ABC Classification for Optimizing Medication Inventory Management at Prince Rashid Ben Al-Hasan Military Hospital in the Jordanian Royal Medical Services

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ABSTRACT

1. Introduction: Inventory management usually doesn't get enough attention outside the operational circles, but in healthcare especially in the under-resourced systems, it may be a major factor that determines whether things run smoothly or fall apart. In institutions like military hospitals operating under Jordan's Royal Medical Services (RMS). This study examine how one simple-but-powerful tool (the ABC classification system) might help make that balancing act possible since it categorizes medications based on how much they cost each year in an attempt to recognize those high-impact drugs that make up the bulk of spending and therefore deserve closer monitoring.

2. Objective: This research aims to identify whether a structured ABC classification can improve inventory management practices at Prince Rashid Hospital. More specifically, it intends to: (a) apply the ABC classification to the hospital's medications using their annual cost as the primary measure; (b) examine the resulted distribution across each category; (c) develop specific control strategies for each category; and (d) assess the possible effect of these tactics on cost management, service level, and resource distribution, which may help the hospital to reduce redundant expenditures and improve operational responsiveness.

3. Methodology: Using real consumption and cost data obtained from Prince Rashid Ben Al-Hasan Military Hospital pharmacy department during the period of January to October 2024, on around 350 medications. For each item, an annual consumption value (ACV) will be calculated by multiplying the average monthly quantity consumed by its unit price and by twelve months. The resulting parameters will then be sorted in descendent order, and the cumulative percentages will then be used to allocate each item to a specific class: Class A, Class B, and Class C. This classification will function as the basis for recommending separated inventory control strategies that align with each class's financial and operational significance. The anticipated outcomes of this method include better prioritization of high-impact medications, rationalized inventory management, and an overall enhancement in the hospital's ability to manage its pharmaceuticals more efficiently and sustainably.

Keywords: ABC analysis, inventory management policies, pharmaceutical supply chains, military hospital, Jordan, healthcare logistics

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1. INTRODUCTION:

Healthcare establishments globally encounter an increasing pressure to deliver high quality patient care while also controlling costs and maximizing operational efficiency, Hospitals in the developing countries and resource constrained environments face particular challenges in managing pharmaceutical inventories which often denote a significant share of hospital expenses (Uthayakumar & Priyan, 2013). The Jordanian healthcare system including its military health services encounters these challenges while struggling to maintain high standards of medical care. Prince Rashid Ben Al-Hasan Military Hospital which is operating under the Jordanian Royal Medical Services (RMS) and serves both military personnel and civilians, positioning it as an important component of Jordan's healthcare infrastructure. Like many military healthcare facilities must balance operational promptness with resource optimization therefore making the effective inventory management a crucial driver to this balance as it affects medication availability, financial performance and ultimately patient outcomes.

Inventory management in healthcare systems differs substantially from other commercial settings due to the critical nature of the medical supplies, variable demand patterns and strict regulatory requirements. Stockouts can lead to delayed treatments and therefore to a compromised patient care while overstocking ties up capital, increases holding costs and risks medication expiration before use (Gebicki et al., 2014). ABC analysis based on the Pareto principle offers a systematic methodology to inventory classification by categorizing items according to their relative importance which is typically measured by their annual consumption value (Gupta et al., 2007) and this classification permits organizations to implement differentiated management strategies across inventory segments and therefore concentrating resources on items with the highest impact.

Despite its likely benefits the application of the ABC analysis in healthcare systems especially in the military hospitals in developing countries remains understudied and therefore this research aims to address this gap by examining how the ABC classification can enhance medication inventory management at Prince Rashid Ben Al-Hasan Military Hospital, using data from 355 medication types and their average monthly consumption quantities from January 2024 to October 2024.

The primary objectives of this research are: To apply the ABC classification methodology in order to categorize the hospital's medication inventory based on their consumption patterns, To analyze the distribution characteristics of medications across ABC categories, To propose inventory management policies that are tailored to each category in order to optimize resource allocation and to discuss the possible impact of implementing these policies on inventory costs, service levels and the operational efficiency.

