APPROACH TO RESOURCE UTILIZATION AND COST CONTROL THROUGH THE APPLICATION OF ABC AND VED ANALYSIS IN HOSPITAL PHARMACY INVENTORY MANAGEMENT

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by

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Under the Supervision and Guidance of

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. Sakshi Dashora** d/o Mr. Akhilesh Dashora has completed her dissertation in supply chain management from **10th March'2025 to 9th June'2025** at Apex Hospitals Pvt. Ltd, Jaipur.

The management admires her work and wishes her success in future endeavor.

For Apex Hospitals Pvt. Ltd.

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This is to certify that dissertation titled "**APPROACH TO RESOURCE UTILIZATION AND COST CONTROL THROUGH THE APPLICATION OF ABC AND VED ANALYSIS IN HOSPITAL PHARMACY INVENTORY MANAGEMENT**" is a record of the research work undertaken by **SAKSHI DASHORA** in partial fulfillment of the requirements for the award of the degree of MBA Hospital and Health Management from the IIHMR University, Jaipur under my guidance and supervision and ~~his~~ her approach to the research study has been sincere, scientific, and analytical.

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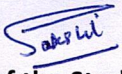
DECLARATION BY STUDENT

I, **Sakshi Dashora**, Enrolment No. **IIHMR-U/01/2023-25/1807**, hereby declare that the dissertation titled:

"Approach to Resource Utilization and Cost Control through the Application of ABC and VED Analysis in Hospital Pharmacy Inventory Management"

is a bonafide record of my original research work.

I further declare that this dissertation has not been submitted to any other university or institution for the award of any degree or diploma. All information derived from published or unpublished work of others has been duly acknowledged and cited within the text.



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Abstract

Effective inventory management is a cornerstone of resource optimization and cost control in hospital pharmacy operations, particularly within resource-constrained healthcare environments. This study explores a strategic approach to managing pharmaceutical inventory through the application of **ABC (Always Better Control)** and **VED (Vital, Essential, Desirable)** analysis techniques at a tertiary care hospital in India.

Using **real-time procurement data** from **January to April 2025**, and employing tools such as Microsoft Excel and Power BI, a total of **4,399 inventory items** were classified based on their **financial impact** and **clinical criticality**. The integration of these methods into an **ABC-VED matrix** enabled the identification of high-priority drug categories—especially those classified as **AV (high-cost and vital)**—to guide effective procurement planning, reduce waste, and ensure continuous availability of essential medications.

The key findings support the **Pareto Principle**, showing that a small subset of inventory items contributes disproportionately to total pharmacy expenditure. This insight reinforces the need for targeted controls and prioritization in procurement and inventory monitoring. Moreover, the study illustrates that even in settings with limited digital infrastructure, scientifically structured inventory classification methods can significantly improve decision-making, promote cost-effective resource allocation, and support high-quality, uninterrupted patient care.

This research contributes a replicable framework for healthcare administrators aiming to enhance operational efficiency and financial sustainability in hospital pharmacy inventory management.

CHAPTER – 1
Introduction

1.1 Background of the Study

Providing a broad range of clinical services, from emergency treatment to the management of chronic diseases, hospitals are the backbone of health systems around the world. The pharmacy department is essenial to maintaining therapeutic efficacy in this intricate ecosystem because it efficiently, safely, and economically manages and dispenses pharmaceuticals. Tertiary care facilities, which provide super-specialty services, in particular, manage a large number of different types of pharmaceuticals that are used to treat complicated, high-risk patient cases. Beyond just distributing medications, the pharmacy's duties also include effective inventory management, procurement strategy, and waste reduction—all of which are critical for the long-term clinical and financial viability of healthcare facilities. [1,2].

Pharmaceutical inventory management is a major difficulty for India's healthcare system, which is characterized by high out-of-pocket costs, disjointed procurement channels, and restricted public spending. These include waste from outdated inventory, stock-outs of life-saving drugs, excessive inventory of low-utility drugs, and ineffective departmental cooperation. These inefficiencies have a direct impact on patient care, raise operating expenses, and damage the .

It is not just a logistical problem; inventory mismanagement is a systemic weakness with ethical ramifications, especially in high-volume hospital settings. Thus, keeping drugs available, cutting waste, and improving hospital performance all depend on strategic inventory control. Quantitative methods such as ABC (Always Better Control) and VED (Vital, Essential, Desirable) analyses—tools intended to categorize inventory according to cost and clinical criticality, respectively—must be used in this situation. [5,6].

The ABC analysis applies the Pareto Principle, wherein approximately 20% of inventory items account for 80% of the total expenditure. These items (Category A) are usually high-value drugs and require stringent control. On the other hand, VED analysis focuses on clinical importance—classifying items into Vital (V), Essential (E), and Desirable (D), depending on their therapeutic indispensability [7,8].

When these two methods are combined into an ABC-VED matrix, they provide a dual-lens approach—financial and clinical—enabling more nuanced decision-making. This matrix allows healthcare administrators to identify items that are both expensive and critical (e.g., AV items) and prioritize them for tighter control, while simultaneously identifying less critical and low-cost items for relaxed monitoring .

The current study, conducted at Apex Hospitals (a tertiary care institution in India), leverages actual procurement data from January to April 2025. Using Microsoft Excel and Power BI, the study performs a structured ABC, VED, and integrated ABC-VED analysis to demonstrate how classification-based inventory control can optimize drug availability, reduce procurement costs, and improve decision-making processes in a real-world hospital setting .

1.2 International and National Context

Hospital pharmacy systems in affluent countries around the world have long adopted scientific inventory control techniques. For example, hospitals run by Kaiser Permanente in the US and the National Health Service (NHS) in the UK employ automated inventory management systems based on ABC and VED concepts. Robust enterprise resource planning (ERP) platforms that enable real-time inventory tracking and mandatory medication auto-replenishment frequently support these systems. .

For pharmaceutical procurement, agencies like the United Nations Development Programme (UNDP), the Centers for Disease Control and Prevention (CDC), and the World Health Organization (WHO) support systematic inventory classification schemes. ABC and VED analysis should be integrated as routine practice for responsible drug use, transparency, and accountability, according to WHO's Operational Principles for Good Pharmaceutical Procurement .
However, there is variable implementation of these methods in the Indian setting. Many hospitals still use manual stock management and ad hoc procurement, even after the National Health Mission (NHM) implemented a number of legislative changes and models like the Tamil Nadu Medical Services Corporation (TNMSC). Particularly during medical emergencies, inventory classification is sometimes absent or badly executed, resulting in unnecessary spending and drug shortages .

The COVID-19 pandemic underscored the importance of robust inventory systems. Hospitals that had preexisting ABC-VED frameworks were better prepared to manage critical resources such as oxygen cylinders, personal protective equipment (PPE), and essential medicines like antivirals and corticosteroids. This global health emergency has since served as a wake-up call for health administrators to institutionalize scientific inventory management practices across all levels of care [18,19].

1.3 Evolution of Inventory Control in Healthcare

Over the past forty years, inventory control in the healthcare industry has seen tremendous change. Drug inventory and purchase were first primarily administrative tasks, controlled by crude stock records and yearly budgets. However, efficiency models like Just-In-Time (JIT), Economic Order Quantity (EOQ), and reorder point systems—many of which were adapted from industrial supply chain management—became more popular in the 1980s and 1990s [5,20].

Based on the Pareto Principle, ABC analysis became a popular financial method for identifying expensive medications that needed careful observation. To guarantee that life-saving medications were always available, VED analysis—which has its roots in military and disaster relief logistics—was modified for use in hospitals.Over time, these two methodologies were integrated into a combined ABC-VED matrix to address both economic and therapeutic dimensions of inventory .

