A Lean Perspective of the Medication Delivery System at the Veterans Hospital (VA Boston Healthcare System – West Roxbury Campus)

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Abstract

Nurse-patient interaction time is vital to increasing the quality of patient care at any hospital. To increase the amount of time that nurses can spend with their patients hospitals are focusing on reducing the amount of time nurses spend delivering medications and locating missing medications. To reduce time spent dealing with missing medications the West Roxbury campus of the VA Hospital has recently installed a number of Omnicell units. This automatic medication delivery system provides a larger stock of medications for nurses to use in the event of a missing medication. This system also provides a convenient way of tracking the medications that are dispensed. Our project team worked to quantify the success of the Omnicell system at reducing missing medication reports and to characterize the medication delivery process from a nursing standpoint in order to identify areas of improvement.

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Authorship

Kristine DeSotto

Kristine managed the use of industrial engineering principles, in particular Lean, throughout the project. She was responsible for the process mapping and time studies and she created several forms that were used for data collection, including the time study tracking sheet.

Casey Krawic

Casey developed and carried out nurse interviews to evaluate the use of the Omnicell system on A1. Casey also was responsible for analysis of Omnicell usage data and creation of associated visuals that were used within this report.

Zachary Theoharidis

Zack was responsible for an extensive review of the past Rapid Process Improvement Workshop (RPIW) that took place at the hospital last May. Zack evaluated changes that were implemented as a result of the RPIW and evaluated their sustainability. He helped ensure that our recommendations were usable and sustainable within the hospital.

Joshua Wimble

Josh was responsible for much of the transition between data gathered to forming usable suggestions. Much of the initial Omnicell research was carried out by Josh. In addition, Josh worked in conjunction with other group members to ensure an appropriate amount of nurse interviews and cycle time data was collected.

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Chapter 1: Introduction

The goal of this project was to increase the amount of time that nurses at the West Roxbury Veteran's Hospital spend with their patients by decreasing the impact of non-value added activities. Our group worked to achieve this by obtaining and analyzing information related to medication delivery. In particular we focused on nurses' activities on the ward and the effects of the Omnicell, a medication storage device. A previous project team from Worcester Polytechnic Institute focused on the problem of missing medications from the pharmacy standpoint (Adams, Bishop, Corbo, Tabrizi 2010). After obtaining cycle time, Omnicell use data and nurse satisfaction information, we were able to advise the hospital on ways to reduce the impact of non-value added activities in order to streamline the medication delivery process. Reviewing the results of the Rapid Process Improvement Workshop (RPIW) from last spring also helped us to make suggestions which were feasible and sustainable in the West Roxbury campus. Although these suggestions were made for this particular hospital, the underlying ideas are applicable to any healthcare setting.

This project is based on the Institute of Healthcare Improvement's initiative, *Transforming Healthcare at the Bedside* (TCAB), which focuses on (1) safe and reliable care, (2) vitality and teamwork, (3) patient-centered care, and (4) value-added care processes (Institute of Health Initiatives 2010). One way the hospital is working to improve patient care is by increasing the amount of time that nurses spend with their patients. Activities such as searching for missing medications and being interrupted while administrating medications take away from this vital nurse-patient time. These activities are labeled as non-value added since they do not increase the quality of patient care. Throughout our project we were able to examine the current process and identify additional non-value added activities related to medication delivery.

In this report, information is presented in three major sections. Each section deals with a particular area of interest of the project. First, we present the information we gathered about the hospitals use of the Omnicell system including data analysis and feedback obtained directly from the nursing staff on A1. Next, we present our findings on the medication delivery process from a Lean perspective with a focus on the process from a nursing standpoint. Finally, we present our thoughts and evaluation of the Rapid Process Improvement Workshop (RPIW) which took place at the West Roxbury VA Hospital in May of 2010. Each of these sections contains a short background description, an overview of our methodology and a series of recommendations. The final section of this report is an overview of our overall findings and a discussion of future projects at the hospital.

Chapter 2: Omnicell Implementation

2.1 Omnicell Background

To reduce the number of missing medication reports, the West Roxbury campus has recently installed a series of Automated Medication Dispensing Devices on the wards. The particular system being used at the West Roxbury VA campus is the Omnicell. Systems similar to the Omnicell have been successfully deployed in hospitals since the 1980's as a way to increase efficiency of medication delivery (Shojania 2001). Our team followed up on the implementation of the Omnicell system in the hospital to evaluate its effect on the medication delivery system and to create suggestions for improvement, if necessary.

The purpose of the Omnicell is to have medications on the ward so they are available when the nurses need them. This becomes useful when a medication is missing from a patient's drawer or a new medication has been prescribed and not enough time has passed for it to come up from the pharmacy. Instead of spending time talking to pharmacy, filing a missing medication report and waiting for the medication to arrive, the nurse can go to the Omnicell and get the medication right away.

To use the Omnicell the nurses log into the system using a password or fingerprint. From there they select their patient from a digital list on the Omnicell which brings up a list of all his/her medications that are stored in the Omnicell. Once a medication has been selected the machine uses light indicators to assist the nurse in opening the correct medication bin. To ensure that medications are stocked for the nurses the pharmacy created par levels for each medication in the Omnicell. The system sends notifications to the pharmacy when levels go below the par levels. The pharmacists are then able to assemble the medications and refill the Omnicell in a timely manner.

2.2 Omnicell Methodology

The Omnicell was installed on the wards in order to reduce the large number of missing medication reports. To see the effect of the Omnicell on the number of missing medication reports, we obtained the number of missing medications reported and total medications dispensed between March 2010 and January 2011. Using this data, we were able to determine the number and percent of missing medications in the hospital, during that time period. See Figures 1 and 2 below for plots of the data.
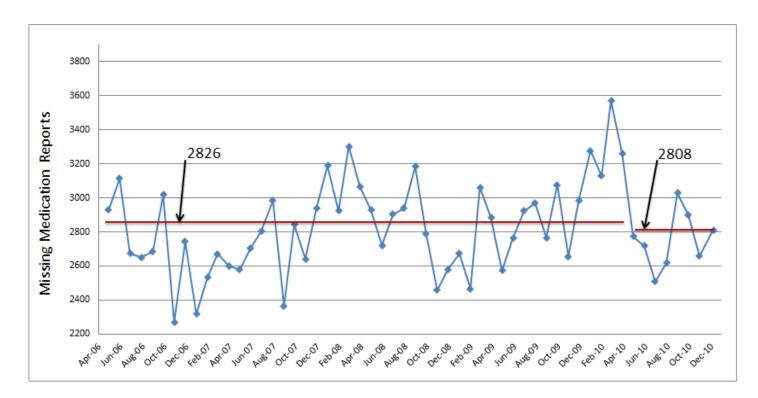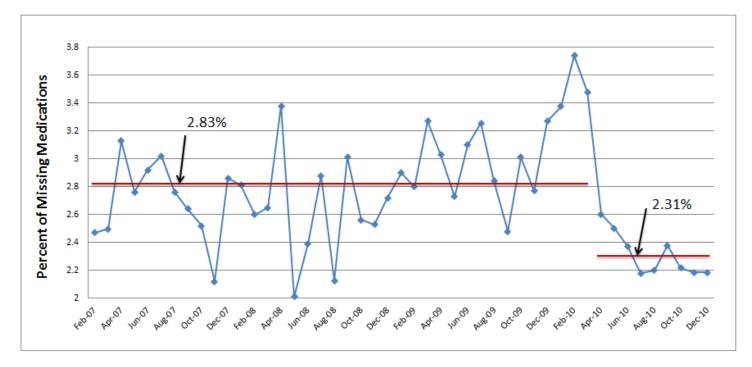
FIGURE 1: MISSING MEDICATIONS (NUMBER)

