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Improving Pharmacy Services at Lerdsin Hospital

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by

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Abstract

The outpatient pharmacy at Lerdsin Hospital in Bangkok, Thailand, struggles to meet the demands of an increased prescription workload due to a new social healthcare scheme. Through an analysis of the present process, we identified the main factors that contribute to the substandard thirty-five minute prescription wait time. Recommendations were developed for pharmacy service improvements in the areas of layout, staffing, and equipment in an effort to decrease patient wait time and prescription error.

Executive Summary

Introduction

The Ministry of Public Health (MPH) in Thailand recognizes the necessity of providing affordable healthcare for the average Thai citizen. The most recent policy implemented by the MPH, the "30 Baht Scheme," is Thailand's version of socialized healthcare. Thai citizens can receive medical treatment and medication for just 30 baht per visit, which is equivalent to slightly less than one US dollar. Since its inception in April 2002, this plan has made healthcare more accessible and affordable to Thai citizens, causing a continual increase in the number of people seeking medical attention. Public hospitals in Thailand now struggle to maintain high-quality service despite the surge of patients.

The growing number of patients due to "30 Baht Scheme" has forced the expansion of Lerdsin Hospital, a public healthcare facility located in Bangkok. Between forty and fifty percent of Lerdsin's pharmacy outpatients use the "30 Baht Scheme" as their primary form of health insurance. Unlike other departments, structural constraints have kept the outpatient pharmacy its original size. This circumstance has prevented it from accommodating the increased workload, creating the potential for prescription error. The hospital is updating its computer system in order to address some of their preexisting prescription errors. However, this system cannot eliminate all of the pharmacy's problems. Hospital administrators foresee the worsening of the situation and have enlisted our help to develop proactive solutions as the number of patients continues to increase.

Our goal for this project was to suggest improvements for Lerdsin Hospital's outpatient pharmacy, focusing on the areas of layout, equipment, and division of labor. After compiling our data, we formulated multiple solutions for renovating and reorganizing the pharmacy. Given Lerdsin Hospital's structural and financial constraints, we prioritized our suggestions by relevance and feasibility.

Methodology

To achieve our goal of suggesting relevant improvements for Lerdsin, we first needed to understand the issues leading to delays within the outpatient pharmacy, and then identify qualities of efficient pharmacies that would be most useful. In order to determine the areas in need of improvement within Lerdsin's outpatient pharmacy, we conducted staff interviews and performed many observational studies in and around the pharmacy. These studies include prescription timing, patient and staff traffic flow, and pharmacy layout analysis. To determine the best practices used in pharmacies throughout Thailand, we observed the

prescription systems at Nakornping Hospital in Chiang Mai, and Bumrungrad Hospital in Bangkok. The efficient aspects of these two pharmacy units fueled suggestions for Lerdsin's pharmacy.

Findings

Overall, the prescription process at Lerdsin is very similar to that of the other two pharmacies we observed; it is the implementation of the process that is different. These otherwise identical processes diverge in one important way--wait time. Lerdsin's wait time is approximately thirty-five minutes, whereas Nakornping's is fourteen minutes, and Bumrungrad's is five minutes. Differences such as layout, input process, cashiering and technology in each pharmacy's system contribute to differences in quality of services. An efficient system for Lerdsin would include aspects of best practice found in the literature and at the two model hospitals.

Once we established that it was not the process that caused the delays and prescription errors, but the implementation of the process, we found the areas of the system that needed improvement. There are three main issues that cause delays in the pharmacy, the cashier step, pharmacy layout, and prescription volume.

The cashier step causes the most significant delays in the process. Our timings show that this step absorbs forty-five percent of the total wait time. The two insurance sections that use a cashier, the 30 Baht and private, have a wait time that is on average thirty-two minutes while the civil insurance section, which does not utilize a cashier, has an average wait time of nineteen minutes. This step causes delays because the blue carbon copy of the prescription, which is used for billing, isn't given to the cashier until the prescription is completely ready for dispensing. In other words, the cashier step does not occur in parallel with the filling of the prescription, even though it takes the same amount of time.

The pharmacy layout also has issues in the both the exterior and interior set-up that cause delays in the prescription process. The window set-up, a key feature in the exterior layout, is very confusing to patients and causes crowding in the waiting area. Staff interviews indicated that they are constantly taking time away from other tasks to direct patients to the correct window. This congestion in the waiting area caused by the window set-up prevents patients from easily getting to the correct window to get their prescriptions in a timely fashion.

The interior layout is responsible for delays and prescription errors because of the uneven distribution of utilized space, as well as the location of materials throughout the pharmacy. Data collected through staff traffic flow analysis established that the medication

area is a very high traffic part and is responsible for many collisions and distractions which have led to observed prescription errors. Conversely, the area located towards the back of the pharmacy is used as office space and is rarely traveled through during peak hours. The materials and resources needed to successfully fill prescriptions are not easily accessible and may cause technicians to travel to opposite sides of the pharmacy.

There are many issues in the pharmacy that are affected by the inefficiencies in the layout, window set-up, and the organization of its resources. These issues range from time delays to extra steps to travel for materials, but all of these issues contribute to the overall quality of the system. No individual issue is too hard to remedy, but compounded together, they require a complex set of solutions.

Recommendations

We recommended two different layouts for the outpatient pharmacy. The first of these uses minimal funding, making no structural changes, and utilizes preexisting equipment (furniture, printers, etc). The second layout incorporates structural changes, and equipment replacement. By creating both a low budget and high budget set of recommendations, we gave the hospital a wide range of tools to draw from when improving their pharmacy.

The first layout, seen below in Figure A, merely reorganized the furniture and equipment that is already present in the pharmacy. The area to the far right, the former 30 Baht area, will be designated as the prescription drop-off area. Patients of all insurance types will drop off prescriptions at these 2 windows. This rearranged window set-up will promote a linear patient traffic pattern. Then the next wall of windows will be for cashiers. The patients will carry their blue copy to those three cashiers to pay. Separating the cashier step from the rest of the process so that it runs parallel to the filling of prescriptions will decrease patient wait time. Next the patient will receive their prescriptions from windows five through eight. The pharmacists will be located in the block between windows five through eight and windows nine through twelve. This will allow them to be close to dispensing incase counseling is needed.

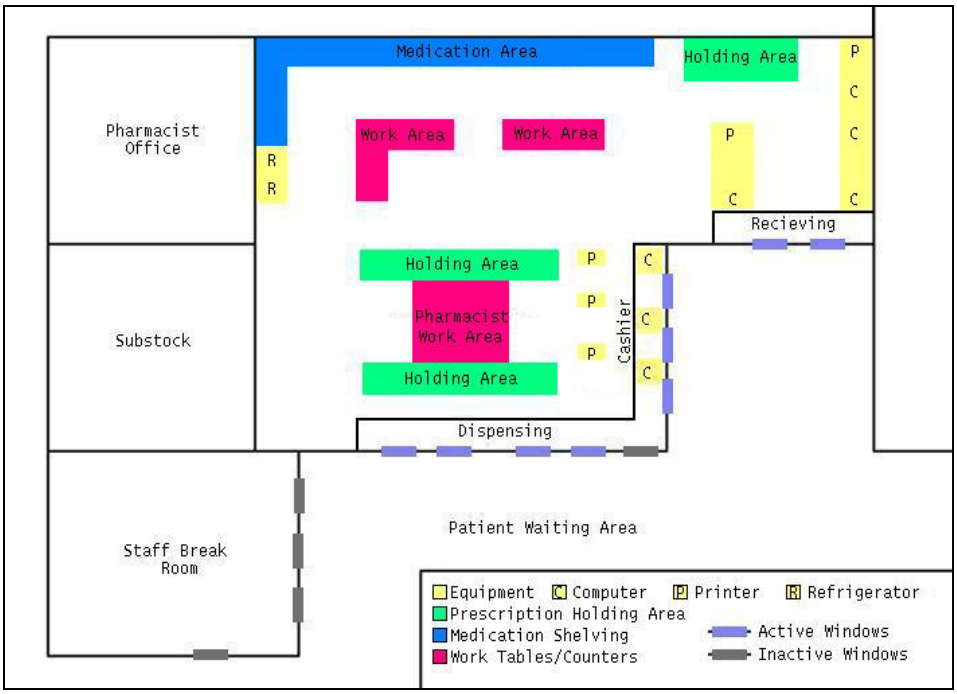

Figure A: Highly suggested layout using existing furniture and structures

The medications will be located along the back wall of the pharmacy beginning with 30 Baht medications. The shelves and refrigerators will be lined along the walls and island counter spaces will be in front of those. This will help the pharmacy to keep an assembly line system. The room containing windows one through four will be the staff area. This will house the desks formerly located towards the back of the pharmacy.

Our second layout recommended for the Lerdsin pharmacy includes new equipment such as refrigerators designed specifically for medical facilities and automatic pill counters. Also, with the correct amount of space, it would be most efficient to separate the cashier completely from the pharmacy to his/her own room. The ideal situation would be to separate the insurances by giving each type its own pharmacy. This resembles the other hospitals set-up that we visited that separate their pharmacies by department. Expanding the pharmacy into the 30 Baht waiting section would make the pharmacy a rectangle which would have more workspace. This layout requires time and the appropriate financing, so therefore it is less feasible than the first layout mentioned.

Research into prescription software that eliminates the patient bringing down the prescription sheet such as the scanning system that Bumrungrad is also recommended. Ridding the pharmacy of the need for a drop-off window would increase the efficiency dramatically. Our research indicates that having the pharmacy on the first floor is best except in the case that the first floor is at premium. Possibly relocating the pharmacy or sections of

the pharmacy maybe by insurance to the empty space on the second floor would improve services tremendously. These recommendations are the higher end, expensive suggestions. They would require a lot of planning and budgeting and are more long term suggestions. The priority in these recommendations goes to the set-up that makes no structural changes, just reorganization. We believe that reorganization alone will improve pharmacy services at Lerdsin Hospital outpatient pharmacy by reducing the wait time and also preventing prescription errors caused by distraction.

I. Introduction

The Ministry of Public Health (MPH) in Thailand recognizes the necessity of providing affordable healthcare for the average Thai citizen. The most recent policy implemented by the MPH, the "30 Baht Scheme," is Thailand's version of socialized healthcare. Thai citizens can receive medical treatment and medication for just 30 baht per visit, which is equivalent to slightly less than one US dollar. Since its inception in April 2002, this plan has made healthcare more accessible and affordable to Thai citizens, causing a continual increase in the number of people seeking medical attention. Public hospitals in Thailand now struggle to maintain high-quality service despite the surge of patients.

The growing number of patients due to "30 Baht Scheme" has forced the expansion of Lerdsin Hospital, a public healthcare facility located in Bangkok. Between forty and fifty percent of Lerdsin's pharmacy outpatients use the "30 Baht Scheme" as their primary form of health insurance. Unlike other departments, structural constraints have kept the outpatient pharmacy its original size. This circumstance has prevented it from accommodating the increased workload, creating the potential for prescription error and a substandard wait time of forty minutes. The ideal pharmacy at Lerdsin Hospital would have enough space to serve the growing number of patients in an organized manner while keeping prescription error to a minimum. Hospital administrators are seeking a proactive solution as the situation is likely to worsen with the number of patients continuously increasing.

Some preliminary steps taken by the hospital to remedy the pharmacy issues include studies on prescription error and plans for an improved electronic system. The highest cause for outpatient prescription errors in 2004 was due to doctors ordering drugs that patients are allergic to, causing the pharmacy to reorder prescriptions. Other errors include improper dosage and dispensing the wrong medication, stemming from both the doctors and the pharmacists. These three errors should be significantly decreased with the inception of their new computer system. Lerdsin Hospital contracted with SSB Bangkok Ltd. to design a state-of-the-art computer system that integrates all their services together. This system remedies the flaws pointed out by the doctors in the current system, allowing the hospital services to run more smoothly, decreasing prescription errors overall.

Although the new electronic system remedies many of the errors in the pharmacy, some problems such as medicine duplication and poor turn-around time remain. These problems are due to flaws in the system such as too much traffic and chaos within the pharmacy. A larger space for the pharmacy would eliminate these problems but this space would have to be designed to be as efficient as possible. To improve the current system, many processes in the pharmacy needed to be updated. Innovative equipment will make the Lerdsin Hospital pharmacy more organized, which will minimize error and increase the efficiency of the staff.

Our goal for this project was to suggest improvements for Lerdsin Hospital's Outpatient Pharmacy with emphasis on layout, division of labor, and traffic flow. We achieved this goal by evaluating Lerdsin's pharmacy, researching appropriate literature, and observing efficient pharmacy systems in Thailand. Given Lerdsin Hospital's structural and financial constraints, we prioritized our suggestions by relevance and feasibility. This project has the potential to affect many people throughout Thailand who utilize the services provided by Lerdsin, through creating a safer and quicker system for all of its patients.

II. Background

In order to improve the services and understand the particular situation at Lerdsin Hospital, we first examined the current situation. How does the state of healthcare in Thailand affect Lerdsin Hospital and its pharmacy? What is the prescription process in Lerdsin's outpatient pharmacy? What are the typical causes of prescription errors? How does pharmacy inefficiency contribute to prescription errors? What is an ideal layout for an outpatient pharmacy unit? How can we go about improving the system within Lerdsin? Through answering these background questions, we narrowed our scope to the most pertinent information to understanding and addressing the problems faced by Lerdsin Hospital.

The State of Thai Healthcare

The goal of Thailand's Ministry of Public Health is to provide citizens with "access to rational and appropriate health services, with good quality and at a reasonable, equitable cost" (Ministry of Public Health, 2002). To achieve this goal, the "30 Baht Scheme" was implemented nationwide in April 2002, allowing all Thais to receive healthcare from government health services and public hospitals for only 30 baht per occasion. This price includes all necessary procedures and medications. Because of this, Thais began to fully utilize the health services around them.

Before the "30 Baht Scheme" was implemented, the Ministry of Public Health set a goal to reduce the pharmacist to patient ratio from 1:10,532 to 1:5,200 (Ministry of Public Health, 2003). Based on this, and information gained through the project specification, we inferred that the two-fold increase of patients at Lerdsin Hospital was due to the "30 Baht Scheme." Lerdsin would need to double its number of pharmacists in order to simply maintain its pharmacist to patient ratio, and quadruple its pharmacists to achieve the ratio improvements specified by the Ministry. These improvements are unrealistic, given the state of Lerdsin's pharmacy.