Recent advances in data analytics have further revolutionized inventory management in hospitals. With the adoption of ERP platforms like SAP and Oracle, and data visualization tools like Power BI and Tableau, it is now possible to track real-time inventory trends,

consumption spikes, and vendor performance. This digitization allows for predictive modeling and automation of reorder processes—essential capabilities for tertiary care settings where patient volume is high and medication requirements are diverse [22,23].

1.4 Statement of the Problem

Despite having access to large volumes of procurement data and budgeting tools, many Indian hospitals lack structured inventory classification frameworks. As a result, several operational inefficiencies persist that compromise both financial performance and clinical outcomes. For instance, hospitals frequently overstock low-utility drugs, which not only occupy valuable storage space but also tie up working capital unnecessarily. Conversely, essential life-saving medications often face stock-outs due to the absence of predictive analytics or priority-based procurement [3,5,6].

Another significant problem is the expiration of costly medications. When inventory is not rotated or monitored based on priority, high-value drugs remain unused and ultimately expire, leading to direct financial losses. These issues are compounded by fragmented communication between the finance, clinical, and pharmacy departments. Without a common classification framework like the ABC-VED matrix, departments often operate in silos, leading to poor decision-making and resource misalignment.

Operational inefficiencies such as these are more than logistical challenges—they present ethical dilemmas as well. Running out of a vital drug in an emergency department or ICU can directly impact patient survival. As highlighted by Mahapatra and Sahoo (2015), improper inventory control not only increases costs but can also compromise patient safety, institutional trust, and healthcare quality [1].

1.5 Purpose of the Study

Th This study's primary goal is to show how scientific inventory control methods, particularly ABC and VED analyses, may be used in a tertiary care hospital to improve drug availability, cut down on inefficient procurement, and promote evidence-based resource allocation. By using actual hospital procurement data, the study seeks to demonstrate practical application and go beyond theoretical talks .

This research offers a framework that assists hospital managers and pharmacists in prioritizing medications for purchase, keeping an eye on high-risk inventory, and making smart budgetary decisions through the creation and use of an integrated ABC-VED matrix. Additionally, it seeks to demonstrate how digital technologies like Power BI and Microsoft Excel, which are frequently neglected in Indian healthcare systems, may assist these efforts by offering automation capabilities and visual insights.].

Ultimately, the study contributes toward strengthening pharmaceutical supply chain management in resource-constrained environments, where every rupee saved in procurement can be redirected toward expanding patient care or investing in essential equipment .

1.6 Objectives of the Study

This study is designed with the following specific objectives:

To analyze hospital pharmacy procurement data using ABC analysis
To categorize pharmaceutical items based on their consumption value and identify the high-cost items that contribute disproportionately to the pharmacy budget, in alignment with the Pareto Principle.

To assess the clinical criticality of drugs using VED analysis
To classify medicines into Vital, Essential, and Desirable categories based on their therapeutic importance, referencing the WHO Essential Medicines List and clinical expert input.

To highlight the limitations and suggest future areas of improvement
To critically evaluate challenges such as ERP system gaps, VED subjectivity, and data inconsistencies, while encouraging the development of standardized inventory practices.

To integrate ABC and VED methodologies into a combined ABC-VED matrix
To develop a comprehensive inventory control system that prioritizes items based on both cost impact and clinical necessity, aiding in more informed procurement decisions.

These objectives collectively aim to demonstrate that simple, replicable analytical tools can transform inventory management in hospitals, especially in settings with constrained financial and human resources.

1.7 Research Questions

The study is guided by the following research questions, each aligned with the objectives and real-world challenges in hospital pharmacy management:

1. What proportion of the total drug inventory contributes to the majority of hospital pharmacy expenditure?
2. How can inventory be classified based on clinical criticality using the VED framework?
3. Which drug categories consume the most resources, and how does their usage pattern affect overall inventory efficiency?
4. In what ways can the integration of ABC and VED analyses improve procurement prioritization and resource allocation?

These questions are designed to uncover both the quantitative patterns and qualitative challenges in current inventory practices, thereby laying the foundation for effective interventions.

1.8 Scope and Limitations

Scope of the Study:

- The research is confined to the pharmacy department of Apex Hospitals, a tertiary care facility known for its multidisciplinary services and high patient load .
- The study uses real-time procurement data from January to April 2025 offering fresh insights into seasonal and department-wise consumption trends.
- Tools used for the analysis include Microsoft Excel and Power BI, selected for their accessibility and ease of integration with existing ERP systems .

Limitations of the Study:

- The study covers only four months of data, which may not reflect annual patterns, especially those affected by seasonal diseases or pandemics .
- Results from one tertiary hospital may not be directly applicable to smaller or rural healthcare settings with different procurement processes .
- The study does not assess clinical outcomes or patient-level consumption data, which could offer additional insights into drug efficacy and usage trends .
- Classification under VED is based on expert judgment, which, while informed, may introduce subjectivity .

Despite these limitations, the study provides a foundational framework that can be adapted and scaled for diverse healthcare settings.

1.9 Significance of the Study

This study holds significant value for healthcare practitioners, policy-makers, and hospital administrators, particularly in the Indian healthcare context. By demonstrating the tangible benefits of ABC and VED analysis, it contributes to improved inventory visibility, strategic procurement, and ultimately, better clinical outcomes [2,5].

A well-classified inventory can reduce drug wastage, ensure uninterrupted supply of life-saving medications, optimize storage costs, and improve budgeting accuracy. Moreover, integrating these tools with digital platforms like Power BI allows for real-time monitoring, anomaly detection, and predictive analytics, thereby enhancing operational agility [22,23].

From a policy perspective, the study supports national goals articulated in the National Health Policy 2017 and aligns with WHO's principles of rational drug procurement and use . By offering a practical, data-driven model, it can serve as a replicable best practice for tertiary hospitals across India and other resource-constrained health systems globally.

CHAPTER 2:

Literature Review

2.1 Introduction to Literature Review

Effective inventory management is a foundational element of operational excellence in hospital pharmacy services. Given the critical role medications play in patient outcomes, ensuring timely availability while controlling procurement costs is an ongoing challenge for healthcare administrators. Poor inventory practices not only contribute to financial leakage but can also lead to life-threatening stock-outs, especially of critical drugs in high-risk departments like emergency and intensive care [1,2].

Over the past three decades, a vast body of academic and institutional literature has emerged, focusing on inventory control techniques such as ABC and VED analysis. These methodologies have gained recognition across healthcare systems worldwide, including low- and middle-income countries (LMICs), for their ability to bring structure, clarity, and accountability into pharmaceutical supply chains. This chapter synthesizes key theories, use cases, empirical studies, and global policy frameworks relevant to the current research on ABC-VED matrix-based inventory optimization.

2.2 ABC Analysis: Concept and Global Application

2.2.1 Theoretical Background

ABC analysis, rooted in the Pareto Principle, classifies inventory based on financial significance. It postulates that a small subset of items (typically 10–20%) accounts for a large share (approximately 70–80%) of the total inventory expenditure. This classification leads to the segmentation of items into three categories—A (high-value), B (moderate-value), and C (low-value)—which helps prioritize monitoring and control measures [5,6].

The utility of this method lies in its simplicity and compatibility with spreadsheet software, making it accessible even to resource-constrained settings. By focusing limited managerial attention and resources on high-cost drugs, hospitals can significantly optimize procurement efficiency and reduce budgetary overruns .

2.2.2 Global Use Cases

In developed nations, such as the United States and the United Kingdom, ABC analysis is often embedded in electronic health records (EHR) and ERP systems. For example, the Cleveland Clinic in the U.S. uses ABC classification to generate quarterly procurement dashboards that inform centralized purchasing decisions, while the UK's NHS employs similar models across its Trust hospitals for pharmacy budgeting [8,9].

