2017

Intravenous Solution Wastage in Hospital Pharmacy at Baptist Memorial Hospital-North Mississippi (Oxford)

Yujing Zhang
University of Mississippi. Sally McDonnell Barksdale Honors College

Intravenous Solution Wastage in Hospital Pharmacy at Baptist Memorial Hospital-North Mississippi (Oxford)

By

Yujing Zhang

A thesis submitted to the faculty of The University of Mississippi in partial fulfillment of the requirements of the Sally McDonnell Barksdale Honors College

Oxford

May 2017

Approved by

____

Advisor: Professor Erin Holmes

____

Reader: Professor Meagen Rosenthal

____

Reader: Professor David Gregory

DEDICATION

This manuscript is dedicated to my little brother, Noah Stevens, who was born at the Baptist Memorial Hospital-North Mississippi (Oxford) in 2009. Noah, I hope that one day you may come across this thesis and say, "I can do much better!" You probably will, and I cannot wait to see what your future holds.

ACKOWLEDGEMENTS

First, I would like to thank the Sally McDonnell Barksdale Honors College for the amazing education that I have received these past four years. Thank you DSG, Penny Leeton, Dr. Debra Young, and the rest of the Honors staff, for your open doors and unwavering support.

Next, I would like to thank Dr. Erin Holmes, my thesis advisor, for going above and beyond in helping me make this thesis a reality. Some days I wonder if Dr. Holmes is fully human because she has to be part angel, and I cannot ask for a better person, friend, and cheerleader to accompany me on this thesis journey. I would also like to thank Dr. Meagen Rosenthal and Dr. David Gregory, my second and third readers, for their time and energy in editing my thesis and attending my defense.

In addition to these wonderful individuals at the University of Mississippi, my project would not have happened without my coworkers at the Baptist Memorial Hospital-North Mississippi (Oxford). Thank you Dr. Todd Williamson for agreeing to be my hospital sponsor and eagerly fulfilling every task that I requested. Thank you, my fellow pharmacy technicians, and the pharmacists, for helping me with data collection and also being a great work family for the past three years.

Last but not least, I would like to thank my friends and family for believing in me and challenging me to do my best every day. I love you all.

ABSTRACT

YUJING ZHANG: Intravenous Solution Wastage in Hospital Pharmacy at Baptist Memorial Hospital-North Mississippi (Oxford)
(Under the direction of Erin Holmes)

Introduction: IV solution wastage refers to IV medications made for a patient that remain unused by that patient for a variety of reasons, and have subsequently expired, or for other reasons cannot be used for another patient (recycled), and therefore must be disposed of. This problem is widespread across hospital pharmacies in the U.S. and the world. BMH-NM (Oxford) pharmacy utilizes many waste reduction strategies but has never monitored its IV solution wastage. Therefore, the objective of this study was to identify the number of IV solutions wasted in a month and the subsequent financial loss in terms of drug cost, and categorize the wastage by drug name and drug class. **Methods:** This study was conducted using a cross-sectional, observational, prospective study design to quantify the amount of IV solution wastage that occurred at BMH-NM (Oxford). For 30 days in March, 2017, the researcher collected data from wasted IV solutions set aside by pharmacy technicians and calculated the drug cost. For each wastage indicator (number of bags and drug cost), the top 10 drugs and drug classes were ranked, and descriptive statistics were conducted to further visualize the impact. **Results:** From March 1, 2017, to March 30, 2017, the BMH-NM (Oxford) pharmacy wasted 285 bags of IV solution, resulting in a financial loss of $4025.66 in drug cost. There were 46 different types of drugs from 28 different drug classes. **Conclusion:** The financial loss from a single month of IV solution wastage was significant for a 217-bed rural hospital. A variety of drugs and drug classes were identified as targets for waste reduction. Potential causes for wastage were drug-specific, and both volume and cost of waste need to be considered for reducing overall IV solution wastage.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF ABBREVIATIONS

BMH-NM	Baptist Memorial Hospital-North Mississippi (Oxford)
CF	cart fill
CPOE	computerized physician order entry
D/C	discharged, discontinued
FD	first dose
IRB	Institutional Review Board
IV	intravenous
MVI	mutivitamin
NSAID	non-steroidal anti-inflammatory drug
PRN	as needed
STAT	immediately

BACKGROUND

Description of the Problem

In hospital pharmacies across the country, and even the world, pharmacists and technicians experience the frustration of intravenous (IV) solution wastage. This wastage refers to IV medications made for a patient that remain unused by that patient for a variety of reasons, and have subsequently expired, or for other reasons cannot be used for another patient (recycled), and therefore must be disposed of.

There can be several negative consequences that result from wasted IV solutions. On the anecdotal side, IV solution wastage could lead to reduced work satisfaction and reduced productivity in the pharmacy. It takes time and resources for technicians and pharmacists to verify the order, prepare the solution, double-check the bag, and send it to the appropriate location. Seeing IV bags go to waste and realizing that all the work was done in vain can sometimes be frustrating and discouraging to the pharmacy staff. In addition, they could have used that time verifying other orders or preparing other medication, resulting in opportunity costs for labor.

On the quantitative side, the financial cost of IV solution wastage can be a significant burden on a hospital pharmacy's budget. Uchida et al. (1994) conducted a year-long study at the 493-bed University of California, Irvine Medical Center in 1991 and found 14,035 wasted IV solutions totaling an estimated $86,000 in drug costs, or 2.5% of the total IV drug cost, in a 12-month period. Accounting for inflation, the loss equates to about $150,000 in today's value. Of course, other factors over the past 25 years, such as healthcare reform and rising drug costs, may realistically result in a much higher wastage cost.

Literature Evaluation of IV Solution Wastage

Because IV solution wastage is a serious and widespread problem in hospital pharmacies, many researchers around the world have looked into the magnitude of waste in their local hospitals. In an 800-bed teaching hospital in Saudi Arabia, for example, Al-Dhawailie (2011) collected 265 unused intravenous medication in a single month in 2009. A year earlier at a large teaching hospital in Cincinnati, OH, Chiu (2009) found that an average of 2,173 IV bags was wasted per month during a 3-month study period, costing the pharmacy on average $47,977 each month and an estimated $575,000 per year. A dated, but more comprehensive study, conducted by Birdwell et al. (1993) showed that among 237 surveyed U.S. hospitals, the mean IV solution wastage rate was 2.83%—meaning for every 100 bags made, 3 were wasted. Most alarming is that despite hospital pharmacies being aware of the issue of IV solution wastage, only a minority of those pharmacies regularly monitor for IV wastage. In the same survey by Birdwell, only 35.9% of the respondents indicated that waste is monitored and recorded on a daily basis. Over 40% said that they either only monitored waste occasionally or never monitor it at all.

Causes of IV Solution Wastage

Quantifying IV wastage is important, but it is also important to understand the causes of wasted IV solutions. Just like everything else in health care, the reasons are complicated. Most often, IV bags are wasted because they have short expiration dates, and by the time technicians bring them back to the pharmacy, they can no longer be recycled. There are several reasons why IV bags are returned to the pharmacy. Usually it is because the doctor discontinued or changed the order, and the solution has already been mixed and sent up to the floor. Other times nurses do not transfer the medication with the patient to a different unit, causing the bag to expire in a medication bin on the patient's old floor. Lastly, if a patient passed away before the medication was due, but after it was made, the nurse has no choice but to return the bag to pharmacy. Uchida (1994) observed in her article, "most of these problems can be attributed to poor communication between physicians, nurses, and pharmacists."

