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A REVIEW On Inventory Control in Hospital Pharmacy: Principles, Techniques, Challenges and Strategies for Optimizing Pharmaceutical Inventory

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Abstract

Inventory control is an essential component of hospital pharmacy practice because medicines must remain continuously available while unnecessary expenditure, overstocking, expiry and wastage are minimized. Hospital pharmacies manage a wide range of pharmaceutical products that differ considerably in cost, clinical importance, rate of consumption, storage requirements and procurement lead time. Therefore, a single inventory-control method is rarely sufficient for effective management. Hospital pharmacy inventory requires a systematic approach that combines financial analysis, clinical prioritization, demand forecasting, procurement planning, storage management and regular monitoring.

The basic purpose of inventory control is to maintain the right medicine, in the right quantity, at the right place and at the right time without unnecessarily tying up hospital resources. Early work in hospital pharmacy emphasized the importance of controlling inventory levels and order quantities because poor inventory practices can substantially influence pharmacy operating costs. [1] Over time, several selective inventory-control techniques have been adopted, including ABC analysis, VED analysis, ABC-VED matrix analysis, HML analysis, FSN analysis, SDE analysis, EOQ, minimum-maximum stock systems and safety-stock approaches.

ABC analysis prioritizes medicines according to annual consumption expenditure, whereas VED analysis prioritizes medicines according to clinical criticality. Combining the two methods allows hospitals to identify medicines that are both financially significant and clinically important. [2] Recent evidence continues to demonstrate the usefulness of ABC-VED approaches in tertiary, secondary and public healthcare settings. [3] Digital inventory systems, barcode technologies, electronic procurement, automated stock monitoring and data analytics are also changing the way hospital pharmacies manage medicines.

This review discusses the principles, objectives, techniques, implementation strategies, challenges and future directions of hospital pharmacy inventory control. Particular attention is given to ABC, VED and ABC-VED analysis; procurement and storage; EOQ and minimum-maximum systems; stock-outs and wastage; digital

technologies; supply-chain performance; forecasting; quality assurance; and the role of pharmacists. A practical framework for developing an effective hospital pharmacy inventory-control system is also proposed.

Keywords: Hospital pharmacy, inventory control, pharmaceutical inventory, ABC analysis, VED analysis, ABC-VED matrix, EOQ, stock management, drug procurement, pharmacy supply chain.

INTRODUCTION

Medicines are among the most important resources managed by a hospital. Unlike many other commodities, pharmaceutical products directly influence diagnosis, treatment, emergency response and continuity of patient care. A medicine that is unavailable when required may delay therapy, whereas excessive purchasing can result in unnecessary expenditure, accumulation of stock and expiry. Consequently, hospital pharmacy inventory management must maintain a careful balance between availability and economy.

Hospital pharmacy inventory control refers to the systematic planning, procurement, receipt, storage, distribution and monitoring of medicines and related pharmaceutical products. The objective is not simply to keep large quantities of medicines in the store. Instead, inventory should be maintained at an appropriate level based on consumption, clinical importance, lead time, budgetary limitations, storage capacity and anticipated demand.

The economic importance of pharmacy inventory was recognized decades ago. Noel emphasized that hospital pharmacy inventory management could influence operating costs and that appropriate control of inventory levels and order quantities could provide financial advantages. [1] This principle remains relevant because medicines represent a recurring expenditure for hospitals, and ineffective inventory practices can unnecessarily consume financial resources.

Hospital inventories are also different from conventional commercial inventories. A commercial organization may primarily focus on reducing holding costs or maximizing profitability. A hospital must simultaneously consider patient safety and clinical necessity. A relatively inexpensive medicine may be medically indispensable, while a very expensive medicine may have limited demand. Therefore, inventory decisions must consider both economic and clinical dimensions.

ABC analysis addresses the economic dimension by grouping medicines according to annual consumption value. VED analysis addresses the clinical dimension by classifying items as vital, essential or desirable according to their importance to patient care. [4] When these approaches are combined, hospital pharmacists can prioritize items requiring strict monitoring.

Indian hospital studies have repeatedly demonstrated that a relatively small proportion of medicines may consume a substantial proportion of the pharmacy budget. [2] Consequently, inventory control should focus managerial attention on medicines that have the greatest financial or clinical consequences rather than applying identical monitoring intensity to every item.