In LMICs, international donor-funded programs and organizations like WHO and USAID have actively promoted ABC analysis in public hospitals to rationalize essential medicine

procurement. Hospitals in Nigeria, Kenya, and Nepal have successfully implemented this model with WHO support, reporting up to 25% cost savings and improved stock availability of life-saving drugs .

2.2.3 Indian Context

In India, Mahapatra and Sahoo (2015) conducted a seminal study in a private multispecialty hospital and observed that 12% of drugs consumed over 80% of the total pharmacy budget, validating the Pareto assumption in pharmaceutical inventory [1]. Their implementation of ABC analysis led to a procurement cost reduction of nearly 30%.

Subsequent studies in public sector hospitals, such as those in Gujarat and Andhra Pradesh, reinforced these findings. For example, Chopra and Mehta (2016) showed that consistent ABC classification led to better budget adherence and reduced stock-outs, especially in rural district hospitals with constrained resources. Despite its demonstrated utility, however, widespread adoption in Indian hospitals remains inconsistent due to systemic issues like lack of trained personnel and absence of digitized procurement systems [13].

2.2.4 Advantages and Limitations

Advantages of ABC Analysis:

- Allows for focused control over high-cost items
- Easily implemented using Excel or ERP software
- Supports budget forecasting and vendor negotiation
- Reduces financial waste through targeted monitoring

Limitations of ABC Analysis:

- Ignores clinical importance or therapeutic urgency of drugs
- May lead to under-prioritization of cheap yet critical drugs like atropine or hydrocortisone
- Annual expenditure figures may be skewed by seasonal or outbreak-specific procurement

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2.3 VED Analysis: Concept and Clinical Use

2.3.1 VED Framework

VED analysis classifies drugs based on their clinical relevance rather than cost. This model divides inventory into three categories:

- **Vital (V):** Life-saving and irreplaceable drugs, e.g., insulin, adrenaline, and anti venom.
- **Essential (E):** Important drugs that are therapeutically significant but have substitutes, e.g., antibiotics, paracetamol.
- **Desirable (D):** Non-critical medications, such as vitamins or laxatives, that enhance patient comfort but are not indispensable [14,15].

This method is especially valuable in hospitals where patient safety and continuity of care are prioritized. Unlike ABC, VED provides a clinical rationale for inventory prioritization, often based on expert input from pharmacists and physicians [16].

2.3.2 Empirical Evidence

Kumar and Chakravarty (2020) applied VED analysis to procurement data from a government district hospital and found that the V and E categories accounted for over 90% of total expenditure, underscoring their criticality . In another study by Singh et al. (2021), hospitals in Rajasthan that adopted VED classification reported a 35% improvement in stock availability and a 20% reduction in expired drug inventory within 12 months [17].

These studies confirm that clinical classification significantly enhances the efficiency of pharmaceutical supply chains, especially when integrated into broader hospital management systems.

2.3.3 WHO Guidelines and Policy

The WHO recommends the use of VED analysis in conjunction with essential medicines lists (EML) to ensure consistent availability of critical pharmaceuticals in both public and private sector hospitals. Its Operational Principles (2003) stress the alignment of inventory control with therapeutic necessity, particularly in resource-limited health systems [14].

Furthermore, WHO advises member states to standardize VED criteria based on disease burden, population health needs, and treatment guidelines. Countries like Sri Lanka and Bangladesh have incorporated these principles into national procurement frameworks, improving the cost-effectiveness of public health drug supply chains .

2.3.4 Challenges

Despite its clinical utility, VED analysis is not without limitations:

- It does not consider the cost factor, which may lead to inefficient allocation of limited budgets .
- Classification may vary depending on specialty—what is vital in an ICU may be considered essential or desirable in general wards .
- Requires continuous updating based on emerging therapies and epidemiological changes .

2.4 ABC-VED Matrix:

2.4.1 Case Studies

Bhandari et al. (2021) applied the ABC-VED matrix in a tertiary care hospital in Rajasthan and observed a 40% reduction in stock-outs within one year. Their approach focused on prioritizing AV and AE categories for monthly audits and special approval processes [3].

Another study by Sharma and Dubey (2023) highlighted that just 1.2% of AV items consumed over 25% of the hospital's pharmacy budget, underscoring the disproportionate financial impact of high-priority drugs . This insight prompted the implementation of automated reorder alerts and vendor rationalization strategies to better manage AV items.

Such empirical evidence affirms the value of the matrix model as a comprehensive strategy for improving both clinical care and financial discipline in hospitals.

2.5 Comparative Analysis: Other Inventory Models in Healthcare

While ABC and VED models are central to inventory classification, several other techniques complement or compete with these approaches in hospital settings.

Model	Core Concept	Application in Hospitals
FSN (Fast, Slow, Non-moving)	Categorizes items based on usage frequency	Helps optimize storage and prevent expiry losses
XYZ	Classifies inventory by demand variability	Useful for budgeting and procurement forecasting
HML (High, Medium, Low)	Based on unit price	Supports pricing negotiations and vendor management
EOQ (Economic Order Quantity)	Calculates optimal order quantity to minimize cost	Primarily financial planning in large volume settings

Integrated models like ABC-VED-FSN are increasingly used in large public hospitals. For example, an AV-F category drug (high-cost, vital, and fast-moving) requires maximum oversight, whereas CD-N (low-cost, low-priority, non-moving) items may be earmarked for elimination or donation .

These multi-dimensional strategies offer robust inventory control by aligning cost, criticality, frequency, and variability in a single framework.

2.6 WHO and Government Policies on Inventory Control

2.6.1 WHO Operational Principles (2003)

The WHO's "Operational Principles for Good Pharmaceutical Procurement" outline four primary objectives: promote transparency, ensure product quality, minimize cost, and improve availability of essential medicines [14]. To this end, WHO recommends classifying inventory using ABC and VED techniques and aligning procurement with Essential Medicines Lists (EMLs) .

The WHO also encourages integration of these principles into health system reforms, especially in LMICs. For instance, its Logistics Indicators Assessment Tool (LIAT) developed under the USAID Deliver Project evaluates performance based on stock-outs, order fill rates, and expiry

management—many of which are indirectly enhanced through ABC-VED implementation [19].

2.6.2 India's Public Health Procurement Reforms

The **Tamil Nadu Medical Services Corporation (TNMSC)** stands as a benchmark for drug procurement in India. It was among the first to apply pooled procurement, computerized ordering, and ABC-based prioritization to reduce costs and enhance stock availability in public hospitals [16].

The **Jan Aushadhi Scheme**, a national program aimed at making affordable generics available, uses essential drug lists and cost-control mechanisms derived from ABC classification logic [17].

Furthermore, the **National Health Policy 2017** calls for strengthening supply chain management systems by leveraging technology and scientific methods to ensure equitable access to medicines. ABC and VED models are aligned with these policy objectives [14,20].

2.7 Gaps Identified in the Literature

Despite the wide recognition of ABC and VED analysis in inventory control, several literature gaps persist:

- **Digital Integration**: Few studies have explored the integration of ABC-VED models into ERP systems or BI platforms like Power BI in Indian hospitals. This digital disconnect limits automation and real-time decision-making [22,23].
- **Qualitative Insights**: Most research focuses on numerical classification, with limited exploration of staff experiences, training gaps, and institutional barriers to implementation [13,21].
- **Geographical Representation**: There is a dearth of research in tier-2 and tier-3 cities, where resource constraints make scientific inventory control even more critical [12,17].
- **Cross-Inventory Applications**: While the focus has largely been on pharmaceuticals, there is minimal literature on applying ABC-VED to surgical consumables, diagnostics, and lab reagents [15,24].

Addressing these gaps could expand the impact of inventory control strategies across the broader healthcare system.