Methods to Reduce IV Solution Wastage

From my personal experience working for three years as a hospital pharmacy technician, potential IV solution wastage is inevitable, but many times it is avoidable. There are many measures to reduce waste. Birdwell et al. (1993) focused on four areas. First, he found that the lowest wastage rate occurred when there is computerized notification (versus written or verbal notification) to discontinue IV administration. Specifically, "as the elapsed time from the discontinuation of an IV drug or solution to notification in the pharmacy increased from <1 hour to >4 hours, the actual and perceived mean wastage rates also increased." Second, he found that the active retrieval of IV solution from wards or from designated location reduced wastage rate. Third, 85.9% of the surveyed hospitals recycled IV bags until their expiration date, and compared to more conservative recycling policies, this policy had the lowest wastage rates. Lastly, the highest wastage rates came from hospitals that used manufacturer stability data in determining the expiration dating policy, while the lowest rates came from the handful of hospitals who used sterility instead of stability data. Again, Birdwell's survey was conducted in 1990 when computerized physician order entry (CPOE) system was not yet widespread, so today there are many other methods, such as barcode scanning technology, that could be used to reduce intravenous solution wastage.

Baptist Memorial Hospital-North Mississippi (Oxford) Pharmacy Efforts to Reduce Wastage

The pharmacy at Baptist Memorial Hospital-North Mississippi (BMH-NM) in Oxford, a 217-bed large rural hospital, already incorporates many of these best practices to reduce waste. When physicians order certain IV solutions (e.g., those with short stability periods or those that are made with expensive drugs) using a CPOE system, pharmacists process the order as usual. However, technicians pin the label on a board outside the IV room rather than immediately making the IV after the order is placed. An hour before the medication is due, the technician checks to see if the order has been discontinued or if the patient has been transferred. If the order is still active, and the patient location is updated, then the technician will make the bag, and the medication will be either sent by pneumatic tube or hand-delivered to the nursing unit.

There are several other mechanisms that the pharmacy at BMH-NM (Oxford) has in place to minimize IV wastage. When technicians are on nursing floors on routine medication deliveries, they will actively retrieve unused IV bags that were due at least 6 hours ago, and once the technician gets back to the pharmacy, they will credit the bags back to the patients (meaning, to ultimately remove this IV from the patient's hospital bill). If not expired, these IVs will be stored for the purpose of reuse for other patients as appropriate (see batch fill process section, below).

In other instances, when the IV technician makes extra bags for frequently used solutions, he or she will put the new bags behind the old ones in the overstock bin so the ones expiring first will get used first. Also, to avoid IV bags from going missing on nursing units, the technicians try to hand deliver as many IV bags as possible to the medication room on the nursing unit instead of sending them by pneumatic tube to the nursing unit. If a nurse calls the pharmacy for replacements of missing IV bags because a patient has recently transferred from a different floor, the tech will call the nurse from the patient's previous floor to try to find the bag before making a new one. Finally, for IV bags with short stability, the hospital pharmacy purchases premixed bag with longer expiration dates.

Batch Fill Process of IV Solutions at BMH-NM (Oxford)

To fully understand how IV wastage is managed at BMH-NM (Oxford), it is important to understand the daily process of filling IV orders for patients. Every morning at 7:00 am, labels are printed for IVs due between noon and 6:00 pm that day. The IVs are made and delivered at 9:30 am. The timeline for the second, third, and fourth batches of IVs for the day are outlined in Table 1 below.

Table 1. IV Batch Fill Process at BMH-NM Pharmacy.

7:00 AM	First batch prints for IVs due noon to 6 PM today
9:30 AM	Rounder delivers first batch
11:00 AM	Second batch prints for IVs due 6 PM to midnight today
2:00 PM	Rounder delivers second batch
3:00 PM	Third batch prints for IVs due midnight to 6 AM tomorrow
4:00 PM	Rounder delivers third batch
6:00 PM	Fourth batch prints for IVs due 6 AM to noon tomorrow
7:30 PM	Rounder delivers fourth batch

In addition to the scheduled IV batches illustrated above, labels for new orders, STAT doses (immediate does for patients), and PRN (as needed) doses print out sporadically throughout the day. The IV technician usually makes these bags as soon as the labels print out, and the mixed solutions are tubed to the floor, unless it contains drugs that cannot be shaken or are narcotics, in which case the bags will be hand-delivered to the nurse.

Recycling and Wasting Policy at BMH-NM (Oxford)

BMH-NM (Oxford) has established a process for collecting discontinued IV bags. Every time an IV order gets discontinued, a D/C (shorthand for “Discontinue”) label prints out. If the label prints out before the rounding technician delivers, then a technician would first try to find the original label and credit it before a bag is even made, or if the bag is already made, find the bag, credit it, and save it for use for another patients (recycling). If the D/C label prints out after the rounder has left the pharmacy for delivery, then the next rounding technician will bring the discontinued bag back and credit it. The IV bag will be stored for use for another patient if appropriate. If the solution has already expired and cannot be recycled for another use, then the bag will be cut up in the sink as a means of destruction.

In addition to making IV solutions for specific patients, the pharmacy also prepares commonly used IV bags in bulk to be stored in the pharmacy and in different hospital units, which can be another source of IV solution wastage. As mentioned in the previous section, technicians often make extra IV bags for frequently used drugs, and occasionally the extra bags expire before they can be used. In nursing units, BMH-NM (Oxford) installed Omnicell Automated Dispensing Cabinets in 2015 to store unit-dose medication, premixed fluids, and frequently prescribed IV solutions with a 15-day or 30-day stability period at room temperature. These medication cabinets allow nurses to retrieve medication for their patients instantly instead of waiting on pharmacy technicians to deliver or tube the medication. Every day, an item expiration tracking report prints out, detailing every item in every Omnicell cabinet that will expire in the next 30 days. In this way, technicians keep track of which IV solutions are expiring in which Omnicell cabinet, and every weekend the rounding technicians bring back bags that expire in the following week to be cut up in the sink.

Study Significance

Conducting a study to monitoring IV solution wastage at BMH-NM (Oxford) is important for several reasons. First, there has been little recent research on IV solution wastage in the United States, especially in rural hospitals. It will be interesting to see how findings at BMH-NM (Oxford) compare with numbers from previous studies and at large teaching hospitals. Second, this hospital pharmacy has never monitored its drug wastage, even though inefficiencies arising from IV wastage have been noted. Lastly, this research can have important financial and policy implications for the pharmacy. Anecdotally, BMH-NM (Oxford) has often been referred to as the "cash cow" for the Baptist healthcare corporation. Quantifying IV solution waste and subsequent financial costs has the potential to create real policy changes within the pharmacy and the hospital at large.

Study Objectives

The overall purpose of this study is to monitor and quantify IV solution wastage at the pharmacy at BMH-NM (Oxford). The specific objectives of this study are:

1. To identify the number of IV solutions wasted at BMH-NM (Oxford) in a month and to categorize the solutions by drug name and drug class.
2. To quantify the financial loss in terms of drug cost to BMH-NM (Oxford) as a result of wasted IVs at BMH-NM (Oxford) pharmacy and categorize the loss by drug name and drug class.