As more individuals take advantage of the affordable healthcare, hospitals in Thailand, such as Lerdsin, struggle to maintain the quality of services they provide. The Lerdsin Hospital Pharmacy has neither the space, nor the funding to employ more pharmacists. These limitations hinder pharmacy operations. Considering Lerdsin's particular

situation, it was necessary to investigate the various manifestations of prescription error and pharmacy inefficiency, and the ways in which they occurred, before determining the cause.

Lerdsin Hospital

Lerdsin Hospital was first opened in 1889 as a nursing home under the name of Bangrak Hospital. It was transferred to the Ministry of Public Health in 1957. A generous donor, Khunying Pakdi Norased Sin Settabut, gave the hospital approximately USD 27,000 in memory of her late husband, Praya Pakdi Norased Lerd Settabut. The hospital was then named Lerdsin Hospital, after the donor and her late husband (Prasartritta 2004).

In addition to its role as a public hospital, Lerdsin is also an academic institute and research center. It provides a wide selection of services as well as providing treatment to patients under the social healthcare plan. In regard to its services and amenities, Lerdsin is comparable to the quality of private hospitals. It offers training programs for all levels of the medical profession and hosts meetings and international conferences with world-renowned guest speakers. Research done at Lerdsin often appears in international journals of science and medicine, showcasing the work of many doctors employed by Lerdsin (Prasartritta 2004).

Lerdsin has made considerable progress since its establishment, particularly in the areas of services, organization, and equipment. While the inpatient capacity has gone from 485 to 650 beds, the number of outpatients has nearly doubled over the years. Improvements are evident in almost all parts of the hospital; however one area, the pharmacy unit, was identified as in need of improvement. Due to financial and structural constraints, the outpatient pharmacy has not expanded to meet the needs of its patients. The staff currently fills almost twice as many prescriptions with the original number of workers, and the original amount of workspace. We researched the system at Lerdsin Hospital to better understand the current prescription process.

Lerdsin's Prescription Process

Lerdsin's pharmacy faces an increased workload on a system already at its maximum prescription-filling capacity. There are two outpatient pharmacies at Lerdsin Hospital. The second floor pharmacy serves primarily the departments of orthopedics, ear-nose-throat, pediatrics, and surgery. This pharmacy is only open until noon every day. After this point, staffing constraints force all prescriptions to be handled by the first floor pharmacy. With the

increased demands on this pharmacy, prescription error and reduced speed of service are the inevitable consequences. Unfortunately, due to financial constraints, the staffing in the pharmacy department cannot be increased (Prasartritta 2004). Examination of the current prescription process allowed us to determine areas in need of improvement and a better distribution of man-power.

The current prescription process consists of several steps. First, the patient personally carries prescription orders from their doctor to the pharmacy. The receptionist screens the order, which may contain up to ten medications, for possible allergies or drug interactions. The order is given to a computer technician who prepares the labels. A pharmacy technician picks up the labels and then retrieves, counts, and packages the medication. The filled prescription is brought to the pharmacist, who notes and corrects any prescription errors. When the pharmacist finishes checking the prescription, she separates the blue carbon copy from the original medication order and sets it aside for the cashier. The cashier calls the patient up to the window, completes the transaction, and prints out another receipt. Finally, the patient brings this receipt to the dispensing window to retrieve their medication, after one last check for patient identification. This general process is used throughout the pharmacy in each subsection.

The first floor pharmacy is divided up into subsections by patient insurance. There are three different classes of insurance at Lerdsin Hospital: 30 Baht scheme, private insurance, and people that pay out of their pocket. Forty to fifty percent of patients are 30 baht scheme and thirty percent of patients have insurance. Each type of insurance has its own area for patients to hand in their orders, pay, and receive their prescriptions. There is one pharmacist and two to three technicians for each insurance area, surrounding one central medication supply. The 30 baht section has its own medication supply, which consists primarily of generic brands. However, if a medication in this area runs out or if the doctor orders a non-generic medication, then the medication is taken out the central medication supply.

Lerdsin Hospital's outpatient pharmacy is responsible for the well-being of its patients, and should take great care in its operations. It deals with a high volume of prescription orders, filling approximately 30,000 prescriptions per month. Containing at least 1,000 different medications at any given time, it is important to have a high level of organization in their prescription process. To assist in managing this large volume of

prescriptions, Lerdsin will rely more on technology as the years progress.

Hospital Information Technology Systems

Technology within the pharmacy and prescription process is growing in importance with the number of prescriptions increasing. To address this problem, Lerdsin Hospital enlisted the help of a software company called SSB Bangkok Ltd to upgrade from their old system. This new software utilizes aspects of other electronic prescription systems, including SureScript and barcoding technology. This system will allow prescription information to be passed between physicians and pharmacies through a hospital-wide network.

Lerdsin Hospital is currently running a computer system, designed by the Thai company Datamat, called "Hospitals VIA Open Systems." This system helps by automating different processes in the hospital, including processes in the pharmacy. After a pharmacy technician enters the medication information, Datamat prints out labels with the name of the medicine and instructions on taking the medicine. Datamat also assists with the accounting aspect of the pharmacy. While the system is a help to hospital staff, it has not kept up with the growth and changes in the hospital. The system, being one of the first editions of the software, contains many bugs that have hindered productivity. It is also dependent on legacy software and hardware which continually becomes harder to support and maintain.

Lerdsin Hospital spent the last year auditing companies in search of a computer system to replace their currently aging system. After looking through different available systems, Lerdsin contracted with SSB Bangkok Ltd. to customize and implement their new system. SSB is currently being used in other hospitals across Thailand, such as in Nakornping Hospital. SSB visited Lerdsin to speak with employees and learn what Lerdsin's staff likes and dislikes about their current system. The new system will allow for better integration of hospital data, making it easier for different departments to share patient information.

The system provided by SSB Bangkok Ltd. is expected to be of great help to the pharmacy department, as it follows the recommendations made by a group of experts on creating an efficient prescription process (Bell, 2004). SSB is capable of allowing doctors to input patients' prescriptions through the computer system, eliminating potential error through poor handwriting. With this, pharmacies can start preparing a patient's medication before

they get there, speeding up prescription turn-around time. Recommendations from pharmacy systems experts, which follow the steps one has to make when filling out a prescription, include many characteristics of SSB's software. The system should always list the current patient to prevent accidentally affecting another patient's medical records. Patients' history should be accessible to allow for those who are treating the patient to determine what to prescribe for the patient. When selecting the medicine and dosage, a list of medications should be listed based on the diagnosis, if entered. A prioritized alert system should warn if there are any conflicts with the medication when it is selected. Once the medication is prescribed, the information should be electronically forwarded to the patient's pharmacy. To protect the confidentiality of the patient, security measures must be implemented into the system to both limit the records to only those who are qualified to see them, and to insure the integrity of the data (Bell, 2004).

Barcoding technology can be easily incorporated into the SSB system, and provides another option for Lerdsin to consider. The US Food and Drug Administration is currently supporting a plan that would include the barcoding system in all hospitals by the year 2006. The barcoding system prevents prescription errors in hospitals by assigning a wristband with a unique barcode to each patient. The nurses on duty use a laptop to scan the patient's barcode and then scan the barcodes of bedside medication. If the medication does not match the medications that the patient should be receiving, a warning message pops up on the screen and prevents the error from occurring. This system has been very successful in the Veteran Association hospitals across the United States and is expected to reduce prescription errors when integrated into other hospitals (http://www.fda.gov/fdac/features/2003/303_meds.html).

The technological advances of the new SSB system and the prospective barcoding system have the potential to greatly improve the efficiency of hospital operations. The pharmacy department can benefit from this technology to provide better services and run more efficiently. In addition to this, such technology can help detect and correct prescription error, which is the inevitable result of pharmacy inefficiency. Prescription errors are an important aspect of any pharmacy system.

Prescription Error

Prescription errors are a major source of inadequate service at hospitals all over the world. According to the US National Coordinating Council for Medication Error Reporting

and Prevention (1997), a medication error is defined as, "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer" (http://www.nccmerp.org/aboutMedErrors.html). The sources of prescription error most often include illegible prescription handwriting and inefficient use of pharmacy resources. Consequences of prescription error range from no visible side-effects to the extreme circumstance of death.

Illegible handwriting on prescriptions can lead to problems at various steps of the prescription process. If a pharmacist cannot clearly recognize what a doctor has written, they must call the doctor to confirm the medication order. This delays the prescription-filling procedure, and potentially creates distractions for staff members. Furthermore, if the pharmacist does not correctly confirm badly written prescriptions, wrong medications can be given to the patients. Poor prescription handwriting leads to inaccuracies with the medication name, amount, and type; seriously jeopardizing a patient's safety and well-being.

According to the Food and Drug Administration, there are many medications with similar names which have led to patients being prescribed wrong medications. One example of this type of prescription error is the similarity in spelling between Zantac which is prescribed for heartburn, Zyrtec which is prescribed for allergies, and Zyprexa which is prescribed for other medical conditions. Another very similar pair of medications which has been reported to the FDA is Celebrex, an arthritis medication, and Celexa, a medication for depression. As more medications are created, it is increasingly harder to decipher what medicine is being prescribed. These similarities in names cause problems for both doctors and pharmacists, in writing and recognizing correct prescriptions (http://www.fda.gov/cder/drug/mederrors/default. htm#drug).

Inefficient use of space and resources within the pharmacy unit is another contributing factor to prescription errors. If a pharmacy is taking in more prescriptions than they are capable of filling, the increased workload and stressful atmosphere this creates allows errors to go unnoticed. Errors by pharmacists include wrong medication, wrong count, wrong dosage, and even the wrong identity of patients. Poor pharmacy turn around time, particularly within an in-patient hospital, causes problems with the time-sensitive administration of medication. This can cause patient discomfort at the least severe circumstance, and can even be responsible for death.

An analysis done by the Institute for Safer Medication Processes(ISMP) showed that errors result from bad handwriting, omitted or misplaced zeros, and omitted or misplaced decimal points (http://www.ismp.org/msaarticles/ whitepaperprint.htm). One American study found that in an outpatient setting, 17% of prescriptions contained errors, the most common error being in dosage (Mercola 2004). Dosage errors were also the most common prescription errors found in a Western European studies, indicating that over a two year period, 292 possible errors were detected, and 183 were confirmed (Goyache et al., 2004).

Lerdsin Hospital recorded the prescription errors that occurred in the outpatient pharmacy during the year 2004. According to the statistics, 852 errors were found in the 361,805 prescriptions dispensed. The errors were discovered by the pharmacist and recorded on a tally sheet. The most prevalent error in the outpatient pharmacy was re-ordering allergic drugs, meaning that the doctor prescribed a known allergic drug to a patient and then the prescription had to be rewritten. This occurred 215 times in 2004. Other common errors were improper dose and duplication of the medication, occurring 185 and 181 times respectively. Duplication of the medication occurs when a patient is the given the same prescription by more than one doctor in different departments. The rest of the errors found were wrong medicine which occurred 121 times, improper wait time, and dispensing the medication to the wrong patient.

Prescription errors are reported all over the world, even in countries that use technological advances in their healthcare systems. Within the United States, as many as 5% of the three billion prescriptions given per year are not correct, causing approximately 7,000 deaths annually (http://www.ppsinc.org/rxerror.htm). This figure is estimated to increase in coming years due to a rise in prescriptions and a decrease in pharmacists (http://www.consumeraffairs.com/rx/cvs_rx.html). Although Thailand may carry different statistics, prescription error is a global issue for which Thailand is not exempt. It is important to understand the different types of prescription errors in order to identify where they are initiated. Prescription errors are closely related to the efficiency of the pharmacy system.

Pharmacy Inefficiency

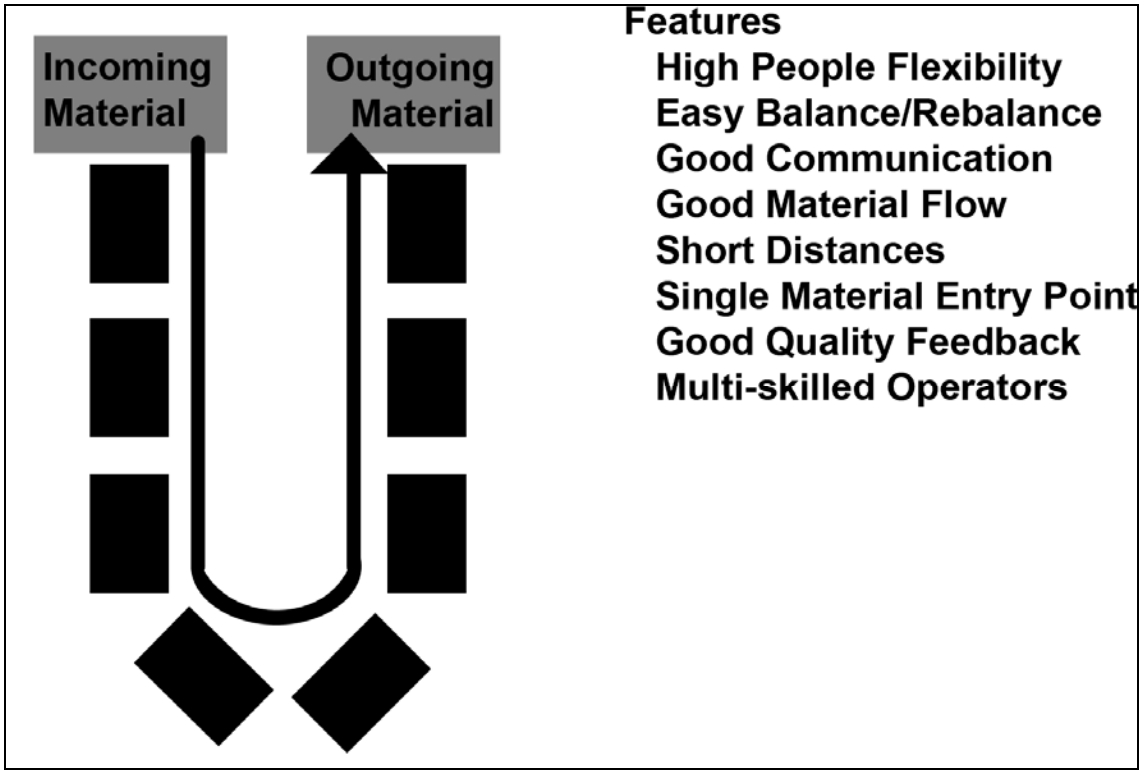

Figure 1: This figure of the work cell shows the dimensions of the design. Notice that the information comes in one side, goes through processes in a linear motion, and then is output. The features listed on the right side are aspects of the work cell which may be improved upon in the Lerdsin Hospital pharmacy (Lee 1997).

