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Information Sharing Increases Drug Sample Inventory Management Efficiency in Healthcare Clinics: Evidence from a Quasi-Experiment

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Abstract

Inefficient drug sample inventory management in healthcare clinics results in over $2.2 billion worth of drug samples being wasted in the United States every year. Pharmaceutical sales representatives are largely responsible for the forecasting, ordering, and delivery of drug samples in healthcare clinics. Thus, drug samples are a form of vendor-managed inventory, which requires inventory information sharing in order to be effective. A quasi-experimental study was conducted in order to assess the impact of information sharing on drug sample inventory management efficiency in healthcare clinics. A proprietary dataset of anonymized inventory transactions detailing the inflow and outflow of 19,400 drug samples, as well as the access data of said inventory information by pharmaceutical sales representatives was obtained from CheckSamples, a leading drug sample inventory management platform. Data collection took place during the nine month period from November 2016 to July 2017, covering multiple US-based clinics located in rural and urban settings, which range in size from single practitioners to clinics with over ten practitioners. Results indicate that information sharing improves inventory management efficiency, measured by average days in inventory, inventory days of supply, and dispense-through rate, by about 65% on average. Based on these results, information sharing in the context of drug samples holds the potential to generate significant cost savings while improving administrative efficiency and regulatory compliance. These findings are particularly relevant given the rising cost of healthcare and the associated policy debates in the United States today.

Keywords: information sharing, vendor-managed inventory, drug samples, healthcare

1. INTRODUCTION

Drug samples play a critical role in improving patient care by helping to establish preference, efficacy, and tolerance in patients, while reducing time to treatment and increasing drug adherence (Alikhan et al, 2010; Bastiaens, Chowdhury, & Gitelman, 2000). Moreover, drug samples provide access to medications among patients in high-risk groups (Tija et al., 2008). However, an examination of drug sample closets in healthcare clinics[i] revealed that, on average 14% of medications were expired (Evans & Brown, 2012). Extrapolating this finding suggests that an estimated $2.2 billion worth of drug samples are wasted annually in the United States. This waste can be attributed to inefficient inventory management in healthcare clinics and should thus be preventable.

A closer examination of the drug sample inventory management process in healthcare clinics points to the need for collaboration between pharmaceutical sales representatives and healthcare providers (Poser, 2007). Specifically, the responsibility for forecasting, ordering, and delivery of drug samples in healthcare clinics lies largely with pharmaceutical sales representatives. Thus, drug samples in healthcare clinics are an example of vendor-managed inventory (Hines et al, 2000).

Vendor-managed inventory (VMI) generally promises to lower inventory levels while increasing service levels (Levy and Grewel, 2000). However, in order to lead to such positive outcomes, VMI requires information sharing between buyer and vendor. In the context of drug sample inventory management, this suggests that drug sample inventory information should be shared between healthcare providers and pharmaceutical sales representatives in order to improve drug sample inventory management efficiency. Despite previous research on the topic of VMI in healthcare, the topic of drug sample inventory management and the benefits of information sharing in this context have been overlooked. The present study aims to address this gap by assessing the impact of information sharing on drug sample inventory management efficiency in healthcare clinics. The implications of this study are particularly relevant today, given the rapid growth of healthcare costs in the United States and the associated ongoing debate among policy-makers on how to combat this rise (e.g. Groves et al., 2013; Orszag & Ellis, 2007; Bodenheimer, 2005).

The remainder of this paper is structured as follows. The second section provides a brief overview of previous research on VMI implementations in the healthcare sector. The following section describes the methodology of the present study. Sections four and five present and discuss the results, while the last section summarizes this study's conclusions.

2. BACKGROUND

Vendor-managed inventory (VMI) has been defined as a collaborative initiative between a buyer and a vendor to optimize the availability of items and minimize cost to both network partners (Hines et al., 2000). Although VMI arrangements can take many forms (Christopher, 2016), the main goal of VMI is reducing inventory levels while improving service levels at the same time (Levy and Grewel, 2000). Performance benefits in VMI are generally achieved through information sharing between buyer and vendor and appropriate decision-making by the vendor (Sari, 2007). Information sharing, in particular of inventory information, is typically accomplished through information systems that provide real-time electronic data exchange (Yao & Dresner, 2008). Although VMI has been a popular topic in the logistics literature since the 1980s (Williams and Tokar, 2008), it has not received much attention in the healthcare sector until the early 2000s (Haavik, 2000). The following overview of recent studies examining VMI in the healthcare sector is meant to highlight the importance of, and difficulty associated with, implementing VMI in healthcare.