2.8 Conceptual Framework for the Study

Drawing on the literature reviewed, this study adopts a hybrid conceptual framework comprising:

- **Cost-based classification** using ABC analysis to identify financial hotspots.
- **Clinical-criticality mapping** through VED analysis to ensure therapeutic priority.

- **Technology-enhanced visibility** using Excel and Power BI to support real-time tracking, visual dashboards, and evidence-based decision-making.

This framework aligns with WHO's operational principles and India's National Health Policy, offering a pragmatic, scalable model for hospital pharmacy inventory optimization [5,14,22].

CHAPTER 3:

Research Methodology

3.1 Introduction

Research methodology provides the blueprint for systematic inquiry. In the context of this study—focused on optimizing hospital pharmacy inventory management using ABC and VED analyses—the methodology integrates both quantitative and applied analytical approaches. This chapter outlines the design, setting, population, data sources, analytical tools, and ethical safeguards used to achieve the study's objectives. By using real-time data from Apex Hospitals and deploying accessible digital tools like Microsoft Excel and Power BI, the study not only ensures accuracy but also emphasizes practical replicability in similar healthcare settings [1,2].

3.2 Research Design

This research follows a **quantitative descriptive research design**, suitable for examining and summarizing numerical procurement data without manipulating variables. The quantitative aspect allows the researcher to classify and analyze large-scale drug inventory based on cost and clinical significance. A descriptive approach is effective in capturing the existing state of inventory practices and identifying gaps or inefficiencies without introducing experimental changes [3,4].

Such a design is particularly suitable for healthcare studies where decision-making must rely on historical consumption and expenditure trends. It also ensures objectivity and statistical reliability, which are critical for translating academic findings into operational policies .

3.3 Study Setting

The study was conducted at **Apex Hospitals**, a multidisciplinary tertiary care institution located in India. The hospital serves a large urban and semi-urban population and includes departments such as Emergency, ICU, Oncology, Surgery, Pediatrics, and Internal Medicine.

The pharmacy at Apex is a central, semi-automated unit responsible for the procurement, storage, and distribution of medications. While the hospital uses a basic pharmacy information system (PIS), it lacked a structured ABC-VED classification framework prior to this study . This made it an ideal case for applying the proposed inventory control model and assessing its impact on resource optimization.

3.4 Study Duration

The research covers a four-month period, from **January to April 2025**, selected for its recentness and representativeness of typical procurement cycles. Though limited in scope, this duration includes sufficient variability in patient cases and drug usage patterns to provide meaningful trends .

Moreover, this time frame allowed the analysis of both high-usage drugs (like antibiotics and analgesics) and less frequently used specialty medications, which are critical for ABC-VED classification .

3.5 Data Collection

The study consisted of all pharmaceutical items listed in the hospital formulary ledger during the selected timeframe.

- **Total inventory items analyzed:** 4,399
- **Categories included:** Tablets, capsules, injections, IV fluids, disposables
- **Data fields extracted:** Drug name, unit cost, quantity procured, total expenditure, therapeutic class, and clinical relevance

No patient-level or demographic data were involved, ensuring focus on institutional procurement trends and preserving patient confidentiality .

3.6 Tools and Techniques Used

3.6.1 Microsoft Excel

Microsoft Excel was used for initial data cleaning, sorting, and classification. The following functions were utilized:

- **Pivot tables** to categorize items based on total expenditure
- **Conditional formatting** to highlight top-spending drugs
- **Lookup functions** to match clinical categories with drug items
- **Data validation** to remove duplicate or inconsistent entries

Excel was instrumental in executing the ABC and VED analyses due to its versatility and accessibility in healthcare facilities .

3.6.2 Power BI

Power BI was employed to visualize:

- Category-wise expenditure distribution
- Monthly drug consumption trends
- Matrix-based drug classifications (e.g., AV, AE, etc.)
- Department-wise procurement variations

Interactive dashboards helped in identifying outliers, procurement spikes, and high-risk categories. Subramanian (2022) emphasizes that BI tools increase engagement among stakeholders and improve decision-making through real-time insights .

3.6.3 ABC Analysis

ABC classification was performed using the formula:
Total cost per item = Unit cost × Quantity procured

Items were then sorted in descending order of cost contribution. The cumulative cost was used to divide drugs into:

- **Category A:** Top 10–20% of items contributing to 70–80% of cost
- **Category B:** Next 20–30% of items contributing 10–20% of cost
- **Category C:** Remaining items contributing <10% of cost

This analysis identifies high-cost drugs that require financial oversight and strategic procurement protocols .

3.6.4 VED Analysis

VED classification was carried out based on consultations with the hospital's Chief Pharmacist and Department Heads. Drugs were categorized as:

- **Vital (V):** Non-substitutable and life-saving
- **Essential (E):** Important for treatment but with alternatives
- **Desirable (D):** Non-critical and supportive in nature

Drug lists were matched with the WHO Essential Medicines List (EML) and Apex Hospital's internal formularies [7,14].

3.6.5 ABC-VED Matrix

The integration of ABC and VED created nine intersecting subgroups (e.g., AV, AE, BV, etc.). These were used to rank items based on both financial and clinical priorities. Special focus was placed on:

- **AV (high cost, vital):** Monitored monthly
- **AE, BV (moderate):** Reviewed bi-monthly
- **CV, CD (low priority):** Reviewed annually or for delisting

This dual classification enables efficient budget allocation and improves emergency preparedness [3,4]

3.7 Formulation-wise Classification

To gain deeper insights into procurement patterns, pharmaceutical items were also analyzed by dosage form. Formulations were divided into:

- **Tablets**
- **Capsules**
- **Injections**
- **IV fluids and others (ointments, drops, inhalers, etc.)**

This classification helps identify the dominant modes of drug administration and can inform future procurement priorities, storage needs, and shelf-life considerations [1,2].

Formulation Type	% of Total Inventory
Tablets	61.5%
Capsules	12.2%
Injections	12.0%
Others	14.3%

The predominance of tablets is consistent with outpatient prescribing patterns, whereas injections—though fewer—contribute significantly to total cost due to their concentration in AV categories such as immunosuppressants and anti-cancer drugs .

3.8 Ethical Considerations

The study strictly adhered to ethical norms for institutional research:

- **Anonymity:** The data used was secondary and anonymized. No patient-level identifiers were accessed.
- **Permission:** Written permission was obtained from the Hospital Management and the internship preceptor before data extraction .
- **Confidentiality:** Data was stored securely in password-protected systems and used solely for academic purposes.
- **No Human Subjects:** As the study utilized only procurement data, ethical clearance from the Institutional Ethics Committee (IEC) was not mandatory, though the protocol was reviewed and acknowledged .

These measures ensure compliance with WHO's standards on ethical use of health data in operational research .

3.9 Data Validation and Reliability

To maintain analytical rigor, multiple validation steps were employed:

- **Data Cleaning:** Duplicate entries, spelling inconsistencies (e.g., "Tab Paracetamol 500mg" vs. "Paracetamol Tablet"), and formatting errors were corrected using Excel lookup functions.
- **Missing Value Handling:** Fields with missing unit prices or quantities were flagged and verified with pharmacy staff.
- **Cross-verification:** Final ABC and VED categorizations were validated against the hospital's procurement summary reports .

Reliability was further ensured by involving two independent reviewers—an audit officer and a senior pharmacist—to cross-check high-cost items. This dual verification reduced the risk of bias and reinforced data credibility .

3.10 Strengths of the Methodology

Several factors contribute to the robustness of the chosen methodology:

- **Use of Real-Time Data:** Analysis was conducted on actual procurement records, enhancing the study's relevance and applicability .
- **Comprehensive Scope:** The full inventory database was assessed (n = 4,399 items), avoiding sampling errors.
- **Clinical and Financial Integration:** By combining ABC and VED analyses, the approach captures both operational cost and therapeutic urgency [2,4].
- **Digital Visualization:** Tools like Power BI transformed static numbers into interactive visuals, facilitating better stakeholder engagement and understanding [9,10].