Inefficiency within the Lerdsin hospital pharmacy may result purely from the way in which work is performed. The distance that the workers have to travel to complete tasks, the flow of tasks, and division of labor all could contribute to making the prescription process more time-consuming and less accurate.

The pharmacy department of a hospital is comparable to a work cell within a factory. Figure 1 illustrates that the most efficient way to complete a task is by taking the material in through one point and outputting the material at another point. The staff participating in the process of the work cell must be skilled in more than one area for the process to run smoothly with the least amount of people. A pharmacy usually consists of several pharmacists and technicians who perform several tasks including, but not limited to: verifying prescription authenticity; stocking, ordering, and filling a wide variety of prescriptions; and handling patient insurance issues. Good communication between the staff is also necessary to guarantee that the processes are being carried out accurately and to make a more proficient working environment. Inefficiency within the actual pharmacy can slow down the

prescription process and lead to prescription errors (Lee, 1997).

Inappropriate layout in the pharmacy may lead to distractions and interruptions, which cause errors and hinder productivity (Flynn, 1999). The floor plan of a pharmacy should take into account input, output, and intermediate locations. An input location is the place where either patients or doctors drop off prescriptions. An output location is the place where filled prescriptions are picked up by the patient or shipped out to another location. Intermediate locations are designated as places where individual items in the assembly are located. This includes medications, bottles, prescription labels, personnel and technology; all vital in transforming the prescription order to the finished filled prescription (Lee, 1997). Constant jostling in an overcrowded pharmacy breeds distraction. By streamlining the layout, the pharmacy can decrease chaos, allowing individuals to focus more on their task than avoiding collision.

Tasks within the assembly line of the factory must be assigned to qualified people in the correct order to ensure accurate work. This also guarantees that everyone is doing a fair amount work. When one individual is in charge of an entire process, errors have a tendency to go unchecked. This issue is compounded when coupled with long work hours and high product volume, because the average healthcare worker is more likely to make mistakes at the end of a long work shift (Levy, 2000). The volume of prescriptions has increased greatly over past years, and burnt-out pharmacists are less likely to double-check prescriptions and take the time necessary to verify that the correct medication and dosage is given to the patient.

The concept of process timing within a work cell is a key link to productivity. The prescription process is somewhat linear, in that the process requires some operations to be completed before others can begin. When several phases of production are performed simultaneously, there is a high possibility of timing inefficiency. Some tasks take inherently less time than others, leaving some of the individuals with less work than their co-workers. The process as a whole cannot go any faster than the slowest operation within it (Lee, 1997). The ISMP documented that over 150 million calls are placed from pharmacists to physicians a year to clarify prescription orders. This causes hours of time wasted and money wasted as well. This impediment in the process decreases the efficiency of the pharmacy and prescription process as a whole, and causes more work for pharmacists (http://www.ismp.org/msaarticles/whitepaperprint.htm).

Knowledge of work cell design will be helpful in our analysis of the pharmacy unit at Lerdsin Hospital. It is important for the staff to make the best use of the space given to carry out work as efficiently as possible. The increased workload Lerdsin is experiencing causes crowding and noise pollution in the workspace, leading to prescription errors. Organization of the pharmacy could be improved by using the work cell components such multi tasking, improving material flow, decreasing distances, and consolidating data entry points. These improvements may lead to a more productive work environment in the pharmacy and less prescription errors.

Pharmacy Organization Planning

Many experienced hospital planners have stated that "before the architect's pencil touches paper, he must become thoroughly familiar with the hospital's objectives, plan of operation and operational policies relating to the area to be designed" (Hassan, 1986). This is true for planning the layout of a pharmacy, where location and space are essential to the operation of an efficient system. Organization of working areas and equipment, and location of the unit in regard to other departments, are important considerations in implementing a new design.

Choosing the location of the pharmacy unit within the hospital involves a thorough evaluation of the facility and other departments that rely heavily on pharmacy services. The pharmacy should be located on the first floor, unless first floor space is at a premium as it is in many large hospitals (Hassan, 1986). If there are separate outpatient and inpatient pharmacies, each should be in a location that is easily accessible to the patients and caregivers utilizing their service. An outpatient pharmacy should be located either in or immediately adjacent to the outpatient department. It is not suitable for hospital personnel to accept the prescription from the patient and retrieve the medication for a pharmacy located in some other section of the hospital. "Although man-hours may be conserved by combining inpatient dispensing units, this advantage should not take precedence over locating the outpatient pharmacy facility in the immediate area serving outpatients" (Francke, 1986).

The Public Health Service has made recommendations for the number of square feet of space necessary for hospitals to appropriately serve their patients. By giving the size of the facility, most commonly through the number of inpatients the hospital can hold, the

recommendations can account for the space needed in an outpatient pharmacy by approximating the number of outpatients the hospital can serve. In a study completed by Francke, medical administrators were surveyed about how much space they feel should be allotted for each bed in order to provide what they felt was adequate service. The following graph shows the Public Health Service recommendations and the results of Francke's survey:

Number of Beds	Public Health Service Recommendations	Survey Findings
100	6.3 sq.ft/bed	8.12 sq.ft/bed
200	5.9 sq.ft/bed	6.62 sq.ft/bed
300		5.39 sq.ft/bed
400		5.0 sq.ft/bed

Figure 2: Area Distribution—Square Feet Per Bed

The Public Health Service did not provide recommendations for more than 200 beds, and the survey findings did not go past 400 beds. This information can be obtained and customized to Lerdsin's 650 bed facility using extrapolation. An extra 170 square feet per 100 beds should be designated for reserve storage.

When a hospital is ready to renovate or expand any departments, there are certain considerations to address. Hospitals undergoing structural changes need to be particularly careful not to disrupt their daily operations. The plan of implementation must allow both the pharmacy and construction teams to complete necessary tasks simultaneously. This requires taking into account floor plan dimensions, areas of congestion, and construction needs. The pharmacy under construction will benefit from utilization of temporary spaces that are easy to adapt to and work smoothly from (Hassan, 1986).

Organizing the layout of a pharmacy involves careful evaluation of location and space requirements. Lerdsin's pharmacies are in logical locations according to experienced architects. Structural renovations or expansions of these units must be organized and run smoothly in order for the pharmacy to provide the necessary quality of service. Another aspect of the pharmacy that contributes to efficiency is the equipment the staff uses to complete the prescription process. Faulty, outdated, or lack of certain equipment may cause delays and possibly prescription errors.

Pharmacy Equipment

The time and ease with which the staff can perform tasks partly relies on the equipment found in the pharmacy. Any machine used in the prescription process and all furniture in the unit are considered equipment. Improvements in this area contribute to both a faster and more accurate pharmacy. Better equipment can possibly reduce errors in dosage and strength of the medication and furniture that reduce congestion may decrease the time in which a patient has to wait for his/her prescription.

Prescription errors in the pharmacy may be caused by outdated equipment for simple processes such as counting out the pills and labeling the bottles. Products offered by Apothecary Products, Inc. are designed specifically to improve the processes performed in the pharmacy. This solution is a low-tech solution for problems in a pharmacy that will help the staff to do their work faster and more accurately. Important criteria to remember when choosing equipment to improve the efficiency of a pharmacy include making sure that the equipment is both cost-effective and requires minimal maintenance. (Hassan 1986). Counting products such as the spin count, can count up to 100 tablets in 5 seconds. There are also products geared towards dosing which is an area where deadly mistakes can take place. Apothecary Products, Inc. offers 69 different labels for the pill bottles that give instructions to the patient to insure that the medication is taken properly. All of these products and many more improve the efficiency of the pharmacy and make the activities in the prescription process easier and faster (www.highbeamresearch).

Storage in a pharmacy must be organized to ensure that the processes in the pharmacy run smoothly. Access to medication is important for the staff to be able to serve the patients in a timely fashion. One system currently being used in Australia is the Carousel System. This system was created by a company in Sweden and is distributed in Australia by Pharmacy Workshops which is headed up by a pharmacist named Peter Feros. This system consists of multiple horizontal revolving shelves. There are two models; the smaller of the two has seven to ten conical shelves and the larger one has twelve shelves. The smaller model comes with dividers to compartmentalize the shelves and the larger model is separated into six sections, each having a tray that can be further divided. These shelves are sloping so that the supply can be replenished from the back. According to Mr. Feros, this system decreases product selection time from fifteen to two seconds. This system also eliminates

much of the congestion and confusion in a pharmacy because the pharmacy technician just needs to turn around to the carousel and spin until the correct medication is found instead of walking around searching (Pharmacy News 2004).

In researching our background topics, we have gained a better understanding of the Lerdsin Hospital Pharmacy situation and pharmacies in general. We investigated our domains of knowledge by researching these topics in previously written reports. This information helped us to recommend possible solutions once we determined the issues concerning the Lerdsin's Pharmacy.

III. Methodology

In order to achieve our goal of suggesting improvements for Lerdsin Hospital's pharmacy, we first determined the areas of the outpatient pharmacy in need of improvement. Then, we identified aspects of other systems that if implemented, might make for a more efficient system. Examples of our research methods included: interviewing staff, performing observational studies on Lerdsin's pharmacy and other pharmacies, timing the prescription process, and analyzing traffic flow in and around the pharmacy. The results from these methods provided the analytical data necessary to is research allowed us to conclude what needed to be altered in order to better Lerdsin's pharmacy services.

Objective 1 Assessing Lerdsin Hospital Outpatient Pharmacy

Our first objective was to assess the Lerdsin Hospital pharmacy in terms of the current pharmacy layout, the prescription process, staffing, and patient traffic flow. Information gained from researching these sub-objectives helped us to understand where the delays in the process are and where customer service could be improved.

Objective 1.1 Analyzing Current Pharmacy Layout

In order to understand the system in Lerdsin Hospital's pharmacy, we examined the physical structure of the pharmacy. Examining the layout gave us a floor plan and map of all the equipment, furniture, and set-up of the windows. By constructing a model of the pharmacy we could relate inefficiencies such as congestion and collisions found in later objectives to structural inadequacies.

The point of assessing the current pharmacy layout at Lerdsin Hospital was to visualize points of inefficiency related to the structure and layout. To accomplish this goal, we examined the floor plan of the pharmacy and the organization of the medications. We created a scaled visual representation through observing and measuring the outpatient pharmacy, noting dimensions and locations of structures, furniture, and equipment. With this model of the Lerdsin Hospital outpatient pharmacy, we were able to asses the structural needs of the pharmacy, while avoiding future inefficient use of space. The model we construct will be the control of the possible reorganizations of the pharmacy

We analyzed our measurements and observations by creating a model of the pharmacy that both the project team and the stakeholders could understand. It was important to begin with making this model so that we could accurately present where inefficiencies were occurring in the pharmacy in a visual manner as well as in written form. Our access to the pharmacy was provided by the head pharmacist Mrs. Pranee and our liaison, Dr. Thavat.

Objective 1.2 Examining Current Prescription Process

Once our model of the pharmacy was developed, we began to research the utilization of the layout. The prescription process depends largely on the layout as the order of the steps may relate directly to where equipment, walls, and shelves are located. To see where the layout may be flawed, we had to understand how the prescription process is implemented. Through in-depth understanding of the current process, we determined the level of necessity each task holds in order to suggest amendments to the process where superfluous tasks lay.

The prescription process in place at Lerdsin Hospital is a compilation of basic and complex tasks using staff of various skill levels, from technicians to pharmacists. Inefficiencies occurring in the prescription process cause unnecessary delays. Through mapping the prescription process, our purpose was to find where any impasses and inefficiencies occur. We timed various tasks in the prescription process, noting the amount of time required during and between each task to find where time is being lost. Quantitative research for this topic was necessary so that we could compare how efficient some aspects of the prescription process compare to others. We took great care not to interrupt the process and the work being done in the hospital while performing our research.

The prescription process in place at Lerdsin relates to all aspects of the pharmacy, including staffing and layout. How the process is carried out depends largely on where each task is performed and by whom. To gain an expert knowledge of the prescription process, we analyzed not only the tasks in the process as a stand alone flow diagram, but how the staff move in the pharmacy to complete these tasks. We also obtained more information about the staff through interviews that led to the acquisition of data and opinions to support our suggestions for improving the pharmacy.

Objective 1.3 Analyzing the Staff Component of Lerdsin Pharmacy

The prescription process at Lerdsin relies on well trained staff to carry out each task as quickly and accurately as possible. Documenting the traffic patterns of the staff allowed us to develop traffic flow diagrams. These diagrams show where the congested areas within the pharmacy are and areas that may be used inefficiently. Interviewing the staff aided us in drawing conclusions on what needs improvement in the pharmacy.

Staff Traffic Flow

The staff members at the Lerdsin outpatient pharmacy must accomplish many tasks that involve different areas of the unit. These tasks range from picking up labels in one room to depositing a filled prescription with the pharmacist in another room. The paths in which the workers travel to complete the prescription process rely on the layout and the how the process is broken down. Analyzing the traffic patterns of the staff allowed us to see where inefficiencies were in the layout and the process itself.

The staff must work around the pharmacy layout in order to execute the prescription process. We analyzed the traffic flow of the staff within the pharmacy to find where paths could be rearranged for the sake of efficiency. We performed a traffic analysis noting areas of frequent use, to pinpoint the location and occurrences of organizational inefficiency. There paths were mapped, labeling pharmacists, pharmacy technicians, assistants, and cashiers with different colors. Color-coded traffic flow diagrams aided us in visualizing the traffic pattern of the staff. From this, we determined congested areas within the pharmacy that would most benefit from layout reorganization.