METHODS

Study Design

This study was conducted using a cross-sectional, observational, prospective study design to quantify the amount of IV solution wastage that occurred at BMH-NM (Oxford). The study was approved by the Baptist Memorial Healthcare Corporation IRB as well as the University of Mississippi IRB.

Data Collection

In February 2017, the researcher prepared the pharmacy staff at BMH-NM (Oxford) for the data collection by holding a staff meeting with the pharmacy technicians and sending an email to technicians and pharmacists about the study. Technicians were given detailed instructions pertaining to the collection process in the meeting as well as in the email, and pharmacists were given a broad overview of the study purpose and method in the email so that they were aware of the ongoing data collection. The data collection process was piloted prior to the start of the study to assure adherence to, and understanding of, procedures.

There are three general sources of wasted IV solutions: unused bags from nursing units, expired pre-made bags in Omnicell machines, and expired bags in refrigerator overstock bins in the pharmacy. Technicians were given separate instructions for each source.

- For bags returned from daily rounding and retrieved from nursing units (see Figure 1), technicians were told to sort out the wasted IV solutions, leave the medication labels intact, and place the wasted IV bags in one of the designated collection bins in the pharmacy. They were instructed not to credit the bags back to the patients to avoid the reflex of tearing off the label immediately after crediting. To assure them that the bags would still be credited, they were told that the researcher would credit the bags once she finishes data collection for the day.
- For expired pre-made bags returned from Omnicell machines, technicians were instructed to simply place them in the collection bins. These bags would be identified as Omnicell expires because they lack medication labels.
- For bags that expired in the pharmacy refrigerator, technicians were similarly instructed to place them in the collection bins instead of cutting them up in the sink. These bags would be identified as overstock expires because they would have incomplete medication labels that lack the section with patient-identifying information.

If technicians accidentally tore off medication labels or cut up the bags in the sink, they were told to put the unlabeled or empty bags in the collection bins regardless so that the researcher can get an accurate count of the number of IV bags wasted.

The physical preparation for data collection included hanging up signs in conspicuous areas of the pharmacy to remind technicians on the data collection process and setting up two collection bins in the pharmacy. Three signs were hung: one above the computer at the technician island, one below the monitor of the computer used for crediting medications, and one above the sink in the IV room. These locations were chosen because they are visible to technicians and are key sites where wasted IV bags are normally processed. Two labeled collection bins were set up: one next to the crediting computer, and one near the sink in the clean room.

Data collection began on March 1st, 2017, and ended on March 30, 2017. Each day at 8 pm, the researcher went to the pharmacy to check the collection bins, enter data onto an encrypted data collection Excel spreadsheet, credit appropriate bags back to the patients, and properly dispose of the wasted IV solutions by tearing off and shredding the medication labels and cutting the bags up in the sink.

The encrypted data collection Excel spreadsheet, henceforth referred to as the daily log, is a table with descriptions of each wasted bag in rows (see Table 2 below). The descriptors included bag number, hospital unit, drug name, dose strength, and order type. Each bag was coded using a 6-digit code: the first three numbers indicated the date of collection, and the last three numbers differentiated bags wasted on the same day. The hospital unit was the unit on the medication label, not necessarily where the technician retrieved the bag. For example, bags expired in the fridge might be a recycled bag returned from a nursing unit, but because the patient-identifying section of the medication label, which contains the unit number, has been removed, the bag is only identifiable as fridge overstock. The drug name and dose strength were either identified from the medication label or, in the case of the pre-made bags expired in Omnicell machines, from the attached vials. The order type indicated whether the bag was made as a first dose

(FD), a PRN (as needed) dose, a scheduled dose that was printed in the IV batch (CF), or a redispensed dose to replace a missing dose.

Table 2. Sample Daily Log

Date: 3/1/2017	Bag #	Unit	Drug	Dose	Order Type
	301001	2nd	Potassium Chloride	40mEq/20ml	CF
	301002	SD	Ibuprofen	400mg	CF
	301003	ER	Thiamine	100mg	FD
	301004	Omnicell	meropenem	500mg	restock

At the end of the 30-day collection period, the researcher provided the pharmacy buyer with a list of drug products with specific brand/drug name, concentration, and vial sizes used to make each of the wasted IV solutions from the daily log. The specific products were determined based on the standardized process of sterile compounding at the BMH-NM (Oxford) pharmacy, which is knowledge that I acquired from working as a technician at this pharmacy for three years. For example, three different types of vancomycin vials are used to prepare three different dosage strengths: a 750mg Add-Vantage vial for the 750mg dose, a 1g Add-Vantage vial for the 1g dose, and a 5g bulk vial for any doses above 1g. The buyer then provided the cost of each item in unit price ($/vial) format in a report generated from the wholesaler website.

Data Analysis

A list of all of the drugs wasted was compiled by alphabetizing the "Drug" column in the daily log. Then the number of bags wasted was summed for each dosage strength of each drug.

Next, the drug cost of each bag was calculated by determining the unit dose multiplier (i.e. the number of vials used) for each bag. Using the standardized process for sterile compounding as a guide, the researcher normalized the different dose strengths of each drug to a unit price multiplier (see Figure 1). By multiplying the unit price multiplier with the unit price of each product, the drug cost of each wasted IV solution was calculated.

Next, the total number of bags for each drug was calculated by summing the number of bags for each dosage strength. Similarly, the total drug cost was calculated for each drug.

To calculate wastage by drug class, the pharmacological class of each drug was determined using Lexi-Comp. Then the drugs were grouped into various classes. Within each class, each drug's wastage was summed to calculate wastage by number of bags and by drug cost per drug class.

For each of the four wastage indicators (number of bags wasted by drug, number of bags wasted by drug class, drug cost by drug, and drug cost by drug class), the numerical value was sorted from highest to lowest to reflect the impact on IV wastage by each drug or drug class. Descriptive statistics was conducted to further visualize the impacts.

