Medication inventory optimization and oral solution workflow implementation and integration into pharmacy inventory management system

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Abstract

Pharmacy teams continually innovative practice models to satisfy the financial goals of their hospitals. As medication costs are anticipated to persistently rise, many strategies aimed at drug utilization have been recommended to reduce this cost burden on hospitals.[1] Additionally, optimized pharmacy inventory can improve the hospital's ability to provide comprehensive patient care. Medication stock-outs and expirations lead to interruptions in care; diligent inventory management can ensure patients will receive continuous access to necessary medications throughout the duration of their stay.

Allegheny Health Network inpatient pharmacies currently utilize an automated inventory management system. At Allegheny General Hospital (AGH), a need for further optimization of current par levels has been identified to meet changing inventory demands. Average stock-outs are approximately 300-500 per month, leaving room for improvement. Additionally, oral solutions are not currently integrated into this system. The purpose of this study is to optimize current inventory par levels and to integrate oral solutions into the automated pharmacy inventory system at AGH.

This project is relevant to public health, as hospitals must find effective ways to identify potential waste and delays in services that do not add value to the patient experience and eliminate them.[2] Improving medication supply-chain strategies can increase nursing time at the patient's bedside and reduce expenditure on wasted or expired medications that can be reallocated to value-add patient care services.[3]

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1.0 Background

Pharmacy teams continually pursue innovative practice models to satisfy the financial and strategic goals of their hospitals. With shrinking pharmacy reimbursement and medication costs continuing to rise, many strategies aimed at drug utilization have been recommended to reduce financial burden on hospitals.[1,4] Effective inventory management can be a key cost-saving initiative hospital pharmacy departments can employ to reduce unnecessary drug waste and expenditure. Inventory procurement and management is a core function of a hospital pharmacy,[5] and it requires teams to strike a balance between meeting patient needs, while minimizing the amount spent on medications stored within and outside of the pharmacy.[1]

A core focus of this study is review of medication stock-outs; the researchers of the study defined a stock-out as the complete absence of medication at the point of service or delivery to patient care areas. Medication stock-outs lead to interruptions in care, which can prove detrimental to patient outcomes. When indicated for the treatment of acute ischemic stroke, current best practice guidelines recommend the administration of alteplase within 60 minutes of arrival to the hospital.[6] To delay thrombolytic therapy in the case of an ischemic stroke could result in irreversible brain tissue death. Other patient conditions, such as sepsis or traumas, would demand similar expedience in medication administration. Without diligent inventory management strategies, we cannot ensure continuous and reliable access to time-sensitive medications.

Though not directly addressed in this study, medication shortages contribute to interruptions in care and have become a world-wide public health issue in healthcare today.[8] Per the University of Utah Drug Information Service, a shortage is defined as "A supply issue that affects how pharmacies prepare and dispense a product or that influences patient care when

prescribers must choose an alternative therapy because of supply issues"[9]. Shortages have impacted almost every drug class, including life-saving rescue medications like epinephrine, chemotherapy agents, and others. This was especially revealed during the peak of the COVID-19 pandemic, as many patients were utilizing a large proportion of critical care medications, such as analgesics, sedatives, paralytics, and antibiotics.[10] Increased mortality and even death as a result of shortages have been shown in several studies. In an ISMP survey, drug shortages have also resulted in unsafe practices as a way to account for unattainable product; due to fluid shortages, medications typically diluted in large volumes are administered via IV push, potentially disposing nurses to medication preparation or administration errors.[11] Though beyond the control of pharmacy personnel, if optimal inventory management controls are in place, pharmacies can anticipate shortages early on and swiftly identify alternative agents.[8,12]

As discussed, medication stock-outs and shortages can have major impacts on delivery of patient care. Alternatively, excessive drug supply contributes to unnecessary hospital expenditure and waste. These funds could have otherwise been allocated to improve patient care and outcomes. Pharmacy departments have a responsibility to manage waste, as they are a major cost center for hospitals. Many have employed measures to reduce waste through purchase of multi-use vials for IV room compounding, reduction of supply on-hand for high-cost medications, and procurement of ideal vial sizes and dosage forms, considering per unit cost and average daily usage.[13, 14]

Allegheny Health Network inpatient pharmacies currently utilize an automated inventory management system, which is a software used to manage pharmacy medication supply in real-time and partially automates the drug dispensing process. They are excellent tools for tracking medication supply and streamlining the medication ordering process via automatic reordering directly from the medication supplier.[6] Additionally, these systems track important data on

medication inventory that can be leveraged to optimize supply – usage information, quantity on hand, and expiration dates.[15] However, even with an automated system, there are challenges associated with its use.