Interviewing Staff

Through interviews with pharmacy staff, we gained first hand knowledge of the possible flaws in the prescription process and layout. The staff work within the pharmacy system at Lerdsin daily and were deemed to be a viable source of information by our liaison, Dr. Thavat. Our interviews asked the following questions:

1) Where do delays occur in the prescription process?
2) What aspects of the pharmacy do you find to be most distracting?
3) Is the window set-up separating each insurance type best for this hospital?
4) Would removing the cashier from the pharmacy help with traffic flow and efficiency?
5) Do you often have to direct patients to the correct window?

These questions were asked to assistants, cashiers, pharmacy technicians, and pharmacists verbally and their answers were written down. We analyzed this data by combining similar answers for each question into groups.

The answers to these questions illustrate the needs of the staff in the pharmacy. The delays and distractions discussed suggest what aspects of the system could be improved. Whether or not the staff members believe that the window set-up is inefficient or that the cashier should be removed aided us in developing other possible layouts of the pharmacy.

Gaining a better understanding the staff component in the pharmacy aided us in developing improvements based on what would make their job easier. In turn, this could possibly decrease prescription error and wait time. The people interacting most with the most with the prescription process are the staff members. One task in the prescription process that hardly involves the prescription itself is the customer service aspect of the pharmacy. A major responsibility of the assistants is to direct the patient to the correct windows in order for him/her to begin the process of obtaining their medications. This responsibility is just as important as filling the actual prescription.

Objective 1.4 Assessing the Patient-Pharmacy Interface

The pharmacy unit at Lerdsin Hospital's main purpose is to serve its patients in the best way possible by making sure they get the correct medication in a timely fashion. It was necessary to analyze the way the patients obtain their medications. This knowledge allowed us to gage how confusing the exterior window set-up is within the prescription process. We researched this topic by assessing the traffic flow around the windows for the three different insurance sections and at different times of the day.

Our team analyzed the patient flow around the pharmacy to assess how confusion within the interactions between the pharmacy and the patients affect the process. By patient interaction with the pharmacy, we mean the traffic pattern the patient follows to communicate with the pharmacy during the prescription process. This includes the path they travel when dropping off the prescription, paying, and picking up the medication.

By directly observing and understanding the flow around the pharmacy, we determined if the current patient flow limited patient movement in the area. To construct

these traffic flow diagrams, we randomly selected patients to monitor their path from when they entered and left the pharmacy area. Once the observation data was gathered, it was organized into traffic flow diagrams. This made it easier to visualize the patient flow and locate areas of congestion.

The data we gathered helped us to determine where the inefficiencies and confusion lie in the patient-pharmacy interactions at Lerdsin Hospital's outpatient pharmacy. The primary function of the pharmacy unit is to dispense medications to serve the patients. The patient traffic flow diagrams led us to develop concrete proof that the window set-up is flawed. By improving communication and traffic flow outside of the pharmacy, we are also improving the services offered to the patient.

In the course of this project, we realized that our background research into literature concerning pharmacy layout, staffing, and systems, was not sufficient to guide our recommendations. Examining the system at Lerdsin only allowed us to establish what could be improved, not necessarily how to improve it. To remedy this problem, we chose to observe the efficient systems in other pharmacies in order to learn about possible solutions for the situation at Lerdsin Hospital.

Objective 2 Examining Alternative Pharmacy Systems

We visited other hospitals in Thailand to examine their prescription process and pharmacy layout in order to suggest the best plan for Lerdsin Hospital. We studied not only the layout of the pharmacy, but also their furniture, equipment, and patient traffic flow. Our project team visited Bumrungrad Hospital, a private hospital in Bangkok, and Nakornping Hospital in Chiang Mai. Personal communication with our liaison, Dr. Thavat, indicated that Bumrungrad Hospital has an extremely efficient pharmacy and so we examined what aspects of their system led to faster and more efficient processes and results. The Nakornping Hospital in Chiang Mai is a government-run hospital similar to Lerdsin and has a system designed by SSB Bangkok, the same company that Lerdsin has contracted for their new system. At this hospital we observed how their pharmacy and prescription process works with this technology. These observations helped us to suggest the best possible solutions for the Lerdsin Hospital pharmacy.

We organized this objective into three sub-objectives that are very similar to our sub-objectives for objective one. Our methodology acts as a control in our comparison of the layout, prescription process, and service in the each pharmacy. The differences between objective one and two are that we couldn't get as much quantitative information from Bumrungrad and Nakornping as we could from Lerdsin because we couldn't spend as much time at the other hospitals.

Objective 2.1 Assessing Pharmacy Layout in Other Pharmacies

Our goal for assessing the layout of efficient pharmacies in both Bumrungrad Hospital and Nakornping Hospital was to compare the efficiencies of these pharmacies to the Lerdsin Hospital unit. The first step to achieving our goal was to observe the pharmacy layout of these other pharmacies qualitatively and quantitatively. We first noted where the furniture, equipment and staff were located. We also measured the dimensions of the pharmacy structure. This allowed us to begin formulating a model of these pharmacies similar to the one we created for Lerdsin. We examined how these other pharmacies stored medications to further understand how they utilize the space given. By scrutinizing the layout of each pharmacy, we were able to construct models of these units to compare and contrast with our model of Lerdsin. We organized our observations and measurements of the pharmacies into maps similar to those constructed for Lerdsin's pharmacy illustrating similarities and differences. Visits to these pharmacies organized by our liaison, Dr. Thavat, made these observations possible.

Objective 2.2 Examining Prescription Process at Other Pharmacies

Analyzing the division of labor, traffic flow, and prescription process in other pharmacies allowed us to establish a clear model of how operations could be run in Lerdsin Hospital. Bumrungrad Hospital and Nakornping Hospital provided good examples of efficient use of staffing, space, and resources. The information we gathered from these facilities allowed us to suggest changes in Lerdsin's current system to better serve their hospital patients.

In order to gain relevant data, we interviewed pharmacy personnel regarding the number of workers employed by the pharmacy unit, and the staff during each shift. These interviews also provided details about staff rotation and job descriptions. It was important to

study the staffing aspect of pharmacies at hospitals other than Lerdsin to gauge the efficiency of Lerdsin's staffing, and the appropriateness of any staffing suggestions we made.

The prescription processes of Bumrungrad and Nakornping were essential areas to study for suggesting improvement in Lerdsin's pharmacy services. By shadowing the process from the time the doctor prescribed a medication to the time the patient received the medication, we could assess the efficiency of the system. Additionally, we made informed observations on the processes, comparing it to Lerdsin, to determine the feasibility of incorporating any beneficial aspects of their prescriptions processes. The information gained from observing other processes gave the project group tools for which to suggest appropriate changes to Lerdsin Hospital's pharmacy.

In order to evaluate the level of pharmacy efficiency in other hospitals, we focused observation on staff traffic flow, similar to that of the staff as they move about the pharmacy. Observation of the traffic patterns within the pharmacy allowed us to determine the impact these problematic locations could have on prescription timeliness.

Visiting Bumrungrad and Nakornping Hospitals provided significant information for our project objectives. Through staff interviews and observations, we gathered relevant information of efficient systems. By comparing this data to Lerdsin's situation, we were able to provide suggestions for adapting and improving Lerdsin's pharmacy services.

Objective 2.3 Analyzing Window Set-up in Other Pharmacies

Examining the patient traffic flow in Bumrungrad and Nakornping Hospital's pharmacy aided the project team in establishing other traffic flow diagrams to compare to Lerdsin. Time was limited at these other hospitals, so we were only able to observe how the patients use the pharmacy's receiving, dispensing, and paying windows and if any confusion occurred. We noted the signage on the exterior of the pharmacy and studied how the pharmacy notifies the patients of when they were needed for tasks such as paying. From observing the window set-up and the notification system, we constructed a simple traffic flow diagram of each pharmacy. This allowed us to compare those traffic diagrams to the Lerdsin diagram. We also compared the traffic flow diagrams from all pharmacies observed to the work cell figure, which explained that one data entry point (reception window), a u-shaped assembly line (prescription filling), and one data output point (dispensing window) at the

opposite end of the ‘u’ was the most efficient system. Speaking with our contact at Bumrungrad and Nakornping allowed us to gain insight into what made their design successful or inefficient. These findings were analyzed in report form to further compare the three pharmacies.

Knowledge of the work cell design and the input from staff at each hospital helped us to determine what aspects of each traffic flow diagram would benefit Lerdsin’s pharmacy. Access to the pharmacy and staff of the Bumrungrad and Nakornping hospital was gained through contacts made by our liaison, Dr. Thavat.

Once we compiled all of the data collected through assessing the Lerdsin pharmacy and observing the Nakornping and Bumrungrad systems, we had to analyze the data to make possible improvements. These improvements were to be suggested in the areas of layout inside and outside the pharmacy and division of labor in the staff. Our data led us to establish where the inefficiencies lie in the Lerdsin pharmacy and what could be done to correct them.

IV. Findings and Discussion

Overall, we found the prescription process in use at Lerdsin to be very similar to that of the other two pharmacies we observed. However, the execution of this process differs. The differences in implementation cause delays within the prescription process at Lerdsin. The cashiering component, as well as individual aspects of the layout provided the greatest contribution to these delays. Features found in Nakornping and Bumrungrad pharmacies, in addition to the literature we researched, led to appropriate recommendations for Lerdsin.

Prescription Processes

Lerdsin's outpatient pharmacy follows a prescription process similar to the steps involved in Nakornping and Bumrungrad hospitals, as Figure 3 illustrates. The pharmacies at these two hospitals are also comparable to Lerdsin in terms of the number of prescriptions served per day. In addition to this, Nakornping and Lerdsin are both government-run hospitals using very similar computer systems. These otherwise identical processes diverge in one important way--wait time. Lerdsin's wait time is approximately thirty-five minutes, whereas Nakornping's is fourteen minutes, and Bumrungrad's is five minutes. Differences found in each pharmacy's process contribute to differences in quality of services.

The individual steps involved in filling a prescription are the same in all three hospitals. The orders are received, labels are printed out, prescriptions are filled by pharmacy technicians, prescriptions are checked by pharmacists, and patients pay for and receive medications. However, each hospital varies with the sequence of these steps and the addition of technological advances.

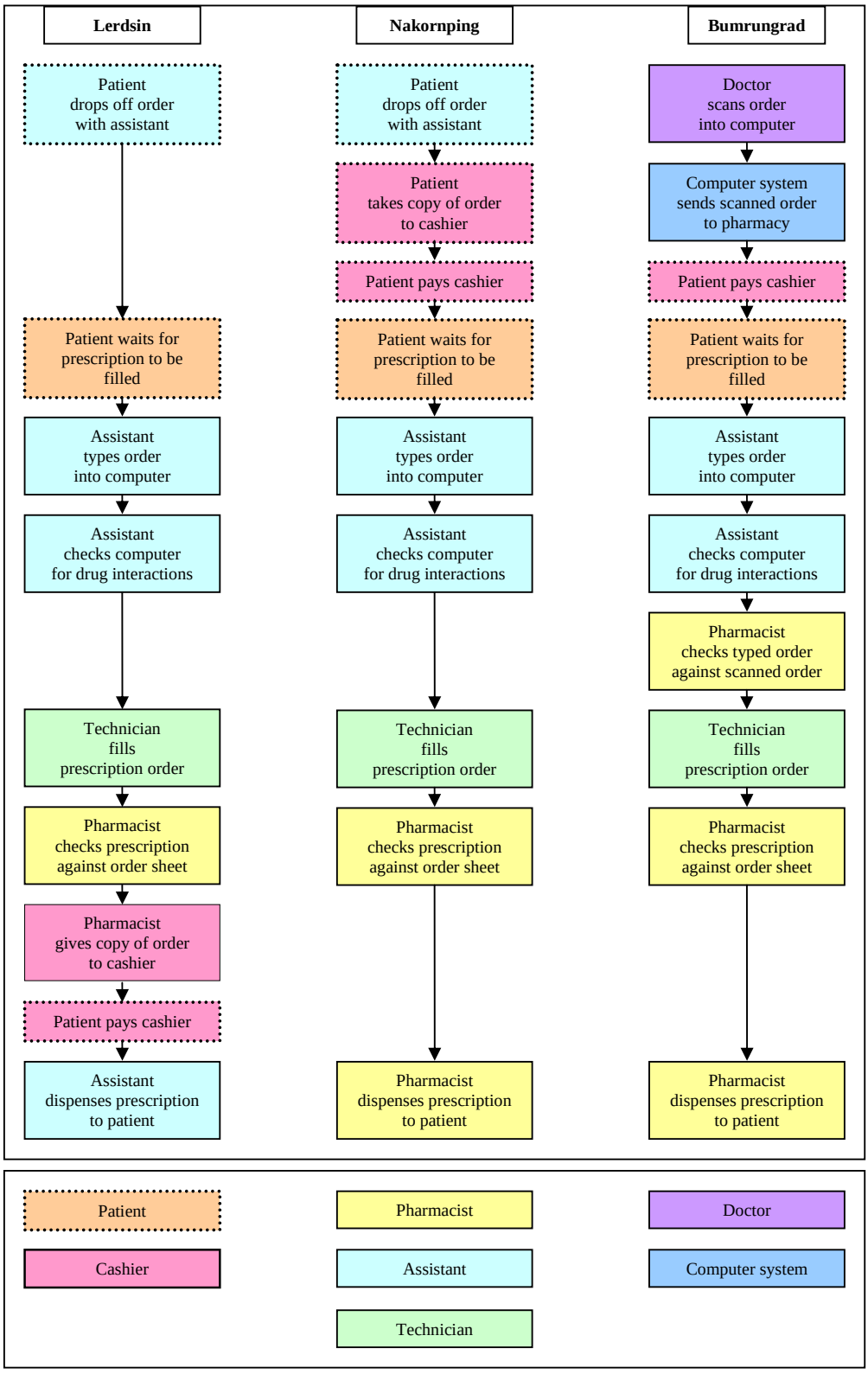

Figure 3: Prescription process for Lerdsin, Nakornping and Bumrungrad Outpatient Pharmacies

The pharmacies at Lerdsin and Nakornping hospitals follow the exact same steps in their prescription process, but in a slightly different order. At Nakornping, once the order

information has been typed into the computer, the patient personally takes a copy to a separate location to pay the cashier. In Lerdsin, the pharmacist gives the copy to the cashier after checking the prescription. The cashier aspect of the process is initiated while the prescription is being ordered at Nakornping, while it doesn't begin until the prescription is ready to be dispensed at Lerdsin. These small differences account for a great discrepancy in process timing, as we will see in the next section.