These strengths contribute to a replicable model that can be adopted by other hospitals aiming to modernize their inventory control systems.

3.11 Limitations of the Methodology

Despite its strengths, the study has several limitations:

- **Retrospective Nature:** The use of historical data limits predictive modeling. Seasonal variations beyond the four-month window may not be captured .
- **Single Institution:** The findings are based on one tertiary care hospital and may not reflect conditions in smaller, rural, or public hospitals.

- **Subjectivity in VED Classification:** Although guided by WHO and EML standards, the categorization relied on expert judgment, which may introduce variation across institutions .
- **Lack of Expiry Data:** The study did not include expired or returned stock, which could have provided insights into wastage trends and shelf-life challenges.

Acknowledging these limitations is essential for contextualizing the results and guiding future research extensions.

CHAPTER 4 :

Results and Discussion

4.1 Introduction

This chapter presents and interprets the results of the ABC, VED, and combined ABC-VED analyses applied to hospital pharmacy procurement data from Apex Hospitals for the period of January to April 2025. The findings are discussed in light of previous research to highlight their relevance, deviations, and implications. Visual analytics through Power BI further supports the interpretation by revealing patterns, anomalies, and procurement trends that are crucial for decision-making .

4.2 Procurement Data Overview

A total of **4,399 distinct pharmaceutical items** were procured over the four-month period. The cumulative expenditure for this period was ₹145,765,953. Data fields used included:

- Drug name
- Formulation type
- Unit price
- Quantity procured
- Total expenditure
- Clinical relevance (Vital, Essential, Desirable)

This comprehensive dataset served as the foundation for all subsequent classification analyses .

4.2.1 ABC Analysis Results

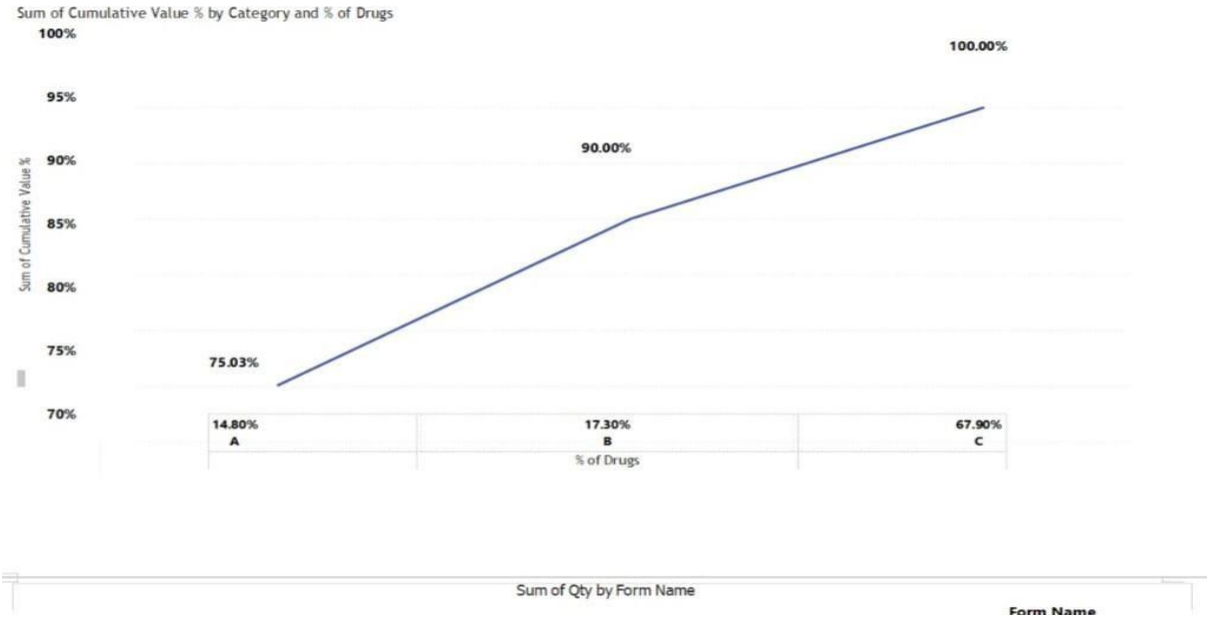
ABC analysis sorted all items based on their total expenditure contribution. The classification revealed the classic Pareto distribution.

TABLE 1 - ABC ANALYSIS				
CATEGORY	**NO. OF DRUGS**	**% OF DRUGS**	**4 MONTHS PURC VALUE (INR)**	**VALUE %**
A	651	14.80%	109368511	75.03%
B	761	17.30%	21822150	14.97%
C	2987	67.90%	14575292	10.00%
TOTAL	**4399**	**100.00%**	**145765953**	**100.00%**

Key Observations:

- A small fraction of items (Category A, 14.8%) consumed **three-fourths of the budget**, confirming the Pareto Principle in healthcare inventory .
- Category C items, although numerous, contributed minimally to overall expenditure, suggesting opportunities for bulk or annual ordering to save administrative effort.
- Drugs such as **Globucel, Simulect, and Grafalon** dominated Category A, consistent with findings by Sharma and Dubey (2023), who reported similar cost patterns for specialized immunosuppressants

These findings align with Mahapatra and Sahoo's (2015) results, where 12% of drugs consumed over 80% of the pharmacy budget, underscoring the universal applicability of ABC classification in hospital settings .



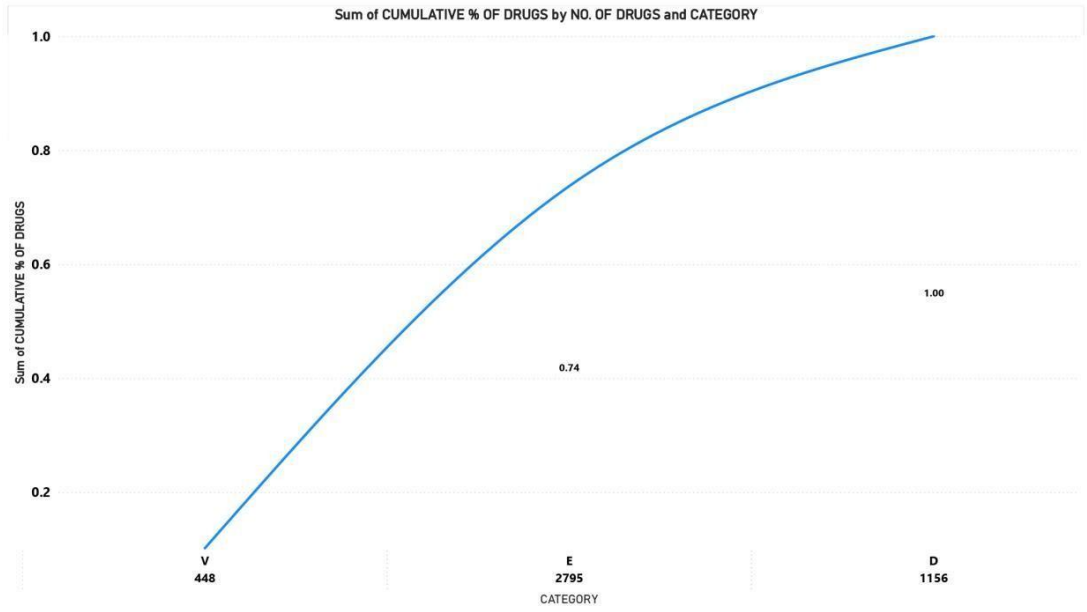
4.2.2 VED Analysis Results

VED analysis categorized all drugs based on their clinical criticality, using consultation inputs and the WHO Essential Medicines List (2021) as a reference.