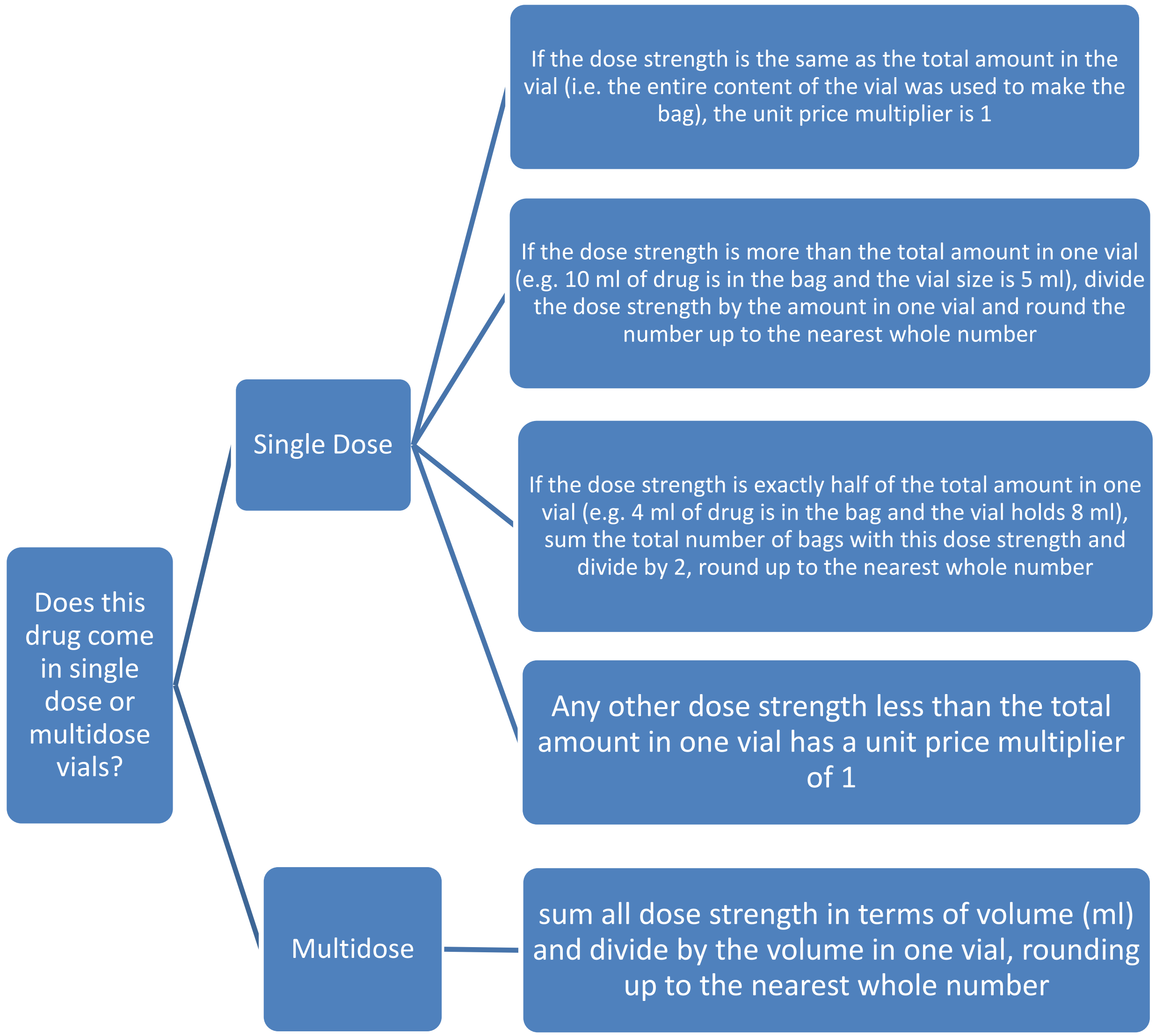

Figure 1. Unit Price Multiplier Calculation

RESULTS

From March 1, 2017, to March 30, 2017, the BMH-NM (Oxford) pharmacy wasted 285 bags of IV solution, resulting in a financial loss of $4025.66 in drug cost. There were 46 different types of drugs from 28 different drug classes. Table 3 gives a summary of the total IV solution wastage for each drug as well as an index for the drug class that each drug is in.

The top ten drugs wasted by number of bags included potassium chloride, meropenem, penicillin G potassium, cefazolin, ibuprofen, thiamine, vancomycin, folic acid, phenylephrine, and multivitamin infuvite (Table 4). These drugs represented 68% of the total waste by number of bags (Figure 2).

The top ten drug classes wasted by number of bags included electrolytes, vitamins, penicillin antibiotics, carbapenem antibiotics, cephalosporin antibiotics, NSAIDs, glycopeptide antibiotic, alpha-adrenergic agonist, aminoglycoside antibiotics, and anticonvulsant (Table 5). These drug classes represented 83% of the total waste by number of bags (Figure 3).

The top ten drugs wasted by drug cost included vasopressin, daptomycin, ceftaroline fosamil, nitroprusside, meropenem, norepinephrine, aztreonam, anidulafungin, sodium bicarbonate, and phenylephrine (Table 6). These drugs represented 71% of the total loss in drug cost (Figure 4).

The top ten drug classes wasted by drug cost included hormone analog antidiuretic, cephalosporin antibiotics, cyclic lipopeptide antibiotic, electrolytes, vasodilator antihypertensive, antifungal, carbapenem antibiotics, alpha-/beta- agonist, monobactam antibiotics, and vitamins (Table 7). These drug classes represented 79% of the total loss in drug cost (Figure 5).

Table 3. Total IV Solution Wastage in a 30-Day Period

Drug Class	Drug Name	Total Waste (# of bags)	Total Waste ($)
alpha-/beta- agonist	norepinephrine	1	175.1
alpha-adrenergic agonist	phenylephrine	12	121.1
Analgesic	Acetaminophen	2	63.24
antianginal	diltiazem	2	21.24
antibiotic, aminoglycoside	gentamicin	6	50.58
antibiotic, aminoglycoside	tobramycin	2	65.55
antibiotic, carbapenem	Meropenem	31	186.25
antibiotic, cephalosporin	cefazolin	20	40.22
antibiotic, cephalosporin	cefepime	2	2.31
antibiotic, cephalosporin	ceftaroline fosamil	3	434.37
antibiotic, cephalosporin	ceftriaxone	1	6.33
antibiotic, cyclic lipopeptide	daptomycin	1	458.8
antibiotic, glycopeptide	vancomycin	14	82.58
antibiotic, macrolide	azithromycin	3	11.16
antibiotic, miscellaneous	bacitracin	5	23.4
antibiotic, monobactam	aztreonam	5	173.69
antibiotic, penicillin	Ampicillin	1	1.79
antibiotic, penicillin	ampicillin-sulbactam	8	14.76
antibiotic, penicillin	penicillin G potassium	25	76.31
antibiotic, penicillin	piperacillin-tazobactam	6	13.8
anticonvulsant	Levetiracetam	6	22.96
anticonvulsant	valproate sodium	1	2.2
antidiarrheal	octroetide	2	24.2
antidiuretic hormone analog	vasopressin	3	734.88
antiemetic	ondansetron	1	1.15
antifungal	anidulafungin	4	168.56
antifungal	fluconazole	3	25.29
antihypertensive, diuretic	bumetanide	1	1.85
antihypertensive, diuretic	chlorothiazide	1	48.84
antihypertensive, diuretic	furosemide	3	5.82
antihypertensive, vasodilator	nitroprusside	1	280.92
Antiviral	Acyclovir	1	17.6
corticosteroid	methylprednisolone succinate	3	58.22
electrolyte	sodium bicarbonate	10	144.72

Table 3. Total IV Solution Wastage in a 30-Day Period (continued)

Drug Class	Drug Name	Total Waste (# of bags)	Total Waste ($)
electrolyte	calcium glucanate	1	4.02
electrolyte	potassium chloride	40	96.72
electrolyte	potassium phosphate	3	38.28
electrolyte	sodium chloride	5	12.6
electrolyte	sodium phosphate	4	38.28
insulin	Humulin R	6	2.54
iron salt	sodium ferric gluconate	1	19.66
NSAID	Ibuprofen	18	79.65
oxytocic agent	oxytocin	4	11
vitamin	folic acid	13	19.6
vitamin	MVI infuvite	12	92.76
vitamin	thiamine	18	50.76

Table 4. Top 10 Drugs by Number of Bags Wasted

Drug Name	Total Waste (# of bags)
Potassium Chloride	40
Meropenem	31
Penicillin G Potassium	25
Cefazolin	20
Ibuprofen	18
Thiamine	18
Vancomycin	14
Folic Acid	13
Phenylephrine	12
MVI Infuvite	12

