5mg Tab	20	20	10	5	15	7
299679	cefuroxime 750mg Inj	20	18	10	4	2	7
299674	cefTAZidime 1g Inj	15	19	15	6	5	7
300888	norepinephrine 1mg/1mL 4mL Inj	10	8	4	2	24	7
300860	NIFEdipine 10mg Cap	10	10	5	2	10	7
300343	diltiazem 30mg Tab	10	10	6	2	7	7
300808	sodium bicarbonate syringe 1mmol/1mL 50mL Inj	10	10	8	4	7	7
308230	betahistine 16mg Tab	10	9	5	2	4	7
300223	clobazam 10mg Tab	10	10	5	3	2	7
1160767	methocarbamol 500mg/1tab 4tab Vial	4	4	2	1	0	7
1160772	cloxacillin 250mg/1cap 8cap Vial	4	4	2	1	0	7
300333	dihydroergotamine 1mg/1mL 1mL Inj	3	5	1	0	3	7
307771	oseltamivir 75mg Cap	0	0	0	0	40	7
308312	gliclazide MR 30mg Tab	30	30	15	5	52	6
299809	HYDROmorphone CR 6mg Cap	25	25	10	5	30	6
300667	lidocaine 2%/EPINEPHrine 1:100000 20mL Inj	10	10	5	2	40	6
301240	verapamil SR 180mg Tab	10	10	5	2	22	6
309079	esomeprazole EC 40mg Tab	10	13	7	4	13	6
300569	indomethacin 100mg Supp	10	11	5	2	0	6
300543	hydrALAZINE 20mg/1mL 1mL Inj	10	10	5	2	0	6
1160777	penicillin V potassium 300mg/1tab 8tab Vial	8	12	4	2	7	6
1077384	magnesium sulfate in NS 2g/54mL 54mL Inj	6	6	3	2	38	6
300632	labetalol 5mg/1mL 20mL Inj	6	12	3	2	1	6
304212	amoxicillin (BCCDC) 500 mg x 21 cap 1ea Vial	6	6	4	2	1	6
588919	fondaparinux 7.5 mg/0.6 mL 7.5mg/0.6mL 0.6mL Inj	5	5	4	2	0	6
300806	sodium bicarbonate 0.5mmol/1mL 10mL Inj	4	4	4	2	7	6
300388	DOPamine 1.6mg/1mL 250mL Inj	2	3	1	1	3	6
299852	metroNIDAZOLE 5mg/1mL 100mL Inj	40	29	20	10	66	5
300550	hyoscine butylbromide 20mg/1mL 1mL Inj	30	29	15	6	94	5
306181	valACYclovir 500mg Tab	20	16	10	5	41	5
303723	warfarin 3mg Tab	20	23	10	5	24	5
1045384	morphine UD 5mg/5mL 5mL Syrup	20	16	10	4	19	5
464887	ampicillin 2g Inj	20	20	10	5	2	5
300758	Depo-Medrol 40mg/1mL 1mL Inj	10	8	5	3	15	5
300542	hydrALAZINE 10mg Tab	10	6	5	2	14	5
303209	OLANZapine ODT 5mg Tab	10	8	5	2	12	5
304334	valsartan 80mg Tab	10	6	5	2	6	5
300256	cyclopentolate 1% ophthalmic 1ea Minim	10	8	4	2	0	5
1160774	dimenhyDRINATE 50mg/1tab 8tab Vial	8	5	3	2	4	5
1225405	naproxen 250mg/1tab 6tab Vial	6	6	2	1	10	5