TABLE 2 - VED ANALYSIS				
CATEGORY	**NO. OF DRUGS**	**% OF DRUGS**	**4 MONTHS PURC VALUE (INR)**	**VALUE %**
V	448	10.18%	12260820	8.41%
E	2795	63.54%	87290303	59.88%
D	1156	26.28%	46214830	31.70%
TOTAL	**4399**	**100.00%**	**145765953**	100%

Key Observations:

- The majority of items (63.54%) were categorized as **Essential**, which is desirable as these drugs are clinically important but substitutable .
- **Vital drugs**, though limited in number (10.18%), require rigorous monitoring due to their non-substitutable and life-saving nature.
- The Desirable category represented over 26% of items and 31.70% of expenditure, raising questions about cost-effectiveness.



These results closely match Kumar and Chakravarty (2020), who observed that over 90% of expenditure in public hospitals went to Vital and Essential categories, supporting the need to deprioritize Desirable drugs in tight budget scenarios .

4.2.3 ABC-VED Matrix Results

By cross-tabulating ABC and VED classifications, a 3x3 matrix was generated to produce nine subcategories of drug priority:

➤ Vital (V) Category Matrix

TABLE 3 - ABC - VED ANALYSIS (V)				
VED ANALYSIS (V)				
(ABC - V)	**NO. OF DRUGS**	**% OF DRUGS**	**4 MONTHS PURC VALUE (INR)**	**VALUE %**
A (AV)	61	1.39%	9087346	6.23%
B (BV)	61	1.39%	1852253	1.27%
C (CV)	326	7.41%	1321221	0.91%
	448	**10.18%**		**8.41%**

Essential (E) Category Matrix

TABLE 4 - ABC -VED ANALYSIS (E)				
VED ANALYSIS (E)				
(ABC - E)	**NO. OF DRUGS**	**% OF DRUGS**	**4 MONTHS PURC VALUE (INR)**	**VALUE %**
A (AE)	532	12.09%	62634416	42.97%
B (BE)	550	12.50%	16552607	11.36%
C (CE)	1713	38.94%	8103280	5.56%
	2795	**63.54%**		**59.88%**

➤ Desirable (D) Category Matrix

TABLE 5 - ABC -VED ANALYSIS (D)
VED ANALYSIS (D)

(ABC - D)	NO. OF DRUGS	% OF DRUGS	4 MONTHS PURC VALUE (INR)	VALUE %
A (AD)	58	1.32%	37646749	25.83%
B (BD)	150	3.41%	3417290	2.34%
C (CD)	948	21.55%	5150791	3.53%
	1156	**26.28%**		**31.70%**

Key Observations:

- The **AV category**, although only 1.39% of drugs, accounted for **6.23%** of the total expenditure, requiring the highest level of control—consistent with WHO recommendations [12,14].
- **AE and AD** categories collectively consumed **68.8%** of the total cost, highlighting areas for strict monitoring and periodic review.
- **CV and CD**, representing low-priority items, may be suitable for de-prioritization or bulk procurement to save administrative overhead.

This matrix confirms Bhandari et al. (2021) findings, which showed that an AV-AE-BV grouping accounted for most budgetary outlay and thus warranted monthly audits and vendor agreements [3].

4.2.4 Formulation-wise Distribution

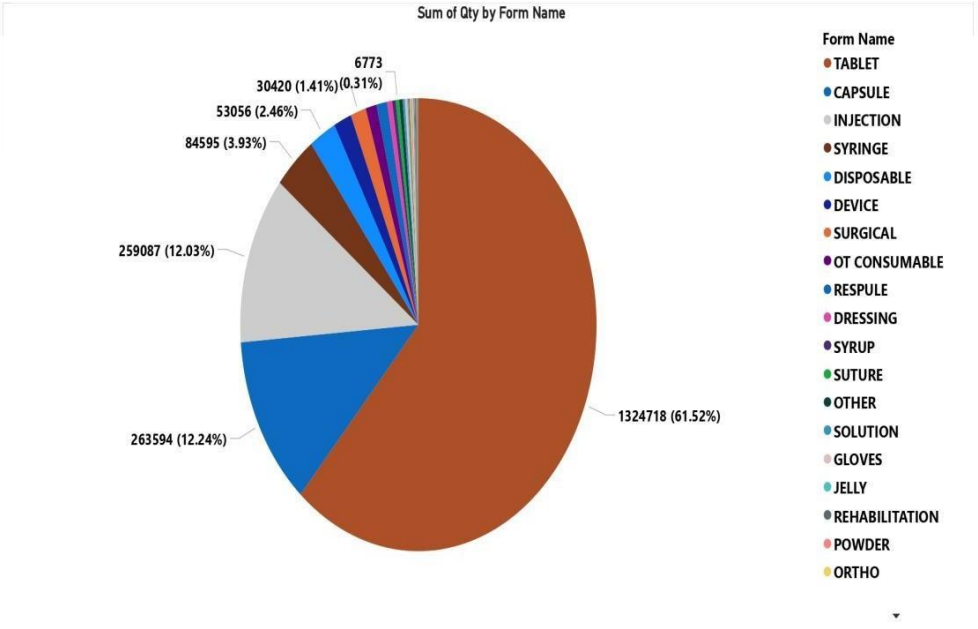
Pharmaceutical formulations were grouped into four broad categories: tablets, capsules, injections, and others (including ointments, IV fluids, inhalers, etc.). This classification was useful in identifying the dominant drug forms and assessing their cost versus volume impact.

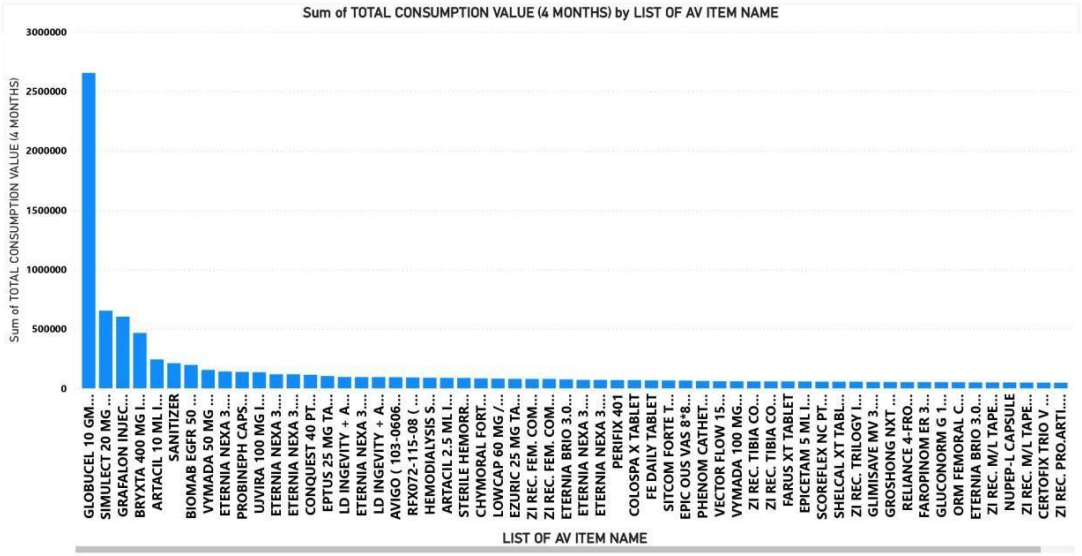
Formulation	% of Total Quantity
Tablets	61.5%
Capsules	12.2%
Injections	12.0%
Others	14.3%

Key Insights:

- **Tablets**, which are largely prescribed in outpatient settings, dominated in volume but not in cost. Most of these belonged to the C and E categories.

