RECREATING THE WHEEL: REDEPLOYING PHARMACY SERVICES TO IMPROVE EFFICIENCY AND PATIENT SAFETY

by

John Carroll Cadwalader

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The essay is submitted

by

John Carroll Cadwalader

on

April 20th, 2015

and approved by

Essay Advisor: ______________________________
Julia Driessen, PhD
Assistant Professor
Department of Health Policy and Management
Graduate School of Public Health
University of Pittsburgh

Essay Reader ______________________________
Sandra Kane-Gill, PharmD, MS, FCCM, FCCP
Associate Professor
School of Pharmacy
University of Pittsburgh

Essay Reader ______________________________
Alfred L'Altrelli, PharmD
Pharmacy Manager
UPMC Presbyterian Hospital

Julia Driessen, PhD

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John Carroll Cadwalader, MHA

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ABSTRACT

The Institute of Medicine's (IOM) publication *To Err is Human* identified medical and medication errors as a significant threat to public welfare and public health. In response to the publication the Institute for Healthcare Improvement (IHI) has created the "5,000,000 lives" campaign to reduce adverse outcomes due to error. Simultaneously, the IHI has promoted it's Triple Aim Campaign which compels health care organizations to increase the health of populations while also minimizing patient costs and enhancing the patient experience. The UPMC Presbyterian Pharmacy department is redeploying its pharmacy resources in an attempt to better contribute to the principles of the Triple Aim Campaign and improve patient safety by enhancing its technical efficiency, improving operational services, and optimizing its automation to improve medication safety.

The pharmacy department created service line groups that treat specific patient populations such as cardiology and neurology. These groups consist of a central pharmacist, unit-based pharmacist, and service line technician. This intervention was created to address the problem of medication delays and the lack of standardization and accountability for the provision of operational and clinical pharmacy services. Objective measures of performance include reported medication delays, missing medications, number of discharge prescriptions, and percent of total medications discharges from the automated dispensing cabinets and from the RobotRx

machine. Comparison of pre-model to post-model pharmacy services showed that medication delays and missing medications decreased by 49% and 85%, respectively.

The pharmacy department service line model has taken measures to improve patient health by minimizing medication delays and missing medications within UPMC Presbyterian hospital. This was accomplished by stream-lining services and improving the department's technical efficiency and patient safety surrogates measures.

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HEALTHCARE ENVIRONMENT

Healthcare spending reached $2.9 trillion dollars or $9,255 per person, in 2013; accounting for 17.4% of the nation's gross domestic product (GDP).[1] This figure is more than two-and-a-half times higher than the average of other developed nations. Hospital services alone accounted for $936.9 billion of those GDP dollars, a growth of 4.5% from 2012.[1] Despite spending seventeen cents of every dollar on health care, the United States still have fewer physicians and hospital beds per person compared to developed nations, and poorer average outcomes than the Organization for Economic Co-operation Development (OECD) nations in life expectancy and infant mortality.[2,3] The Common Wealth Fund recently ranked the United States health care system last of eleven nations in quality measures related to access, equity, quality, efficiency, and healthy lives.[4] The country has been osolating around this current state for well over a decade despite legislative efforts to slow inflating healthcare cost by creating incentives to improve quality while decreasing quantity.

Legislators have attempted to control health care costs with the passage of laws that created the diagnosis-related-group (DRG), bundled payments, and value-based purchasing, all of which have been an attempt to decrease total reimbursement dollars for health care services billed to the Centers for Medicare and Medicaid Services (CMS). This reimbursement climate has resulted in health care insurance entities and providers to consolidate, streamline, and find efficiency in every aspect of health care operational service models.[5] High level health care administrators are asking front-line managers to provide cost-savings initiatives (CSI's) to trim excessive waste from each individual department, preferably while providing more consistent and better quality care.

Simultaneously, there is a second trend within contemporary health care in the United States that is focused on patient-centered care, patient safety, and a universal desire to diminish and potentially abolish medical errors. This issue was most famously noted in the landmark publication, *To Err is Human: Building a Safer Health System*, published in 1999 by the Institute of Medicine (IOM).[6] This was one of the first patient safety publications to highlight the sheer volume of medication and procedural errors that happen in United States hospitals. The Institute for Healthcare Improvement's (IHI) reaction to the IOM publication was to create initiatives such as the 5,000,000 Lives Campaign to directly reduce adverse outcomes in patients due to error.[7] The campaigns attempted to mitigate these errors by partnering with health care institutions to support the following efforts:

- create and deploy rapid response teams at the first signs of significant clinical decline
- deliver reliable, evidence-based care for acute myocardial infarction to prevent death
- prevent adverse drug events (ADEs) by utilizing a variety of medication safety tools including medication reconciliation
- prevent central line infections
- prevent surgical site infections
- prevent ventilator-associated pneumonia.[7]

The IHI has also compelled health care organizations to consider and pursue solutions that align with it's Triple Aim Campaign designed to optimize health system performance. The Triple Aim pursues three goals:

1. Improve the patient experience of care (including quality and satisfaction)
2. Improve the health of populations
3. Reduce the per capita cost of health care.[8]

The IHI Triple Aim is largely a call to improve health care "efficiency." Efficiency is a term widely used by economists to describe the best use of resources in production.[9] A health care organization that does not fully maximize the productive potential of its resources is in a state of technical and/or allocative inefficiency.[10] Technical inefficiency is a production state that does not achieve a maximum output from the mix of input combinations that are within a process, and therefore not producing at maximum capacity.[10] Allocative inefficiency is a state of production that does not minimize cost with given input prices or maximize revenues with given output prices.[9]

This paper will analyze and discuss a pharmacy department operational model modification designed to address the triple aim challenge. Through process redesign, the pharmacy department will seek to achieve technical efficiency while achieving greater patient safety by reallocating pharmacist medication order verification responsibilities, optimizing medication dispensing automation, and redeploying pharmacy technicians into a customer service role rather than a purely delivery role. This study will assess pharmacy order volume per unit, order volume per time, and order volume per verification queue, in order to best inform service line redistribution. For simplicity, each model will be referred to as "Pre-model" and "Post-model," respectively. A pre/post comparison will be conducted in order to evaluate automation efficiency and surrogate markers for medication delays. Automation efficiency will be assessed by comparing automated dispensing machine (ADM) stockouts and percent of medications dispensed by the RobotRx machine. Technician workflow efficiency will be assessed by comparing missing/delayed medications reported by nursing. This paper will also discuss the potential positive impact on patient safety and consistency of pharmacy services.