Inventory demands constantly change due to introduction of new medications to formulary, recommended treatments change based on new and updated guidelines, and medication shortages. These factors can shape prescribing patterns. Items that are not tracked or overstock medications not visible within the system are vulnerable to mismanagement. Additionally, automatically generated stock-out and waste/expiration reports are inaccurate, making it difficult to harness this data to improve inventory management.

At Allegheny General Hospital (AGH), a need for further optimization of current par levels has been identified to meet changing inventory demands. Par levels are quantities on-hand that determine how much of a particular medication is stored in the pharmacy and the threshold for supply replenishment. Setting appropriate par and reorder levels for medium and high cost medications should be reviewed routinely.[1] Average stock-outs are approximately 300-500 per month, leaving room for improvement. In an ideal state, the desired quantity on-hand for a medication is a minimum of five days' supply and a maximum of seven days' supply. The minimums and maximums are unique to each medication and are based on hospital-wide utilization of the medication. These target days' supply on hand account for weekends and holidays that disrupt the typical ability to order the medication next day, delays in medication delivery, and, from a usage perspective, accounts for concurrent use of therapy and variations in prescriber and patient-specific dosing. It is important to note that conservative par levels leave departments vulnerable to stock-outs, while overestimates may ensure timely delivery of medications but contribute to unnecessary drug expenditures.

Another key component to this study is oral solution inventory. Oral medication solutions are not currently integrated into the inventory system. The pharmacy inventory team periodically estimates what stock needs replenished, which is not the most effective method of management. With oral solutions, utilization is inherently difficult to track. When removing 10 mL from a 150 mL bottle, it is difficult to measure the remaining quantity, and variability exists between formulations with overfill and underfill, further complicating the issue.

With this background in mind, the hypothesis is that medication par levels tracked in the inventory management system do not align with site-level usage. The primary objective of this study was to adjust medication par levels in the inventory management system to reflect the average five-day medication utilization. For the purposes of this project, the focus was more so on minimum par levels, as these are the thresholds for medication ordering and drive on-hand supply more strongly than maximum par levels. The second primary objective was to develop a staff-driven process for stockout reporting, especially one that facilitated better communication to the inventory management team. A third primary objective was to integrate oral solutions into the pharmacy inventory system and develop an effective method for utilization tracking.

2.0 Methods

For inventory transaction review, a retrospective review of all medication transactions through the inventory management system was conducted for a period of three months. Based on this usage data collected, an average five-day use was calculated for each medication. This quantity was compared to the current minimum par level set in the inventory management system. Medications were determined to require a par level adjustment if there was a greater than or equal to 50% difference between the current minimum and the actual average five-day usage. Inclusion criteria were all medications dispensed through the inventory management system. Exclusions were any medications not dispensed through inventory management system (in the case of controlled substances and oral solutions) and any transaction dispenses of zero quantity.

For the stock-out review, a prospective review of all stock-out data was collected over the course of six months. Inclusion and exclusion criteria are shown in Figure 1. Inclusion criteria was any stock-out requiring medication ordering, borrowing, or a switching to an alternative agent. Exclusions were again medications not dispensed through the inventory management system, as well as any back-order medications (in which case, the medication is on shortage and is outside of the control of the inventory management team).

Figure 1. Inclusion/Exclusion Criteria

The stock-out reporting form developed in this project can be found in Appendix A. The procedure for use is as follows: when a medication order label prints, a technician or pharmacist will be prompted to dispense the medication. When finding insufficient quantity to fill the order, the technician or pharmacist will place the label on this stock-out sheet and answers the questions listed. For example, if the inventory management system reports there are 255 amlodipine 5 mg tablets, but the technician encounters an empty bin when physically dispensing the supply, the technician would indicate the “med is out of stock” and mark “inventory count incorrect”.