Enablers and performance outcomes associated with industrial vending systems in healthcare, which represent a specific form of VMI, were recently investigated by Falasca and Kros (2016). Their results suggest that the success of VMI in healthcare depends on the quality of the information generated by the information system and the quality of the buyer-vendor relationship. Moreover, their findings indicate that the successful implementation of VMI in healthcare can result in improved inventory management, enhanced service levels, and reduced costs.

An in-depth case study of VMI in a public, general multi-site hospital was conducted by Guimaraes and Carvalho (2013). They found that VMI led to significant improvements in inventory management, such as reduction of inventory costs, optimized inventory levels, decrease of emergency orders, and no stock-out episodes of pharmaceutical supplies. However, strong implementation barriers that are unique to the healthcare sector, such as regulation and a general lack of activity planning, were also found to hinder many of the benefits of VMI. The most significant factor in the successful implementation of VMI was found to be collaboration between partners and information sharing in the supply chain.

A survey of material managers and executives in healthcare by Callender and Grasman (2010) revealed that most respondents have received formal training and acquired appropriate skills and knowledge about supply chain best practices. However, an overwhelming majority of healthcare providers still believe that their inventory-related inefficiencies cannot be improved through information sharing and VMI. Although slightly outdated at this point, the findings of this study still point to a general need for better training and more education regarding the benefits of VMI in the healthcare sector.

Taken together, recent studies investigating VMI in the healthcare sector have generally found that VMI can cause significant improvements of inventory management efficiency. However, significant barriers, including regulation and education, appear to hinder the implementation of VMI in healthcare. The present study aims to contribute to the growing body of knowledge surrounding VMI in healthcare by focusing on the impact of information sharing on drug sample inventory management efficiency – a topic which has hitherto not been addressed in the literature.

3. METHODOLOGY

A proprietary dataset detailing the inventory of drug samples in multiple US-based healthcare clinics during the nine month period from November 2016 to July 2017 was obtained from CheckSamples. CheckSamples is a drug sample inventory management platform that helps healthcare providers increase administrative efficiency and ensure regulatory compliance with regards to the management and control of drug samples. In addition, CheckSamples provides pharmaceutical sales representatives the option to remotely access their clinics' drug sample inventory information, which allows them to optimize the supply of drug samples to clinics.

The dataset consists of anonymized inventory transactions detailing the inflow and outflow of all drug samples, as well as the access data of said inventory information by pharmaceutical sales representatives. The data stem from multiple US-based clinics, located in rural and urban settings, which range in size from single practitioners to clinics with over ten practitioners. During the nine month period from November 2016 to July 2017, a total of 19,400 drug samples were added to clinics' inventories, of which 8,954 (46.15%) were dispensed. The samples belong to 272 distinct drugs, which are made by 148 different pharmaceutical companies and represent 67 FDA Established Pharmacological Classes (EDCs). The top five EDCs are insulin analogs (25.86%), biguanides (6.49%), dipeptidyl peptidase 4 inhibitors (6.25%), l-thyroxines (5.60%), and GLP-1 receptor agonists (5.50%). For 214 (78.68%) of the 272 drugs, clinics' inventory information is not shared with any pharmaceutical representative. For the remaining 58 (21.32%) drugs, inventory information is actively shared with pharmaceutical sales representatives. Table 1 provides an overview of the dataset.

Three inventory management efficiency indicators were calculated for each drug: average days in inventory, inventory days of supply, and dispense-through rate. The indicators have been adapted to the context of drug sample inventory management based on established key performance indicators in inventory and supply chain management practice (Sylver, Pyke, & Thomas, 2017).

Table 1. Dataset Overview

Drugs and Drug Samples	
Drug samples added	19,400
Drug samples dispensed	8,954
Distinct drugs	272
Distinct pharmaceutical companies	148
Distinct FDA Established Pharmacological Classes	67
Information Sharing	
Drugs without information sharing	214
Drugs with information sharing	58

Average days in inventory (ADI) measures how long, on average, a sample of a particular drug is stored in inventory until it is dispensed. Healthcare providers and pharmaceutical sales representatives should strive to minimize it, since a shorter ADI indicates more efficient inventory management. The ADI is calculated as:

$$ADI_i = \frac{Total\ Days\ in\ Inventory_i}{Total\ Samples\ Dispensed_i}$$

where i denotes the drug. When making between-group comparisons, the ADI is averaged across all drugs.