UPMC PRESBYTERIAN HOSPITAL AND PHARMACY SERVICES

UPMC Presbyterian is the large academic medical center that acts as the flagship hospital for the UPMC Hospital System. It is a designated level 1 trauma center and renowned center for excellence in abdominal transplant, cardiothoracic transplant, cardiology, critical care medicine, and neurosurgery. It consists of two patient care towers UPMC Presbyterian (PUH) and UPMC Montefiore (MUH) which house approximately 700 patient beds, combined, and both towers are serviced by a single central pharmacy located within PUH tower.

Pharmacy Services

The pharmacy department at PUH is responsible for the procurement, storage, compounding, labeling, and delivering of medications to all patient units and departments in a safe and timely manner. The pharmacy provides comprehensive clinical pharmacy services to those units and departments with most need (i.e. intensive care units, high acuity patients, sophisticated medication regimens). The clinical pharmacy services offered by the pharmacy department are driven by unit-based pharmacists and University of Pittsburgh School of Pharmacy faculty members that provide cognitive services such as medication recommendations, drug-disease state monitoring, and medical/pharmacy resident education. All pharmacists within the department are available to answer drug information questions regarding dose range verification, drug-laboratory evaluation, therapeutic medication interchanges, and medication route of administration recommendations to ensure the safest and most stream-lined drug administration regimen.

PHARMACY MEDICATION VERIFICATION AND DISTRUBUTION PROCESS

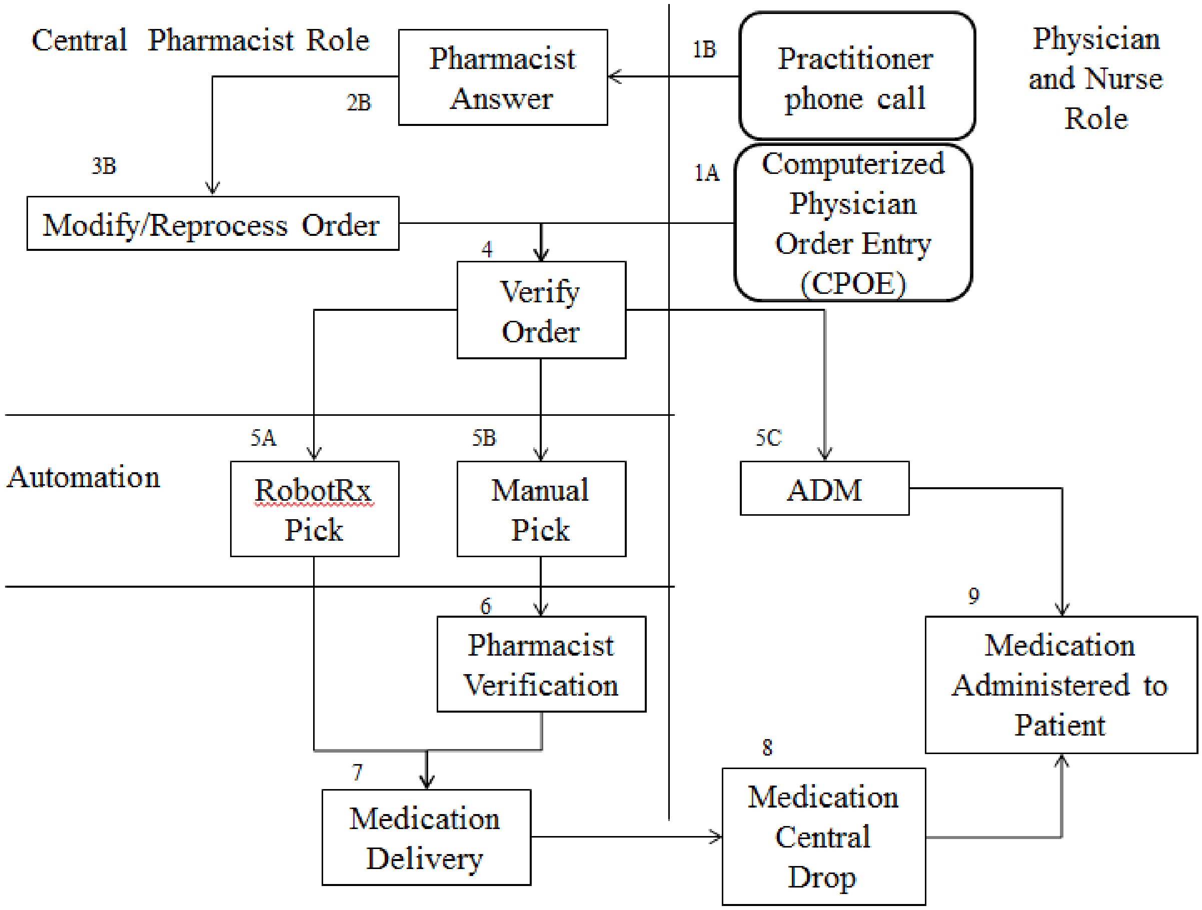

Figure 1: Medication order and process flow chart

ADM=Automated dispensing machine

Figure 1 is a schematic of the medication ordering, verification, processing, and delivering workflow at UPMC Presbyterian. The process begins with an electronic order that is entered into a computer system that links a drug regimen request to a specific patient. This electronic order is called a computerized physician order entry (CPOE) (1A). That order is then electronically routed to a pharmacist who assesses the appropriateness of the order (4). Once the order is verified by the pharmacist an electronic signal is sent to pharmacy automation system to be process the requested medication by one of three pathways; by manual pick by a pharmacy technician (5B), by pick and verification by the RobotRx® machine (5A), or by dispensing from an automated dispensing machine (ADM) strategically located within a patient unit or hospital department (5C). Note that all medications manually picked by a technician and verified by a pharmacist (6) or dispensed by the RobotRx® machine must be delivered by a pharmacy technician to the medication central drop area located within each hospital units (7-8). If the medication is located within the ADM the automation system will activate the medication within the patient's medication profile to be dispensed from that ADM located on the unit (5C).