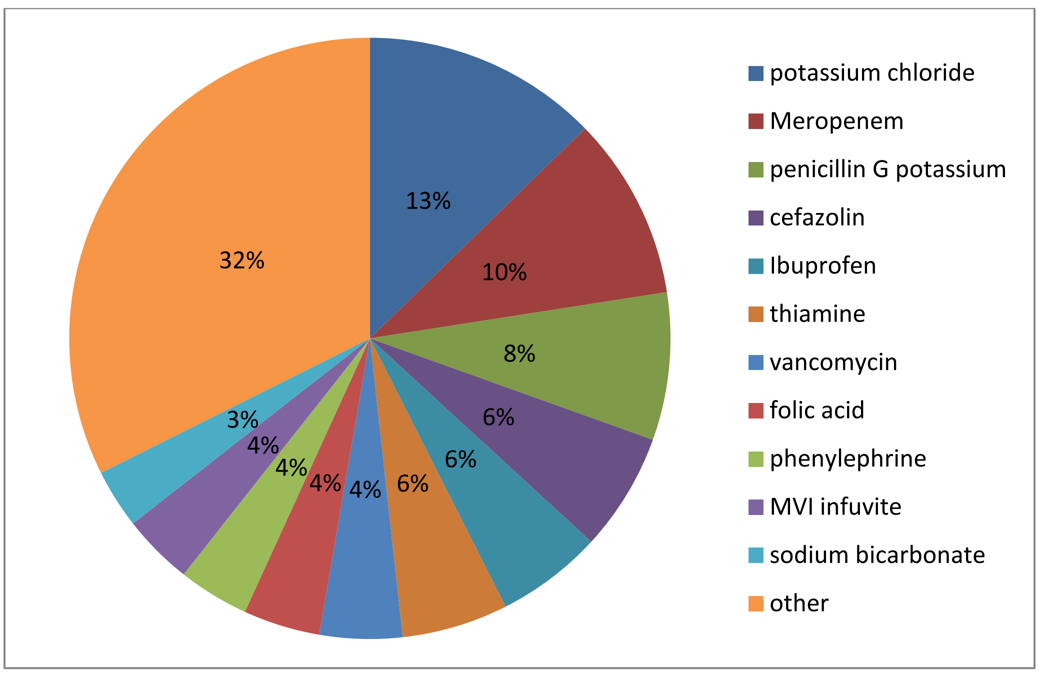

Figure 2. Percentage of Top 10 Drugs in Total Number of Bags Wasted

Table 5. Top 10 Drug Classes by Number of Bags Wasted

Drug Class	Total Waste (# of bags)
Electrolyte	63
Vitamin	43
Antibiotic, Penicillin	40
Antibiotic, Carbapenem	31
Antibiotic, Cephalosporin	26
NSAID	18
Antibiotic, Glycopeptide	14
Alpha-Adrenergic Agonist	12
Antibiotic, Aminoglycoside	8
Anticonvulsant	7

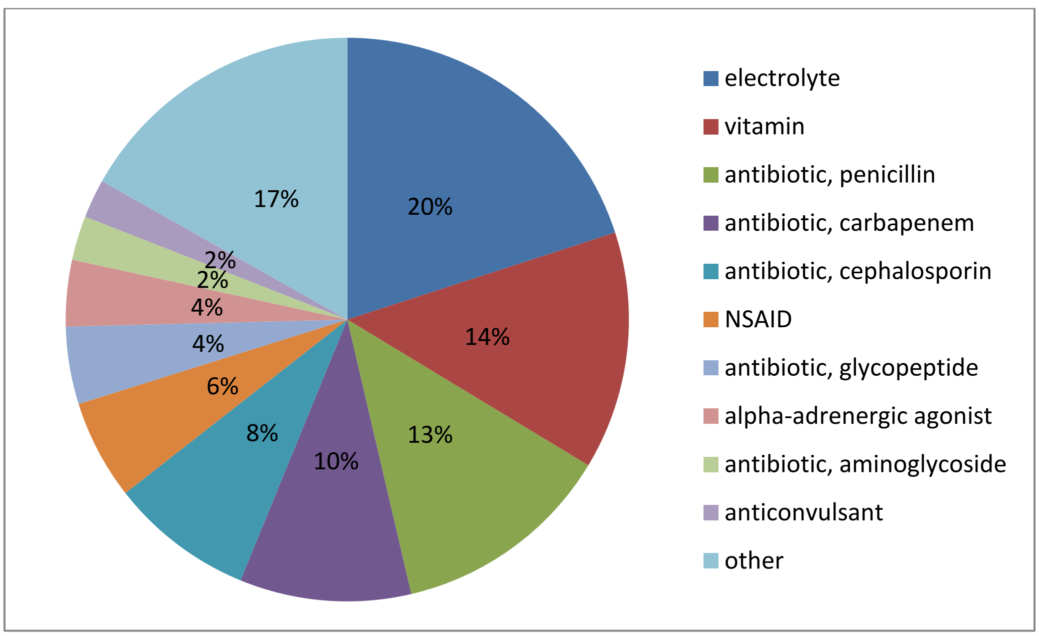

Figure 3. Percentage of Top 10 Drug Classes in Total Number of Bags Wasted

Table 6. Top 10 Drugs by Drug Cost

Drug Name	Total Waste ($)
Vasopressin	734.88
Daptomycin	458.8
Ceftaroline Fosamil	434.37
Nitroprusside	280.92
Meropenem	186.25
Norepinephrine	175.1
Aztreonam	173.69
Anidulafungin	168.56
Sodium Bicarbonate	144.72
Phenylephrine	121.1

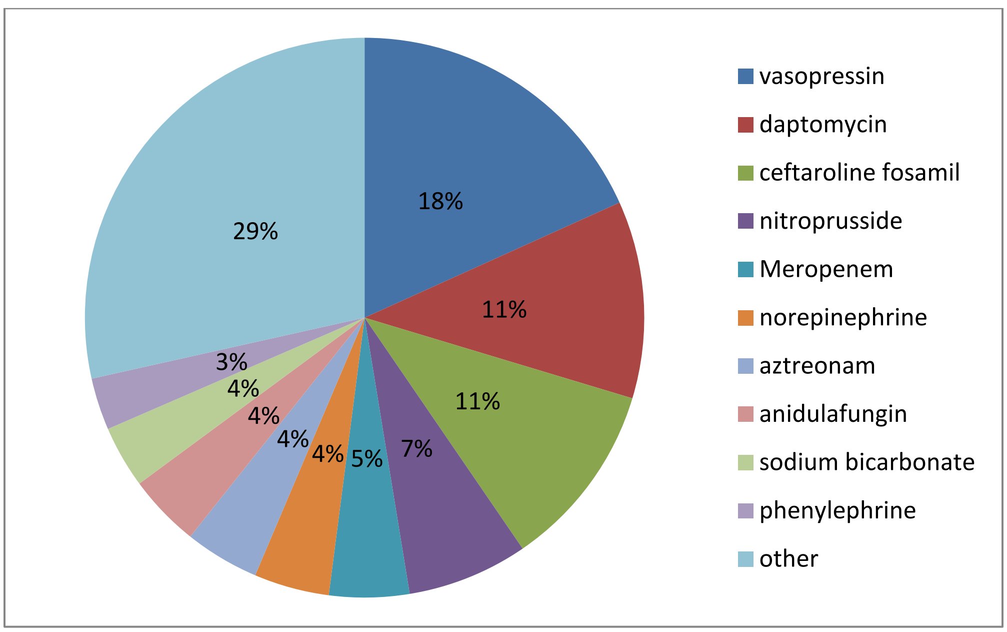

Figure 4. Percentage of Top 10 Drugs in Total Drug Cost

Table 7. Top 10 Drug Classes by Drug Cost

Drug Class	Total Waste ($)
Antidiuretic Hormone Analog	734.88
Antibiotic, Cephalosporin	483.23
Antibiotic, Cyclic Lipopeptide	458.8
Electrolyte	334.62
Antihypertensive, Vasodilator	280.92
Antifungal	193.85
Antibiotic, Carbapenem	186.25
Alpha-/Beta- Agonist	175.1
Antibiotic, Monobactam	173.69
Vitamin	163.12