Modern hospital pharmacy practice has expanded beyond manual stock registers. Electronic inventory systems, barcode scanning, automated alerts, electronic purchasing and data-driven forecasting are increasingly being used to improve visibility of stock levels and reduce preventable errors. [15] However, technology alone cannot solve inventory problems. Accurate data, trained personnel, appropriate policies and regular supervision remain essential.

OBJECTIVES OF INVENTORY CONTROL

The major objectives of hospital pharmacy inventory control are:

1. To ensure uninterrupted availability of essential and life-saving medicines.
2. To minimize unnecessary investment in pharmaceutical stock.
3. To reduce stock-outs and emergency purchases.
4. To prevent overstocking and excessive inventory holding.
5. To minimize expiry, deterioration and wastage.
6. To maintain appropriate safety-stock levels.
7. To improve purchasing efficiency.
8. To support rational allocation of the pharmacy budget.
9. To improve accountability and record accuracy.
10. To support patient safety.
11. To ensure appropriate storage and stock rotation.
12. To provide reliable information for procurement and forecasting.
13. To identify medicines requiring strict managerial control.
14. To improve coordination between pharmacy, clinical departments, procurement and finance.

Effective inventory management should therefore be considered a continuous management process rather than a one-time classification exercise.

IMPORTANCE OF INVENTORY CONTROL IN HOSPITAL PHARMACY

The importance of pharmaceutical inventory control can be understood from both clinical and economic perspectives.

Ensuring medicine availability

A hospital cannot provide uninterrupted treatment if essential medicines are repeatedly unavailable. Inventory control helps identify medicines that require high levels of monitoring and ensures that appropriate quantities are maintained.

Studies applying ABC-VED methods have shown that medicines can be categorized according to both expenditure and clinical criticality, allowing managers to concentrate their attention on the most important categories. [3]

Controlling expenditure

Medicines can account for a substantial proportion of hospital expenditure. ABC analysis helps identify medicines responsible for the largest proportion of annual consumption expenditure.

The traditional ABC principle generally identifies approximately 10% of items as high-value A items, around 20% as B items and the remaining larger proportion as C items, although actual percentages vary between hospitals. [4]

Reducing wastage

Overstocking increases the possibility of expiry, damage and obsolescence. Understocking, on the other hand, may result in emergency procurement and treatment interruptions.

The balance between these two problems is one of the central challenges of inventory management.

Improving patient safety

Inventory management is directly connected with patient safety because unavailable medicines, expired products, damaged products or inappropriate storage conditions can compromise treatment.

Therefore, pharmacy inventory control should never be considered purely an accounting activity.

CHARACTERISTICS OF HOSPITAL PHARMACEUTICAL INVENTORY

Hospital pharmaceutical inventory has several unique characteristics.

High clinical variability

Demand may change according to disease patterns, seasonal infections, emergency admissions, outbreaks and changes in prescribing practices.

Different levels of criticality

Some medicines are life-saving and must remain continuously available. Others may be useful but can be substituted or temporarily omitted.

Different financial values

Some low-volume medicines may have extremely high unit costs, whereas frequently used medicines may have relatively low individual prices.

Expiry and shelf-life concerns

Medicines are generally perishable products with finite shelf lives. Improper purchasing can therefore create significant wastage.

Storage requirements

Certain medicines require controlled temperature, humidity, protection from light or restricted access.

Variable supplier lead times

Procurement time can vary according to supplier availability, tender procedures, manufacturing conditions and transportation.

Regulatory requirements

Pharmaceutical products must comply with applicable quality and regulatory standards.

The Indian Pharmacopoeia provides official standards for the identity, purity and quality of medicines included within its scope and is therefore relevant to pharmaceutical quality management in India. [21]

INVENTORY MANAGEMENT CYCLE

Hospital pharmacy inventory management can be viewed as a continuous cycle:

Selection → Quantification → Procurement → Receipt → Inspection → Storage → Distribution → Consumption → Stock recording → Monitoring → Evaluation → Reordering

Each stage influences the next.

For example, inaccurate consumption data may lead to incorrect forecasting. Incorrect forecasting may lead to over-ordering or under-ordering. Poor storage may subsequently produce product deterioration despite appropriate purchasing.