Inventory days of supply (IDS) measures how long, on average, it would take to dispense the remaining sample inventory for a particular drug. Healthcare providers and pharmaceutical sales representatives should strive to minimize it, since a shorter IDS indicates more efficient inventory management. The IDS is calculated as:

$$IDS_i = \frac{Total\ Samples\ in\ Inventory_i}{Average\ Samples\ Dispensed\ per\ Day_i}$$

where i denotes the drug. Just like the ADI, the IDS is averaged across all drugs when making between-group comparisons.

The dispense-through rate (DTR) is a normalized measure of the amount of samples dispensed relative to the amount of samples added. Healthcare providers and pharmaceutical sales representatives should strive to maximize it, since a larger DTR indicates more efficient inventory management. the DTR is calculated as:

$$DTR_i = \frac{Total\ Samples\ Dispensed_i}{Total\ Samples\ Added_i}$$

where i denotes the drug. Like the ADI and IDS, the DTR is averaged across all drugs when making between-group comparisons.

The data analysis exploits the access of clinics' drug sample inventory information by pharmaceutical sales representatives through the CheckSamples platform as an exogenous variable. This allows for between-group comparisons between drugs for which pharmaceutical sales representatives access clinics' drug sample inventory information (i.e. information sharing takes place) and drugs for which pharmaceutical sales representatives do not access clinics' drug sample inventory information (i.e. no information sharing takes place). Since pharmaceutical sales representatives are responsible for restocking clinics' drug sample inventories, one would expect better inventory management efficiency indicators under conditions of information sharing than under conditions of no information sharing. Thus, the research employs a single factor (no information sharing vs. information sharing) quasi-experimental design with three dependent variables (ADI, IDS, and DTR).

4. RESULTS

Average Days in Inventory

For the combined sample, average days in inventory (ADI) is about 35 days (*M* = 35.39, *SD* = 50.30). This suggests that, on average, drug samples remain in inventory for about 1.1 months before they are dispensed. Figure 1 depicts the difference in ADI between drugs with and without information sharing.

As depicted in Figure 1, for drugs without information sharing ADI is about 43 days (*M* = 42.75, *SD* = 53.98). In contrast, for drugs with information sharing, ADI is about 19 days (*M* = 18.55, *SD* = 35.70). Welch's t-test for difference in ADI between drugs without information sharing and drugs with information sharing is significant (t = 3.44, p < .001). In other words, drugs for which pharmaceutical sales representatives access clinics' drug sample inventory information remain in inventory for less than three weeks, whereas drugs for which pharmaceutical sales representatives do not access clinics' drug sample inventory information remain in inventory for over six weeks. Thus, ADI is significantly shorter (by 24 days, a decrease of 57%) for drugs with information sharing than for drugs without information sharing.

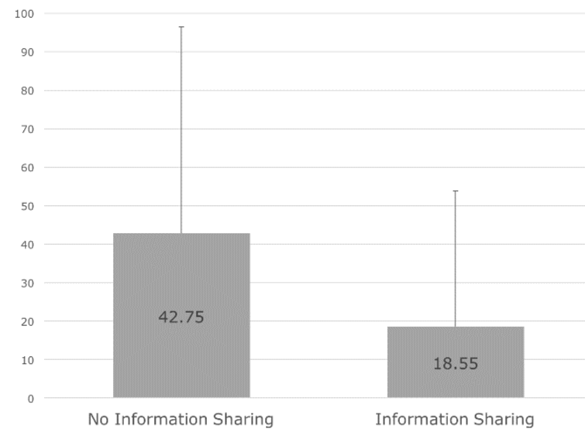

Figure 1: Average Days in Inventory

Inventory Days of Supply

For the combined sample, the inventory days of supply (IDS) is about 1,039 days (*M* = 1038.82, *SD* = 2134.95). This suggests that, on average, clinics' drug sample inventory lasts for about 2.8 years before being depleted. Figure 2 shows the IDS for drugs with and without information sharing.

Figure 2: Inventory Days of Supply

As shown in Figure 2, for drugs without information sharing the IDS is 1276 days (*M* = 1276.00, *SD* = 2457.71). In contrast, for drugs with information sharing, the IDS is about 496 days (*M* = 496.05, *SD* = 886.62). Welch's t-test for difference in IDS between drugs without information sharing and drugs with information sharing is significant (t = 3.04, p < .05). Stated differently, drugs for which pharmaceutical sales representatives access clinics' drug sample inventory information have inventories lasting about 1.4 years, whereas drugs for which pharmaceutical sales representatives do not access clinics' drug sample inventory information have inventories lasting about 3.5 years. Thus, IDS is significantly shorter (by 780 days, a decrease of 61%) for drugs with information sharing than for drugs without information sharing.