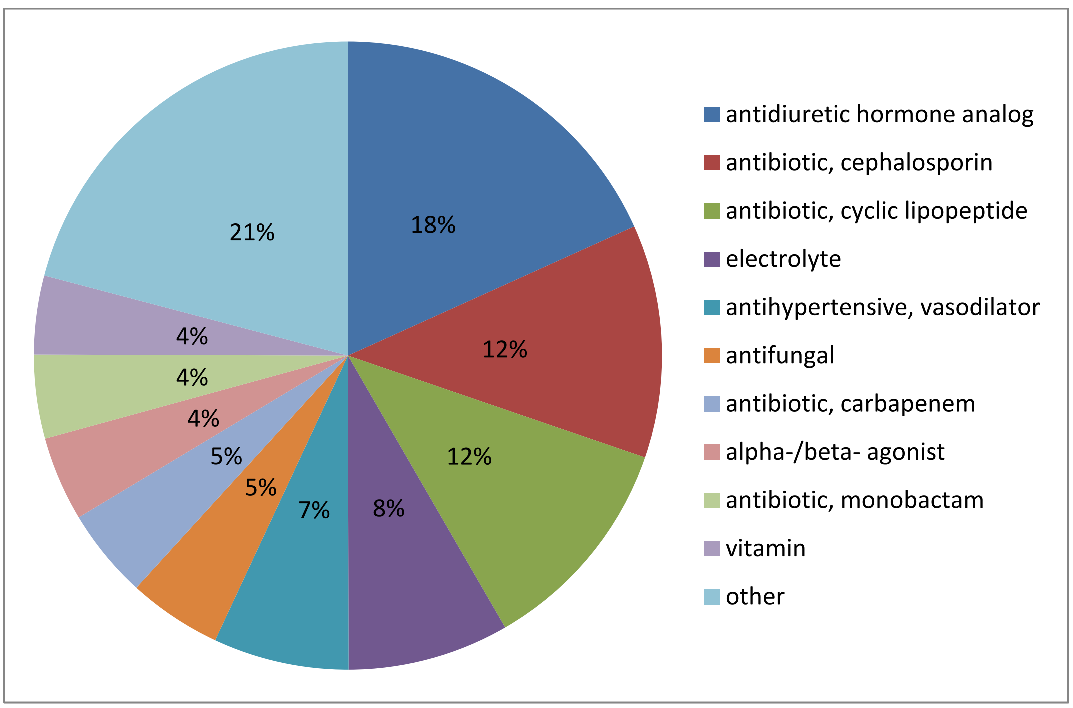

Figure 5. Percentage of Top 10 Drug Classes in Total Drug Cost

There were only two drugs that were in both the top 10 drugs wasted by number of bags and by drug cost: meropenem and phenylephrine. Tables 8 and 9 are summaries of the daily log. All 31 of the meropenem bags were expired from Omnicell machines. All 12 of the phenylephrine infusions were expired bags retrieved from the IV room fridge.

Table 8. Meropenem Daily Log Summary

Dose	Location	Order Type	# of Bags	Drug Cost ($)
500mg	Omnicell	Restock	18	76.14
1g	Omnicell	Restock	13	110.11
Total			31	186.25

Table 9. Phenylephrine Daily Log Summary

Dose	Location	Order Type	# of Bags	Drug Cost ($)
20mg	Fridge	Overstock	5	40.4
20mg	Fridge	PRN	3	24.24
20mg	Fridge	FD	1	8.08
40mg	Fridge	Overstock	2	32.32
40mg	Fridge	PRN	1	16.16
Total			12	121.2

There were 4 drug classes that were represented in the top 10 drug classes wasted both by number of bags and by drug cost:

- electrolytes: sodium bicarbonate, calcium gluconate, potassium chloride, potassium phosphate, sodium chloride, sodium phosphate
- vitamin: folic acid, multivitamin infuvite, thiamine
- carbapenem antibiotics: meropenem
- cephalosporin antibiotics: cefazolin, cefepime, ceftaroline fosamil, ceftriaxone

Figure 6 shows how each drug in these 4 drug classes compare in terms of number of bags wasted and drug cost. The red line and the y-axis on the right represent the total drug cost of each drug. The cost of each drug is labeled on the graph. The blue bars and the y-axis on the left represent the number of bags wasted for each drug.

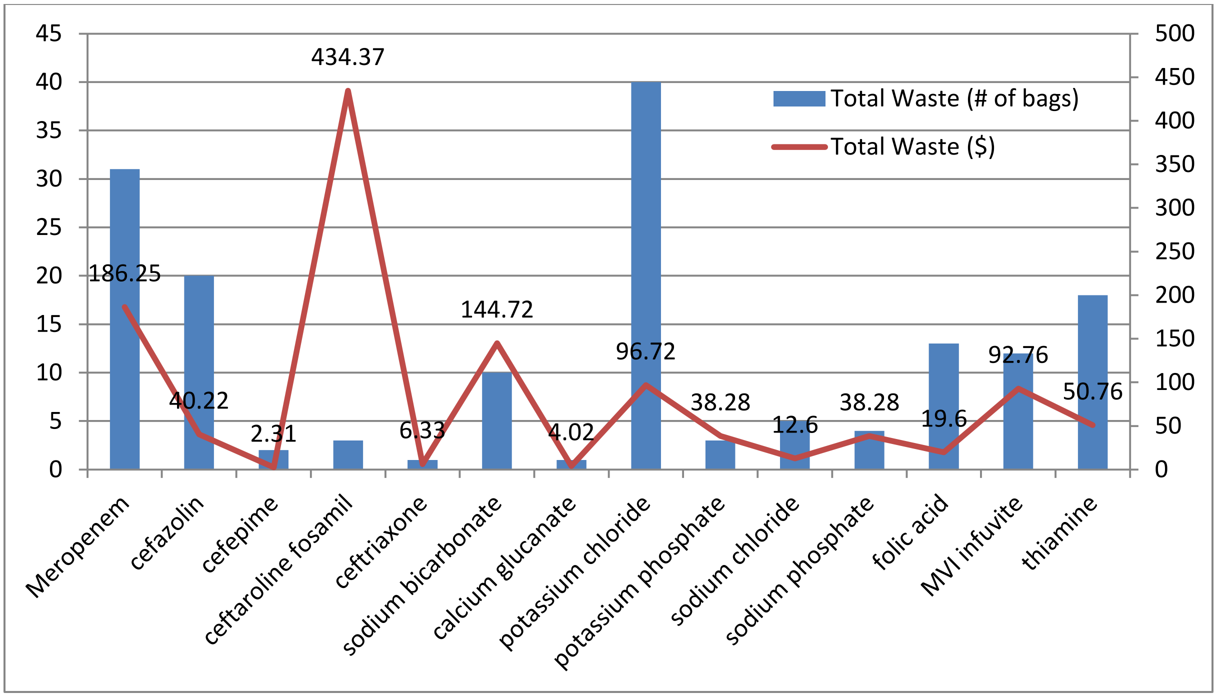

Figure 6. Comparison of IV Wastage by Number of Bags Wasted and by Drug Cost

DISCUSSION

Major Findings

In a 30-day period in March 2017, The BMH-NM (Oxford) pharmacy wasted over 280 IV solution bags, resulting in over $4000 of financial loss in drug cost alone. This wastage is significant for a rural hospital pharmacy with a limited budget. The following discussion will examine the meaning of the findings in relation to the two study objectives and why the findings are important.