FIGURE 2: MISSING MEDICATIONS (PERCENT)

This data was also used to determine which medications were filed as missing most often. We focused on working with A1 so their most common missing medications were also compiled. The most common missing medications for before and after Omnicell implementation were compared. Although the Omnicell system collects vast amounts of data from its use including which medications were removed and the amount of time it takes for each access, this information is not available to the hospital in a convenient manner. The Omnicell company supplied the hospital with data on which medications were taken from the Omnicell during a 3 week period. The most commonly dispensed medications for the entire hospital and ward A1 were compiled and compared to the most common missing medications to ensure the Omnicell was stocking the appropriate medications.

In addition to an analysis of missing medication reports we performed a number of interviews with the nursing staff to gauge the nurses' reactions to the Omnicell. We performed informal interviews with the nurses on ward A1 following the morning and afternoon med runs, and followed up with a second survey three weeks later. In total, 11 surveys were completed, and 4 nurses were interviewed twice to gauge the changes in their attitudes over time. These surveys were structured to gather information about the nurses' use and comfort with the machine as well as their understanding of how it was integrated into the system. Their problems, concerns and suggestions were also collected and considered when analyzing the success and future applications of the Omnicell. The blank survey below (Figure 3) displays the questions we used to structure our interviews.

Date _____   Nurse _____

How often do you use the Omnicell?
_____ times per shift

For what reasons do you use the Omnicell? (indicate most common reason)
□ Medication not in drawer
□ Patient needs medication outside of med run
□ Narcotics
□ First dose
□ _____

Where do you check before you use the Omnicell?

Do you feel that it has been integrated well into the system? (1- poorly integrated. 5- well integrated)
□ 1 (poorly integrated)   □ 2   □ 3   □ 4   □5 (well integrated)

What effect does the Omnicell have on the medication delivery process? (1- hurts the process. 5- helps process)
□ 1 (hurts the process)   □ 2   □ 3   □ 4   □5 (helps process)

How does it affect the time spent on administrating medications? (1 – increases time. 5 – reduces time)
□ 1 (increases time)   □ 2   □ 3   □ 4   □5 (reduces time)

How does it affect the number of missing medications? (1 – increases number. 5- decreases number)
□ 1 (increases number)   □ 2   □ 3   □ 4   □5 (decreases number)

Has the Omnicell caused any problems for you? Which ones?

Overall comfort with the Omnicell   (1- comfortable. 5- very comfortable)
□ 1 (comfortable)   □ 2   □ 3   □ 4   □5 (highly comfortable)

Overall satisfaction with the Omnicell (1- not satisfied. 5- highly satisfied)
□ 1 (not satisfied)   □ 2   □ 3   □ 4   □5 (highly satisfied)

If you have a problem with the Omnicell, how fast can pharmacy help you fix it?

When do you file missing med reports?
□ When med is not in Omnicell
□ After retrieved from Omnicell
□ After stealing from another drawer
□ _____

What is the purpose of the missing med reports?
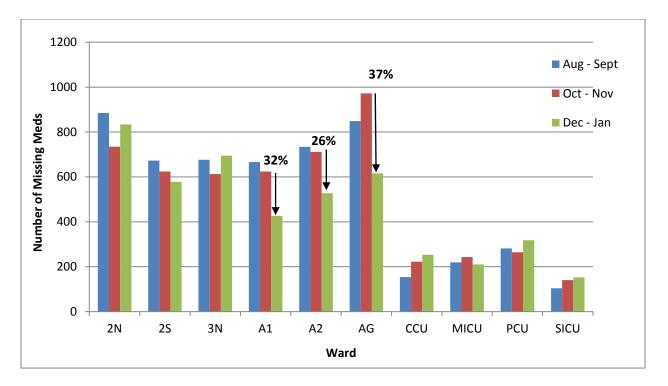□ Get a needed medication
□ Inform pharmacy
□ _____
□ _____

Any concerns or other opinions?

FIGURE 3: OMNICELL INTERVIEW QUESTIONS

2.3 Omnicell Results and Discussion

Since the Omnicell was implemented on the wards between October and December, the number of missing medications in two month intervals was compared (Figure 5). This way, the before and after Omnicell effects can be seen no matter when the Omnicell was implemented. A decrease in number of missing medications is apparent on A1, A2 and AG after the implementation of the Omnicell on December 1. The largest decrease was on AG which went from 972 missing medication reports to 616. This was a 37% decrease. The percent decrease from October and November to December and January for A1 and A2 can also be seen on the graph. The Omnicell appeared to have very little effect on the other wards in terms of number of missing medication reports.

In a few cases the number of missing medications went down and then increased again after the Omnicell was implemented. We believe that this could be a result of "false" missing medication reports and the learning curve of the hospital. During our interviews with the nurses, we found that some nurses were unsure of when they should be filing missing medication reports. This uncertainty could play a factor in why a decrease was not seen in all wards. With the Omnicell being new on all the wards it could take the nurses a little while to figure out what medications are in there. Each Omnicell holds about 200 different medications and there is a paper list that the nurses can check to see if their Omnicell contains the needed medication. If a nurse did not know that a certain medication was stored in the Omnicell and forgot to look at the list, he/she might've unnecessarily filed a missing medication report.

FIGURE 4: NUMBER OF MISSING MEDICATIONS BEFORE AND AFTER THE OMNICELL

Using the Omnicell data, a list of the most common medications taken from the Omnicell between December 17, 2010 and January 12, 2011 for A1 was created (Table 1). This list shows how many medications were retrieved from the Omnicell, the percent of these medications that were from A1 as well as the type of each medication. This showed that 8 out of the top 10 medications pulled from the Omnicell are narcotics and that these mediations make up 76.9% of all medications pulled from the Omnicell. This supported the statements from the nurses about their use of the Omnicell. When asked what they primarily use the Omnicell for, all the nurses responded with retrieving narcotics. This shows that the primary use of the Omnicell on A1 is to safely store narcotics. A similar list was developed for all wards with the Omnicell. Five medications were labeled with a color to show that they are located on both lists. Since each ward has different medications stored in the Omnicell, based on their specific demand, the top 10 medications pulled from the Omnicell in the entire hospital only represented 40.3% of all medications pulled from the Omnicell.