The advanced technology utilized at Bumrungrad hospital, though changing the input process, does not change the overall prescription process drastically from the other two hospitals. Doctors scan hand-written medication orders at nursing stations throughout the hospital. These orders are sent to the appropriate pharmacy through Bumrungrad's advanced computer system, Hospital 2000. This allows pharmacy staff members to begin preparing mediations before the patient arrives at the pharmacy. Wait time commences when they pay the cashier, which is the first step once patients arrive at the pharmacy. With these advantages, Bumrungrad is able to provide an additional prescription check in their prescription process, which accounts for their low rate of prescription errors.

The prescription process for the pharmacies at Lerdsin, Nakornping, and Bumrungrad Hospitals are primarily the same, with minimal variation. However, it is the execution of these processes that accounts for the large difference in process timing. In terms of layout, staffing, and technology, it is the implementation of the prescription process that differs among the three hospitals.

Finding Two: Causes of Delay in the Outpatient Pharmacy

Lerdsin's outpatient pharmacy has three main issues causing delay in the prescription process. Most significantly, the pharmacy cashier doubles the amount of time it takes to complete the prescription process. Secondly, the layout of the current pharmacy creates a significant amount of hindrances to the smooth process flow. Thirdly, given the current system for outpatient doctor appointments, the volume of prescriptions inevitably increases the wait time during peak hours.

Cashiering

The cashiering task of Lerdsin's prescription process causes the greatest delay within the pharmacy, as supported by our timing data and staff interviews. Though this step could be performed in parallel with the prescription filling steps, currently it is tagged on to the end of the entire process.

It takes on average fourteen minutes and seventeen seconds out of the total thirty-two minutes from the time the prescription is filled and ready to pickup, to the time the cashier calls the patient up to pay. This represents forty-five percent of the total prescription process time. This timing data, as seen in figure 4, was gathered by following forty prescriptions through the pharmacy.

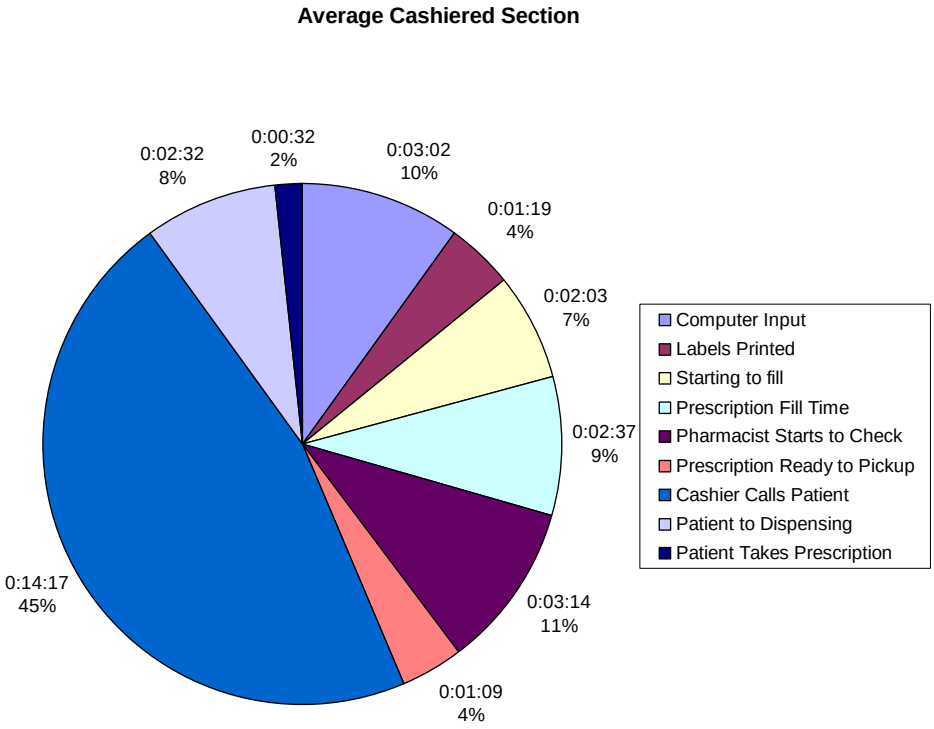

Figure 4: Average time for tasks in prescription process for 30 Baht and Private. Taken from 40 samplings.

When the process does not involve a cashier, the total wait time is decreased by one third as seen in figure 5. The actual cashier task takes on average two and a half minutes. The majority of the cashier step is the amount of time the prescription order is waiting in queue. Unlike Nakornping and Bumrungrad, the cashier step in Lerdsin's prescription process does not begin until the medications are completely ready for dispensing.

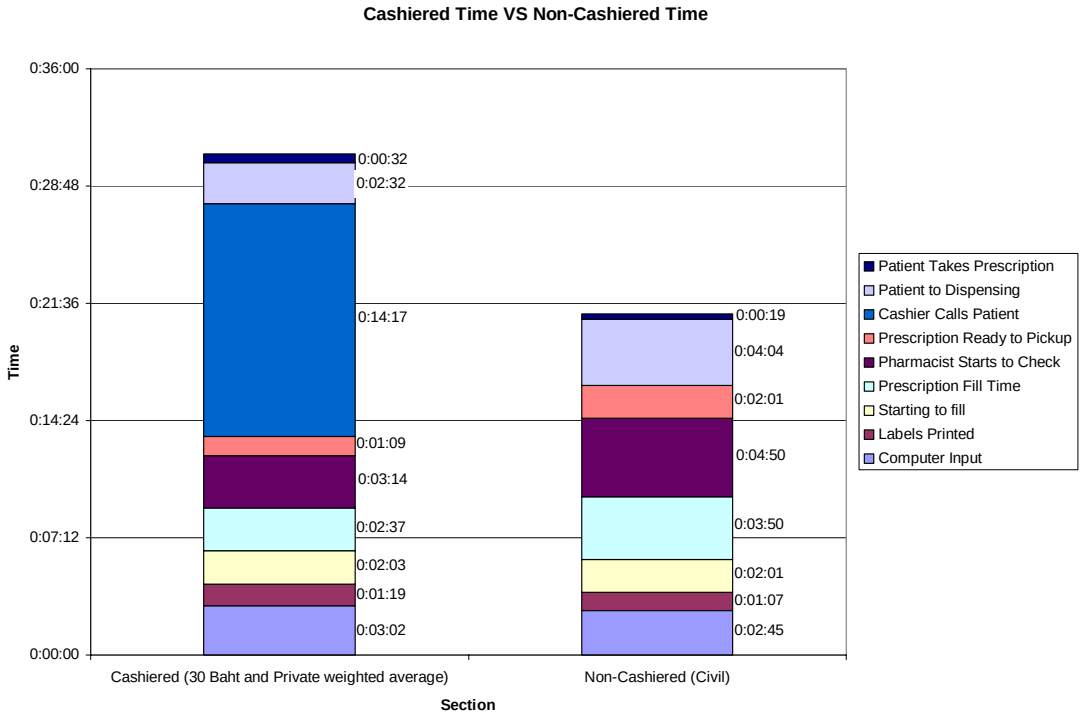

Figure 5: Average time for prescription process for 30 Baht and private versus the average time for the non cashiered civil section. Developed from 40 timings.

The tasks performed by the cashier do not take long individually; the delay is in obtaining necessary documents to complete these tasks. The blue carbon copy of the prescription form is used to bill the patients in the private and 30 Baht insurance schemes. The cashier is the only staff member in the pharmacy who makes use of this document. The original white sheet is used by the technicians to fill the prescription. Currently, this blue copy stays with the main prescription order through the entire process, forcing the cashier to wait until the prescription process is complete before she begins her task.

The standard deviation of the data collected for the cashier step is approximately fifteen minutes. This wide range for data is seen not only in the total data sample, but also when split up into time frames. Particularly in the 30 Baht section, no consistency exists from one prescription to the next. An observed prescription waited six minutes, while another, observed in the same section, on the same day, in the same time frame, waited twenty minutes. This was not an isolated occurrence as we observed this in all insurance sections multiple times. This inconsistency is most likely caused by not following the 'first in, first out' policy, as well allowing order sheets to accumulate before working on them. Nearly all the prescriptions we observed waited in queue with other prescriptions at some point within the process.

While it is important to focus on hold ups inside the pharmacy, often times the actions of the patients outside directly affect the productivity of the pharmacy staff members. The physical layout, both the exterior and interior of the pharmacy, contribute greatly to the delays in the prescription process.

Pharmacy Layout: Exterior and Interior

Many aspects of the pharmacy layout lead to delays in the prescription process. In this next section, we will first discuss the delays caused by the exterior layout. We will then examine the more significant delays related to interior layout.

Exterior

Issues with the pharmacy's exterior layout cause delays with the prescription process. Confusion in the waiting area relating to the window set-up keeps patients from getting their prescriptions in a timely manner and distracts staff members. Congestion around the windows is the result of this wandering.

Thirty-three of forty patients observed through traffic flow analysis during peak hours went to more than the necessary three windows. On a number of occasions, we observed patients traveling to as many as six different windows to achieve the three tasks of dropping off their prescription, paying the cashier, and then picking up their medication. An example

of a patient traffic pattern that approached six windows, seen in Figure 6, shows the chaotic path taken by a typical patient in receiving his medication.

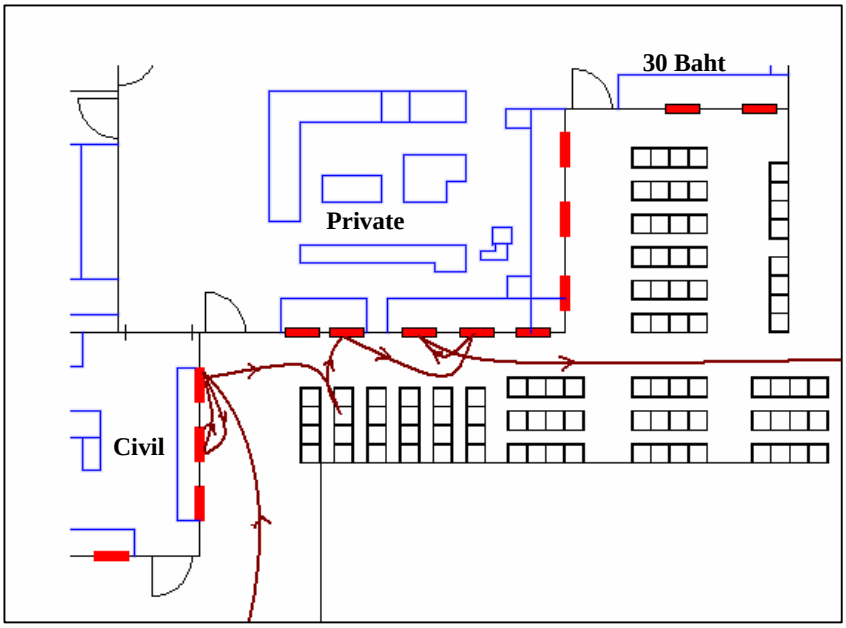

Figure 6. Patient Traffic Flow Analysis of a Typical Patient

The search for the correct windows delays the prescription process. Picking up and paying for prescriptions both require the patient to approach a certain window. Delays in finding the correct window hinder these steps within the process. The window setup itself also distracts the staff. All fourteen staff members including eight pharmacy technicians, three assistants, and three pharmacists agreed that they are constantly directing patients to the correct window. The time taken away from the staff members tasks increase the wait time for the 2,055 patients that utilize pharmacy services everyday.

The staff members are constantly guiding patients to the correct window because of the window arrangement. The windows for 30 Baht scheme patients are not visible when entering the pharmacy. We have observed that many 30 Baht patients go to window four to drop-off their prescriptions because it is the first window they see. This is actually the window for civil and private insurance drop-off. They wait in line only to find out that their drop-off window is farther down the line at window twelve. While the private and civil insurance patients have the same drop-off window, their windows for dispensing are separate. These discrepancies confuse the patients. There are usually two cashier windows for private insurance patients during the peak hours, but only one dispensing window. Once patients pay, both lines crowd around the one dispensing window.

Delays also occur in the interior of the pharmacy. To establish the inefficiencies in the layout and organization of the materials in the pharmacy, we observed the staff. The tasks in the process were analyzed in relation to where and how fast the staff performed them, and how the staff interacted with the current layout. The majority of staffing issues stem from layout inefficiencies.

Interior

Two main issues affect the prescription wait time with respect to the interior layout. First, the current layout is improperly utilized, causing disparity in the level of traffic flow in various areas of the pharmacy. Also, the arrangement of prescription materials creates the need for staff to travel across the entire pharmacy to complete the prescription process.