2. LITERATURE REVIEW:

2.1 Inventory Management in Healthcare Settings: Inventory management in healthcare systems has acquired substantial research attention globally because of to its significant impact on both the financial performance and the quality of care, Rachmania and Basri (2013) have recognized that inventory related costs in hospitals typically account for 10-18% of net revenue and Uthayakumar and Priyan (2013) noted that pharmaceuticals specifically represent approximately 20-40% of the hospital budgets in developing countries. The healthcare inventory management literature emphasizes on several unique challenges that faces the hospital supply chains, Kelle et al. (2012) highlighted the complexity that is arising from uncertain demand patterns, critical service requirements and limited shelf life of many pharmaceuticals and Gebicki et al. (2014) has also identified that stockouts in healthcare settings can carry not only financial implications but also carry clinical consequences.

Military hospitals face further challenges which goes beyond those of civilian healthcare institutions, Narayana et al. (2014) described how military medical facilities must maintain a readiness state for diverse emergencies at all times while also still managing the day-to-day operations efficiently and Al-Qatawneh (2022) studying Jordanian hospitals specifically found that resource constraints often necessitate more sophisticated and complex inventory management tactics.

2.2 ABC Classification Methodology: ABC analysis has originated from the Pareto principle which suggests that about 80% of the effects come from 20% of the causes (Chu et al., 2008) and in the case of inventory management practices this typically translates to that a small percentage of items are accounting for a large portion of inventory value or consumption, In 1986 Flores and Whybark formalized the traditional ABC classification method by categorizing the items based on their annual dollar usage into three classes: class A (high-value items) and class B (medium-value items) and class C (low-value items) and researchers have explored the application of ABC analysis specifically in healthcare contexts, Gupta et al. (2007) demonstrated how ABC analysis combined with VED (Vital, Essential, Desirable) classification created a more thorough inventory control framework for hospital pharmaceuticals, Nigah et al. (2010) applied ABC-VED matrix analysis in a tertiary care hospital reporting a significant potential for cost reduction without compromising the service quality.

2.3 Applications of ABC Analysis in Healthcare Supply Chain: The implementation of ABC classification in healthcare settings has produced promising results throughout various environments. Soraya et al. (2022) documented how a Czech hospital has reduced inventory costs through ABC analysis while maintaining its service levels. Similarly Taddele et al. (2019) reported through a case study which was conducted at an Ethiopian hospital where the ABC-VED implementation has identified that 10.9% of the studied items which were classified as Class A have accounted for 80% of the overall expenditure and in Jordan specifically Al-Qatawneh (2022) investigated the inventory management practices in Jordanian hospitals and found that substantial opportunities for improvement through analytical approaches like ABC analysis. Moons et al. (2019) also conducted a systematic review of the inventory management practices in hospital pharmacies and also confirming that ABC analysis remains one of the most widely adopted approaches. Military hospitals represent a specialized environment within healthcare inventory management research, Kumar and Chakravarty (2015) applied the ABC-VED matrix analysis in an Indian Armed Forces hospital and also demonstrating how this approach could identify critical medications requiring stringent controls while allowing more relaxed procedures for less critical items.

2.4 Inventory Policies Based on ABC Classification: The literature emphasizes that the value of ABC classification rests in its capability to inform a differentiated inventory management policies, Ernst and Cohen (1990) proposed that Class A items warranted tight control measures including frequent reviews, accurate record-keeping and safety stocks based on high service level targets and for Class B items they recommended moderate controls with periodic review systems while suggesting simplified procedures for Class C items. More specially for pharmaceuticals Kelle et al. (2012) developed inventory models for hospital pharmacies that varied safety stock levels, order quantities and review frequencies based on the ABC classification also research has focused on integrating technology with ABC-based inventory policies, Leaven (2017) demonstrated how automated inventory management systems could implement differential monitoring based on the ABC categories.