Ward A1		Total Meds: 596	
#	**Medication/Dose**	**Percent**	**Type**
1	OXYCODONE IR 5MG TAB	43.5	Narcotic
2	HEPARIN 5000UNIT/1ML 1ML INJ	7.9	**None**
3	OXYCODONE 5MG/APAP 325 1TAB TAB	5.7	Narcotic
4	MORPHINE 2MG/1ML 1ML TUBEX	4.2	Narcotic
5	MORPHINE PCA 1MG/1ML 30ML PCA	3.5	Narcotic
6	METHADONE 10MG TAB	3.4	Narcotic
7	METHADONE 5MG TAB	3.4	Narcotic
8	LORAZEPAM 1MG TAB	2.0	**Schedule IV***
9	HYDROMORPHONE 2MG/1ML 1ML TUBEX	1.8	Narcotic
10	HYDROCODONE/APAP 5/500 M 1EA TAB	1.5	Narcotic
		Total	**76.9%**

All Wards		Total Meds: 4440	
#	**Medication/Dose**	**Percent**	**Type**
1	OXYCODONE IR 5MG TAB	14.3	Narcotic
2	MORPHINE 2MG/1ML 1ML TUBEX	4.4	Narcotic
3	OXYCODONE 5MG/APAP 325 1TAB TAB	3.9	Narcotic
4	HYDROMORPHONE 2MG TAB	3.5	Narcotic
5	HEPARIN 5000UNIT/1ML 1ML INJ	3.0	**None**
6	DIAZEPAM 5MG TAB	2.3	**Schedule IV***
7	FUROSEMIDE 10MG/ML 1VIAL INJ	2.3	**Prescription Only**
8	LORAZEPAM 1MG TAB	2.2	**Schedule IV***
9	OMEPRAZOLE EC 20MG CAP	2.2	**OTC**
10	MORPHINE 4MG/1ML 1ML TUBEX	2.2	Narcotic
		Total	**40.3%**

* labeled under Controlled Substances Act (International Narcotics Control Board)

To see if the Omnicell had an effect on which medications were reported missing, the most common medications for A1 were compiled. Table 2 was created by last year's IQP team and shows the most common missing medications for A1 in year intervals. Five medications were highlighted to show that they appear every year in the top 10. This was compared to the common missing medications on A1 in October and November: the two months before the Omnicell was implemented (Table 3). The five common missing medications were still in the top 10 in the months leading up to the Omnicell. When compared to after the Omnicell implementation (December and January), only two of these medications remain (Multivitamin and Omeprazole 20mg). The only other medications that were found on both the before and after lists were Travoprost and Metoprolol Tartrate. All the other medications were not located on the before Omnicell list. Also, as seen in Figure 5, there was a decrease from 624 to 426 missing medication reports. You can see in these tables that the number of missing medications has been reduced for each individual medication.

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The data presented in Table 2 and Table 3 also show if the medication can be found in the Omnicell. After the implementation of the Omnicell, there were fewer medications that are found in the Omnicell that are reported missing. If the medication is located in the Omnicell, the nurse should not be filing a missing medication report. If all nurses were following this procedure, the list should not show any medications that are located in the Omnicell. While talking to the nurses, some were unsure when was the correct time to file a missing medication report after the addition of the Omnicell. This data is still early in the implementation so the nurses may not have been informed of the correct procedure which led to many "false" missing medication reports. Once the nurses are informed of the correct procedure, the most common missing medications for A1 should change to only be medications not found in the Omnicell.

TABLE 2: COMMON MISSING MEDICATIONS ON A1 PER YEAR

A1	Mar 2006 - Feb 2007			Mar 2007 - Feb 2008	
MMs: 3489			MMs:	3372	
#	Drug/Dose		#	Drug/Dose	
1	DOCUSATE NA 100MG CAP	94	1	RANITIDINE HCL 150MG TAB	83
2	FERROUS SO4 325MG TAB UD	94	2	FERROUS SO4 325MG TAB UD	79
3	OMEPRAZOLE 20MG EC CAP	69	3	DOCUSATE NA 100MG CAP	71
4	HEPARIN 5,000 UNITS/1 ML INJ	59	4	HEPARIN 5,000 UNITS/1 ML INJ	63
5	RANITIDINE HCL 150MG TAB	57	5	OMEPRAZOLE 20MG EC CAP	61
6	MULTIVITAMIN CAP/TAB	57	6	ENOXAPARIN SODIUM INJ 30MG	61
7	METOPROLOL TARTRATE 25MG TAB	47	7	MULTIVITAMIN CAP/TAB	51
8	SENNOSIDES 8.6MG TAB	40	8	FORMOTEROL FUMARATE 12MCG INHL	43
9	FOLIC ACID 1MG TAB	39	9	FOLIC ACID 1MG TAB	38
10	ALBUTEROL 90/IPRATROP 18MCG 20	38	10	ALBUTEROL 90/IPRATROP 18MCG 20	37
	Total	594		Total	587
	%	17.02%		%	17.41%

A1	Mar 2008 - Feb 2009			Mar 2009 - Feb 2010	
MMs: 3574			MMs: 3814		
#	Drug/Dose		#	Drug/Dose	
1	DOCUSATE NA 100MG CAP	92	1	DOCUSATE NA 100MG CAP	119
2	OMEPRAZOLE 20MG EC CAP	91	2	OMEPRAZOLE 20MG EC CAP	76
3	FERROUS SO4 325MG TAB UD	87	3	MULTIVITAMIN CAP/TAB	71
4	RANITIDINE HCL 150MG TAB	73	4	HEPARIN 5,000 UNITS/1 ML INJ	70
5	ENOXAPARIN SODIUM INJ 30MG	69	5	FERROUS SO4 325MG TAB UD	62
6	MULTIVITAMIN CAP/TAB	59	6	TRAMADOL HCL 50MG TAB	57
7	SENNOSIDES 8.6MG TAB	53	7	RANITIDINE HCL 150MG TAB	54
8	FORMOTEROL FUMARATE 12MCG INHL	50	8	ENOXAPARIN SODIUM INJ 40MG	51
9	HEPARIN 5,000 UNITS/1 ML INJ	45	9	FOLIC ACID 1MG TAB	47
10	TRAMADOL HCL 50MG TAB	44	10	ACETAMINOPHEN 500MG TAB	46
	Total	663		Total	653
	%	18.55%		%	17.12%

A1	Missing Meds on A1: **624**		Oct-Nov
#	**Medication/Dose**	**# of Meds**	**Omnicell?**
1	OMEPRAZOLE 20MG EC CAP	21	**Yes**
2	FERROUS SO4 325MG TAB UD	20	**Yes**
3	DOCUSATE NA 100MG CAP	14	**Yes**
4	RANITIDINE HCL 150MG TAB	14	**Yes**
5	ACETAMINOPHEN 500MG TAB	13	**Yes**
6	MULTIVITAMIN CAP/TAB	13	**Yes**
7	ENOXAPARIN SODIUM INJ 40MG	12	**Yes**
8	METOPROLOL TARTRATE 25MG TAB	11	**Yes**
9	MOMETASONE 220MCG/INHL INHL,OR	10	No
10	TRAVOPROST Z 0.004% OPH SOLN	10	No
	Total	**138 (22.2%)**	