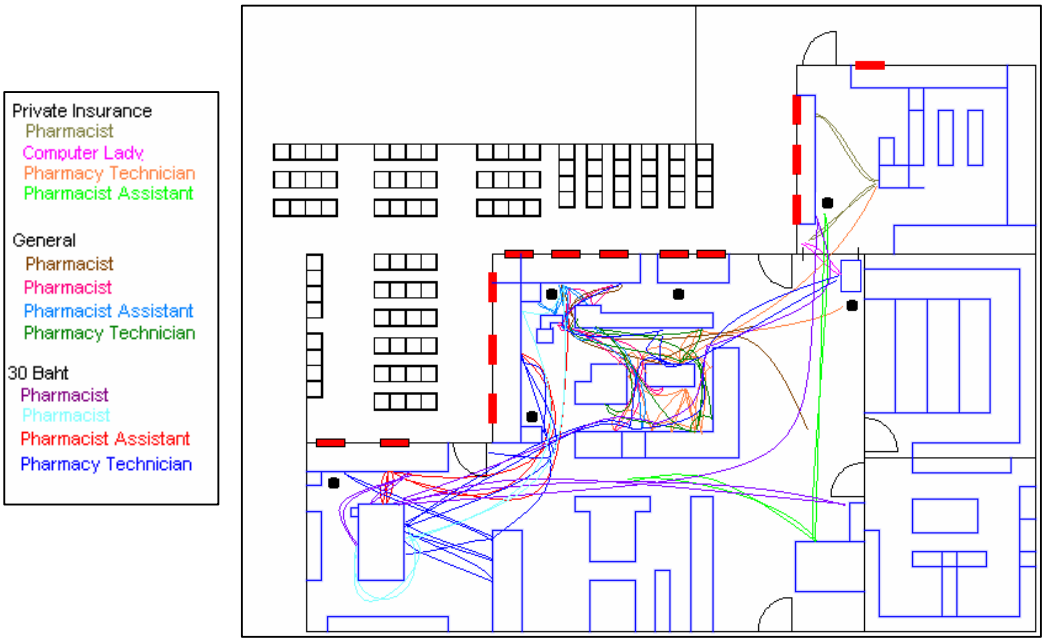

Figure 7: Staff Traffic Flow Diagram at Lerdsin Outpatient Pharmacy at 12:30 PM

By conducting traffic flow analysis of the staff, we determined that delays are caused by congestion in the work area. The staff traffic flow diagram, seen in Figure 7, was documented at 12:30 PM on a typical day. This figure suggests that the medication area in the middle has the highest traffic, but also that the staff members' paths take them all over the pharmacy to fill prescriptions.

From staff interviews, we learned that thirty-six percent of pharmacy staff members, including all three pharmacists, believe that the slowest aspect of the prescription process is filling the medications (Appendix 2). The staff viewpoint likely comes from the daily

observation of interruptions and collisions during the filling process, slowing the completion of their task. The workspace used most often is a counter top island that is approximately two meters long and one meter wide. At any given time, upwards of seven staff member use this small counter for the task of filling prescriptions. We observed that the technicians rarely use the counter spaces that are integrated into the medication shelving.

Crowding in the pharmacy is also caused by a disparity in the level of use for different areas. The front half of the pharmacy experiences constant traffic, while the back half is not used at all during peak hours. The regions around the drug supplies are particularly congested because of the minimal space available. Narrow passages are strewn with empty boxes and pieces of unused furniture that serve as a hindrance to the process. The back of the pharmacy is only used as an employee break area, and takes away from the space available for working, causing areas to be overcrowded.

Not only does the staff lack the space to safely and comfortably fill prescriptions, but the materials necessary are not organized in an easily accessible manner. At Lerdsin, the location of materials causes the staff to go out of their way looking for supplies. The organization of furniture, label printers, medications, and staff members causes time to be lost within the process.

We determined that delays and prescription errors are caused by staff members traveling all over the pharmacy to fill prescriptions. A 30 Baht technician path, shown in Figure 8 below, was extracted from the previous staff traffic flow diagram. The pharmacy technician made a prescription error while filling an order. Her error of retrieving the wrong medication was caused by distractions along her path. Approximately six minutes were spent fixing this prescription error, and then the prescription had to wait an additional four minutes to be rechecked. This is one example of the twenty-three percent of prescriptions observed that contained errors, extending the length of patient wait time.

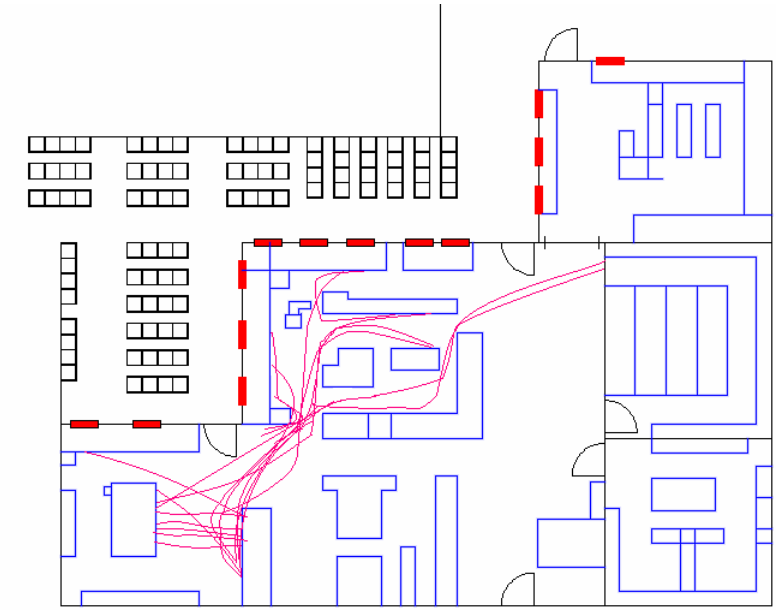

Figure 8: Staff Traffic Flow Diagram of 30 Baht Pharmacy Technician during Peak Hours

The explanation for the chaotic path of this technician lies in the layout. The 30 Baht technicians fill prescriptions using their own stock of generic medications, unless the doctor specifically orders a medication or if the 30 Baht stock runs out. The 30 Baht medications line the back wall of the 30 Baht section and the central medication supply is boxed in towards the middle of the pharmacy. The narrow walkway between the two sections causes delay and congestion because it only comfortably accommodates the width of one person.

The resources needed for the prescription process in the civil insurance room are not in easily accessible locations. A computer near window one, is used during peak hours for typing in prescriptions to alleviate the work load of the main typist located outside the room. Both the civil and private prescriptions are done by these two computers. On one typical day during peak hours, labels for approximately fifteen medications were printed out from the window one computer and left in a roll on the floor until someone could pick them up. The time elapsed while the labels were unattended was ten minutes and one second. The label step in the civil and private insurance prescription processes account for ten percent and seven percent of the total average time respectively.

Labels printed out in the civil insurance section are difficult to access because of the pharmacist desk and chair blocking the path to the printer. The printer in the civil insurance room is approximately eight meters from the medications. The baskets put together in the private insurance section have to travel this distance through a narrow doorway. The assistant

typing in prescriptions is right outside this door space making the path through the door even more constricted. She collects orders to input by reaching through this doorway into the private insurance section room which further obstructs this narrow path.

The many issues with the layout cause delays and prescription errors, but are repairable under the scope of this project. An aspect of the pharmacy that inevitably causes delays in the process is the amount of prescriptions within a small period of time. This issue was outside the scope of our project, but observations suggested that it was a significant cause of delay. The next section explains this finding and its limitations.

Prescription Volume

The third major factor causing delays is prescription volume. Lerdsin's doctors primarily visit with their outpatients between the hours of 9:00 AM and 12:00 PM. This creates a concentration of outpatient prescriptions. Regardless of how efficient the pharmacy unit may be, the outpatient appointment system will still cause back ups in the process based on this prescription influx.

The volume of prescriptions in the pharmacy is very dense during peak hours. Fifty-nine percent of the total patients come in between 11:30 and 1:30(Appendix 3). Because of this, the staff work nonstop through the midday. During these hours, the waiting area for the pharmacy is completely full.

The longest wait time, approximately thirty-nine minutes, occurs during the 10:30 to 11:30 time frame. However, this time frame does not get the most prescriptions, as Figure 9 illustrates. The 11:30 to 12:30 time frame takes in 140 more patients and has a shorter wait time by approximately eight minutes.

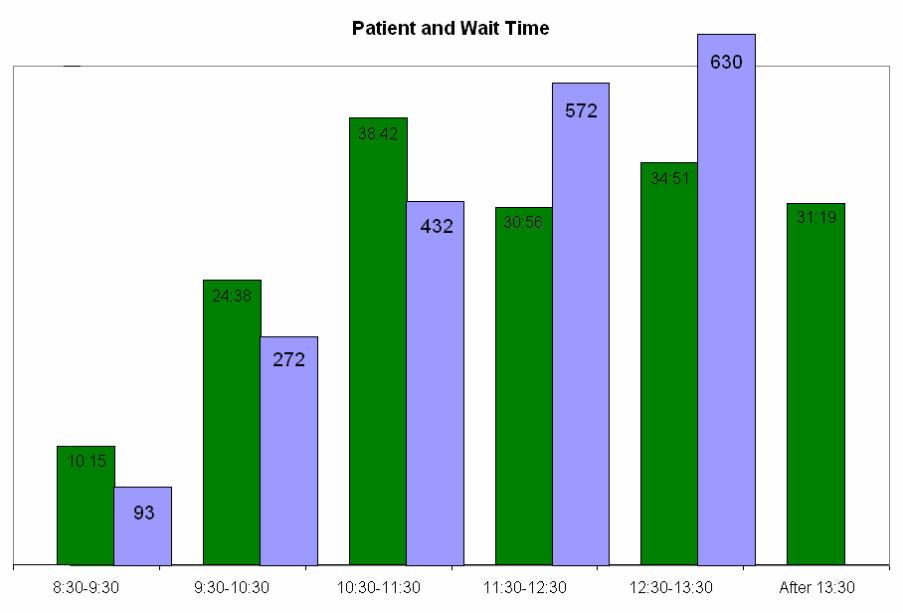

Figure 9: Graph shows the number of patients and average wait time for each time slot. Number of patients not available after 13:30.

Our preliminary conclusions are that the wait time is longer for the earlier time frame because of the initial accumulation of prescriptions. Like a machine getting started, once the pharmacy is accustomed to the high influx of prescription orders, they pickup their pace. More research into this topic would be needed to concretely determine the cause of the non parallel correlation between patient numbers and prescription wait time. Prescription volume is the most difficult issue to fix because it is not controlled by the pharmacy unit, but rather is dependent on patients, doctors, and administrators.

There are many issues in the pharmacy that are affected by the inefficiencies in the layout, window set-up, and the organization of its resources. These issues range from time delays to extra steps to travel for something, but all of these issues contribute to the overall quality of the system. No individual issue is too difficult to remedy, but compounded together, they require a complex set of solutions.

V. Recommendations

Based on our findings, along with research and observation of best practices, we found many potential solutions for Lerdsin's situation, including reorganization, a more intensive renovation, and future technology suggestions. The reorganization of the pharmacy using the same equipment would be the least invasive recommendation and financially burdening, while renovations would include structural expansion. By providing solutions for any budget, Lerdsin will be able to incorporate any number of recommendations into their final plan for the pharmacy.

Suggested Layout with Existing Structures

The first layout removes the division between the separate insurance sections and restructuring the layout so that there is a single point for each step involved in the prescription process. The setup would allow the staff members to work collectively rather than in divided teams, further increasing the efficiency of the unit. This layout, seen in figure 10, uses existing furniture and space but is reorganized with efficiency and the work cell in mind.

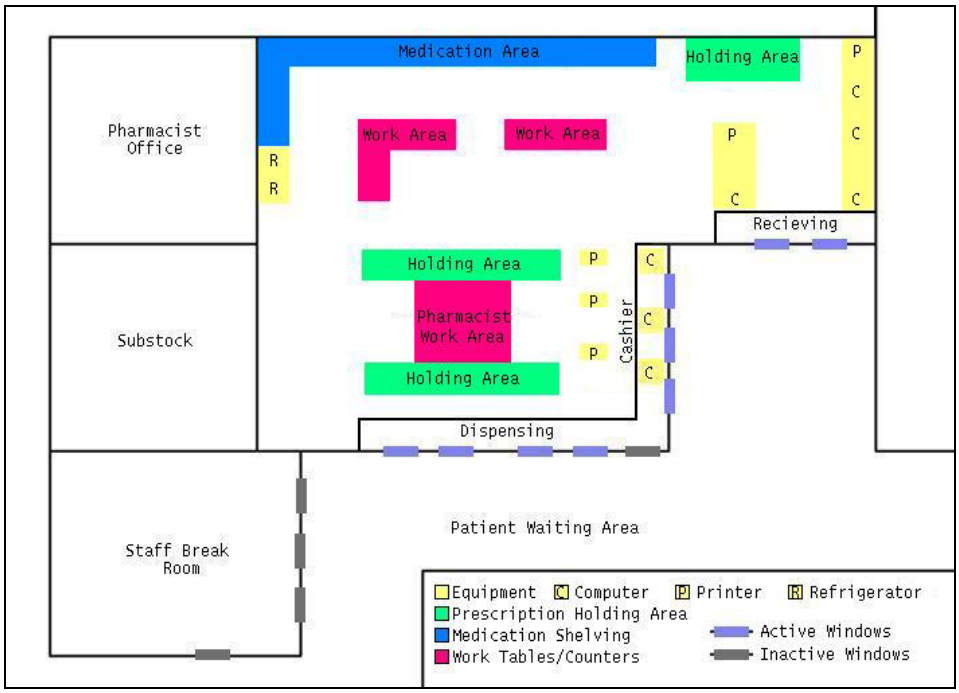

Figure 10: Recommended reorganization of existing layout (See larger version in App. 4)

For the exterior of the pharmacy, we recommend one area to be designated for dropping off the prescription, one for paying the cashier, and one for prescription pick-up.

This traffic flow is consistent with the literature we researched about assembly lines and work cells, which strongly suggests that processes should be linear. A similar layout was observed to be successful at Nakornping. We recommend converting the 30 Baht area to the order drop-off area, converting the 30 Baht receiving area to the cashiering area, and converting the private insurance area to the dispensing area. These sections would be located in this order so that they coincide with the sequence of steps involved in the process.

Not only was the pick-up window separated from the drop-off window at Nakornping, but the cashier was removed from the actual pharmacy entirely. This is rationalized by the observation that the cashier has little to do with the pharmacy prescription process, and more to do with patient accounting. The staff of Lerdsin agreed (13 out of 15) that separating the cashier would speed up the prescription process. According to this data, the cashier step and the prescription preparation step should actually run in parallel. The patient should take the blue carbon copy to the cashier while their prescription is being filled. This recommendation, as seen in figure 11, would decrease the wait time by half.