The inventory system should therefore be evaluated as an integrated process rather than by examining procurement or storage separate

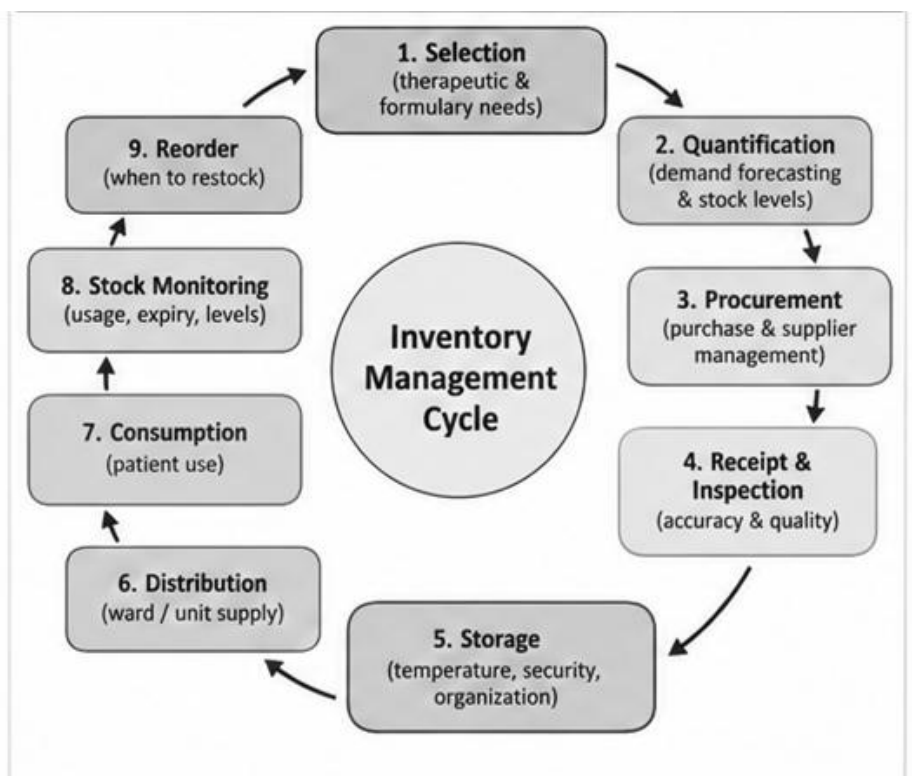


Figure 01: Inventory Management Cycle in Hospital Pharmacy

ABC ANALYSIS

ABC analysis is one of the most widely used selective inventory-control techniques.

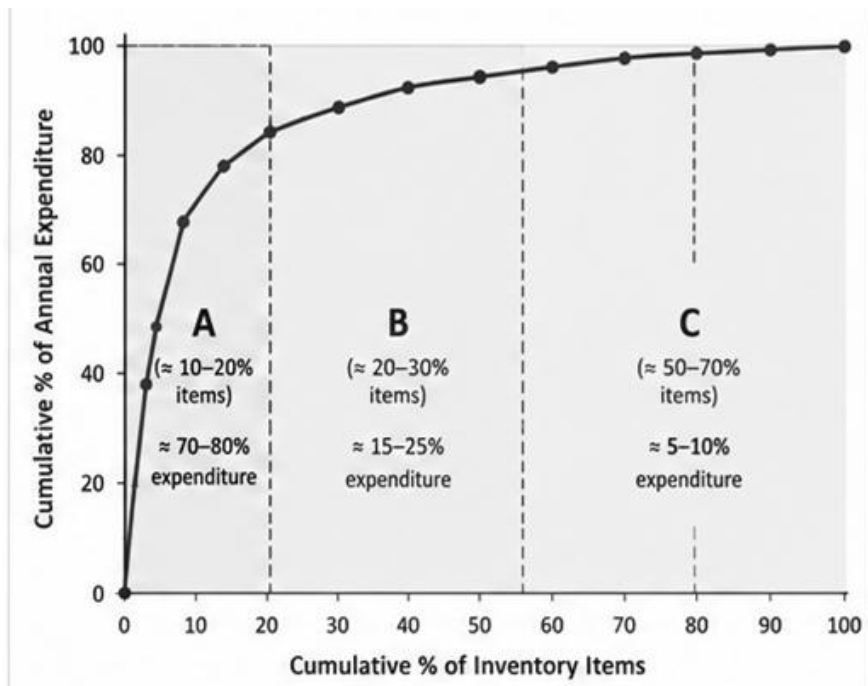


Figure 02: ABC Analysis of Pharmaceutical Inventory Based on Annual Consumption Expenditure

Formula

Annual Consumption Value = Annual Quantity Consumed × Unit Cost

After calculating the annual consumption value of each medicine, items are arranged in descending order. The cumulative expenditure is then calculated.