3.0 Results

In total, 505 stock-outs were screened, 255 were excluded, and 250 remained for review. All inventory transactions in the three month period were also screened, excluding transactions with a zero dispense. Then transactions were categorized per each unique medication formulation, dose and strength, and was able to evaluate 567 unique medications for par level adjustment. As shown in Figure 2, for the first primary endpoint, of the 567 medications included, 401 medications were identified that required a par level adjustment, based on that threshold of a 50% difference. 70% of the 401 medications were recommended for a reduction in the par level. 1% of the 401 medications were recommended for expansion beyond the par level. 166 medications were reviewed and a change was not recommended. The new and improved stock-out reporting was used as a check to assess if a change (specifically a reduction in stock) was a sound recommendation.

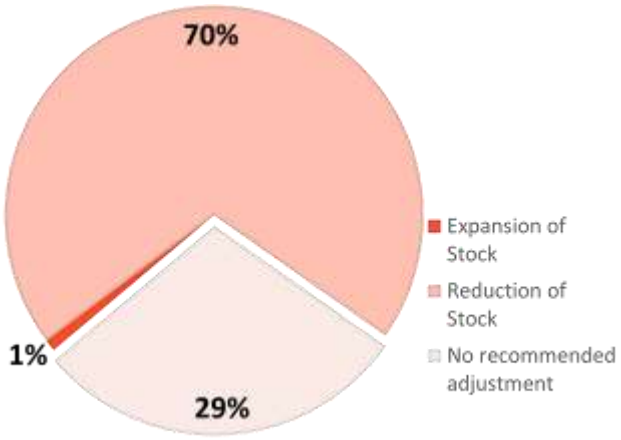


Figure 2. Distribution of Par Level Recommendations

4.0 Discussion

For 70% of the medications, the recommendation was to reduce current par levels. With the enhanced inventory visibility resulting from the new stock-out reporting structure, it was discovered that members of the AGH inventory management team were adjusting par levels throughout the period of review – this new reporting made it much easier to identify where more inventory was needed. This contributed to why so few medications required an increase in the minimum par level compared to medications requiring a reduction in par level. As recommendations for 1% of the medications was to reduce supply, overstock may be a potential issue.

Given these findings, a consideration for future directions is tracking of expired or wasted medications. Hospitals do not typically trend the amount of drug expired annually or the dollar amount associated with this waste. As this study identified needs to reduce medication supply in a majority of cases, there is potential that expired drug is a major contributor to waste at AGH. For these underutilized medications, it may be prudent to consider if they should remain on the formulary. There may be therapeutic alternatives that provide better, more effective care, or a particular drug is no longer recommended for use. Adjusting the formulary can help reduce unnecessary supply of medication and assist providers with ordering the most appropriate medications for their patients.[1]

A key consideration related to waste observed in this study was based on medication formulation. After reviewing the data, there was surprisingly low usage for medications that are heavily prescribed; this was found to be attributable to the specific dosage form. For example, oral ciprofloxacin is a high-use antibiotic; the 500 mg tablet reflected this high-use, but the 250 mg

tablet was rarely utilized. It may be prudent in these situations to only stock the 500 mg tablets. If deciding to only supply 500 mg tablets, increased tablet splitting could be a safety concern, which increases nursing workload and potential for misdosing. Another consideration is the ability of the medication formulation to be partially dosed; some tablets and capsules cannot be split or opened. For future steps, review of medications that come in multiple formulations on a case-by-case basis would be a great strategy to reduce unnecessary on-hand supply.[13,14]

After this project, there were some limitations identified. Oral solutions integration was originally a component of this project – the goal was to integrate them into the inventory system as they are manually reviewed at this time and are not integrated into this system as it is inherently difficult to track utilization. Challenges were encountered when considering addition of these medications to the inventory management system; the proposed changes made to integrate the oral solutions within the inventory management system would have adversely impacted other hospitals' operations within the Allegheny Health Network. Other hospitals track their oral solutions differently, and changes made in the inventory management system for medication units of tracking cannot be limited to one site. The decision was made to defer the integration.

Another limitation was that a staff-driven process for stock-out reporting may not have captured all stock-outs when considering compliance and accuracy of reporting. Additionally, when assessing day-to-day usage with a five-day average usage, it is difficult to capture all scenarios of range or variability in the typical dose and course of treatment depending on the patients and any medication use outside the norm.