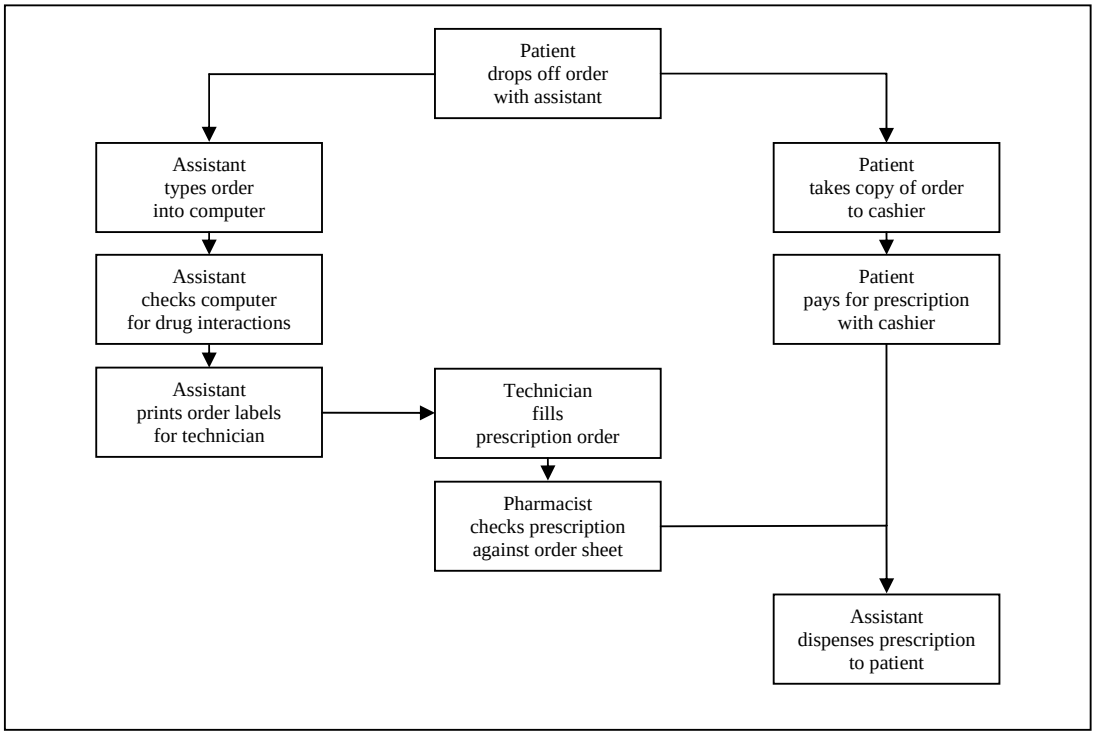

Figure 11: Flow diagram showing the cashier step as a parallel process to the filling of prescriptions

There are limitations to running these processes in parallel. Sometimes when there is a change in the medications before it is given to the patient, the cost may also change. In this

case, waiting for the prescription to be complete before billing would be beneficial. This area would require more research before considering implementation.

The interior of the pharmacy should be modeled after the work cell, allowing employees to follow an assembly line when filling a prescription. Input areas will be on one side of the pharmacy, with the medications centrally placed, and the pharmacist checking station closest to the dispensing area. The pharmacy technicians would fill one prescription sheet at a time in this system. Traffic flow analysis from the interior of the pharmacy illustrates the need for certain areas to be expanded. Currently, staff members convene around a small work station, increasing the potential for prescription errors due to distractions and congestion. Meanwhile, the back half of the pharmacy, only used to store staff belongings, remains vacant through most of the day. We recommend the staff area be moved to the current civil insurance section, eliminating the bottleneck caused by prescription traffic through that doorway. The pharmacists and desks will be located in the block where the medication is currently located. This central location near the dispensing windows will make it easy for the staff members to drop off prescriptions to be checked. A table would need to be set up possibly with lanes between the pharmacist area and the new medication area for easy organization of medications that need to be checked. This type of table was observed at Bumrungrad Hospital and aided the staff in organizing waiting prescriptions.

This layout can be implemented without changing the structure of the space and therefore is our first recommendation for Lerdsin's situation. More room in the pharmacy would of course only help the situation. Our research indicated that the more open space in a pharmacy, the less likely crowding and congestion is. The next section describes a layout of the pharmacy that incorporates structural renovations to obtain more space in the unit.

Pharmacy Layout with Structural Changes

Future recommendations for Lerdsin would include extensive renovations of the pharmacy. This would include expanding the interior of the pharmacy into the 30 Baht waiting area thus creating a rectangular floor plan. According to our research, this set-up would limit the potential for bottlenecking in the staff traffic patterns. Furthermore, increasing the space would open up the prescription filling area and decrease congestion. This possible layout is seen in Figure 12.

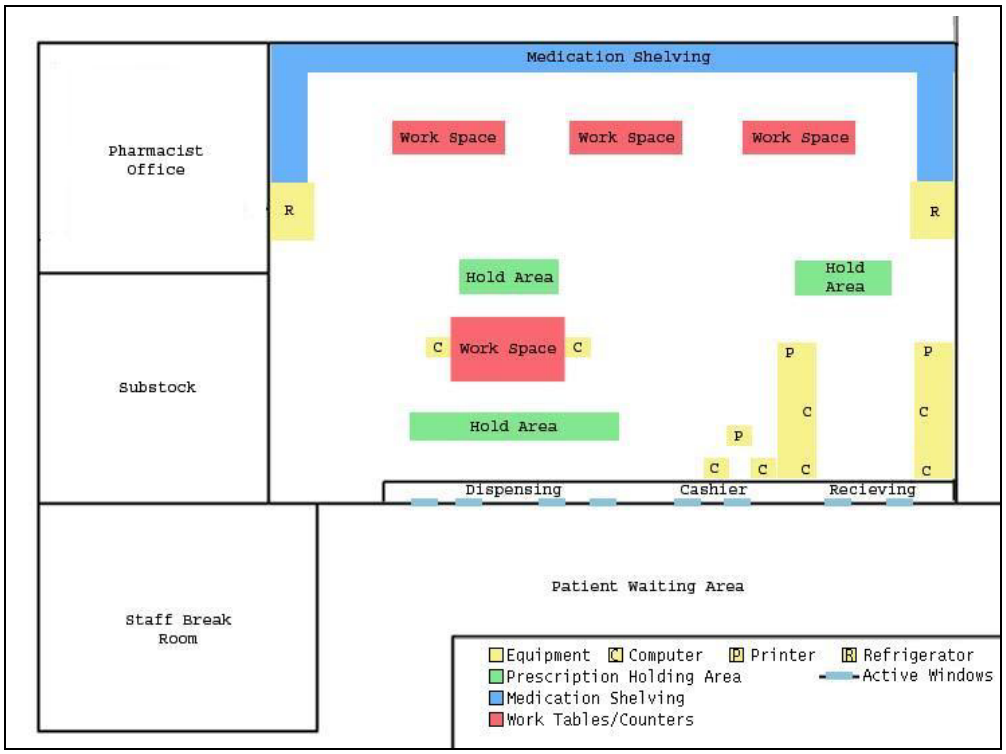

Figure 12: Layout of pharmacy with structural changes (See larger version in App. 5)

All of the aspects from the first layout, such as the work cell and combining the insurance, are also incorporated in this layout. The major difference is that this layout is a rectangle which we found to be the most efficient shape for a pharmacy. The staff technicians have even more room and workspace to safely and quickly fill prescriptions. Also the windows are in a straight line which will further prevent stagnant crowds of patients and confused traffic patterns.

There are some limitations for this layout that make it less feasible than the one described in the previous section. This layout does cut out an area of seats used for waiting patients, but our observations of Nakornping indicate that with a shorter wait time, there is less need for the waiting area. Structural renovation of the first floor pharmacy may shut down the pharmacy for a period of time and is more financially demanding than the first recommended layout. While our research suggests that this expanded layout is more efficient, the budget and time needed make it second priority to the first layout.

Another option to consider would be to relocate the pharmacy to the vacant space on the second floor. Although our research suggests that the prime location of an outpatient pharmacy be located on the first floor, it makes an exception when first floor space is at a

premium. This is certainly the case at Lerdsin. The second floor provides enough space to allow the division of each insurance section into separate pharmacies. This idea was observed in Nakornping and Bumrungrad hospitals, where there were separate pharmacies for different departments. However, Lerdsin would only benefit from this suggestion if they had the necessary space and staffing.

Suggestions for Pharmacy Technology

Improvements in equipment may also improve the quality of services at Lerdsin's pharmacy. The ideal situation for the pharmacy unit would include the same features as in the previous examples, with the addition of new advanced equipment. Refrigerators with transparent doors on a sliding track would replace the domestic kitchen refrigerators currently in use. This appliance would allow pharmacy technicians to find the medication without opening the doors, decreasing the amount of time involved in that component of the process. In addition to this, the sliding doors would create less of a hindrance for staff members passing by, as they would not open out into traffic paths.

Figure 13: Picture of Recommended Style of Refrigerator from Nakornping Hospital

Automatic pill counters are supplemental tools that would speed up the process. Pharmacy technicians at Lerdsin currently spend afternoon counting pills because the pharmacy isn't as busy at this time. There are still patients waiting for prescriptions in the afternoon and their wait time is still the same length as patients in the morning. Pill counters would count the pills for the staff so that they could be free to continue working.

Figure 14: Picture of Pill Counter by Packomatic at Nakornping Hospital

The furniture used throughout the pharmacy would include shelves at the appropriate height that easily display medications. Counter space is also essential to this ideal model so that there is enough individual workspace to prevent crowding of staff members. We observed these features used with great success in both Nakornping and Bumrungrad hospitals, and therefore recommend them for Lerdsin Hospital.

The recommendations we made for Lerdsin Hospital are aimed at simplifying the pharmacy in an effort to improve pharmacy services. Improvements to the interior and exterior layouts of the pharmacy allow other aspects of the prescription process to also improve. The recommendations may be combined in any number of ways to cater toward the ambitions of the hospital staff, and budget committee. These recommendations give Lerdsin Hospital the tools to improve their pharmacy services, thus achieving our goal.

VI. Summary

There are many possible recommendations to improve the efficiency of the outpatient pharmacy in Lerdsin Hospital. We have provided recommendations for reorganizing the existing layout, incorporating new equipment into the floor plan, and possible future renovations. In addition to this, our research has guided us to further areas of exploration. We prioritized our suggestions based on the financial capability of Lerdsin to best improve their outpatient pharmacy.

Simple reorganization of the existing layout would provide Lerdsin with a more efficient pharmacy. We recommend that Lerdsin remove the division between three insurance sections and rearrange the interior layout so that there is a single point for each step involved in the prescription process. This would work in collaboration with the work cell model by positioning input areas on one side of the pharmacy, with the medications centrally placed, and the pharmacist checking station closest to the dispensing area.

In addition to this, these recommendations would require the exterior window set-up of the pharmacy to be restructured in order to be consistent with the changes on the interior. We recommend converting the 30 Baht area to the order drop-off area, converting the 30 Baht receiving area to the cashiering area, and converting the private insurance area to the dispensing area. These sections would be located in this order so that they coincide with the sequence of steps involved in the process.

Improvements in equipment and technology are also suggested for future plans to better the pharmacy. We recommend refrigerators with transparent doors on a sliding track for Lerdsin. This would cut down on time taken to find medications and rid the pharmacy of obstructions caused by swinging refrigerator doors. Our observation of other hospitals has led us to recommend height appropriate shelves with ample counter space so that there is enough individual workspace to prevent crowding of staff members. We also recommend automatic pill counters for Lerdsin as supplemental tools that would speed up the process and allow staff to be used in more important areas instead of counting pills.

Future recommendations for Lerdsin would include extensive renovations of the pharmacy unit. This would include expanding into the 30 Baht waiting area to create a rectangular floor plan. According to our research, this set-up would limit the potential for

jamming in staff traffic patterns. Furthermore, increasing the space would open up the prescription filling area and decrease congestion.

Another option to consider would be to relocate the pharmacy to the vacant space on the second floor. Although our research suggests that the prime location of an outpatient pharmacy be located on the first floor, it makes an exception when first floor space is at a premium, which is the case at Lerdsin. Additionally, the second floor provides enough space to allow the division of each insurance section into separate pharmacies. However, Lerdsin would only benefit from this suggestion if they had the necessary space and staffing.

For further research, we suggest that Lerdsin work with SSB Bangkok Ltd. to implement a system that would eliminate hand-written prescriptions. In our interview with SSB administrators, they confirmed that they are capable of doing this. Illegible doctor handwriting is one of the greatest causes of prescription error. In addition to this, our staff interviews revealed that one of the biggest distractions in the pharmacy is calling doctors to clarify prescription orders. Because of financial constraints, we are classifying this as a future recommendation which should be further explored.

With the findings produced through our methodology, we were able to achieve our project goal of suggesting improvements for Lerdsin Hospital's outpatient pharmacy with emphasis on layout, division of labor, and technology. Through the recommendations we made, Lerdsin can better their pharmacy services by working more efficiently and reducing prescription errors. These recommendations have the potential to affect the lives of many people throughout Thailand who utilize the services provided by Lerdsin, through creating a safer and quicker system for all of its patients.