A1	Missing Meds on A1: **426**		Dec-Jan
#	**Medication/Dose**	**# of Meds**	**Omnicell?**
1	HEPARIN 5,000 UNITS/1 ML INJ	8	**Yes**
2	SIMVASTATIN 20MG TAB	8	No
3	TRAVOPROST Z 0.004% OPH SOLN	7	No
4	ALBUTEROL 90/IPRATROP 18MCG 20	6	No
5	BUPROPION HCL 150MG 12HR SA TA	6	No
6	CARBIDOPA 25/LEVODOPA 100MG TA	6	No
7	MULTIVITAMIN CAP/TAB	6	**Yes**
8	ARTIFICIAL TEARS POLYVINYL ALC	5	No
9	COLLAGENASE 250 UNT/GM TOP OIN	5	No
10	CYANOCOBALAMIN 1000MCG TAB	5	**Yes**
11	GEMFIBROZIL 600MG TAB	5	No
12	METOPROLOL TARTRATE 25MG TAB	5	**Yes**
13	OMEPRAZOLE 20MG EC CAP	5	**Yes**
	Total	**77 (18.0%)**	

We also looked into the effects of Omnicell on the common missing medications for the whole hospital. Table 5 shows the common missing medications for all wards between April and November. By December 1st, all ten wards had the Omnicell implemented so the common missing medications for after Omnicell were gathered from December and January. Between the two time frames, nine medications were the same. Many of these medications can be found in every Omnicell in the hospital. There are still a number of missing medication reports filed when the medication is located in the Omnicell. One could argue that it is unnecessary to file a missing medication report when the medication can be found on

the ward. . In some cases, if the medication is located in the Omincell it should not be reported as missing so that the pharmacy doesn't bring up a medication that can already be found on the ward.

All Wards	Total Missing Meds: 20951		Apr-Nov
# **Medication/Dose**	**Percent**	**Omnicells with Med**	**Notes**
1 OMEPRAZOLE 20MG EC CAP	2.0	**10/10**	
2 DOCUSATE NA 100MG CAP	1.9	**10/10**	
3 MOMETASONE 220MCG/INHL INHL,OR	1.5	0/10	
4 GABAPENTIN 300MG CAP	1.2	3/10	A1, A2, AG
5 FERROUS SO4 325MG TAB UD	1.2	**10/10**	
6 ASPIRIN 81MG EC TAB	1.2	**10/10**	
7 FORMOTEROL FUMARATE 12MCG INHL	1.1	0/10	
8 SENNOSIDES 8.6MG TAB	1.1	**10/10**	
9 MULTIVITAMIN CAP/TAB	1.1	**10/10**	
10 HEPARIN 5,000 UNITS/1 ML INJ	0.9	**10/10**	
11 TIOTROPIUM 18MCG INHL CAP 30	0.9	8/10	Not A2, MICU
12 SIMVASTATIN 20MG TAB	0.8	9/10 (10MG)	Not SICU
Total	**14.9%**		

All Wards	Total Missing Meds: 4609		Dec-Jan
# **Medication/Dose**	**Percent**	**Omnicells with Med**	**Notes**
1 OMEPRAZOLE 20MG EC CAP	2.7	**10/10**	
2 MOMETASONE 220MCG/INHL INHL,OR	2.2	0/10	
3 ASPIRIN 81MG EC TAB	2.0	**10/10**	
4 METOPROLOL TARTRATE 50MG TAB	1.5	**10/10 (25MG)**	
5 FORMOTEROL FUMARATE 12MCG INHL	1.5	0/10	
6 HEPARIN 5,000 UNITS/1 ML INJ	1.4	**10/10**	
7 DOCUSATE NA 100MG CAP	1.3	**10/10**	
8 TRAVOPROST Z 0.004% OPH SOLN	1.3	0/10	
9 SENNOSIDES 8.6MG TAB	1.2	**10/10**	
10 SIMVASTATIN 20MG TAB	1.2	9/10 (10MG)	Not SICU
11 ALBUTEROL 90/IPRATROP 18MCG 20	1.1	1/10	Only SICU
12 VANCOMYCIN ORAL SOL. 250MG/5ML	1.1	0/10	
13 GABAPENTIN 300MG CAP	1.1	3/10	A1, A2, AG
Total	**19.7%**		

The nurse interview indicated that there seemed to be a change in the nurses' perception of the Omnicell from January 19th (round 1) to February 9th (round 2). Overall, the rating of how well the Omnicell was integrated into the process, effect on process, and the nurses' comfort with the system went up, as shown in Figure 6 below. The only rating that decreased was their satisfaction with the Omnicell which went from 4.83 to 4.60.
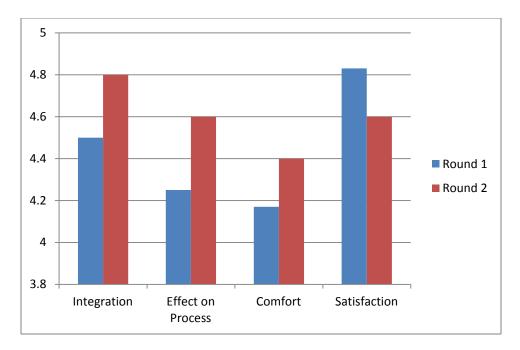
We observed that the nurses are becoming more comfortable with the Omnicell and they feel that it has improved the medication delivery process, but their satisfaction with the system seems to be decreasing. A possible reason for this decrease in satisfaction is the number of times the nurses use the Omnicell per shift. The average number of uses per shift increased from 7.58 in the first interview to 8.00 in the second interview. This was not a statistically significant increase but if nurses feel like they are walking to the Omnicell too much, this could decrease their satisfaction. If the number of trips continues to increase over time, there will be more walking to and from the Omnicell and more opportunities for problems with the system to arise.

Another source of dissatisfaction possibly came from a lack of transparency between the nursing and pharmacy departments. Several nurses felt that the pharmacy was neglecting to ensure that common medications made it in the patient's drawer because they were readily available in the Omnicell. From our interviews with the nursing and pharmacy staff it is our opinion that this is a problem due to a difference in the definition of a missing medication. After interviewing the nurses we discovered that some of them believed that if a medication is not in the patient's drawer it is missing, whether or not it can be obtained from the Omnicell. On the other hand some nurses felt like the pharmacy did not view medications as missing if they were available in the Omnicell. These subtle differences in the definition of a missing medication, in our opinion, contributed to confusion among

nurses on A1. It is possible that this confusion arose since the pharmacy was initially not sending up first doses for all new orders. The hospital attempted to remedy this by sending up first doses as it had in the past, which decreased the number of trips the nurses had to take to the Omnicell. Since we were at the hospital right after the implementation of the Omnicell, it is possible that some of these problems were due to the newness of the system. The hospital is still continuing to improve how the Omnicell is integrated into the medication delivery system.