1. Categorizing the IV solution wastage by drug and drug class

The top ten drugs wasted by number of bags represent IV solutions that were wasted the most often. To examine the possible reasons behind their large wastage, one needs to understand when and where these solutions are made and stored.

Within these top 10 drugs, 5 drugs are kept in separate overstock bins in the IV fridge, meaning these bags are made in batches in anticipation of orders. These drugs include potassium chloride, penicillin G potassium, cefazolin, ibuprofen, and vancomycin. Because they are prescribed often, making them ahead of time in batches reduces the workload compared to making them one bag at a time as needed. The disadvantage of making them in bulk is that sometimes supply exceeds demand, and these bags may remain unused and expire in the fridge. The expiration time for these drugs vary, from 3 days for potassium chloride to 2 weeks for vancomycin, and one can see how drugs with shorter expiration time can be wasted at a higher rate.

Another disadvantage of making these bags in advance has to do with missing medication. Nurses frequently contact the pharmacy about missing IV doses, and usually pharmacy technicians try their best to locate the missing bag before asking the IV technician to make a replacement bag, since it is frustrating for the IV technician to go through the trouble of gowning up just to make a single IV bag that he or she has already made earlier that day. For these "ready-to-go" IV solutions, however, technicians have less incentive to look for the missing dose, since replacing the missing bag is as easy as opening the fridge and grabbing another bag out of the bin. The problem with this behavior is that the missing IV dose is still somewhere in the nursing unit, and it will remain unused and expire there. For these two reasons, the 5 drugs that are used to make these overstock IV solutions may be wasted at a higher rate than other drugs.

The other 5 drugs in the top 10 drugs wasted by number of bags include meropenem, phenylephrine, folic acid, thiamine, and multivitamin infuvite. There will be two sections later dedicated to meropenem and phenylephrine. As for the other three, they are frequently used in combination to make what is known as a "banana bag," named for the yellow color and the high vitamin concentration of the solution. These bags are infused continuously, so they are made as part of the IV batch that prints at scheduled times during the day. The solution has a short expiration time of 24 hours, so if a bag gets returned to the pharmacy after remaining unused in the nursing unit, there is almost never a chance for the bag to be recycled and given to another patient. During this study, 12 "banana bags" were wasted, leading to its spot in the top 10 list. This finding is not surprising. Technicians often joke about the futility of making these multivitamin infusions because sometimes it feels like every "banana bag" they make gets returned and wasted at the pharmacy a day later. The study result supports their observation because these solutions are indeed wasted at a higher rate than most other IV infusions. A possible strategy to mitigate the waste is to change these orders from scheduled to PRN, so that these bags are only made as needed.

The top 10 drug classes wasted include 5 different classes of antibiotics, electrolytes, vitamins, NSAIDs, alpha-adrenergic agonist, and anticonvulsant. The only NSAID in the results was ibuprofen, the only alpha-adrenergic agonist was phenylephrine, and the anticonvulsants were levetiracetam and valproic acid. Antibiotics are some of the most frequently used medication at hospitals, so it is not surprising that they are also some of the most frequently wasted solutions. These bags may remain unused due to order changes, patient discharge, or a variety of other factors. Electrolytes, vitamins, NSAIDs, and alpha-adrenergic agonist all showed up in the top 10 drugs wasted by number of bags list as well, and possible reasons for their wastage either have already been discussed or will be discussed (in the case of phenylephrine). Anticonvulsant was a surprising drug class in the top 10 list, but a quick look at the data shows that only 7 bags were wasted in this drug class, and since both levetiracetam and valproic acid have short expiration time of 24 hours, it is understandable that 7 bags could have been wasted in a month.

2. Quantify the financial loss in terms of drug cost

The top ten drugs wasted by drug cost included 2 types of medications. The top 4 drugs, namely vasopressin, daptomycin, ceftaroline fosamil, and nitroprusside, were in this list because the unit price for each drug was over $100. Vasopressin, for example, costs $122.48 per 2 ml vial. Nitroprusside is even more expensive at $280.92 per 2 ml vial. Therefore, wasting just one IV bag made from one of these high-cost drugs can have the same financial impact as wasting dozens of bags made from a cheaper drug. The other 6 drugs in this list (meropenem, norepinephrine, aztreonam, anidulafungin, sodium bicarbonate, and phenylephrine) are relatively cheaper, with unit prices under $50, but the sheer volume of bags wasted resulted in costly drug loss. It is important to note that wastage from these ten drugs constituted 71% of the total financial loss due to drug cost, so by focusing on strategies to reduce waste in these 10 drugs, the pharmacy can bring the cost down significantly.

The top ten drug classes wasted by drug cost reflect mostly similar results to the top ten drugs. 7 of the ten drug classes are represented in the top 10 drugs wasted by drug cost, and they are hormone analog antidiuretic (vasopressin), cyclic lipopeptide antibiotic (daptomycin), vasodilator antihypertensive (nitroprusside), antifungal (anidulafungin), carbapenem antibiotic (meropenem), alpha-/beta-agonist (norepinephrine), and monobactam antibiotic (aztreonam). The other three drug classes, cephalosporin antibiotics, electrolytes, and vitamins, were also in the top ten drug classes wasted by number of bags, so their presence in the top ten by drug cost list may be explained by the high volume of waste for each drug class.

3. Common drugs and drug classes in top 10 wasted both by number of bags and by drug cost

There are two drugs that are in the top 10 drugs wasted both by number of bags and by drug cost: meropenem and phenylephrine. All 31 bags of meropenem that were wasted came from Omnicell restocks, meaning that these bags were made in the pharmacy and put in the Omnicell machines by rounding technicians, but were never used by nurses prior to their expiration date. These pop-together meropenem preparations are given an expiration time of 15 days. They are kept in almost every nursing unit, in either the 500 mg or 1 g strength or both. Depending on the type of patients at each unit, demand for meropenem fluctuates greatly, so some units might need daily restocks of meropenem IV bags, while other units have a surplus of them. While the unit price of meropenem isn't high, 31 bags ended up costing the pharmacy nearly $200 in a month.

Meropenem wastage is not a problem unique to the BMH-NM (Oxford) pharmacy. Several papers have examined ways to reduce the cost of meropenem acquisition while maintaining clinical outcomes. In a paper published in the American Journal of Health-System Pharmacy, Kotapati (2004) found that a dosing regimen of meropenem at 500 mg every 6 hours yielded similar clinical outcome to a dosing regimen of 1 g every 8 hours and reduced the daily drug acquisition cost for meropenem at a large teaching hospital. Another study by Patel (2007) published in Pharmacotherapy confirmed that the alternative dosing regimen for meropenem reduced total daily dose and almost halved the drug cost in a 417-bed privately owned community hospital. So perhaps switching to this alternative dosing regimen and stocking only 500 mg meropenem in Omnicell machines can reduce cost. Still, there needs to be more research on whether this change can reduce wastage.