SAFETY AND EFFICIENCY CHALLENGES OF THE PRE-MODEL

The pre-model suffers from operational challenges that stem from inequitable order verification volume and non-optimized automation systems resulting in poor workflow, duplicate order processing, excessive medication delay, and therefore potential patient safety risks. The problem list, potential sources and causes of problems, interventions, and possible safety correlations are described in Table 1.

The first identifiable problem is medication delays. There are a variety of different scenarios that may result in a medication delay, the first of which is an ADM stockout. The ADM carries certain medications that are restocked every 24 hours. Each medication within the ADM is programmed with a maximum stock amount (MAX) and a unit amount that triggers that a notification that a restock is needed for that medication during the next refill process (PAR). Poorly programmed medication maxes and pars can result in either an over utilization of valuable ADM medication space, or an under stocking of medication which can result in the ADM medication inventory reaching zero. When this happens nurses are unable to access the needed medication which results in a missing dose request and/or a phone call to pharmacy. The central pharmacy is less prepared to process medications that should be dispensed through the ADM because in order to do so, the pharmacist must bypass the usual automation chain of events to dispense the medication from the central pharmacy. This results in duplication of work for both pharmacists and technicians, potential duplication of medications dispensed, medication delays, and a greater chance for error, jeopardizing the safety of the patient.

Medication delays may also be the product of practitioners ordering and requesting medications urgently, or STAT, when those medications are not truly appropriate for expedition of the typical workflow. The pharmacy is able to expedite STAT medications through one of two processes: 1. sending the medication to the unit through a pneumatic tube system to ensure rapid delivery; 2. sending a technician to hand-deliver the medication to the unit because the medication is too molecularly fragile to send through the pneumatic tube system. An overload of STAT medication requests creates a bottleneck for the pharmacy's capacity to tube medications as well as STAT-run them with a technician resource. This may result in medications that truly are STAT, potentially being delayed because of STAT process flow saturation. An excessive amount of STAT medication requests also sets an unrealistic expectation for nurses and physicians, resulting in a perceived medication delay rather than a true delay. These perceived delays can result in duplicate dose requests and pharmacy phone calls, all of which disrupt normal pharmacy workflow and therefore delays the entire process chain. The overload of STAT medication requests may be the result of a lack of clinical understanding by the ordering practitioner and the verifying pharmacist and/or a CPOE design flaw that prompts physicians to choose STAT more frequently than necessary.

The second problem identified is inefficient and inconsistent deployment of pharmacist services. The first possible cause of inefficiency is the lack of standardization in the types of medication orders. This contributes to the lack of specialized services that are provided by central pharmacists because they are expected to effectively answer questions about all disease-states and all drugs available rather than a sub-specialty of the like. The lack of standardization also results in a lack of accountability for pharmacy cognitive and distributive services because there are not defined roles within the structure. A second possible cause of inefficient service is an inequitable volume of medication orders routed to each pharmacist through the pharmacy verification queue infrastructure. This order volume inequity results in some pharmacists being pushed beyond there verification capacity, creating a bottleneck in order verification through-put; while other pharmacists are not at full capacity.

Another issue that stems from the inconsistent and strained central operations is that it negatively affects the clinical capacity of our unit-based pharmacists. In certain scenarios the capacity of the central pharmacists is maximized but still in need of assistance. In order to fulfill the order verification need, clinical pharmacists may be removed from their clinical role in order to assist in a central pharmacist role to ensure that medications are processed in a timely manner. This results in unpredictable and unreliable clinical services which removes a valuable layer to pharmacy patient care.

METHODS

The first step was to assess average order volume per unit and average order volume over time in order to inform the new structure of verification queues. This was completed by assessing reports of order volume for all units for a one month period and averaging the amount of orders processed per unit per single hour of a day. It should be noted that only orders designated as "new" were included in the order volume assessment. The researchers assume that "discontinue," "cancel," or "modify" orders are less time intensive and therefore were excluded. We used this data to verify the number of orders per pharmacy queue in the pre-model state and then used this pre-model data to redistribute electronic medication order flow in a more equitable manner. Once the verification queues were redistributed in an equitable manner (post-model) the second step was to access surrogate data for efficiency and safety for both the pre and post-model for comparison. Surrogate data for medication safety and efficiency were ADM number of stockouts, reported missing doses, and percent of RobotRx dispenses. This data was compiled by querying the pharmacy automation system using its reporting functionality. The following data surrogates to compare the safety and efficiency of the pre-model versus post-model.

- Average ADM stock-out per 24 hours
- Total number of missing doses over a one week period
- Percent of total doses dispensed from the RobotRx machine over a one week period
- Percent of total doses dispensed from ADM machines over one week period.

These particular measures are surrogates for both safety and efficiency because ADM stockouts and missing medications may potentially cause a delay in patient care which is a medication error. The percent of RobotRx dispenses is also a marker for safety and efficiency because it has a near 100% accuracy when picking medications and it does not require manual manipulation for picking and checking by a pharmacist and technician. Percent of medications dispensed by the RobotRx as well as the ADM will be analyzed using chi square with Yates correction.