This confusion carried over to frustration within the pharmacy. Technicians and pharmacists were frustrated when missing medication reports were filed for medications in the Omnicell. From their point of view since the medication was on the ward it was not missing. In our interviews we observed that nurses were not really sure when they were supposed to be filing missing medication reports. In the first round of interviews one nurse said that she filed a report for every medication that was not in her patient's drawer. Other nurses were filing the report only if the medication was not in the Omnicell but none of the nurses seemed confident that what they were doing was correct.

One of the most significant problems that we observed with the use of the Omnicell was discrepancies. Problems like milligrams instead of tablets showing up on the Omnicell screen creates confusion for the nurses as well as the pharmacy and staff members must spend time sorting out the problem in order to ensure that the patient receives the correct medication. This could also cause problems for other nurses who need to get into the room to use the Omnicell but it is filled with nurses trying to solve a problem.

Apart from our observations a few nurses commented on how the Omnicell is working for them personally. In our first round of interviews, one nurse was frustrated that more medications were not making it to the patient's drawer. Even though she was satisfied with and felt comfortable using the Omnicell she felt that it increased the amount of time it takes to deal with a missing medication and that it causes more work for her. She also wanted to know why all medications could not be stored in the Omnicell. This would simplify the process since nurses would only have to look one place for a medication. Several of the nurses were pleased with the Omnicell since it saved them time on counting narcotics after each shift but one nurse noted that when problems arose with narcotics it could take up to twenty minutes to solve them.

Our second round of interviews also provided us with several comments about the Omnicell. Two nurses liked the Omnicell since it helped them keep track of the medications they had administered and what was still missing. When we asked about pharmacy's ability to help resolve problems, two nurses said that sometimes people at the pharmacy do not know how to fix the problem either.

Even though problems arise from time to time, the nurses are happy that they have the Omnicell. From both surveys, nurses commented on how the Omnicell saves them time during narcotic counts as opposed to the system which was in place before the Omnicell. Additionally, the pharmacy is doing a thorough job ensuring the Omnicell is fully stocked so there are no worries of going to the Omnicell for a medication and finding that it is out of stock.

2.4 Recommendations

To improve the implementation and use of the Omnicell at the VA hospital and in particular on A1, we recommend the following changes. In order to reduce frustration between the nursing and pharmacy departments we suggest standardizing the process so that it is clear for everyone to follow. Nursing managers and pharmacists need to discuss the current use of the Omnicell and understand what is happening outside their own department. Currently nursing and pharmacy representatives meet often to discuss problems and solutions identified by staff members. There are also meetings to discuss the implementation and progress of the Omnicell systems. Although these meetings have done much to maintain communication between pharmacy and nursing we find that there may be room for improvement While talking to the nurses it is evident that many are not completely clear about Omnicell protocol. We suggest an improvement in the way that information is communicated from these meetings to other nurses on the wards. It is important to stress that missing medication reports are to be filed only if a medication is not located in a patient's drawer *and* not located in the Omnicell on the ward. This should help reduce "false" missing medication reports and prevent any duplicate orders from being processed by the pharmacy. In addition, this recommendation should reduce the amount of time nurses have to spend filing these reports, which will have a direct effect on increasing nurse-patient interactions. If the nurses go back to reporting medications as missing even when they are located in the Omnicell, the pharmacy will notice this. They can then inform the person in charge of educating the nurses about the increase in "false" missing medication reports so the wards can be reminded of correct procedures. If nurses and the pharmacy work together, they can reduce the number of "false" missing medication reports.

A vital part of this recommendation is nurse education. We have heard from hospital staff that the Omnicell company has done a great job of training the nurses to use the Omnicell, but more can be done. Nurses need to know exactly when to use the Omnicell. Lack of standardization as to when the nurses should be using the Omnicell is creating confusion and frustration within the medication delivery system. Removing this variation will create a better experience for everyone involved.

A second recommendation is to reschedule when pharmacy technicians fill the Omnicell. During our observations we noticed that the Omnicell was being refilled during the morning medication run. This is one of the busiest times of the day on the ward and a backup at the Omnicell can greatly slow down the medication run. Pushing back the refill time to later in the morning or even after the cart exchange will help alleviate congestion with the Omnicell.

In order to make our recommendations more sustainable we would like to see the hospital create a training program for all incoming nurses. This program should emphasize the purpose of the Omnicell, when it is appropriate to use it, and when to file a missing medication report. This should help eliminate some confusion and variability with the process by creating standards that every nurse follows. We would also like the hospital to pick several dates in the future to review our proposed changes, if they are implemented. It is important to emphasize the usefulness of following up on changes at the hospital. Reevaluation of these changes will help the hospital see if they were successful and what could be done to improve these change for the future. Also, to reiterate one of our previous recommendations, communication between nursing and pharmacy is critical to reducing problems with medication delivery. Regular meetings between the two departments might help reduce the number of miscommunications.

Chapter 3: Process Mapping and Analysis

3.1 Process Mapping Background

Lean is the application of manufacturing principles and techniques to produce a system that focuses on the needs of the customer as well as reduction of waste. To identify needs of the patients we relied on the Transforming Care at the Bedside (TCAB) initiative which focuses on increasing the amount of time nurses can spend with their patients. To improve the medication delivery process we would ideally like to eliminate waste but due to the complexity and many sources of variety in the process, we instead focused on reduction of waste, including waste of time and materials. Applied to current systems at the hospital, Lean principles will help improve patient care while fulfilling patient care goals by the hospital.

One key principle of Lean is that any process should be designed to maximize the value of the final product. The focus of this principle is to "understand the value of the work performed, by defining it as something the customer wants to pay for" (Jacobs 2009). At West Roxbury the customers, or patients, want to receive high quality care. Through the TCAB initiative, the hospital has been striving to achieve high levels of patient satisfaction and safety by improving efficiency of patient care.

Another key principle of Lean is the value chain, which consists of mapping process steps and identifying which steps add value and which steps add waste (Jacobs 2009). This technique was useful in helping us identify what activities take away from the time nurses can spend with their patients. Examples of waste in the medication delivery process include time spent submitting missing medication reports and time spent searching for missing medications. Value techniques allowed us to identify these sources of waste and make recommendations towards reducing waste in the system which will in turn improve patient care.