3. METHOD:

3.1 Research Setting: This study was conducted at Prince Rashid Ben Al-Hasan Military Hospital one of the primary healthcare facilities which is operated by the Jordanian Royal Medical Services, the hospital serves both military personnel and civilian patients offering a comprehensive range of medical services. The pharmacy department manages the medications for inpatient care, outpatient services and emergency preparedness. The research focused on the medication inventory management system which handles approximately 355 different pharmaceutical items. These medications vary broadly in terms of cost, usage volume and supply chain characteristics.

3.2 Data Collection: The primary data for this research consisted of the medication utilization records from the hospital pharmacy department for the period spanning from January 2024 to October 2024, for the 355 medication types the following information was analyzed in order to Classify them into ABC categories based on consumption value and the distribution of medications across these categories.

3.3 ABC Classification Methodology: The ABC classification was performed based on the consumption value of each medication in which the procedure followed these sequential steps: First the calculation of Annual Consumption Value (CV): For each medication item the CV was calculated using average monthly consumption quantity and unit cost, then the arrangement of items: All medication items were arranged in descending order based on their calculated CV, then the cumulative CV calculation: The cumulative CV and cumulative percentage of total CV were calculated for the ordered list of items, then the cumulative percentage of items: The cumulative percentage of items (based on count) was calculated for the ordered list, finally the classification criteria: Items were classified into categories based on the following criteria: Class A: Items accounting for the top 80% of total CV, Class B: Items accounting for the next 15% of total CV (80-95%) and Class C: Items accounting for the final 5% of total CV (95-100%). This classification resulted in 45 items (12.68%) in Class A, 101 items (28.45%) in Class B, and 209 items (58.87%) in Class C, as confirmed by the provided data.

4. RESULTS:

4.1 ABC Classification Outcomes:
The application of ABC analysis to the medication inventory in Prince Rashid Ben Al-Hasan Military Hospital returned a clear stratification of items according to their economic significance. Table (1) and Figure (1) present the distribution of those medications across the three ABC classes.

Table 1: ABC Classes as Percentages of the Products Total Count

Class	N	%
A	45	12.68%
B	101	28.45%
C	209	58.87%
Total	355	100.00%
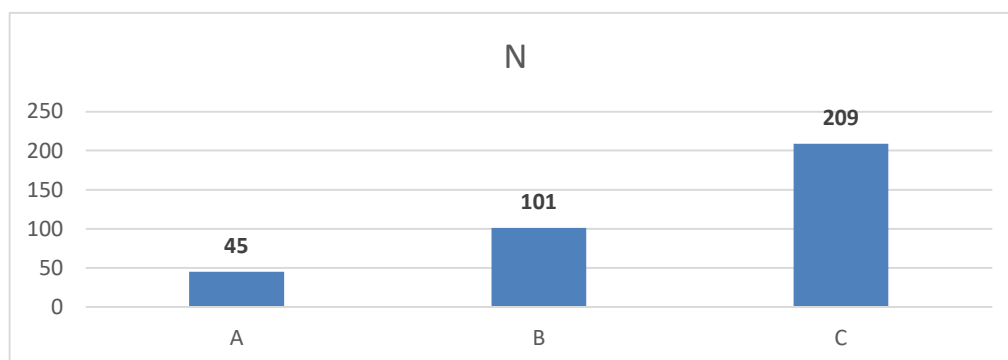
Figure 1: Frequency of ABC Classes of the Products Total Count

The analysis showed a Pareto-like distribution where the small percentage of items accounted for the large fraction of the total consumption value. Specifically Class A which is comprising just 12.68% of the medications (45 items) and represented 80% of the total consumption value and Class B which is constituting 28.45% of the items (101 medications) and accounted for 15% of the total value. Meanwhile Class C which despite containing the majority of items at 58.87% (209 medications) has contributed only to

5% of the total consumption value, this distribution aligns well with the classical 80/15/5 proportions commonly observed in ABC analysis applications in healthcare settings (Gupta et al., 2007; Kumar & Chakravarty, 2015).