Table 1: Pharmacy problem list, possible causes, and system changes pursued

Problem List	Source of Problem	Proposed Cause	System Change	Possible Benefit
Medication Delays	ADM stockouts*	Incorrect medication Max and Par	Modify inventory pars to last 24 hours consistently	Decrease medication delays
		Incorrect medication types within the ADM	Remove medications that are predictability scheduled and non-emergent	Decrease missing medications and delay
	STAT medication order overload	Lack of clinical understanding of medication by requestor	Increased education by cognitive services	Decrease medication delay of true STAT medication
		Lack of clinical understanding of medication by pharmacist	Increased service-line education to specialized central pharmacist	Increase quality of order scrutiny by central pharmacist
	High percentage of manual pick medications	Lack of robotics optimization	Modify RobotRx contents to increase automation utilization	Improved medication dispensing accuracy
	Medication administrator cannot find medication*	Lack of understanding of where medications are stored	Provide education through unit-based technician	Fewer reported missing doses
Inefficient deployment of pharmacy services	Lack of standardization of order verification queues for pharmacists*	Various patient populations within each verification queue	Redistribute pharmacist order verification queues to service particular service lines and to align equity of order volume	Increase quality of order scrutiny by central pharmacist; Consistent communication; increased continuity of pharmacy care
		Inequitable order verification volume per pharmacist		
	Lack of specialized central pharmacy services	Inconsistent pharmacist scheduling practices	Schedule a pharmacist to a service line consistently	
	Lack of accountability for pharmacists distributive functions	Inconsistent pharmacist scheduling practices	Schedule a pharmacist to a service line consistently	Performance may be tracked and critiqued for quality improvement
	Lack of accountability for pharmacists providing cognitive services	Lack of standardization of cognitive services expectations	Provide pharmacist development to create disease state experts	Increase quality of order scrutiny by central pharmacist
		Significant time is spent providing distributive service recovery	Provide technician support to service recovery	Service recovery consistent and tracked for each service line

***** = Associated with data located in Table 4

RESULTS

Order Verification Volume – Medication Delay

Figure 2 shows the average number of new orders to verify per hour of the day averaged over a one month period. The 9:00 AM order verification peak is not surprising because this is the customary time for most patient care teams to begin rounding on intensive care unit patients. These orders are often entered in real-time during rounding, leading to the high order volume between the hours of 9:00 AM to 1:00 PM.

Table 2 features the pre-model pharmacist order verification queues, their corresponding number of patient care units, and average order volume. The average order volume per pharmacist queue is 467 with a range of 279. Using the same order volume data, taking into account the type of disease states located within each unit, each pharmacy verification queue was reconstructed to create more equitable order volume while providing patient specific care. Table 3 features the new pharmacist order verification queues after redistribution. The average order volume per queue is 443 with a range of only 111; a much lower variability. It should be noted that "M" queue in the pre-model and "Ancillary" queue in the post-model were excluded from the calculation because the pharmacists in these responsibilities have administrative duties and therefore are purposefully designed to have a smaller order volume.

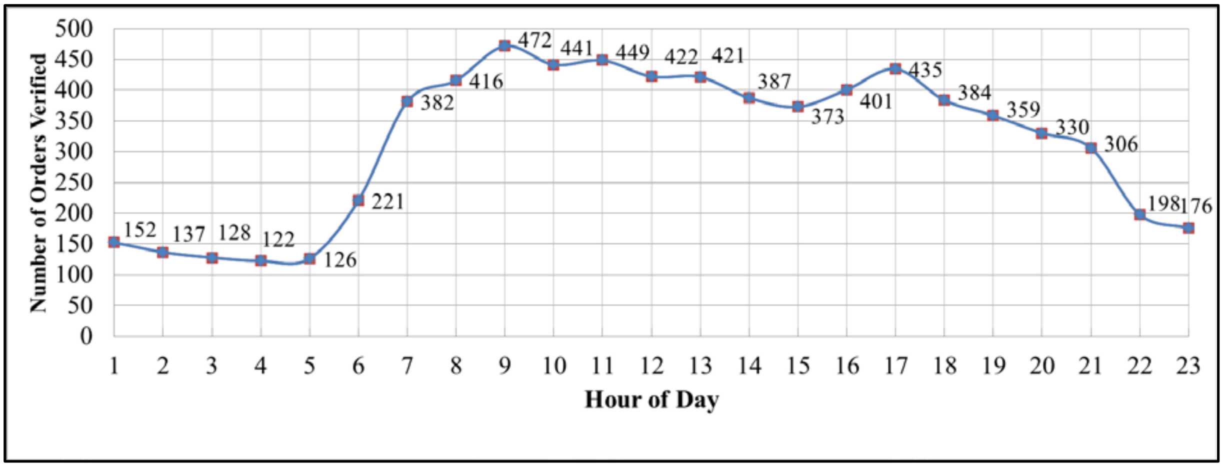

Figure 2: Average new order verification volume over 24 hours

Table 2: Pre-model pharmacist order verification queue structure

	Unit Count	Order Volume	Order volume Average per queue	Variance	Range
L	10	617	467	**150**	**279**
M	7	236*		NA	
N	6	384		-83	
O	7	437		-30	
P	7	371		-96	
H	6	338		**-129**	
I	6	538		71	
J	9	584		117	

* = Not included: This pharmacist services administrative functions; therefore we lighten queue volume

Table 3: Reorganization of pharmacy queues – post-model

	Unit Count	Order Volume	Order volume Average per queue	Variance	Range
TRAUMA	6	384	443	**-60**	**111**
NEUROLOGY	6	402		-42	
CARDIOLOGY	6	465		22	
ANCILLARY DEPARTMENTS	5	286.4*		**NA**	
ABDOMINAL TRANSPLANT	6	494		**51**	
CT TRANSPLANT	5	426		-17	
MEDICINE	9	468		25	
MED SURG	9	464		21	

* = Not included: This pharmacist services administrative functions; therefore we lighten queue volume

The Pharmacy Post-Model

The central pharmacist is paired to a unit-based pharmacist and unit-based delivery technician to create a pharmacy disease-state service line that supports both clinical and distributive functions. The pharmacy service line will triage workflow in the following manner:

- Central service line pharmacist
  - receives all medication orders electronically via CPOE
  - received phone calls from other providers regarding cognitive medication questions
- Unit-based service line pharmacist
  - receives clinical consult requests for drug-disease state management that are relayed by the central service-line pharmacist by telephone
  - provides rounding services with the medical team from 8:30A – 11:00A
  - provide education to physicians and nurses regarding operational
- Unit-based service line technician
  - delivery of medication
  - service recovery by locating missing doses and triaging STAT medications
  - provide education to physicians and nurses about medication locations
  - receives calls for technical service recovery such as missing doses

Pharmacy Order Verification / Phone Queues

Table 5, located in the appendix, features the distribution of all of the pharmacy order verification queues for the daylight shift central pharmacists. Each queue is labelled with a generic letter which is changed in the post-model to be associated to a particular disease state.

The daylight post-model pharmacist order verification structure consists of eight queues total:

1. Trauma – features multiple trauma floors, Neuro trauma overflow, a neurovascular step down unit
2. Neurology – features multiple neuro floors, neurovascular step down, neurovascular intensive care units, and one trauma floor.
3. Cardiology – features multiple cardiac patient floors, the cardiac intensive care unit, the cardiothoracic intensive care unit, and cardiac pavilion.
4. Abdominal Transplant – features solid organ transplant floors, transplant intensive care units, general intensive care unit overflow, and one medicine floor
5. Cardiothoracic Transplant – features cardiothoracic transplant floors, lung transplant floors, and one medicine floor
6. Ancillary – features the post-anesthesia care unit, dialysis unit, medical procedural unit, the emergency department and certain patient overflow areas. Note that this queue has a lower order volume because this person has administrative responsibility as well as order verification responsibility.
7. Medicine – features multiple medicine floors, the medical intensive care unit, as well and the ear, nose, and throat patient units.
8. Med Surg – features the surgical intensive care unit, orthopedics, rehabilitation unit, head and neck/gastrointestinal oncology, and nursing home units.

Table 6 located in the appendix features daylight post-model pharmacist order verification structure including units, their descriptions, and order volume.

The UPMC Presbyterian pharmacy department provides twenty four hour per day service, three hundred and sixty five days a year, therefore the model must be collapsible because staffing allocations are decreased during evenings, nights, holidays, or call-off scenarios. The collapsed pharmacy order verification queues for both evening and nights are located within the appendix under tables 7 and 8, respectively. In order to ensure that every unit is covered during the evening shift the following order verification / phone queue changes were made from the day shift to the evening shift:

1. Abdominal transplant and cardiothoracic transplant were collapsed into a single queue entitled transplant queue
2. The Ancillary queue units are absorbed throughout all of the queues in an equitable manner
3. The medicine queue absorbed one extra unit from the transplant queue in order to ensure equitable verification volume and remains entitled medicine

The pharmacy verification responsibilities collapse again from the evening shift into the night shift. The following order verification/phone queue changes were made from evening shift to night shift.

1. The daylight shift trauma, neuro, and cardio queues were merged
2. The daylight ancillary and transplant queues were merged.
3. The daylight medicine and med surg queues were merged

Pre/Post Surrogate Marker Data Comparing Efficiency and Safety

Table 4 features the pre and post-model safety and efficacy data. Reported medications delays decreased from 39 to 20 for a total decrease of 49%. Technicians were also capable of decreasing reported missing from 45 to 8, an 85% decrease, by located the medications for nurses on the unit. The percent of medications dispensed from the RobotRx and ADM were analyzed using a chi square test with Yate's correction to assess the statistical significance. RobotRx dispenses increased by 26% (P<0.0001) and medications dispensed from ADMs decreased by 28% (P<0.0001). The optimization of the automation resulted in a significant increase in medications that are dispensed by the RobotRx and a significant decrease in medications that are dispensed from the ADM.

Table 4: Process measures pre and post model change

Problem List	**Measurement**	**Pre Model**	**Post Model**	**Percent Change (%)**	**X^2 with Yates correction**	**Proposed Safety Correlation**
Medication Delays	Average ADM stockouts per 24 hours	39	20	49% decrease		Fewer scenarios where medications are unavailable to nurses and physicians
Missing Medications	Reported missing medications	45	7	85% decrease		
Inefficient automated medication distribution	Percent of medications dispensed from the RobotRx	37%	50%	26% increase	P< 0.0001	Greater medication dispensing accuracy and efficiency
	Percent of medications dispensed from ADM	39%	11%	28% decrease	P< 0.0001	Greater utilization of ADM for PRN and STAT

DISCUSSION

Efficacy and Safety

The safety benefits of the RobotRx has been documented in multiple different case studies, and has been reported to have a 99.9% medication filling accuracy.[12-14] The RobotRx has also been shown to decrease technician labor by 72%, pharmacist checking time by 90%, and decrease missing medications by 92%.[12-15] ADMs has been recognized by both the Institute for Safe Medication Practices (ISMP) and American Society of Health-System Pharmacists (ASHP) as a benefit to patient safety when utilized appropriately.[16-19] The UPMC Presbyterian pharmacy department has systematically evaluated its automation in order to optimize the safety and efficiency of medication dispensing. Interventions made to optimize the RobotRx and the ADMs have resulted a 26% increase in the utilization of the RobotRx machine for dispensing doses ($P<0.0001$) and a 28% decrease in utilization of the ADM ($P<0.0001$). This means that there was a significantly greater utilization of the RobotRx for dispensing in the post-model compared to pre-model. This likely contributed to the decrease in utilization of the ADM in the post-model versus the pre-model. The post-model stock out rate also decreased by 49% which may be a result of the decreased variety of medications located within the optimized ADM or a more appropriate max and par setting to ensure that the unit never runs out of a needed medication.