1160773	cotrimoxazole SS 400-80 mg 8tab Vial	6	6	2	1	0	5
838926	fentaNYL 75mcg Patch	5	5	3	2	0	5
300309	diazepam 5mg/1mL 2mL Inj	60	47	30	10	142	4
892430	rivaroxaban 10mg Tab	30	27	20	10	133	4
302056	clopidogrel 75mg Tab	30	20	15	10	124	4
1261418	acetaminophen UD 325mg/10.15mL 10.15mL Syrup	30	18	20	10	25	4
700935	rosuvastatin 5mg Tab	20	23	10	5	19	4
300990	prochlorperazine 10mg Tab	10	8	5	2	6	4
300749	methotrimeprazine 25mg/1mL 1mL Inj	10	10	4	2	0	4
1160769	erythromycin 250 mg x 8 tab 1ea Vial	6	4	2	1	2	4
303208	betahistine 8mg Tab	5	10	3	1	4	4
1160778	amoxicillin 250mg/1cap 8cap Vial	4	4	2	1	2	4
302420	heparin 50unit/1mL 500mL Inj	4	4	3	2	0	4
304032	eptifibatide bolus 2mg/1mL 10mL Inj	4	4	2	1	0	4
300304	diazepam 10mg Tab	50	54	35	20	500	3
300696	loperamide 2mg Tab	40	30	25	10	54	3
460781	fluconazole 50mg Tab	30	38	10	5	48	3
300130	bupivacaine 0.5% 20mL Inj	20	15	10	4	16	3
918396	glycerin pediatric 1supp Supp	12	5	3	0	1	3
300474	folic acid 5mg Tab	10	10	5	2	52	3
301051	ranitidine 25mg/1mL 2mL Inj	10	6	4	2	39	3
300650	levothyroxine 150mcg tab	10	7	5	2	25	3
306890	tiotropium 18mcg Cap	10	8	5	2	21	3
300859	nicotine 7mg Patch	10	7	5	2	17	3
301239	verapamil SR 120mg Tab	10	10	5	2	8	3
299754	erythromycin lactobionate 500mg Inj	10	7	4	2	2	3
1223395	polymyxin-gramicidin ophthalmic-otic 15mL Soln	2	2	1	0	6	3
302006	bovine liquid extract topical 27mg/1mL 5mL Soln	2	2	1	1	0	3
574923	lipid emulsion 20% 250mL Inj	2	2	1	0	0	3
299822	ketorolac 30mg/1mL 1mL Inj	50	36	30	15	513	2
300481	furosemide 40mg Tab	50	40	30	15	174	2
300949	phenytoin 50mg/1mL 2mL Inj	40	41	35	25	129	2
1261415	nystatin UD 100000unit/1mL 1mL Susp	30	21	20	5	137	2
299731	cotrimoxazole DS 800-160 mg 1tab Tab	30	24	15	5	86	2
892253	heparin 10unit/1mL 3mL Inj	20	21	10	5	54	2
300571	indomethacin 25mg Cap	20	18	10	6	39	2
301460	midazolam 5mg/1mL 10mL Inj	10	6	5	2	19	2
308262	rosuvastatin 20mg Tab	10	8	5	3	10	2
300180	carvedilol 25mg Tab	10	8	5	2	8	2
300911	oxybutynin 5mg Tab	10	15	5	2	8	2
300447	fludrocortisone 0.1mg Tab	10	9	5	2	6	2
866923	dalteparin 10000 IntUnit/0.4 mL 1ea Inj	10	10	10	3	3	2
300136	buPROPion SR 100mg Tab	10	15	5	2	1	2
301132	SUMAtriptan DF 50mg Tab	6	6	3	2	14	2
1225404	diphenhydrAMINE 25mg/1cap 6cap Vial	6	3	2	1	10	2
310618	Pico-Salax 1pkt Packet	6	6	4	2	0	2
980380	doxycycline (BCCDC) 100mg/1cap 14cap Vial	6	6	3	2	0	2
299772	fluconazole 2mg/1mL 100mL Inj	6	4	3	1	0	2

304009	tenecteplase kit 50mg Inj	5	5	3	2	3	2
894447	lidocaine 0.4% 250mL Inj	4	4	2	2	1	2
300475	folic acid 5mg/1mL 10mL Inj	4	4	3	3	0	2
301561	fluticasone 250 mcg 60puff Inhaler	2	2	1	0	10	2
301540	fluticasone 125 mcg 60puff Inhaler	2	2	1	0	7	2
454788	azithromycin 20mg/1mL 15mL Susp	2	2	1	1	5	2
300929	permethrin 5% topical 30g Cream	2	2	1	0	2	2
301740	nystatin topical 100000unit/1g 15g Cream	2	2	1	0	0	2
305453	hydrocortisone sodium succinate 100mg Inj	20	17	10	4	14	1
866929	dalteparin 2500IntUn/0.2mL 0.2mL Inj	20	21	11	4	5	1
300887	nitroglycerin 0.4 mg/dose 75spray Spray	6	6	3	1	11	1
1160771	cephalexin 500mg/1tab 8tab Vial	6	5	3	2	5	1
560921	lidocaine non-aerosol endotracheal 10mg/30mL 30mL Spray	4	4	2	1	2	1
299697	ciprofloxacin 0.3% ophthalmic 5mL Soln	2	2	1	0	9	1
299957	tobramycin 0.3% ophthalmic 5mL Soln	2	2	1	0	4	1
300644	latanoprost ophthalmic 0.005% 2.5mL Soln	2	2	1	0	4	1
1160762	ora-sweet SYRUP 100mL Syrup	2	2	1	0	3	1
582919	diclofenac 0.1% ophthalmic 5mL Soln	2	2	1	0	3	1
300033	alprostadil 500mcg/1mL 1mL Inj	2	4	1	0	0	1
1163394	clarithromycin 25mg/1mL 55mL Susp	2	2	1	0	0	1
299925	permethrin 1% topical 59mL Rinse	2	2	1	0	0	1
301617	zinc sulfate topical 0.5% rectal 30g Oint	2	2	1	0	0	1
302207	tetanus immne globulin human 250unit/1mL 1mL Inj	1	2	0	0	2	1
300224	clobetasol 0.05% topical 15g Cream	1	1	0	0	1	1
1160766	ferrous sulfate 30mg/1mL 100mL Soln	1	1	0	0	0	1
301197	triamcinolone 0.1% dental 7.5g Paste	1	1	0	0	0	1
1160761	metoclopramide 1mg/1mL 100mL Syrup	0	1	0	0	1	1

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