4.2 Implications for Inventory Management: Based on inventory management standards and ABC classification results, some implications could be drawn about inventory management practices at Prince Rashid Ben Al Hassen Military Hospital.

4.2.1 Class A Items: Class A is a relatively small group of items which, however, has a value of 80% of the total consumption value and that's why as a result they call out for the tightest inventory control and because of these circumstances these items should be counted on a weekly or bi-weekly basis with close monitoring of level and proper recording and the ordering plans for Class A products need to use a small order quantity and high frequency of ordering policies so that these products are always available, since these are critical items avoiding stockouts of these items and maintaining high safety stock levels while reaching higher service levels should be the goal. Tight control on supplies of these valuable resources should consider very strict storage policies; regular audits of physical stock along with thorough monitoring of consumption; and senior-level sign-off on requisitions.

4.2.2 Class B Items: 15% of the total consumption value are coming from Class B products and that's why they need and call for a reasonable degree of regulation, standard monitoring techniques usually allow the inventory evaluation for these medications to take place in a bi-weekly or a monthly schedule and balancing the order quantities and order frequency can also help to keep efficiency without too much control. For Class B drugs, safety stock levels and service targets can be set at moderate values. For control, regular cycle counting and the use of conventional security protocols are acceptable for control along with frequent monitoring of consumption patterns to identify any odd trends or demands.

4.2.3 Class C Items: simplified inventory methods can be used to keep track of Class C products, which make up the largest portion of the items count but only account to about 5% of the total consumption value. Using basic monitoring systems, these medicines may not be checked as often, maybe once a month or even once a quarter and larger order volumes can be used to cut down on the need to frequent restock, and safety

stock levels and service level targets can be kept lower as long as they are still clinically adequate. Control over these items can be less intensive, involving streamlined record-keeping, less frequent cycle counts and storage in areas with easier access.

5. DISCUSSION:

5.1 Interpretation of ABC Classification Results: The ABC categorization based on the results from Prince Rashid Ben Al-Hasan Military Hospital exhibited a traditional Pareto distribution, with class A constituting 12.68% of the products and about 80% of the total consumption value and this empirical distribution is very similar to what has been found in prior healthcare studies; for example Kumar and Chakravarty (2015) found that 14.8% of products represented 75.5% of costs in a military hospital in India and that's why such monopolization of value in a narrow pool of pharmaceuticals results in both challenges and opportunities, from a control point of view this means that with a relatively small number of items, in our case here a 45 products, controlling influence can be achieved on the overall performance of the inventory system, However these are likely to be critical drugs that need special management strategies and inventory practices in order to ensure their availability when needed while also keeping costs to a minimum and this is especially true for military hospitals which must strike a balance between the need for comprehensive pharmaceutical coverage and the fiscal realities of public healthcare systems.

5.2 Implications for Inventory Management Policies: The large differences of the item proportion among ABC classes provide a solid justification for the adoption of this segmented inventory policies because the usual and conventional approach of applying equal control policies to all drugs regardless of their economic importance was inherently inefficient and a more strategic allocation of management effort according to item importance could be achieved if the classes of items are reviewed more or less often wherein review parameters are ranked and control plans are established, the continuous or frequent review system being proposed for Class A items is appropriate in view of the critical nature of Class A items and their significant cost to the health system and that's why the increased control measures that can be applied to these items are

justified by the disproportional build up in the overall inventory value, for Class B items a more balanced approach to control and efficiency strikes a balance which is suitable for medicines that have a moderate impact on the finances but are still important and needed clinically, this middle ground strategy reflects the basic concept of ABC analysis in its principle of allocation of management resources according to the importance of the item, Lastly the simplified model for Class C products recognizes and acknowledge that these products have a small financial impact on the hospital but they still required for high levels of service, accordingly while the controls for Class A and B products must be more rigorous than those for Class C products the management methodology should also allow clinical availability with the minimum of administrative burden.