There are process flow benefits to the use of the RobotRx and the ADM located within the units. Medications that proceed through the RobotRx are robotically picked and verified which significantly decreased the chances of a medication picking error by a pharmacy technician or a pharmacy verification error by a pharmacist. It also provides efficiency because medications dispensed by the Robot do not need to be handled by those two human resources (the technician and the pharmacist) prior to delivery. The ADM machine features a variety of medications that may be accessed instantly when verified for a particular patient within the unit. This provides the nurse with instant access to the medication rather than having to wait for the medication to be delivered from the central pharmacy. Note that this delivery method is particularly beneficial for medications that are needed as soon as possible or on an as needed basis, or an unpredictable manner.

The pharmacist order verification queues were also redistributed to provide a more equitable order volume per pharmacist in order to decrease medication process bottlenecking and utilizing pharmacist capacity in the most efficient way. The post-model pharmacy queue distribution also associated each new queue with a certain disease state. There are no published articles that speak explicitly to the safety or efficiency of this type of pharmacist order verification structure and it should be noted that this study does not provide data that associates or correlates this model type to increased safety or efficiency. Pharmacy and nursing staff feedback supported pharmacy administration's idea to orient pharmacists to specific types of clinical patients. It is also though that the consistency of pharmacists within a service line will be more accountable and able to seek continuing education and therefore provide better cognitive services within their respective patient population.

The service-line technician model was associated with an 85% decrease in missing medications. This decrease is causative because the service-line technicians personally searched for each individual missing dose and were able to find 85% of the doses in their correct location. The high discrepancy between actual missing doses and reported missing doses is likely a product of a lack of knowledge of the different places that a medication may be located on a patient unit. A medication may be in the medication central drop area, within the ADM, or within a refrigerator located on the unit. The service-line technician has a strong understanding of the locations of medications delivered to the floor and is therefore able to find missing medications with efficiency. Administrators within the pharmacy department are providing the pharmacy technician time to provide nursing education on the potential location of doses so that inappropriate missing dose requests are not processed. There is also an assumption being made by administration that the nurses will be more vigilant in looking for missing medications before reporting it to the pharmacy if they know that someone is going to search for it rather than simply reprocess through the pharmacy work flow to create a duplicate.

The pharmacy department also created a new communication system that provides nursing with an option menu to speak to either the service-line technician or the central pharmacist. The service line technician is capable of taking missing medication, dose expedition, and basic ADM trouble-shooting questions. This results in the central pharmacist receiving only cognitive questions that need to be fielded by a pharmacist, rather than all phone calls that need to be triaged out to the correct person. A schematic of the pre and post model pharmacy phone triage is located in Figure 3.This system, if utilized appropriately will minimize interruptions to pharmacists assessing orders and therefore will allow for a more efficient and safe order verification process. This study did not assess phone call volume or appropriateness of phone call option selection.

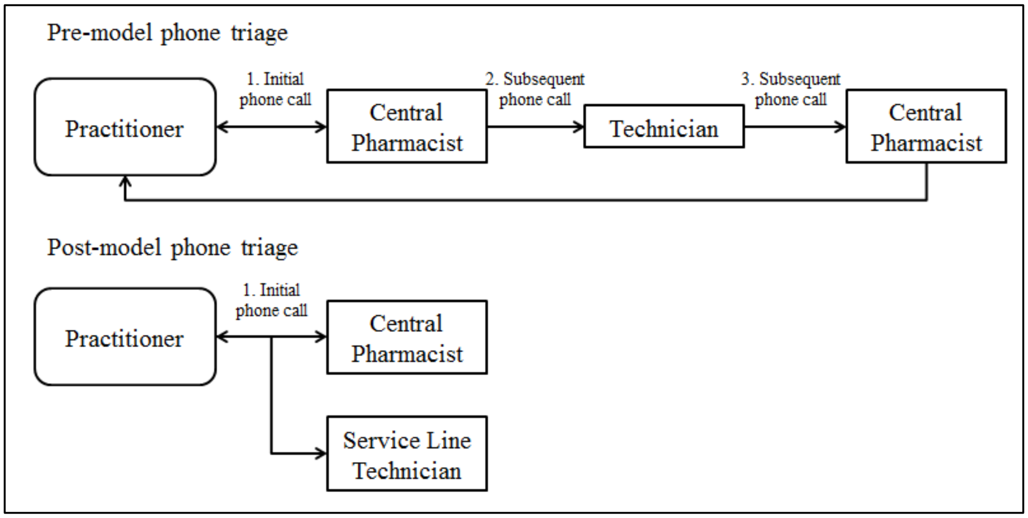

Figure 3: Pre and post model phone triage process

Study Limitations

This study only analyses surrogate markers for safety and efficiency. Therefore the conductors of the study cannot definitively state that these changes have resulted in increased efficiency for pharmacists, pharmacy order processing, or dispensing. The reorganization of the pharmacy order verification queues was based upon pre-model data and therefore theequity of the order distribution has not been confirmed with post-model order volume analysis.

Future Steps

Phone call volume comparisons may be valuable in the future as a marker of productivity/ marker of inefficiency. The manner in which phone calls are being triaged may also be assessed for appropriateness in the future. Administrators have also expressed interest in creating and distributing a nursing satisfaction survey. We have received anecdotal reports that the consistent contact between the nurses and the pharmacist/technician resource has improved their satisfaction with the medication distribution processes, but we do not have official data to speak to this affect.

CONCLUSIONS

The redistribution of pharmacy queues may lead to a more equitable pharmacist order verification volume and therefore a more efficient utilization of pharmacist resources. The pharmacy automation optimization resulted in a significantly greater use of the RobotRx machine which is associated with more efficient and safer medication dispensing. The decreased frequency of ADM stockouts results signifies fewer pharmacy workflow failures post-model compared to pre-model.