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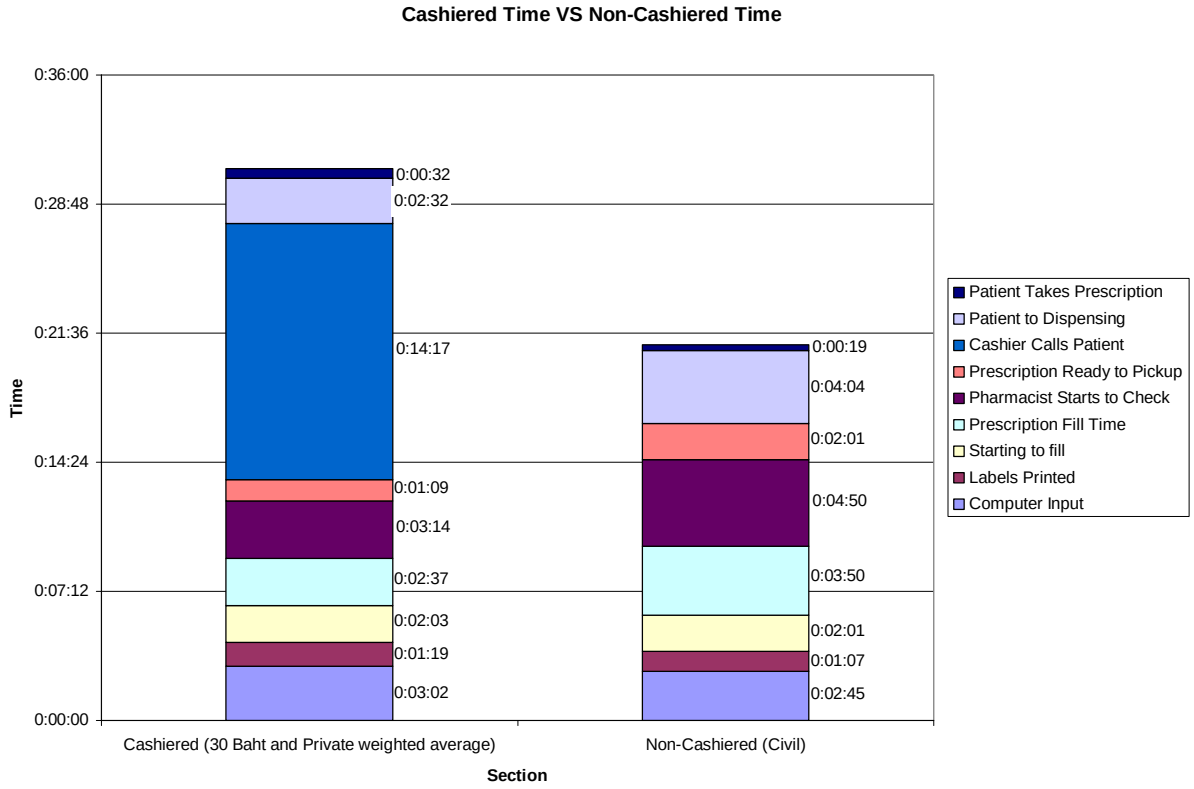
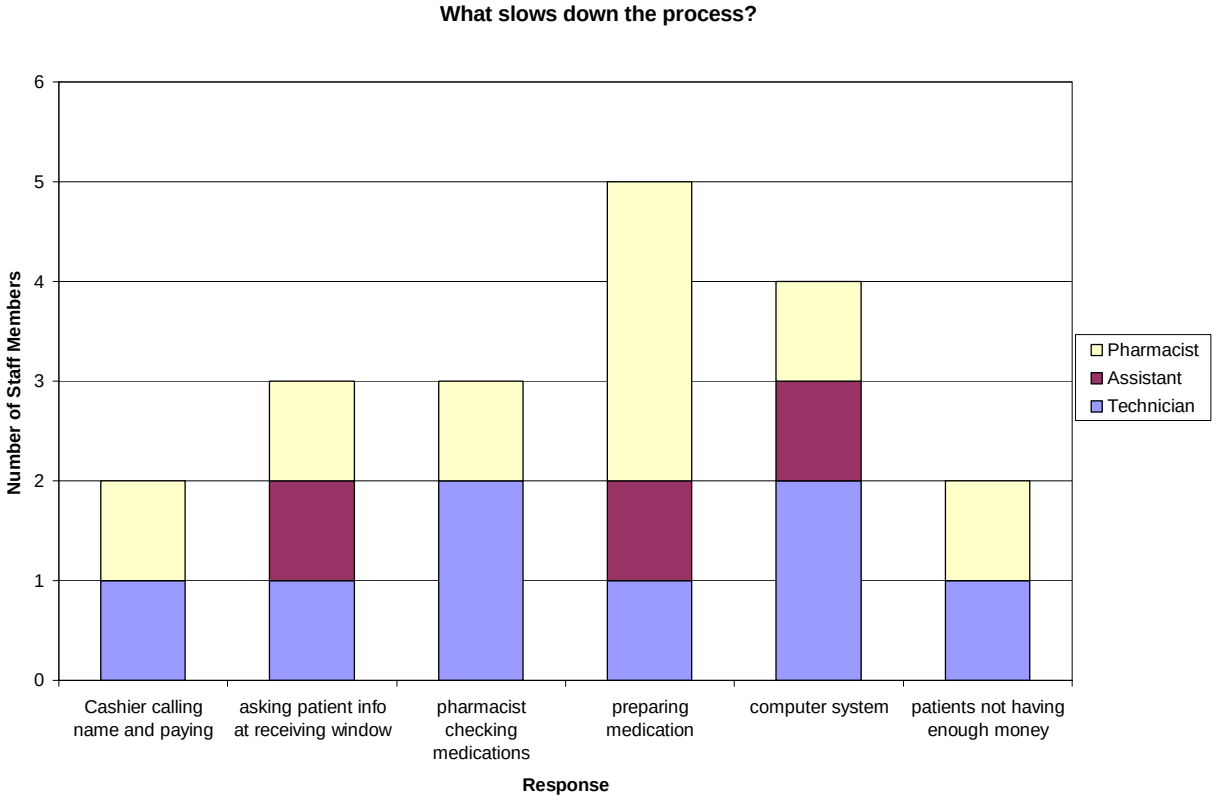
Appendix

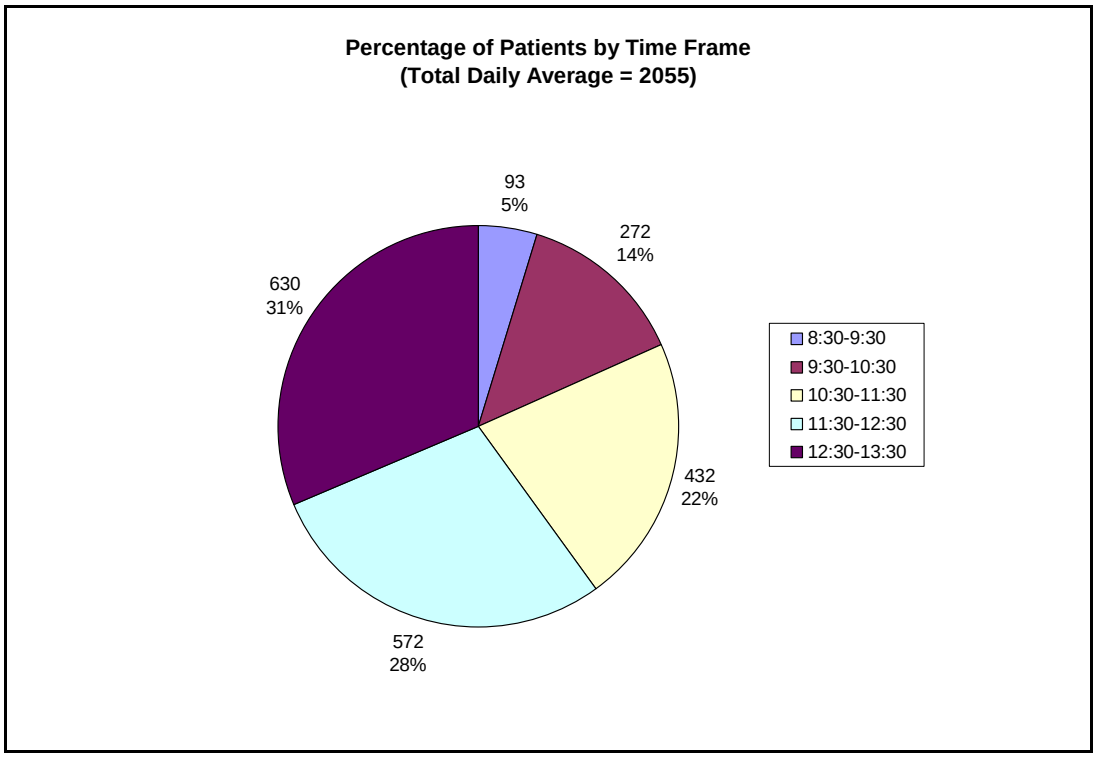
Appendix 1: Timing Comparison

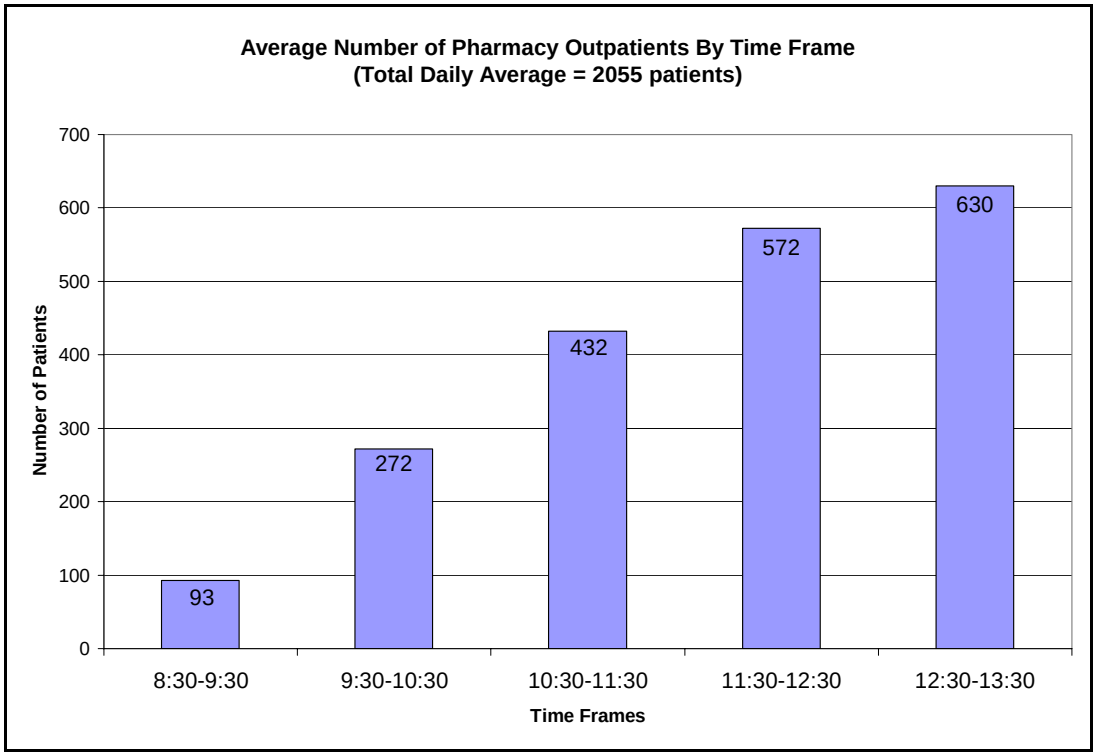


Appendix 2: Staff Questionnaire

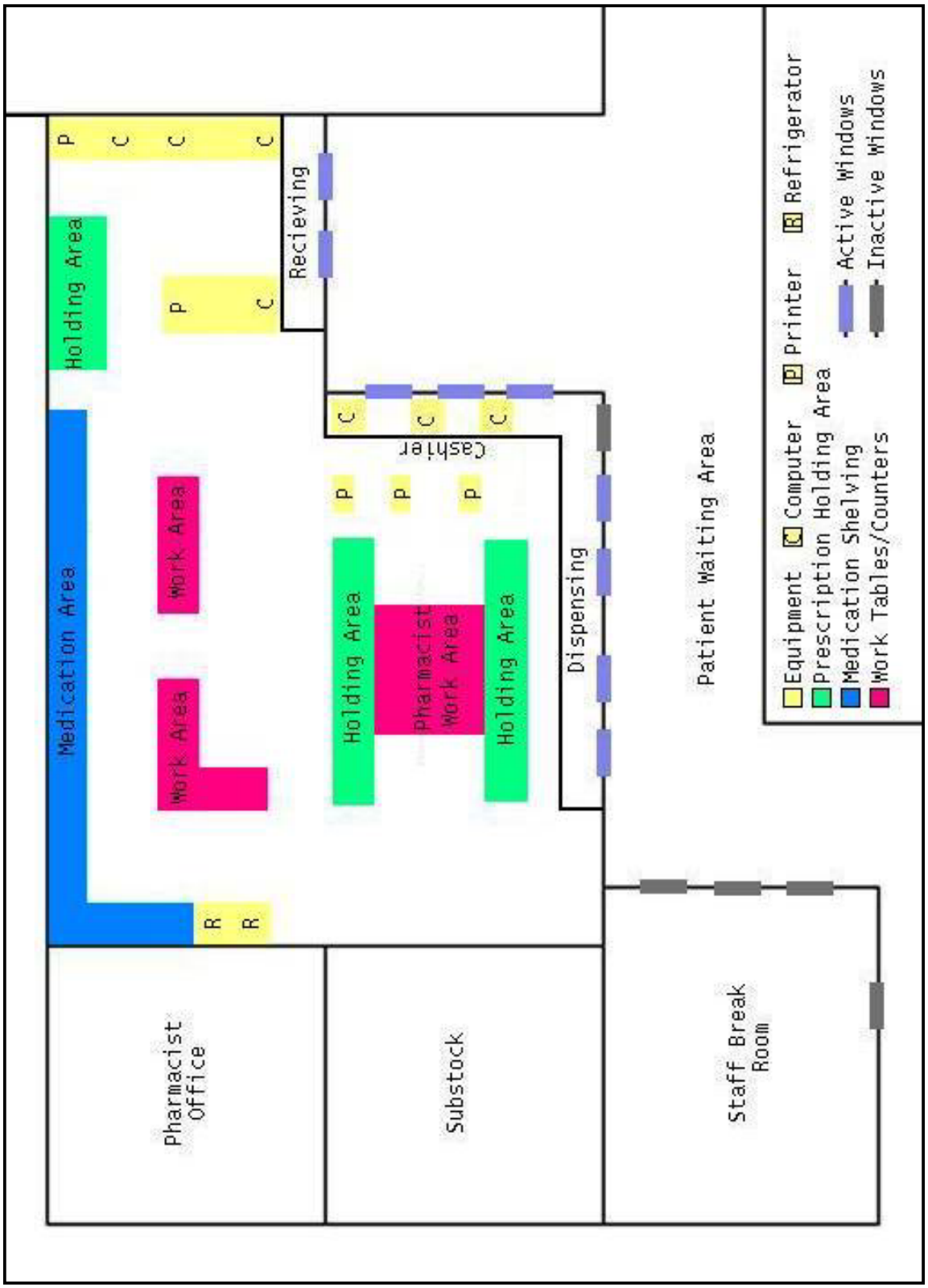


Appendix 3: Patients by Time Frame





Appendix 4: Recommendations with existing structure



Appendix 5: Recommendations with Renovations