5.3 Implementation Considerations: The introduction of ABC-based inventory policies at Prince Rashid Ben Al-Hasan Military Hospital was very successful however there are still some number of important operational and organizational variables which we need to consider for the successful implementation, primarily, the hospital's information systems should be able to accommodate a class-specific inventory parameters which includes the ability to set policy parameters and produce segregated reports so that inventory can be monitored through ABC classifications and allow real-time tracking and some degree of personalized alerts for items within each class in order to ensure a proper oversight and eually important is the training of pharmacy and logistics personnel since staff must be trained on the principles and practical applications of ABC classification in order to ensure an appropriate adherence to class-specific procedures and a clear documentation and standard operating procedures tailored to each classification group must be made available to support its consistent implementation and also establishing metrics that can support the ABC categories is also crucial and these key performance indicators (KPIs) should be developed for each of the class of medication within the ABC system which will enable regular supervising and estimation of inventory practices and these metrics will help to assess the efficiency, to detect potential issues and to guide continuing improvements in inventory management, moreover a periodic reclassification of the inventory

items is also essential since the consumption patterns may change with time due to changing clinical practices or demand instabilities. The hospital should establish an organized process for reviewing and updating item classifications at regular intervals to maintain the relevance and precision of the ABC system. Finally, clinical input must also be integrated into the ABC framework. While the analysis primarily focuses on the economic value of items it is important to keep in mind that some medications despite their low consumption value may hold high clinical importance also input from medical staff should be accounted for and should guide decisions regarding which medications require enhanced controls even if they do not fall into Class A based on financial criteria alone since balancing both economic and clinical considerations ensures that patient care standards are maintained alongside operational efficiency.

5.4 Comparison with Previous Research: The results from Prince Rashid Ben Al-Hasan Military Hospital confirm what prior studies on ABC analysis inside healthcare environments showed, the allocation of products among ABC classes (12.68% in class A, 28.45% in class B, 58.87% in class C) closely mirrors trends that have been observed in other hospitals, at an Indian military hospital Kumar and Chakravarty (2015) documented an allocation of 14.8%, 22.6%, and 62.6% through classes A, B, and C respectively.

Military hospitals are uniquely positioned and faced with inventory management challenges that make them associated with a dual two responsibility to provide routine health care as well as to maintain a state of readiness for emergency at all times, the application of ABC analysis here is consistent with the suggestions made by ALBlushi et al. (2024) a researcher who emphasized the importance of the systematic classification of inventory at military medical facilities as a tool which can balance the operational readiness with cost effectiveness and the findings also support Al-Qatawneh's (2022) conclusions, which stated that inventory management is a challenge which faces health systems due to the shortage of resources and the unsteady supply chain, according to Al-Qatawneh, ABC analysis is an efficient tool which can be used in order to solving these problems by focusing the resources on the areas in which they will do the most good.

6. CONCLUSION:

This study shows how useful and beneficial the ABC classification can be for managing medication inventory at Prince Rashid Ben Al-Hasan Military Hospital in Jordan, we looked at 355 different types of medication and found a distinct Pareto distribution. About 12.68% of these items (Class A) make up 80% of the total consumption value while 28.45% (Class B) account for 15% of the value and the remaining 58.87% (Class C) contribute to just 5% of the total value.

The results clearly support the need for a tailored inventory management strategies that align with the ABC classification results, class A items require strict controls and regular reviews and elevated service levels, class B items need a balanced approach with standard measures while class C items can be handled with more simpler methods that reduce administrative load but still ensure sufficient availability.

The implementation of ABC-based inventory procedures propose several potential benefits including an optimized resource allocation, reduced inventory costs, improved service levels for critical medications and enhanced operational efficiency and these benefits are predominantly valuable in the context of a military hospital operating under resource constraints while striving to maintain high standards of care.

While this study provides valuable perceptions into the application of ABC analysis at Prince Rashid Ben Al-Hasan Military Hospital several limitations should also be acknowledged. The analysis was based solely on consumption value without incorporating other aspects such as criticality, lead time variability or substitutability and future research could explore multi-criteria classification approaches that consider these additional factors.

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