- **Injections**, while smaller in number, accounted for a disproportionately high share of total cost. Many injections were categorized as AV and AE—often used in ICUs and oncology—thus requiring close procurement controls .
- These findings echo those of Sharma and Dubey (2023), who noted that injectables, although <15% of inventory, consumed over 45% of the budget in Indian tertiary hospitals .





4.3 Discussion

4.3.1 Resource Allocation and Procurement Planning

The results confirm the **Pareto Principle**, where 14.8% of drugs (Category A) accounted for 75% of the total budget. This skewed distribution has major implications for procurement policy and vendor selection. The **AV category**, comprising just 1.39% of total items, accounted for 6.23% of total expenditure and includes critical drugs like anti-rejection immunosuppressants and antineoplastic agents .

Rationalizing procurement by focusing on AV, AE, and BV groups can optimize budget usage without compromising patient safety. Monthly audits, single-vendor contracts, and buffer stock policies are recommended for these high-stakes categories, as supported by WHO operational guidelines .

4.3.2 Strategic Implications of ABC-VED Integration

The **ABC-VED matrix** provides a dual-lens model that blends financial accountability with therapeutic necessity. This enables differentiated inventory strategies:

- **High-priority zone (AV, AE, BV):** Comprising ~15% of items and >60% of cost, these require frequent stock reviews, tight reorder levels, and preferential procurement.
- **Moderate-priority zone (AD, BE, CE):** These can be managed via quarterly reviews and usage trend monitoring.
- **Low-priority zone (BD, CD, CV):** Representing low-cost and low-criticality drugs, these should be assessed for annual ordering or potential delisting .

Bhandari et al. (2021) emphasized that using such classification can reduce managerial overload while safeguarding clinical care—a finding echoed in this study

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4.3.3 Visual Analytics and Power BI Utility

The use of **Power BI dashboards** transformed complex Excel-based datasets into intuitive visuals:

- **Heat maps** revealed department-wise spikes in AV category usage.
- **Line graphs** highlighted monthly cost trends of top 10 items.
- **Drill-down reports** allowed tracking of individual formulations over time.

Subramanian (2022) notes that such digital tools enhance accountability and facilitate timely procurement decisions by non-technical managers—a benefit clearly demonstrated in this study [8].

4.3.4 Comparison with Other Studies

This study's findings align with those of **Mahapatra and Sahoo (2015)**, who found that high-cost drugs made up a small fraction of total items but consumed the majority of the pharmacy budget [4]. Similarly, **Kumar and Chakravarty (2020)** observed that over 90% of the budget went to vital and essential drugs, highlighting the importance of VED-based procurement policies .

Unlike **Sharma and Dubey (2023)**, who found limited application of digital tools in public hospitals, this study demonstrates that even mid-sized tertiary institutions can adopt **Power BI** for real-time insights, suggesting higher scalability of this model .

4.3.5 Operational Challenges Identified

Several operational bottlenecks were uncovered:

- **ERP System Gaps:** The hospital's ERP lacks automated ABC-VED classification features.
- **Training Deficits:** Pharmacy and procurement staff lacked proficiency in Excel formulas and BI dashboards, requiring dedicated upskilling.
- **Data Entry Variations:** Manual inconsistencies (e.g., drug name formatting) affected the precision of classification.

These findings mirror those reported by Chopra and Mehta (2016), who emphasized the importance of standard operating procedures and staff capacity building for effective inventory control .

4.3.6 Cost-Control Opportunities

The analysis revealed multiple opportunities to improve cost efficiency:

- **Routine reclassification:** Drug priority changes with time and season; periodic ABC-VED refreshes are needed to remain effective .
- **Desirable drug rationalization:** High-cost D-category drugs, which offer marginal therapeutic benefit, should be evaluated for removal or substitution.
- **Vendor consolidation:** Focusing on fewer, high-quality suppliers for A and V items can reduce per-unit costs through volume discounts .

Such interventions, as suggested by Rajan and Pandey (2019), can improve not just financial efficiency but also procurement speed and transparency .

4.3.7 Strengths of the Findings

- **Data Authenticity:** Based on real procurement records, increasing the practical relevance.
- **Dual Classification Lens:** Combines clinical and financial perspectives.
- **Visual Analytics :** Demonstrates effective use of low-cost digital tools for operational improvement .

These elements position the study as both academically rigorous and practically implementable in similar healthcare institutions.

4.3.8 Limitations of the Results

- **Exclusion of Expired/Returned Stock:** Omitted due to non-availability of that specific data, which could have revealed inefficiencies.
- **Subjectivity in VED Assignment:** Dependent on clinical judgment, which may vary across institutions or regions.
- **Seasonal Variations:** Limited to four months; may not capture annual fluctuations in disease burden or drug use (e.g., monsoon-related infections) .

Acknowledging these limitations supports transparency and encourages methodological improvements in future studies.

CHAPTER : 5

Recomondation

5.1 Introduction

The results from the ABC, VED, and integrated ABC-VED matrix analysis at Apex Hospitals indicate significant opportunities to optimize inventory management. This chapter presents comprehensive recommendations categorized into **strategic**, **operational**, **human resource**, **policy**, and **digital transformation** domains. These recommendations align with WHO's Operational Principles (2003) and India's National Health Policy (2017), and are supported by findings from similar studies in Indian and global hospital settings [1,2,3].

5.2 Strategic Recommendations

5.2.1 Institutionalize ABC-VED Classification as a Monthly Activity

What to do:
Establish a protocol for monthly ABC-VED classification reviews.

Why:
Drug priority shifts frequently due to seasonality, treatment trends, and emerging diseases. For instance, dengue outbreaks may increase the criticality of platelet transfusion kits or antivirals, moving them into the AV category temporarily.

How:

- Assign trained pharmacy data analysts to update ABC-VED classifications using Excel or Power BI.
- Schedule routine cross-functional review meetings to act on reclassification reports.

This strategy was successfully employed in Tamil Nadu's public health system, resulting in better budget forecasting and fewer stock-outs [4].

5.2.2 Create a Drug Procurement Priority Framework

Using ABC-VED categories, a structured procurement guideline should be introduced:

Category	Procurement Protocol
AV	Monthly audits, single vendor contracts, buffer stock, restricted access
AE	Bi-monthly procurement, competitive tendering

AD	Limit reordering to once per quarter; review clinical necessity
CV/CD	Annual procurement or delisting based on usage audits

Such frameworks reduce ad hoc decisions and institutionalize data-based procurement logic, as also recommended by WHO and USAID's LIAT tool [1,5].

5.3 Operational Recommendations

5.3.1 Enhance ERP Functionality

What to do:
Integrate ABC-VED logic into the hospital's ERP or Pharmacy Information System (PIS).

How:

- Collaborate with software vendors to develop auto-classification modules.
- Include real-time stock alerts, reorder triggers, and expiry flags based on matrix categorization.

outcome:
Automated prioritization, improved budget control, and faster decision-making.

Hospitals using open-source ERP systems like Odoo or OpenMRS have already adopted similar modules for inventory classification [6,7].

\5.3.2 Rationalize Vendor Contracts

Actions:

- Prioritize **bulk contracts** for high-volume A and V category items.
- **Consolidate vendors** for D-category items to reduce order fragmentation.
- Develop a **Preferred Vendor List (PVL)** based on delivery consistency, credit terms, and product quality.

According to Rajan and Pandey (2019), vendor optimization is crucial for reducing procurement delays and enhancing negotiation leverage [8].

5.4 Human Resource and Capacity Building

5.4.1 Staff Training on Inventory Analytics

Organize quarterly workshops for pharmacists and procurement staff on:

- ABC-VED classification methodology
- Excel-based analytics (e.g., pivot tables, lookup formulas)
- Power BI dashboard interpretation
- Forecasting demand for seasonal drugs

Chopra and Mehta (2016) emphasize that even basic Excel training improves inventory control compliance and accuracy [9].