To reduce waste it is important to focus on the reduction of natural and artificial variability. Examples of natural variability in the medication delivery system include the changing number of patients in the hospital and the varying severity of illness for each patient. The hospital has no control over these factors and must deal with them as they occur. As more patients come on the ward nurses are put under more stress which could lead to more mistakes. More patients in the ward means more patients per nurse. The optimum staffing ratio is one nurse for every four patients. When there are more than four patients per nurse, the nurse is more likely to be put under more stress and make more mistakes. The only way to deal with this variability is to change the number of nurses working according

to the number of patients on the ward. This is difficult to do when there are financial constraints and limited numbers of nurses (Litvak 2005). Also, the complexity of the patient must be taken into account. One patient could have one or two simple medications so it would only take a few minutes to prepare and administer the medications. Another patient could have many medications including IV medications and may have to take one medication at a time. It would take much longer to administer the second patient's medications. It is important to remember that these variations in patients cause the medication runs to be longer on some days and shorter on others.

Artificial variability consists of non-value added activities that are controllable factors. These factors can range from distractions to activities that should not be performed at a certain time. These factors can be hidden when the natural variability is not taken into account. When a patient with low complexity has a long medication run time, there could be artificial variability that is slowing the process down. When seeing how long a medication run is taking, it is important to note the complexity of the patient in order to have a better sense of what the run time should be without the interruptions of artificial variability.

3.2 Process Mapping Methodology

Due to the complex nature of the current medication delivery system, we limited our observations to one ward, A1, to ensure we are able to develop a detailed understanding of the processes involved in medication delivery. We examined and mapped out the current system and collected data to calculate cycle times. By doing this for a number of different nurses on a single ward we were able to observe variation within the delivery process. Figure 7 is an image of the form we used to time each step within the medication delivery process.

Number of Medications		Start	End
Begin Medication Run			
Walk to Patient Room with Scanner			
Scan Patient ID			
Walk Back to Med Cart			
Confirm Medication			
Assemble Medication			
Check Order Type			
Check Time Ordered			
File Missing Medication Report			
Walk Back to Patient Room			
Administer Medication			
Look in Miscellaneous Places:			
□ Ward Stock □ Omnicell			
□ Bedside □ Inbox			
□ Check Drawers			
Omnicell use?	Yes	No	Time:

FIGURE 6: TIME STUDY TRACKING SHEET

In addition, we worked to identify factors that affect variability and nurse performance. One of the ways we quantified this was by using the following chart, shown in Figure 7. This allowed us to consider the complexity of the patient's needs and his/her medications. It also allowed us to track whether or not a nurse was required to put on a gown before entering a patient's room. Along with this variability chart we tracked the number of patients each medication nurse had. We chose to track these factors since they were identified as some of the major sources of variability within the medication delivery system.

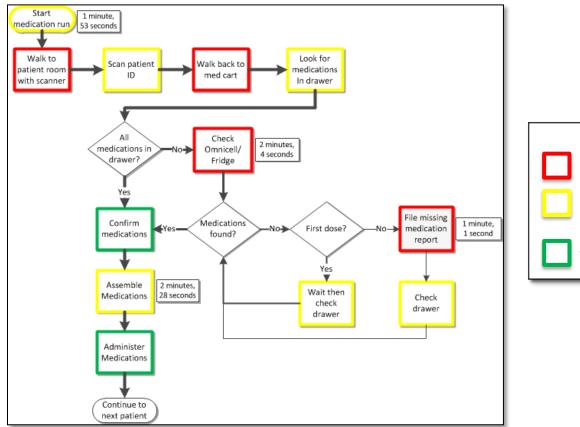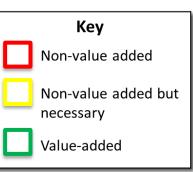| Complexity (Scale 1 to 5)	Patient	Medication	Gown up?
Patient 1			
Patient 2			
Patient 3			
Patient 4			

FIGURE 7: VARIABILITY ANALYSIS SHEET

3.3 Process Mapping Results and Discussion

After analyzing the data we collected, we made a flow chart for a general medication run on ward A1 (Figure 8). We used three different colors to highlight the amount of value that each step adds to patient care. Red highlights non-value added steps that do not directly add to patient care, yellow highlights non-value added but necessary steps and green highlights value-added steps. Analyzing each of the steps allowed us to identify steps in the medication delivery process that are problematic.

In general the nurses would start the medication run at the medication cart and then walk to the patient room with the scanner. The nurses would scan their patient's identification band to verify that they were delivering medications to the correct patient. They would then walk back to the medication cart and look for the needed medications in the patient's drawer at the medication cart. Each patient has his or her own drawer and every medication should be kept there, except narcotics and medications that must be refrigerated.

If all of the medications were found in the patient's drawer than the nurses would confirm that they had the right medications, assemble the medications and then administer the medications. If all the patient's medications weren't in the drawer the nurses would have to check the Omnicell and the refrigerator. If the medications were found then the nurses could go on to confirm, assemble and administer the medications. If the needed medications weren't in the Omnicell or refrigerator then the nurses would need to find out whether or not they were giving a first dose. If it was a first dose then the nurses would need to wait and later on check the patient's drawer to see if the medication had come up from the pharmacy. If it wasn't a first dose than the nurses would need to file a missing medication report and then wait for the pharmacy to deliver the medication. Once the medications were delivered to the patient's drawer the nurses could finish their medication run by confirming, assembling, and administering the medications.

FIGURE 8: FLOW CHART OF NURSE ACTIONS DURING MEDICATION RUNS

During our time on the ward we noticed that, in general, when medication runs went smoothly all of the nurses worked together in a well-organized group to efficiently deliver medications. During one observation, a nurse could not find scissors on her cart so she asked another nurse who was not administering medications to find scissors for her. The medication run nurse was able to continue preparing the medications while the other nurse looked for scissors.

Our flowchart also gives average times for a few steps in the process (Figure 8). We included these times in our discussion since they were higher than we believed they should be. Starting the medication run took 1 minute and 53 seconds. Assembling medications took an average of 2 minutes and 28 seconds. Looking in the Omnicell or refrigerator took 2 minutes and 4 seconds. Finally, filing a missing medication report took 1 minute and 1 second. To explain why these steps took so long we have included a table of common problems (Table 5).

Step	Areas of Improvement
Start medication run	Software problems, cart batteries dying
Check Omnicell/Fridge	Pharmacy restocking during morning medication run, Omnicell stock list not easily accessible
Walk back to medication cart	Medication carts aren't near patient's room, many distractions
File missing medication report	Nurses aren't sure when to file reports
Assemble medications	Cart supplies are sometimes missing, nurses take multiple trips to Omnicell per patient

TABLE 5: AREAS OF IMPROVEMENT WITHIN THE MEDICATION DELIVERY SYSTEM

On the other hand we noticed that in many cases nurses were unable to concentrate their efforts on delivering medications since they were interrupted by various other people and problems. Many of these problems were unavoidable due to the variety of different patients but a few of them present possible areas for improvement which we will discuss in the next section.