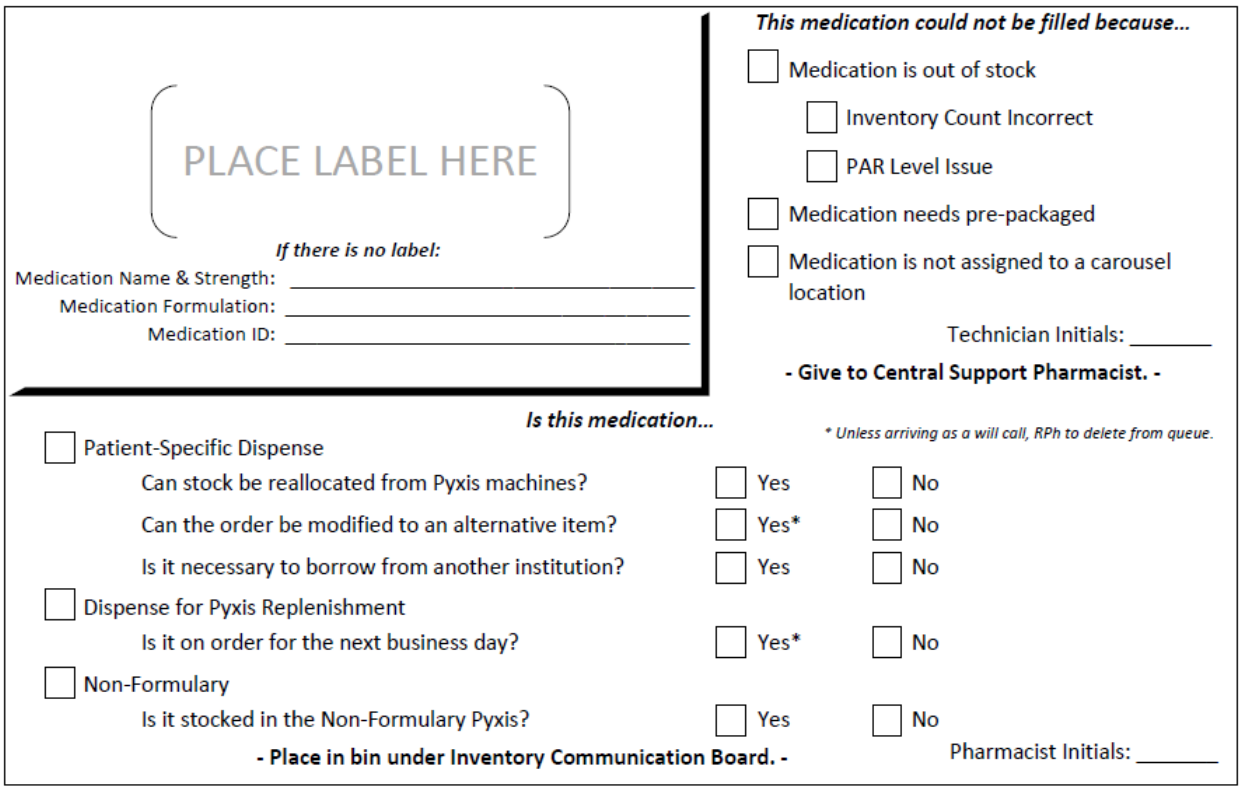
Public Health Relevance: This project is relevant to public health, as hospitals must find effective ways to identify potential waste and delays in services that do not add value to the patient experience and eliminate them.[9] Medication stock-outs lead to delays in patient care, and often

requires nursing to step away from the bedside to address them. This results in delay of medication administration and contributes to reduced quality of care. When considering delays in pain medication or anti-nausea medications, patients can become increasingly dissatisfied, ultimately reflecting poorly on your healthcare institution. Improving medication supply-chain strategies can increase nursing time at the patient's bedside and reduce expenditure on wasted or expired medications that can be reallocated to value-add services.[3]

5.0 Conclusion

In conclusion, 71% of medications dispensed in the three-month period required par level adjustment, and these adjustments made through this analysis will be monitored for effectiveness. There are many additional opportunities that exist to improve inventory management, including oral solutions integration and evaluation of expiring stock. For future direction, as stock-outs are used to assess the need to expand stock, outdates can be used to assess the need to reduce stock. Creating a process for identifying frequent medication expirations would be an excellent proactive measure to reduce waste, as the majority of recommended adjustments were a reduction in supply on hand. Medications identified through this process may be appropriate candidates for formulary review as well.

