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Inventory Management System for Medical Stores in a Primary Health Care Centre in Jada, Adamawa State, Nigeria

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ABSTRACT: Efficient inventory management is crucial for the success of any organization or establishment. Hence, the objective of this paper was to focus on the inventory management system by developing an optimal inventory policy for Medical Stores in a Primary Health Care Centre in Jada, Adamawa State, Nigeria using a multi-item inventory model with the assistance of Excel spreadsheets. Results obtain revealed that the Economic Order Quantity (EOQ) for the Primary Health Care centre under investigation is optimal at 0.0086. This EOQ aligns with the storage capacity of 10,287 square meters, which closely meets the original storage capacity requirement of 10,288 square meters. By implementing this optimized inventory policy, the Primary Health Care could enhance its inventory management, reduce costs, and ensures efficient usage of storage resources. This research underscores the importance of tailoring inventory policies to meet the specific needs of healthcare facilities, which can lead to more effective operations and improved service delivery.

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Countries have different policies and plans in relations to the personal and population-based Effective inventory management is crucial for the healthcare system, ensuring that medical supplies, pharmaceuticals, and equipment are available when needed, thus minimizing the risk of stock out that could lead to compromised patient care. The complexities of healthcare inventory management arise from the need to balance cost efficiency with the imperative to maintain a consistent supply of critical items. In this context, inventory management is not merely a logistical concern but a fundamental aspect of healthcare delivery that influences both operational efficiency and patient outcomes. For instance, poor inventory management practices can lead to the overstocking of perishable items, resulting in wastage and increased costs, or the under stocking of essential supplies, leading to treatment delays and reduced

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quality of care (Gupta and Denton, 2008; Kumar and Kumar, 2020). The adoption of advanced inventory management systems and techniques, such as just-in-time (JIT) inventory and automated replenishment systems, has shown promise in optimizing stock levels and reducing operational costs in healthcare settings (Jarrett, 1998; Moons *et al.,* 2019).

Moreover, the healthcare sector faces unique challenges in inventory management, including the unpredictable nature of demand, regulatory requirements, and the critical need for traceability and accuracy in managing inventory (Pande and Srivastava, 2023; Kumar and Patel, 2024). The COVID19 pandemic highlighted these challenges, as supply chain disruptions led to severe shortages of personal protective equipment (PPE), ventilators, and other critical supplies (Iyengar *et al*., 2020). These challenges underscore the need for robust and resilient inventory management systems that can adapt to sudden changes in demand and supply chain conditions. Furthermore, the integration of information technology, such as electronic inventory systems and data analytics, has been pivotal in enhancing the accuracy and efficiency of inventory management in healthcare (Azzoni, *et al.,* 2023; Mohan, *et al.,* 2022). Therefore, effective inventory management is not only essential for the financial sustainability of healthcare organizations but also for ensuring the delivery of high-quality patient care in a rapidly changing environment (Bialas *et al*., 2023; Rubigha, 2023).

Inventory management in the healthcare system of Nigeria faces significant challenges, which impact the availability and accessibility of essential medical supplies and medications. The inefficiency in inventory management is often attributed to inadequate infrastructure, poor data management, and lack of skilled personnel, leading to frequent stock outs or overstock situations (Olalekan and Adetola, 2022). These issues are exacerbated by corruption and lack of transparency in the procurement processes, which further hinder the timely distribution of medical supplies, ultimately affecting patient care and outcomes (Akinyemi et al., 2021). Furthermore, the absence of an integrated inventory management system results in poor communication between healthcare facilities and central supply units, leading to delays in replenishment and wastage of resources (Ogunleye *et al*., 2023). This paper identifies a lack of research on the specific challenges and inefficiencies in inventory management practices at primary health care centres in low-resource settings, particularly in Adamawa State, Nigeria. There is limited evidence on the impact of tailored inventory management strategies on improving healthcare delivery and reducing resource wastage in rural healthcare facilities in Nigeria. Hence, the objective of this paper is to focus on the inventory management system by developing an optimal inventory policy for Medical Stores in a Primary Health Care Centre in Jada, Adamawa State, Nigeria

MATERIALS AND METHODS

This section of the work addresses the research design employed to investigate the research topic. It focuses on the population and the characteristics of the sample. Furthermore, the procedure and which measuring instrument used to gather the data will be discussed. Finally, the statistical techniques used to capture data as well as data analysis.