At the beginning of the medication runs we observed a number of examples of poorly functioning technology interfering with patient care. More than once, the batteries for the mobile medication carts would die before or during the med run. This would cause lengthy delays as the cart would have to be wheeled back to the docking stations and be replaced with a different cart. The nurse would then have to spend time logging in to the computer and opening the appropriate software. Nurses also experienced issues with the Bar Code Medication Administration software (BCMA) and the computers on the medication carts. On one occasion a nurse spent over five minutes on the phone talking to multiple individuals because her account had been locked out of the network.

We also noticed problems with use of the Omnicell. During one morning medication run the pharmacy came to refill the Omnicell while nurses were trying to access the system for missing medications which greatly slowed down the medication run since nurses couldn't get into the room to access the Omnicell while the pharmacy technician was in there. When a nurse was unsure what medications were located in the Omnicell, he or she had to walk to the ward stock room to look at the list. If the medication was in the Omnicell the nurse was able to retrieve it but if it wasn't the nurse had

to walk back to the medication cart and fill out a missing medication report. This caused the nurse to take an unnecessary trip to the Omnicell.

If a nurse doesn't roll the medication cart close to the patient's room then s/he increases the amount of walking s/he must do. Since walking is a non-value added activity as we mentioned above it was something that we focused on reducing. Additional walking also seemed to correspond with additional distractions, which is another reason for reducing the amount of walking nurses must do during a medication run.

We also observed several nurses who were unsure of when they were supposed to file a missing medication report. A nurse unnecessarily filing missing medication reports is a step in the process that we would like to see improved. Another non-value added activity is searching for missing supplies that are needed when the nurses assemble medications for their patients.

We also noticed nurses taking multiple trips to the Omnicell for the same patient. After scanning the patient's wristband they noticed that the patient had narcotics and went to the Omnicell for these. After retrieving these medications they walked back to the medication cart and noticed that a regular medication was missing from the patient's drawer. This medication was in the Omnicell so they had to make another trip to the stock room which increased the amount of time the medication run took.

3.4 Recommendations

We found that nurses are generally doing a great job of assembling and distributing medications if they are available in the patient's drawer as they should be. To help reduce the amount of time the nurses spend on non-value added activities during the medication run we came up with several recommendations which are listed below (Table 6).

Proposed Solutions
Regularly charge medication cart batteries
Have pharmacy avoid restocking Omnicell during morning medication run
Make Omnicell medication list available on medication carts and outside of ward stock door
Clarify when to file missing medication reports
Keep regularly used equipment (scissors, etc.) on cart
Bring medication carts into the patient's room
Minimize number of trips to Omnicell – once per patient is best

TABLE 6: RECOMMENDATIONS TO IMPROVE MEDICATION RUNS

First of all we would like to see a system for regularly charging the medication cart batteries. This would help the nurses since they wouldn't have to worry about the carts dying in the middle of their medication run.

Our second recommendation is to have pharmacy technicians avoid restocking the Omnicell during the morning medication run. With the implementation of the Omnicell system on the wards, there was some concern among nurses and other hospital staff that access to the Omnicell might be slow and cause backups that would hinder medication delivery. In our experience, nurses generally are very quick about accessing and retrieving the medications they require but these times increase greatly when a technician is trying to restock the Omnicell. This also creates problems later on since nurses must repeat steps like scanning their patient's wristband to administer medications they weren't able to access quickly.

Currently, there is a list of the medications available in the Omnicell posted in the ward stock room which allows the nurses to check availability of medications without having to occupy the unit. We believe that adding this list to each of the medication carts and posting it on the outside of the ward stock door could save nurses time walking back and forth to the ward stock room as well as eliminate some of the spaces issues in the small room.

Our next recommendation is to clarify when nurses should be filing missing medication reports. This will eliminate unnecessary work for nurses and the pharmacy. If both departments are on the same

page as to when medication reports should be filed staff members on both sides will be happier with the current medication delivery system.

To eliminate the need to search for supplies we would like the medication carts to hold supplies like scissors that are commonly used during medication assembly. The nurse knows what medications each patient needs and the supplies that are needed to administer these medications. In addition to organizing the carts if the nurses took a minute to check their supplies before the medication run began it would reduce interruptions later on when the nurses should be focusing on administering medications instead of searching for supplies.

Another recommendation we have is for the nurses to bring the medication carts into the patient's room. This should reduce the amount of walking time and the amount of distractions due to walking around. Although the nurses won't have to walk as far there is a risk that the battery will run out and the computer will shut down. This problem can be solved by making sure the cart is fully charged before starting the medication run. If the nurses know that the cart will not make it through the entire medication run before the battery dies, they should find a location central to a few of their patients and plug it in there. The nurse may have to walk farther but this is much better than starting up a new computer if the original medication cart battery dies.

We also recommend that nurses take one trip to the Omnicell per patient. If there was a set standard for the nurses to check for both narcotics and missing medications before going to the Omnicell, then they can retrieve both in the same trip. This would reduce the amount of time spent using the Omnicell and walking to and from the Omnicell.

While we do have several recommendations we would like to point out that the nurses know what's best for their patients. If any of our recommendations in anyway make it harder for the nurses to safely deliver medications to their patients then they should not be considered.

These suggestions are small but together could have a large impact on the time it takes to do a medication run. When systems like the Omnicell are implemented the process must change to accommodate the new system. If nurses aren't told the best way to use a system like the Omnicell then they will either do what is easiest or what they think is best and the process will not be standardized between all nurses. The nurses must be directly told what the new standard process is and why it is the best way. Through solid implementation these recommendations can greatly improve the current medication delivery system.

Chapter 4: Rapid Process Improvement Workshop

4.1 RPIW Background

A Rapid Process Improvement Workshop (RPIW) is a fully immersive three to five day program that integrates members from all departments of an organization. The goal of the workshop is to fully understand, analyze and improve a complex process. This should result in the processes being more efficient and standardized. In the workshop an RPIW leader guides the group through the workshop to ensure the group gains a full understanding of the process. It is not enough to simply make changes; members of the organization must be educated on these changes and their importance.

In response to recommendations from the previous WPI project team the West Roxbury VA Hospital held an RPIW on May 10, 2010. Staff members from several departments met for three days to address the problem of missing medications and to consider ways to improve the medication delivery process. They used process improvement techniques such as process mapping to highlight parts of the process that were wasteful or problematic.

After the current medication delivery process was mapped out in detail, problem areas were identified. Next, the team developed an "ideal" map that included only those steps necessary to patient care. Finally, team members selected specific areas in which they could create projects within the hospital to reduce the number of missing medications. The team, which included nurses from all surgical units, one nurse from the ICU unit and two pharmacists, analyzed the problem of missing medications and how it compromises patient safety and quality of care. At the end of this workshop, the goal was to implement processes or make changes which would "decrease missing medication incidents to ensure that medications are available 100% of the intended time of administration" (RPIW 2010).