6.0 Appendix A. Stock-Out Reporting Form



PLACE LABEL HERE

If there is no label:

Medication Name & Strength: _____

Medication Formulation: _____

Medication ID: _____

This medication could not be filled because...

- ☐ Medication is out of stock
  - ☐ Inventory Count Incorrect
  - ☐ PAR Level Issue
- ☐ Medication needs pre-packaged
- ☐ Medication is not assigned to a carousel location

Technician Initials: _____

- Give to Central Support Pharmacist. -

Is this medication...

** Unless arriving as a will call, RPh to delete from queue.*

☐ Patient-Specific Dispense		
Can stock be reallocated from Pyxis machines?	☐ Yes	☐ No
Can the order be modified to an alternative item?	☐ Yes*	☐ No
Is it necessary to borrow from another institution?	☐ Yes	☐ No
☐ Dispense for Pyxis Replenishment		
Is it on order for the next business day?	☐ Yes*	☐ No
☐ Non-Formulary		
Is it stocked in the Non-Formulary Pyxis?	☐ Yes	☐ No

- Place in bin under Inventory Communication Board. -

Pharmacist Initials: _____

Bibliography

1. American Society of Health-System Pharmacists. ASHP guidelines on medication cost management strategies for hospitals and health systems. *Am J Health-Syst Pharm* 2008; 65:1368-84.

2. Chakraborty, S. and Gonzalez, J.A. An Integrated Lean Supply Chain Framework for U.S. Hospitals. *Operations and Supply Chain Management: An International Journal* March 2018; 11(2):98–109.

3. Polater, A. and Demirdogen, O. An investigation of healthcare supply chain management and patient responsiveness: an application on public hospitals. *International Journal of Pharmaceutical and Healthcare Marketing* 2018; 12(3):325-347.

4. Johnson, P.E. Pharmaceutical reimbursement: An overview. *Am J Health-Syst Pharm* 2008; 65 (1).

5. American Society of Health-System Pharmacists. ASHP guidelines: minimum standard for pharmacies in hospitals. *Am J Health-Syst Pharm* 2013; 70:1619–30.

6. Powers, W.J., Rabinstein, A.A., et al. American Heart Association Stroke Council. 2018 Guidelines for the Early Management of Patients with Acute Ischemic Stroke: A Guideline for Healthcare Professionals from the American Heart Association/American Stroke Association. *Stroke* March 2018; 49(3): e46-e110.

7. American Society of Health-System Pharmacists. ASHP statement on the role of health-system pharmacists in public health. *Am J Health-Syst Pharm* 2008; 65:462–7.

8. Phuong JM, Penm J, Chaar B, Oldfield LD, Moles R. The impacts of medication shortages on patient outcomes: A scoping review. *PLoS ONE* 2019; 14(5): e0215837.

9. Holcombe B, Mattox TW, Plogsted S. Drug Shortages: Effect on Parenteral Nutrition Therapy. *Nutr Clin Pract* 2018;33(1):53–61.

10. Farrell, N.M., Hayes, B.D., Linden, J.A. Critical medication shortages further dwindling hospital resources during COVID-19. *American Journal of Emergency Medicine* 2021; 40: 202-203.

11. Institute for Safe Medication Practices (ISMP). Drug Shortages Continue to Compromise Patient Care. *ISMP Medication Safety Alert!* 2018.

12. Melchert, R. B., & Fincham, J. E. Escalating medication shortages: a public health and patient care crisis. *Missouri Medicine* 2012; 109(1), 20–23.

13. Fasola, G., Aprile, G., Marini, L. et al. Drug waste minimization as an effective strategy of cost-containment in Oncology. *BMC Health Services Research* 2014; 14(7).

14. Bekker, C.L., Gardarsdottir, H., Egberts, A.C.G., et al. Pharmacists' Activities to Reduce Medication Waste: An International Survey. *Pharmacy* 2018; 6(3):94.

15. Iqbal, M.J., Geer, M.I., and Dar, P.A. Medicines Management in Hospitals: A Supply Chain Perspective. *Systematic Reviews in Pharmacy* Jan-Dec 2017; 8(1): 80-85.