Research Design: The study was conducted using an exploratory strategy because it is unclear whether inventory management and healthcare delivery are related. Exploratory design was used because it allowed the researcher to obtain new and creative results while exploring new experiences, methods, and partnerships in inventory management for healthcare delivery.

The study focused on inventory management of Jada Primary Health care, and how these facilities used the inventory to provide service to their clients. The facilities were managed in the Medical Stores of Jada Primary Health care. Meanwhile the data was obtained from Jada Primary health care, Adamawa State.
The data obtained were analyzed using EOQ multi-item model.

The Multi-Item EOQ Models: This model took into account an inventory system with several items. Production facilities, storage space, time, and financial resources are all limited. Because of this restriction, the many things interact, making it feasible to think about each one independently. However, language multiples approaches can be used to handle simple scenarios. In its most common form, this is

$$\text{minimize TVC} = \sum_{i=1}^{n}\left(\frac{D_i}{Q_i}C_{oi} + \frac{Q_i}{2}C_{hi}\right) \quad 1$$

Subject to

$$\sum_{i=1}^{n} f_i Q_i \leq W \text{ (Warehouse space constraint)} \quad 2$$

$$Q_i \geq 0, \text{ for all } i, \quad 3$$

Where: D_i=Demand Rate: C_{oi} =Set Cost per order: C_{hi} = Unit holding Cost per unit time Q_i =Optimum order quantity f_i=Storage Area Requirement per inventory Unit w =Maximum available storage area for all n items **λ**= Assume various values for λ, so as to obtain optimum value of the langrange multiplier that will satisfy the space limitation constraint. (Taha, 2013)

Procedures for determining and optimal inventory

Step 1: For λ= 1 the EOQ for each item separately by using the formula

$$Q_i^* = \sqrt{\frac{2D_i C_{oi}}{C_{hi} + 2\lambda f_i}} \qquad i = 1, 2, , n \qquad 4$$

Step 2: if Q_i^*,(i= 1,2...,n) satisfies the condition of total storage space available, then stop. Otherwise go to step 3.

Step 3: Increase the value of λ if value of left hand size of space constraint is more than available space, otherwise decrease the value of λ. this means that the only way of finding appropriate solution is to adjust λ iteratively until the space required comes exactly or very close to the available storage space.

D_i: Note that the demand rate for each drug assumed to be uniform; $\mathbf{C_{hi}}$: Holding cost per item = Total holding cost per year/ total number of drugs held in

RESULTS AND DISCUSSION

It is crucial to prove that the demand rate for any medication was thought to remain constant. Additionally, the Jada Primary Health Care Store was 16 by 32 feet, with a total warehouse capacity of 10,288.632 square meters. The N30,000 annual holding cost (C_h) was derived from the rent and security fee. Additionally, since we were interested in the number of months, we calculate it as follows: According to analysis, the holding cost per item was N30,000/79. While holding costs are N31.65 per item, the annual holding cost per unit of medications was N379.75 more than the monthly number of units in each drug. It should be noted that holding cost (C_h) was taken to be constant, meaning that the price of obtaining these various medications did not vary. The maximum area needed is calculated as 16 x 32 feet based on the above optimal order quantity of each medication that Jada L.G. Primary Health Care centre store keeps in stock. to get the lambda value that best satisfies the constraint equation regarding storage space availability.