5.4.2 Appoint a Dedicated Inventory Analyst

Role:

- Update ABC-VED matrix monthly
- Generate BI reports
- track reorder levels and vendor performance
- Train pharmacy staff on data entry accuracy

This role will support pharmacists in focusing on clinical rather than administrative functions, as practiced in high-performing systems like TNMSC [4].

5.5 Policy and Governance Recommendations

5.5.1 Develop an Institutional Drug Policy

Include:

- ABC-VED procurement protocols
- Emergency stocking standards for AV drugs
- Expiry management SOPs
- Procurement thresholds for each category

Align with WHO's procurement and rational drug use guidelines for better governance [1,10].

5.5.2 Annual Review of Essential Drug List (EDL)

Why:
Drug priorities evolve with new treatment guidelines and epidemiological trends.

How:

- Conduct an annual EDL audit in consultation with department heads.

- Remove outdated or duplicated drugs.
- Cross-check against WHO EML and national guidelines.

5.5.3 Promote Sustainable Procurement

Integrate eco-friendly and ethical sourcing into procurement policies:

- Prefer **WHO-GMP certified** suppliers using recyclable packaging
- Evaluate vendors for compliance with **labor and environmental standards**
- Include sustainability clauses in vendor contracts

This aligns with global trends in green hospital management and sustainable healthcare logistics .

5.6 Digital Transformation Recommendations

5.6.1 Standardize Power BI Dashboards

Develop and automate dashboards for:

- ABC-VED priority heatmaps
- Top 20 cost items by department
- Monthly and quarterly consumption trends
- Category-wise stock-out alerts

Subramanian (2022) notes that dashboards significantly improve visibility for administrators and reduce reliance on static spreadsheets [13].

5.6.2 Implement Mobile-Based Inventory Alerts

Use:
Enable mobile alerts for:

- AV stock-outs
- Expiry alerts for C and D category items
- Low stock warnings

Additional Features:

- Doctors and nurses can raise urgent drug requests via the app.
- Inventory team receives real-time stock changes.

This real-time interface reduces communication delays and is particularly effective in high-turnover environments like ICUs and emergency departments

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5.7 Budgeting and Financial Recommendations

5.7.1 Allocate Budgets Based on ABC-VED Priority

Category	Suggested Budget Allocation
AV	35–40%
AE	25–30%
AD, BV	15–20%
Others	10–15%

Ensures that the most impactful drugs receive sufficient funding without starving lower- priority needs. Supported by findings from Khandelwal (2019), who linked budget misalignment with stock-out frequency [15].

5.7.2 Monitor KPIs for Procurement Efficiency

Track the following KPIs quarterly:

- % Reduction in expired drugs
- Inventory Turnover Ratio (ITR)
- % of AV items with zero stock-outs
- Time-to-fulfillment for emergency requests

Performance tracking ensures that control measures yield measurable returns, both financially and clinically [16].

CHAPTER : 6

Conclusion

6.1 Summary of the Study

This dissertation investigated the strategic application of **ABC and VED analysis models** in hospital pharmacy inventory management, focusing on optimizing resource utilization and cost control in a tertiary care hospital—**Apex Hospitals, India**. Through real-time procurement data (January–April 2025), a total of **4,399 drug items** were analyzed using Microsoft Excel and Power BI.

The primary aim was to develop and implement an **ABC-VED matrix** that integrates both **financial value** and **clinical criticality** to guide inventory decision-making. The methodology employed a census-based, quantitative descriptive approach, supported by digital analytics.

Findings reveal a significant clustering of cost and clinical importance in a small subset of drugs, underscoring the importance of structured inventory control .

6.2 Key Findings

- **ABC Analysis** revealed that **14.8% of items (Category A)** accounted for **75.03%** of the total procurement cost, demonstrating the Pareto principle in hospital inventory systems, consistent with Mahapatra and Sahoo (2015)
- **VED Analysis** showed that over **63% of inventory items** were clinically classified as **Essential**, while **10.18%** were **Vital**, reaffirming the importance of a clinical lens in procurement planning
- The **ABC-VED Matrix** identified that **AV, AE, and BV** categories consumed more than **60%** of the total drug budget. These groups are critical for financial sustainability and patient safety and should be prioritized in procurement, as advised by WHO .

6.3 Implications for Hospital Pharmacy Management

The implementation of ABC-VED analysis has profound implications for hospital operations:

- **Resource Optimization:** Procurement budgets can be better allocated by focusing on high-impact categories such as AV and AE drugs.
- **Stock Availability:** Prioritizing vital and high-value drugs minimizes the risk of stock-outs in critical departments like ICU, Emergency, and Oncology .
- **Waste Reduction:** Monitoring D-category items helps prevent overstocking and expiry-related wastage, enhancing sustainability .

In essence, the ABC-VED framework acts as a strategic enabler, shifting hospital inventory management from a reactive to a proactive function.

6.4 Contribution to Knowledge and Practice

This dissertation contributes to both academic literature and operational best practices in healthcare management:

Academic Contribution:

- Builds on existing ABC and VED models by integrating them into a **digitally enabled**, real-time decision-support tool.
- Adds to the growing body of empirical evidence advocating for dual-criteria inventory classification in healthcare supply chains.

Practical Contribution:

- Offers a **replicable inventory management model** for mid-size and large tertiary care hospitals.
- Demonstrates the effective use of **low-cost digital tools** in settings without full ERP integration .

This dual impact aligns with the core objectives of the National Health Policy 2017, which emphasizes quality, affordability, and technology-driven improvements in healthcare delivery .

6.5 Limitations

Despite its comprehensive approach, the study has several limitations:

- **Single-center data:** Results are based on one private tertiary care hospital and may not generalize across public or rural institutions .
- **Retrospective scope:** The study used past procurement data over four months and does not include predictive modeling or seasonal fluctuations .
- **Subjective VED categorization:** While based on WHO guidelines, VED assignment involved expert judgment, which could vary across institutions .
- **Exclusion of non-pharmaceuticals:** Surgical tools, lab consumables, and diagnostic kits were not analyzed, limiting the full spectrum of hospital inventory evaluation.

Acknowledging these limitations is critical for transparent interpretation and planning future extensions of the model.

6.6 Recommendations for Future Research

To build upon this study's findings, future researchers and hospital administrators may consider the following:

1. **Multi-center studies** involving public and rural hospitals to assess replicability in diverse healthcare settings .
2. **Integration of patient outcome data** to evaluate how inventory availability impacts treatment timelines and quality of care.
3. **Longitudinal studies** across 12–24 months to incorporate seasonality, epidemic impact (e.g., dengue, COVID-19), and pricing variations .
4. **Extension of the ABC-VED model** to non-pharmaceutical items such as surgical instruments, diagnostic reagents, and disposables .

AI and Machine Learning integration for real-time forecasting and dynamic ABC-VED classification based on evolving usage patterns, as explored by Deloitte (2022) .

These directions can further strengthen inventory practices and build a robust framework for cost-effective, patient-centric hospital management.

6.7 Final Reflection

In an era where **financial constraints**, **supply chain disruptions**, and **rising disease burden** challenge health systems, scientific inventory management is not just a technical necessity—it is a moral imperative. The integration of **ABC and VED analysis**, especially when supported by **data visualization tools**, has proven in this study to be a transformative approach for tertiary care hospitals.

By prioritizing essential and high-cost drugs, training staff in inventory analytics, and institutionalizing classification systems, hospitals can improve service delivery, reduce costs, and safeguard patient care. As WHO and India's National Health Mission emphasize, **data-driven pharmaceutical governance** is the cornerstone of a responsive and resilient health system [6,7,11].

This study offers a **scalable, practical, and digitally empowered model** that can help hospitals move from passive inventory tracking to **strategic inventory optimization**, setting a new standard in healthcare supply chain management.

CHAPTER : 7

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