APPENDIX: PHARMACY ORDER VERIFICATION QUEUES

Table 5: Pre-model pharmacist order verification queues – daylight shift

Pharmacist Queue Name	Unit Name	Unit Description	Bed Number	Order Volume
L	3F	Cardiac ICU (Valves, MI)	10	617
	3E	Cardiac Pavilion	18	
	CT10	CTICU (Heat/Lung Transplant, Surgery, ECMO) Long	10	
	CT11	CTICU (Heat/Lung Transplant, Surgery, ECMO) Acute	10	
	4D	Cardiac Floor	18	
	5D	Cardiac Floor	18	
	2D Overflow	Overflow SICU	6	
	SICU	Surgical ICU	8	
	PACU	PACU	4	
	10G	Trauma Floor	24	
M	11D	Renal/Dialysis	10	236
	Cath/RCLH	Cath	10	
	MPUP	Medical Producure Unit / GI lab	3	
	5SSU	Overflow	10	
	ED	ED	44	
	8D	Neuro Floor/Step downs as well/Transitional	17	
	7F	Medicine	13	
N	8G	Epilepsy/Neuro/ Neurovascular Step Down	24	384
	6D	Neuro Floor/Step downs as well/Transitional	18	
	5G	Neuro Step Down	18	
	4F	Neurovascular	10	
	5F	Neurovascular	10	
	4G	Neurotrauma/OverflowNeurovascular and Trauma	10	
O	9G	Trauma Floor	24	437
	6F	Trauma ICU/GI Surgery/Neurovascular Overflow	10	
	6G	Trauma ICU/ GI Surgery/Neurovascular Overflow	12	
	9D	Cardiothroacic and Lung Transplant	17	
	7D	Cardiothoracic Overflow	23	
	743F	Neuro/medicine step down	4	
	12D	Trauma Floor	23	371
P	R7SN	Lung Transplant	20	
	R7SS	Lung Transplant	16	
	9F (MICU)	MICU	8	
	10F (MICU)	MICU	8	
	11F (MICU)	MICU	8	
	10C (MICU)	MICU	8	
H	10S (Med)	Medicine	33	338
	8MUH (ENT)	ENT Overflow	5	
	8N	ENT	17	
	9N (Ortho)	Orthopaedics	20	
	11S (RNHome)	Nursing Home	33	
	8W (SurgOnc)		11	
I	12S	Medicine		538
	10W (Med)	Medicine	34	
	10E (Med)	Medicine		
	RHAB (Ortho)	Rehab	20	
	10N (SurgOnc)	Head and Neck Surgical/GI Oncology	25	
J	12N	Solid Organ Transplant	24	584
	11N	Solid Organ Transplant	22	
	5E	ICU Overflow unit/TICU/MICU	9	
	5W	TICU	9	
	5S	TICU	10	
	6NE (ClinRes)	Clinical Research Unit	5	
	7W (TranspOPt)	Outpatient Transplant/Infusion Center	5	
	SDSM (Surg)	Same day surgery	10	
	7G	Observation Unit	20	

Units highlighted in red are Intensive Care Units (ICU)

Table 6: Post-model pharmacist order verification queues – daylight shift

Pharmacist Queue Name	Unit Name	Description	Bed Number	Order Volume
TRAUMA	12D	Trauma Floor	23	384
	9G	Trauma Floor	24	
	7F	Trauma Floor	13	
	8G	Epilepsy/Neuro/ Neurovascular Step Down	24	
	6F	Trauma ICU/GI Surgery/Neurovascular Overflow	10	
	6G	Trauma ICU/ GI Surgery/Neurovascular Overflow	12	
NEUROLOGY	8D	Neuro Floor/Step downs as well/Transitional	17	402
	6D	Neuro Floor/Step downs as well/Transitional	18	
	5G	Neuro Step Down	18	
	4F	Neurovascular	10	
	5F	Neurovascular	10	
	4G	Neurotrauma/OverflowNeurovascular and Trauma	10	
CARDIOLOGY	3F	Cardiac ICU (Valves, MI)	10	465
	3E	Cardiac Pavilion	18	
	CT10	CTICU	10	
	CT11	CTICU	10	
	4D	Cardiac Floor	18	
	5D	Cardiac Floor	18	
ANCILLARY	11D	Renal/Dialysis	10	286
	Cath/RCLH	Cath	10	
	MPUP	Medical Producure Unit / GI lab	3	
	5SSU	Overflow	10	
	ED	ED	44	
	6NE	Clinical Research Unit	5	
	7W	Outpatient Transplant/Infusion Center	5	
	SDSM	Same day surgery	10	
	8N	Observation Unit	17	
ABDOMINAL TRANSPLANT	12N	Solid Organ Transplant	24	494
	11N	Solid Organ Transplant	22	
	5E	ICU Overflow unit/TICU/MICU	9	
	12S	Medicine	33	
	5W	TICU	9	
	5S	TICU	10	
CT TRANSPLANT	7G	Medicine	22	426
	10D	Lung Transplant	22	
	10G	Lung Transplant	13	
	9D	Cardiothroacic and Lung Transplant	17	
	7D	Cardiothoracic Overflow	23	
MEDICINE	10W (Med)	Medicine	34	468
	10E (Med)	Medicine		
	10S (Med)	Medicine	33	
	8MUH	ENT Overflow	5	
	8W	ENT	11	
	9F	MICU	8	
	10F	MICU	8	
	11F	MICU	8	
	10C	MICU	8	
MED SURG	2D	Overflow SICU	6	464
	SICU	Surgical ICU	8	
	9N (Ortho)	Orthopaedics	20	
	743F	Neuro/medicine step down	4	
	RHAB	Rehab	20	
	10N	Head and Neck Surgical/GI Oncology	25	
	11S	Nursing Home	33	
	PACU	Post-Anesthesia Care Unit (PUH)	4	
	PACM	Post-Anesthesia Care Unit (MUH)	4	

Units highlighted in red are Intensive Care Units (ICU)