When the optimal order quantity for the value of lambda (λ) EOQ one (0.1) equals 6.620048, order cartons of ACT forte table. Repeat this step for the remaining medications when λ = 0.01 till lambda (λ) EOQ equals 0.001. Having 9529.005558 of storage capacity that doesn't go over the 16 x 32-foot limit Purchase cartons of ACT Forte tablets when the ideal order quantity for the lambda (λ) value is equal to EOQ two (2), which is 6.624754134 for all medications when λ = 0.0085. The remaining seventy-nine (79) medications will be kept in stock until the lambda EOQ reaches 0.0086. With a storage capacity of 0.099376, it stays inside the 10,288M2 space limit.

The new EOQ develop for Jada Health Care centre leverages a continuous review inventory system to manage the supply of pharmaceuticals effectively. The policy is guided by a predetermined demand rate, λ (lambda), and specific order and reorder levels for various drugs to ensure a balance between holding costs and ordering costs while minimizing the risk of stockouts.

The new policy are as follows, when λ = 0.1, the centre should order 6.62005 cartons of ACT Forte tablets and initiates a reorder when the inventory level drops to 2.620048 cartons. This approach minimizes the chances of shortage while keeping excess inventory low. Similarly, for Lumartem tablets, the order quantity is set at 2 cartons, with a reorder point at 9.351335 cartons, reflecting a relatively lower demand or higher lead time variability. E-Mal Injection, on the other hand, is to be ordered in half-carton quantities, and replenishment is triggered when stock levels fall to 2.952031, indicating its critical but less frequent usage pattern. Artesunate injection and tablets follow similar protocols, with order quantities set at 4 cartons and reorder points at 2.592031 and 2.952031, respectively, in order to maintain sufficient stock levels for high-demand items without incurring excessive holding costs. The policy continues this approach for all 79 drugs, adjusting λ values gradually from 0.1 to as low as 0.0086, ensuring that inventory levels are optimized across varying demand rates for different medications. This methodical inventory management strategy reflects principles of the Economic Order Quantity (EOQ) model, ensuring that the cost trade-offs between ordering and holding are balanced for a wide range of pharmaceuticals (Zhang and Wang 2022; Adekola and Mbatha 2023; Chen and Zhao, 2022, Smith and Patel, 2023).

The optimal value of λ= 0.0086 (The optimal value of λ adjusts the inventory levels to ensure all items fit within the storage constraint. This means that λ will guide the system toward feasible inventory levels that meet storage needs for each item type without exceeding available space.).

Since both λ =1 and 1.5 exceed the space requirement of $10,288M^2$, then store any drug not exceeding the warehouse requirement. Note that λ= 0.0086 is the optimal storage space of drug that satisfied the Kuhn Tucker necessary and sufficient condition that determine the optimal order quantities for different items so as to achieve minimum value of TVC ₦12, 368.92 of the non-negative Langrage Multiplier, (Sharma, 2017)

Conclusion: This research focuses on inventory management at Primary Health Care Jada, utilizing data from a storekeeper interview. The multi-item Economic Order Quantity (EOQ) model with storage limitations was applied to analyze and improve the existing inventory policy. The study highlights the benefits of inventory control for wholesalers and balances these against the costs of carrying inventory, aiming to determine the optimal order quantity and minimize total costs.

REFERENCE

Adekola, B; Mbatha, K (2023). Demand-driven EOQ policies for managing healthcare inventory systems. *Int. J. Phar. Sup. Chn. Mght.* 31(4), 211–225.

Azzoni, A; D'Apice, C; De Marco, M (2023). The Role of Digital Technologies in Enhancing Healthcare Inventory Management: A Systematic Review. *J. Hlth. Manage* 68(4), 275-290. doi:10.1097/JHM-D-22-00234

Bialas, C; Bechtsis, D; Aivazidou, E; Achillas, C; Aidonis, D (2023). A Holistic View on the Adoption and Cost-Effectiveness of Technology-Driven Supply Chain Management Practices in Healthcare. *Sust.* 15(6), 5541, pp. 12-18. https://doi.org/10.3390/su15065541.