Dispense-Through Rate

For the combined sample, the dispense-through rate (DTR) is 29% (M = 29.17%, SD = 35.32%). This suggests that, on average, less than one third of drug samples are dispensed within the study's nine month time frame. Figure 3 presents the DTR for drugs with and without information sharing.

Figure 3: Dispense-Through Rate

As can be seen in Figure 3, for drugs without information sharing the DTR is 25% (M = 25.01%, SD = 35.23%). In contrast, for drugs with information sharing, the DTR is 45% (M = 44.51%, SD = 31.44%). Welch's t-test for difference in DTR between drugs without information sharing and drugs with information sharing is significant (t = 3.97, p < .001). In other words, almost half of the samples for drugs for which pharmaceutical sales representatives access clinics' drug sample inventory information are dispensed within nine months, whereas only a quarter of the samples for drugs for which pharmaceutical sales representatives do not access clinics' drug sample inventory information are dispensed within nine months. Thus, DTR is significantly larger (by 20%, an increase of 78%) for drugs with information sharing than for drugs without information sharing.

5. DISCUSSION

The inventory management of drugs for which pharmaceutical sales representatives access clinics' drug sample inventory information is significantly more efficient than that of drugs for which pharmaceutical sales representatives do not access clinics' drug sample inventory information. Specifically, the results indicate a 57% reduction in average days in inventory (ADI), a 61% reduction in inventory days of supply (IDS), and a 78% increase in dispense-through rate (DTR) for drugs with information sharing over drugs without information sharing. These figures suggest an average improvement of about 65% across all three indicators of inventory management efficiency. Given these results and the exogenous nature of information sharing in this quasi-experimental study, it seems plausible that information sharing causes improvements in inventory management efficiency.

Since inefficiencies in drug sample inventory management have been linked to over $2.2 billion worth of wasted samples per year, an improvement of about 65% could translate to over $1.4 billion worth of savings annually in the healthcare sector. Consequential benefits, such as improved administrative efficiency and regulatory compliance, are not even included in the figure of wasted samples. Thus, these findings indicate that information sharing holds tremendously valuable benefits for healthcare providers and pharmaceutical companies. A drug sample inventory management platform, such as CheckSamples, that allows for automated inventory information sharing between healthcare providers and pharmaceutical companies, is uniquely positioned to realize these benefits and create value for all parties involved.

However, the findings and implications of this study must be evaluated critically in light of its limitations. First, due to the quasi-experimental nature of this study, no random assignment of subjects to conditions took place. In particular, pharmaceutical sales representatives decided for themselves to access clinics' drug sample inventory information through the CheckSamples platform. Hence, it is possible that this self-selected sub-group differs from the overall group of pharmaceutical sales representatives with regards to attitudes and behaviors relevant to inventory management efficiency. Second, the three indicators of inventory management efficiency that are used in this study are not the only types of indicators that can be used to assess inventory management efficiency in the context of drug sample management. Thus, it is possible that the results of this study differ when other indicators for the dependent variables are employed. Third, the dataset, which consisted of transactional drug sample inventory information from multiple US-based healthcare clinics during the time from November 2016 to July 2017 was limited in terms of its geographic scope, time span, and selection of clinics as well as pharmaceutical sales representatives. Therefore, it is possible that a sample with different characteristics will lead to different results with regards to the impact of information sharing on drug sample inventory management efficiency.

Future research may wish to explore several avenues to build on the foundation laid by this work. In particular, future research should try to design and implement a true randomized controlled study in which pharmaceutical sales representatives are randomly given the option to access clinics' drug sample inventory information. Moreover, future research should consider employing alternative indicators of inventory management efficiency, which may shed light on different aspects of inventory management efficiency in the context of drug samples. Lastly, future research would be well advised to expand the sample to a broader section of national and international healthcare clinics in order to mitigate the impact of potential selection bias.

6. CONCLUSION

Over $2.2 billion worth of drug samples expire ever year in the United States. This waste is due to inefficient drug sample inventory management practices in healthcare clinics. However, drug samples are vendor-managed, which means that pharmaceutical sales representatives are largely responsible for the forecasting, ordering, and delivery of drug samples in clinics. In situations of vendor-managed inventory, the sharing of inventory information with vendors is a crucial component of efficient inventory management.