Phenylephrine infusions are usually PRN or as needed orders, but because of the frequency of use, some technicians like to make a couple extra bags to keep in the fridge so they don't have to go back into the IV room every other hour to make this IV solution.

Phenylephrine IV solutions are only good for 24 hours, so sometimes they expire in the fridge before being used. Other times, multiple bags are sent up to the nurse at once because the IV solution is flowing into the patient at a rapid rate continuously, and the nurse wants to makes sure there is no lag time between the first bag running dry and hanging of the second bag. Unfortunately not every bag is hung, and the extra bags either expire in the unit or are brought back to the pharmacy to be wasted. In the 30-day data collection period, 12 bags of phenylephrine were wasted, resulting in a loss of $121.2. While these numbers may seem low, this is still a drug that should be prioritized for reducing wastage because it was in the top 10 list for both wastage criteria.

Finally, there were 4 drug classes that were in the top 10 drug classes wasted both by number of bags and by drug cost, and Figure 15 showed how number of bags and cost related for each drug under these four drug classes. It becomes clear that for some drugs like ceftaroline fosamil, the cost is the driving factor behind its high wastage, whereas potassium chloride had 10 times more bags wasted than ceftaroline fosamil but only a quarter of the drug cost loss. The figure attempts to show that in order for the pharmacy to cut down IV solution wastage, they must consider volume and cost together to reduce financial loss.

Practical Relevance

The data collection process brought forth a few unexpected insights into the practical relevance of this study. First, the daily data collection process was simple and quick, with time ranging from 10 minutes to 20 minutes per day to complete all the tasks, including entering data, crediting the bags, removing and shredding labels, and cutting the bags up in the sink, all (except for data entry) of which are tasks that pharmacy technicians already do as a part of normal work routine. Therefore, a daily log of wasted IV solutions can be easily incorporated into the nightshift technician's work flow.

Second, the data collection process eased the workload of the rounding technicians by cutting out the time they would normally spend on crediting the wasted IV bag, and it eased the workload of the IV technicians by cutting out the time they would normally spend on cutting up the bags in the sink. In fact, at the conclusion of the data collection, several technicians said that they've been "spoiled" and would miss me coming to the pharmacy every night for data collection.

Third, the data collection process increased awareness of IV solution wastage, and even medication wastage in general, for both technicians and pharmacists. By the second week of data collection, the staff began asking me, "how are we doing today (in terms of number of bags wasted)?" By the third week, a few techs and pharmacists had picked up on the fact that meropenem was being wasted at a high rate, and one pharmacist remarked that she was wary of restocking Omnicell machines with meropenem because, "we would end up expiring them anyway." By the fourth week, which is the week that staff conducts medication expiration throughout the pharmacy and the Omnicell machines, the lead tech had asked me if I plan on collecting data on all medication wasted, i.e. pill, insulins, etc. because of the high volume of drugs being wasted that month. In a matter of 30 days, the pharmacy staff became more invested in IV solution wastage and more vocal about their concerns. If this project were continued for a longer period of time, the cultural change might be even more evident.

Study Limitations

There are a number of limitations with this study. First, the study was conducted in a rural hospital in Mississippi that serves a patient population with a distinct regional disease prevalence high in obesity, Type II diabetes, hypertension, and other cardiovascular diseases. The data, therefore, has low external validity. The findings of this study cannot be used to predict or to be compared to IV solution wastage patterns at larger hospitals in urban areas, or in specialty hospitals that cater to oncology patients or pediatrics.

Second, the study was conducted in a brief 30-day period in March. March is usually not the busiest month for hospitals, especially for BMH-NM (Oxford). At this hospital, peak inpatient census happens when the influenza season and the cold winter months collide, from October to February. Therefore, the wastage observed in this study might be an underestimate of the IV solution wastage in the winter months. On the other hand, March is usually busier than the summer months between June and August, so this study's findings might be an overestimate for those months. Clearly, the optimal study duration should be a yearlong study to accurately reflect the average amount of IV solution wastage per month, but due to constraints on time and resources, this study was only able to collect data from one month.

Third, the study only quantified one aspect of the financial loss, which is drug cost. This study did not take into account the cost of fluid bags in which the drugs were injected, nor the supply cost of making IV solutions (i.e. syringes, needles, sterile garbs, etc.), nor the labor cost of the pharmacy technicians and pharmacists. Therefore, the $4000 loss is only a portion of the total financial loss due to IV solution wastage. The findings might be more striking if all aspects of financial loss were taken into account, but due to difficulties in obtaining fluid costs, supply costs, and employee pay rates, as well as constructing a model for calculating the labor cost per bag, this study only quantified the drug cost of IV solution wastage. Even the drug cost alone was calculated conservatively. For example, the drug cost from multidose vials was calculated with the assumption that each vial was used to make as many IV bags as possible before it was thrown away. In reality, multidose vials are frequently discarded with some drug still left in them, so the actual drug cost from multidose vials would be higher than what this study reflects.

Finally, this study did not investigate the cause of IV wastage. To identify the cause of waste for each bag, one would need access to each patient's electronic medical record, which is difficult to obtain as a researcher. One would also need a thorough understanding of the nursing workflow and physician workflow to fully investigate why some IV solutions remain unused. Therefore, while the result confirmed that IV wastage is costing the pharmacy a lot of money, this study cannot provide any definite answers on strategies to reduce IV wastage.

Further Research

Some ideas for further research include expanding the study period from one month to a year to investigate the long-term impact of IV solution wastage, identifying and comparing IV solution wastage in two rural hospitals in Mississippi, and investigating the cause of IV solution wastage at a hospital pharmacy.

CONCLUSION

IV solution wastage is costing the BMH-NM (Oxford) pharmacy over $4000 per month, and identifying this problem is the first step in attempting to mitigate the wastage. Pharmacy directors can use wastage data to pinpoint areas for improvement and enact changes that can most effectively reduce IV solution wastage.

LIST OF REFERENCES

Al-Dhawailie AA. Control of intravenous medication wastage at a teaching hospital in Saudi Arabia. Saudi Med J. 2011 Jan;32(1): 62-5.

Birdwell SW, Meyer GE, Scheckelhoff DJ, Giambrone CS, Iteen SA. Survey of wastage from intravenous admixture in U.S. hospitals. Pharmacokinetics. 1993 Oct;4(4):271-7.

Chiu SF, Lin AC, Ivey MF, McArter J, Chiu CH. Quantifying the intravenous admixture wastage in a hospital. ASHP Summer Meeting: Rosemont, IL 2009 Jun 15. Poster.

Kotapati S, Nicolau DP. Clinical and economic benefits of a meropenem dosage strategy based on pharmacodynamic concepts. AJHP. 2004 Jun;61(12):1264-70.

Patel GW, Duquaine SM, McKinnon PS. Clinical outcomes and cost minimization with an alternative dosing regimen for meropenem in a community hospital. Pharmacotherapy. 2007;27(12):1637–43.

Uchida KM, Iteen SA, Wong NT. Identifying costs of intravenous solution wastage. Pharmacoeconomics. 1994 Sep;6(3):240-8.