Chen, L; Zhao, Q (2022). Continuous review inventory models for hospital pharmaceuticals: Balancing cost and stockout risk. *Int. J. Opr. Prod. Mgt.* 42(3), 241–259.

Gupta, D; Denton, B (2008). Appointment scheduling in health care: Challenges and opportunities. *IIE Trans.* 40(9), 800-819. DOI: https://doi.org/110.1080/07408170802165880

Gordon, P; Lin, W (2024). Economic Order Quantity models in healthcare: Managing pharmaceutical inventories effectively. J. of Sup. *Ch. Mgt. in Hlthc.* 19(1), 92–105

Jarrett, PG (1998). Logistics in the health care industry. *Int. J. Ph. Distr. and Log. Mgmt.* 28(9/10), 741-772. DOI: https://doi.org/10.1108/09600039810248154

Kumar, S; Kumar, S (2020). The impact of information technology on the inventory management in the healthcare industry: An empirical study. *J. Glb. Inf. Mgt.* (JGIM), 28(1), 1-23. DOI: https://doi.org/10.1177/09718907231208761

Kumar, A; Patel, S (2024). Innovations in Inventory Management in Healthcare: Enhancing Efficiency and Patient Safety. *J. Hlth. Sys. Pol.* 18(1), 45-62 DOI: https://doi.org/10.1016/j.jhsp.2023.09.004

Mohan, K; Raghavan, S (2022). Resilient Supply Chain Strategies for Healthcare: The Impact of Inventory Management Practices. *Int. J. Hlth. Mgt.* 15(2), 145-158. DOI:10.1080/20479700.2021.1937731

Moons, KG; Altman, DZ; Reitsma, JB; Ioannidis, JP; Macaskill, P; Steyerberg, EW; Collins, GS (2019). Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD): Explanation and elaboration. *An. Int. Medi.* 162(1), 55-63. DOI: https://doi.org/10.7326/M14-0698

Iyengar, K; Mabrouk, A; Jain, V. K., Venkatesan, A; Vaishya, R (2020). Learning opportunities from COVID-19 and future effects on health care system. *Diab. Met. Synd: Clin. Res. Rev*., 14(5), 943-946 DOI: https://doi.org/DOI: 10.1016/j.dsx.2020.06.036

Kelle, P; Silver, EA (1989). Forecasting the returns of reusable containers. *J. of Opr. Mgt.* 8(1), 17-35.

Lapierre, SD; Ruiz, AB (2007). Scheduling logistic activities to improve hospital supply chain management. *Comp. Opr. Res.* 34(3), 624-641.DOI: https://doi.org/10.1016/j.cor.2005.03.017

Pande, P; Srivastava, A (2023). Challenges and Strategies in Healthcare Inventory Management: A Systematic Review. *Intern. J. Health Care Quality Assurance.* 36(2), 230-245. https://doi.org/10.1108/IJHCQA-05-2022-0169

Reyes, G; Reyes, P; Burns, LD (2020). Inventory management in healthcare: A simulation of factors influencing stock levels and shortages. *Int. J. Prod. Econ.*, 219, 222-233.

Rubigha, K (2023). Sustainability in Healthcare Inventory Management: A Seven-Dimensional Review Framework. *Cont. Manage. Res.* 15(1). 18-30. Available at: https://www.researchgate.net/publication/34973106

Taha, HA (2003). Operations research: an introduction. Pearson Education India. 8th edition, 440-441

Sharma, JK (2017). Operations research theory and application. MACMILAN Publishers. 6th Edition, pp. 503-504

Smith, T; Patel, R (2023). Optimizing pharmaceutical supply chains using EOQ models: A case study in healthcare inventory management. *J. Hlth, Opr, Rrch.* 15(2), 137–152.

Zhang, Y; Wang, H (2022). Balancing holding and ordering costs: An application of EOQ in healthcare inventory management. *J. Med. Log. Opns.* 28(2), 167–180.