A quasi-experiment was conducted in order to evaluate the impact of information sharing on inventory management efficiency in healthcare clinics. A proprietary dataset of anonymized inventory transactions detailing the inflow and outflow of 19,400 drug samples, as well as the access data of said inventory information by pharmaceutical sales representatives, across multiple US-based clinics during the nine month period from November 2016 to July 2017 was obtained from CheckSamples, a leading drug sample inventory management platform.

Results indicate that information sharing improves inventory management efficiency by about 65%. Based on the value of wasted drug samples, information sharing between healthcare providers and pharmaceutical companies could lead to savings of about $1.4 billion annually. These savings, along with consequential benefits of improved administrative efficiency and regulatory compliance, appear to be particularly attractive given the growth of healthcare costs and associated policy debates in the United States.

7. REFERENCES

Alikhan, A., Sockolov, M., Brodell, R. T., & Feldman, S. R. (2010). Drug Samples in Dermatology: Special Considerations and Recommendations for the Future. *Journal of the American Academy of Dermatology*, *62*(6), 1053-1061.

Bastiaens, L., Chowdhury, S., & Gitelman, L. (2000). Medication Samples and Drug Compliance. *Psychiatric Services, 51*(6), 819-819.

Bodenheimer, T. (2005). High and Rising Health Care Costs. Part 1: Seeking an Explanation. *Annals of Internal Medicine, 142*(10), 847-854.

Callender, C. & Grasman, S. E. (2010). Barriers and Best Practices for Material Management in the Healthcare Sector. *Engineering Management Journal, 22*(4), 11-19.

Christopher, M. (2016). *Logistics & Supply Chain Management, Fifth Edition*. FT Press: Upper Salle River, NJ.

Evans, K. L., & Brown, S. R. (2012). Many Sample Closet Medications Are Expired. *Journal of the American Board of Family Medicine, 25*(3), 394-395.

Falasca, M., & Kros, J. F. (2016). Success Factors and Performance Outcomes of Healthcare Industrial Vending Systems: An Empirical Analysis. *Technological Forecasting & Social Change*, in press.

Groves, P., Kayyali, B., Knott, D., & Van Kuiken, S. (2013). *The 'Big Data' Revolution in Healthcare: Accelerating Value and Innovation*. Report of the Center for US Health System Reform, Business Technology Office. McKinsey & Company: New York, NY.

Guimaraes, C. M. & Carvalho, J. C. (2013). Vendor Managed Inventory (VMI): Evidences from Lean Deployment in Healthcare.

Strategic Outsourcing: An International Journal, 6(1), 8-24.

Haavik, S. (2000). Building a Demand-Driven, Vendor-Managed Supply Chain. *Healthcare Financial Management, 24*(2), 56-61.

Hines, P., Lamming, R., Jones, D., Cousins, P., & Rich, N. (2000). *Value Stream Management: Strategy and Excellence in the Supply Chain*. Financial Times Prentice Hall, Upper Saddle River, NJ.

Levy, M. & Grewel, D. (2000). Supply Chain Management in a Networked Economy. *Journal of Retailing, 76*(4), 415-29.

Orszag, P. R. & Ellis, P. (2007). Addressing Rising Health Care Costs – A View from the Congressional Budget Office. *The New England Journal of Medicine, 357*, 1885-1887.

Poser, S. (2007). Unlabeled Prescription Drug Samples and the 'Learned Intermediary': The Case for Liability without Preemption. *Food and Drug Law Journal, 62*, 653–694.

Sari, K. (2007). Exploring the Benefits of Vendor Managed Inventory. *International Journal of Physical Distribution & Logistics Management, 37*(7), 529-545.

Sylver, E. A., Pyke, D. F., & Thomas, D. J. (2017). *Inventory and Production Management in Supply Chains, Fourth Edition*. CRC Press: Boca Raton, FL.

Tija, J., Briesacher, B. A., Soumerai, S. B., Pierre-Jacques, M., Zhang, F., Ross-Degnan, D., & Gurwitz, J. H. (2008). Medicare Beneficiaries and Free Prescription Drug Samples: A National Survey. *Journal of General Internal Medicine, 23*(6), 709-714.

Williams, B.D. & Tokar, T. (2008). A Review of Inventory Management Research in Major Logistics Journals. *The International Journal of Logistics Management, 19*(2), 212-32.

Yao, Y. & Dresner, M. (2008). The Inventory Value of Information Sharing, Continuous Replenishment, and Vendor-Managed Inventory. *Transportation Research Part E: Logistics and Transportation Review, 44*(3), 361-378.

[i] For the purpose of this study, a clinic refers to a healthcare facility that focuses on caring for outpatients, including primary and specialty care.