There were many problems that were highlighted during the RPIW, but only some improvements were selected for implementation On July 20, 2010, a follow-up presentation revealed how well problems were addressed and how successfully the solutions were implemented. The following section describes the projects that took place as a result of the RPIW.
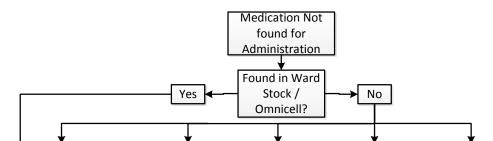
4.2 RPIW Summary

The RPIW in May of 2010 led to the identification of a number of problem areas in the medication delivery process at the West Roxbury campus. The first problem addressed was that the TUG, a medication delivery robot, was not being emptied consistently. This led to the medications being brought back to the pharmacy and nurses would report those medications as missing when they were needed later in the day. To address this problem, the TUG robots needed to wait for longer on the wards before they would return to the pharmacy. Because each TUG waits on the ward for a set and easily changeable amount of time, the solution to this was simple – the wait time was increased from 5 minutes to 10 minutes and the nurses were educated on the importance of emptying the TUG when it arrives. This decreased the percent of times that that the TUG was not emptied from 4.66% to 1.33% (RPIW Review July 2010). While this was a great improvement, it did not have a large effect on the amount of missing medications.

The workshop also revealed that there was not a standard process for cart exchange. When the cassettes containing the next day's medications were replaced by the pharmacy, some cassettes would be misplaced or half empty. This would result in missing medications on the ward. The solution was to implement a docking system for the cassette exchange. This resulted in a decrease in cart exchange time by 22% in the test unit. The system was then implemented in other wards.

Another problem which was examined in detail by last year's project team was that new medications were on occasion being unnecessarily reported as missing. Two major causes were identified for this problem. The most obvious was that the medications were being misplaced on the ward once they had been delivered; either in another patient's drawer or in a non-typical place such as the refrigerator. Upon closer inspection, it was realized that some of the medications were being filed as missing before they could be delivered to the ward. To help solve this problem, nurses were educated on the "two hour window," the time after which it is okay to file a missing medication report.

Additionally, a missing medication algorithm sheet was created for each ward as a reminder of the steps that nurses should be taking if they cannot find a medication (Figure 9). These sheets were created to show nurses a standard list of locations in which they may be able to find their patients medications. After implementation of these changes on trial wards the number of missing medications on two wards dropped significantly by almost 100 medications per month between January 2010 and June 2010. The algorithm was then modified to be implemented on all other wards of the hospital with hopes of achieving the same success.

Lack of understanding of the entire medication delivery process causes confusion in the hospital and is an additional possible cause of missing medications. Often times, there is very little information available to nurses and pharmacists about the processes which take place in other parts of the hospital. This leads to confusion and annoyance between the two parties which is detrimental to their combined efforts. A cross-training program was implemented to help improve this lack of understanding between the wards and the pharmacy. The plan was to have nurses trained on how the pharmacy assembles medications while the pharmacist would observe medication delivery from the wards. This resulted in all new nurses being trained, but pharmacist training on the wards and training of current nurses has been limited due to staffing shortages. However this training is an ongoing process which is still taking place at the hospital. Although we weren't present at the hospital long enough observe changes ourselves, hospital staff has seen an improvement in how well pharmacy and nursing work together and understand each other's roles. The RPIW team also decided that standardization of medication stock rooms might decrease missing medications. If the rooms were standardized, the nurses would know exactly where to find medications instead of reporting them missing when they actually are not. The medication room in ward 2N was standardized on June 8, 2010. There was no change in the percent of missing medication reports in the months that followed so it was not expanded to other wards. Instead, it was decided that implementing the Omnicell in the wards would have a bigger effect on the percent of missing medications.

4.3 Effectiveness and Lasting Impact of RPIW

To compare the impact of the RPIW on missing medications we did a two-tailed, paired t-test on the missing medication data. The first set of data was missing medications reports filed between February 2007 and March 2010. The second set of data was taken from April 2010 to December 2011. This test indicated that the difference between these two samples is statistically significant ($p=0.00029$, $\alpha=.05$). It seems that the RPIW did have an impact in reducing the number of missing medication reports filed, although the difference in the total percentage of missing medication reports filed between the two time periods is 0.52% (as a percentage of the total medications dispensed). This corresponds to a 22% decrease in missing medications, a very significant figure Despite the seemingly small percentage

this actually corresponds to a very large number of physical missing medications which resulted from changes due to the RPIW. Such a large reduction in this number has a huge potential for cost savings.

To ensure that our recommendations were useful to the hospital we set out to present changes which were easy to implement and were also sustainable. We believe it will be very valuable to the hospital to continue to closely monitor the Omnicell use and track its effects on the medication delivery process. In addition, to help simplify the complexity of a new system such as the Omnicell, we believe an increase in nurse education and a standard procedure for using the Omnicell would be useful.

Chapter 5: Conclusions

During our time at the West Roxbury VA we learned several different things about how the hospital system works by viewing the processes and interviewing different staff members at the hospital. It was clear from the beginning that some of the nurses were aware of problems with the system and wanted them to be addressed. The challenging part for our group was finding creative solutions to the hospitals problems. With the strain on staff to do so many things and software issues that often discourage simple solutions we had to look deeply into the process and try to understand the root cause of the hospitals problems.

The first aspect of medication delivery that we examined was the new Omnicell system and its use within the hospital. The goal of the system is to reduce the number of missing medications on the ward. By eliminating the need for a large number of missing medication reports the hospital hoped that it could increase the amount of time the hospital staff members have to treat patients. Although initially it looked to be the solution to the hospitals problems, the nursing staff was concerned that the Omnicell was just a band aid for the missing medication problem; it helped cover up the symptoms but did not completely solve the problem. By obtaining accurate information from the people who used the Omnicell every day and watching them in action we were able to brainstorm several things that might make the system more efficient. After the Omnicell implementation we conducted a number of nurse interviews to develop an understanding of how nurses interacted with the new system. Combining this with the information we gathered directly from missing medication reports and Omnicell use data, we were able to identify some areas for improvement.

We then used process mapping as a way to help identify problem areas within the medication delivery process. We also used these techniques to examine variability within the medication delivery process and its effects on the hospital system. We did this in an attempt to eliminate non-value added steps and also to identify steps and processes that were working well for the teams on the ward. One of the most important observations that we made was that situations are constantly changing and evolving on the wards which makes it difficult to develop a standard set of steps for any event. In emergency situations it is primarily up to the nurses to take care of several things at the same time but creation of a standard workflow for nurses would be beneficial. To help alleviate some of these stresses we worked to create a simple, standard workflow for nursing work on the ward.

To understand how to recommend useful changes to the hospital we reviewed the work completed at the RPIW from this spring. We were able to see some of the current changes to the

hospital and how they were working. In some cases the changes resulted in a sudden spike in effectiveness but eventually, missing medication numbers rose back up as people forgot about the changes. Because of this we knew that sustainability in our recommendations would be extremely important for the success of the system.

Using the information presented in this report as well as the recommendations our team developed, it is our belief that the West Roxbury campus of the VA hospital can implement these changes which will result in a positive impact on patient care and quality of service.

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