Table 7: Post-model pharmacist order verification queues – evening shift

Pharmaicst Queue Name	Units	Description	Bed Number	Order Volume
Neurology	8N	Observation Unit	17	449
	8D	Neuro Floor/Step downs as well/Transitional	17	
	6D	Neuro Floor/Step downs as well/Transitional	18	
	5F	Neurovascular	10	
	4F	Neurovascular	10	
	5G	Neuro Step Down	18	
	4G	Neurotrauma/OverflowNeurovascular and Traum	10	
Cardiology	CT10	CTICU (Heat/Lung Transplant, Surgery, ECMO)	10	417
	CT11	CTICU (Heat/Lung Transplant, Surgery, ECMO)	10	
	4D	Cardiac Floor	18	
	5D	Cardiac Floor	18	
	3F	Cardiac ICU (Valves, MI)	10	
	3E	Cardiac Pavilion	18	
	7G	Medicine	22	
	Cath/RCLH	Cath	10	
Transplant	12N	Solid Organ Transplant	24	567
	11N	Solid Organ Transplant	22	
	5W	TICU	9	
	5E	ICU Overflow unit/TICU/MICU	9	
	5S	TICU	10	
	10D	Lung Transplant	22	
	10G	Lung Transplant	13	
	9D	Cardiothroacic and Lung Transplant	17	
	7D	Cardiothoracic Overflow	23	
Medicine	12S	Medicine	33	571
	10W (Med)	Medicine	34	
	10E (Med)	Medicine		
	10S (Med)	Medicine	33	
	11F (MICU)	MICU	8	
	10F (MICU)	MICU	8	
	10C (MICU)	MICU	8	
	9F (MICU)	MICU	8	
	8MUH (ENT)	ENT Overflow	5	
	8W	ENT	11	
Med Surg	11S (RNHome)	Nursing Home	33	438
	10N (SurgOnc)	Head and Neck Surgical/GI Oncology	25	
	9N (Ortho)	Orthopaedics	20	
	2D Overflow	Overflow SICU	6	
	SICU	Surgical ICU	8	
	RHAB (Ortho)	Rehab	20	
	PACU	Post-Anesthesia Care Unit (PUH)	4	
	PACM	Post-Anesthesia Care Unit (MUH)	4	
	11D	Renal/Dialysis	10	
	MPUP	Medical Producure Unit / GI lab	3	
	7W (TranspOPt)	Outpatient Transplant/Infusion Center	5	
	6NE (ClinRes)	Clinical Research Unit	5	
	5SSU	Overflow	0	
	SDSM (Surg)	Same day surgery	10	
Trauma	743F	Neuro/medicine step down	4	503
	12D	Trauma Floor	23	
	9G	Trauma Floor	24	
	7F	Trauma Floor	13	
	6F	Trauma ICU/GI Surgery/Neurovascular Overflow	10	
	6G	Trauma ICU/ GI Surgery/Neurovascular Overflov	12	
	8G	Epilepsy/Neuro/ Neurovascular Step Down	24	
	ED	ED	44	

Units highlighted in red are Intensive Care Units (ICU)

Table 8: Post-model pharmacist order verification queues – night shift

Pharmacist Queue Name	Units	Description	Bed Number	Order Volume
Trauma/Neuro/Cardio	12D	Trauma Floor	23	665
	9G	Trauma Floor	24	
	8G	Epilepsy/Neuro/ Neurovascular Step Down	24	
	7F	Trauma Floor	13	
	6F	Trauma ICU/GI Surgery/Neurovascular Overflow	10	
	6G	Trauma ICU/ GI Surgery/Neurovascular Overflow	12	
	8D	Neuro Floor/Step downs as well/Transitional	17	
	6D	Neuro Floor/Step downs as well/Transitional	18	
	5G	Neuro Step Down	18	
	5F	Neurovascular	10	
	4F	Neurovascular	10	
	4G	Neurotrauma/OverflowNeurovascular and Trauma	10	
	CT10	CTICU (Heat/Lung Transplant, Surgery, ECMO) Lon	10	
	CT11	CTICU (Heat/Lung Transplant, Surgery, ECMO) Acu	10	
	4D	Cardiac Floor	18	
	5D	Cardiac Floor	18	
	3F	Cardiac ICU (Valves, MI)	10	
	3E	Cardiac Pavilion	18	
Ancillary/Transplant	11D	Renal/Dialysis	10	578
	8N	Observation Unit	17	
	Cath/RCLH	Cath	10	
	MPUP	Medical Producure Unit / GI lab	3	
	ED	ED	44	
	12N	Solid Organ Transplant	24	
	11N	Solid Organ Transplant	22	
	12S	Medicine	33	
	5W	TICU	9	
	5E	ICU Overflow unit/TICU/MICU	9	
	5S	TICU	10	
	10D	Lung Transplant	22	
	10G	Lung Transplant	13	
	9D	Cardiothroacic and Lung Transplant	17	
	7D	Cardiothoracic Overflow	23	
	7G	Medicine	22	
Medicine	10W (Med)	Medicine	34	489
	10E (Med)	Medicine		
	10S (Med)	Medicine	33	
	11F (MICU)	MICU	8	
	10F (MICU)	MICU	8	
	10C (MICU)	MICU	8	
	9F (MICU)	MICU	8	
	8MUH (ENT)	ENT Overflow	5	
	8W	ENT	11	
	11S (RNHome)	Nursing Home	33	
	10N (SurgOnc)	Head and Neck Surgical/GI Oncology	25	
	9N (Ortho)	Orthopaedics	20	
	7W (TranspOPt	Outpatient Transplant/Infusion Center	5	
	743F	Neuro/medicine step down	4	
	6NE (ClinRes)	Clinical Research Unit	5	
	2D Overflow	Overflow SICU	6	
	SICU	Surgical ICU	8	
	RHAB (Ortho)	Rehab	20	
	PACU	PACU	4	
	PACM	PACM	4	
	5SSU	Overflow	0	
	SDSM (Surg)	Same day surgery	10	

Units highlighted in red are Intensive Care Units (ICU)

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