General classification

Category	General proportion of items	General proportion of expenditure
A	Small proportion	Large proportion
B	Moderate proportion	Moderate expenditure
C	Large proportion	Small expenditure

The exact percentages should not be treated as universal rules because actual distributions depend on the hospital.

Studies in Indian hospitals have demonstrated that A-category medicines may account for approximately 70% of annual drug expenditure despite representing a much smaller proportion of total items. [2]

Another Indian hospital study similarly demonstrated the concentration of expenditure within A-category medicines, supporting the usefulness of ABC analysis for identifying high-value items requiring closer supervision. [5]

ADVANTAGES OF ABC ANALYSIS

- Easy to understand.

- Relatively simple to calculate.
- Helps prioritize managerial attention.
- Supports budget control.
- Useful for identifying expensive medicines.
- Can be combined with other inventory methods.

LIMITATIONS

ABC analysis considers monetary value but does not independently consider clinical importance. A low-cost life-saving medicine could be categorized as C even though its absence could have serious consequences.

This is the major reason why ABC analysis should not be used as the sole inventory-control method in hospitals.

VED ANALYSIS

VED analysis classifies medicines according to clinical criticality.

V – Vital

Vital medicines are those whose absence may seriously threaten life or significantly compromise patient care.

Examples may include selected emergency medicines, antidotes and medicines required for critical conditions.

E – Essential

Essential medicines are necessary for routine treatment of common or important diseases. Their temporary absence may be manageable in some circumstances, but prolonged unavailability can disrupt patient care.

D – Desirable

Desirable medicines are useful but generally have lower clinical criticality and may have acceptable alternatives.

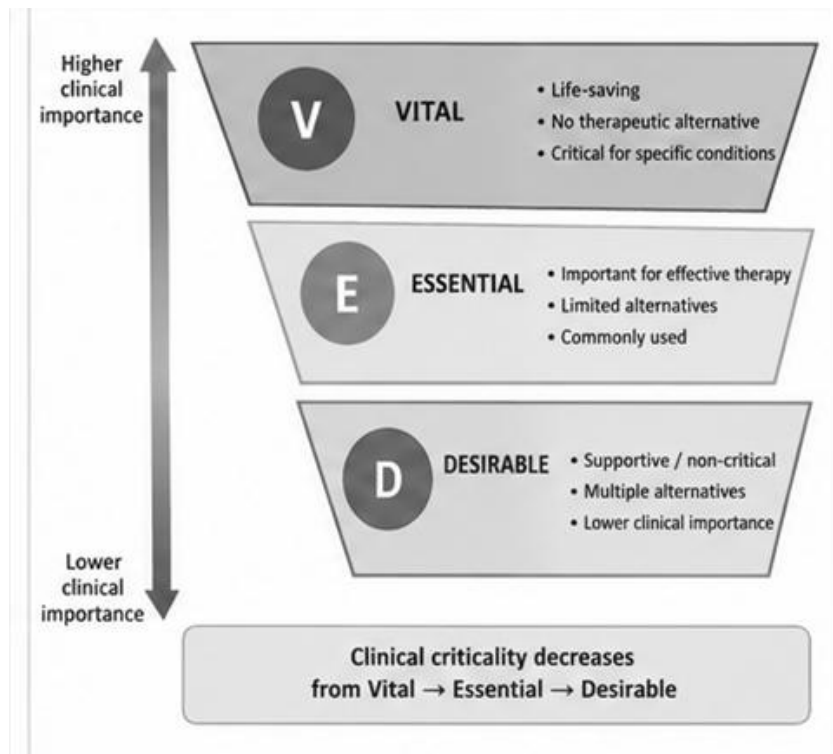


Figure 03: VED Classification of Medicines According to Clinical Criticality

VED analysis is therefore fundamentally different from ABC analysis.

ABC asks: "How much money is spent?"

VED asks: "How clinically important is the medicine?"

ABC-VED MATRIX ANALYSIS

ABC-VED analysis combines financial importance with clinical criticality.

This approach produces nine possible combinations:

VED Classification (Clinical Criticality)			
ABC Classification (Consumption Value)	Vital (V)	Essential (E)	Desirable (D)
A (High value) ≈ 10–20% items	AV	AE	AD
B (Medium value) ≈ 20–30% items	BV	BE	BD
C (Low value) ≈ 50–70% items	CV	CE	CD

Figure 04: ABC-VED Matrix for Pharmaceutical Inventory Prioritization

These combinations are usually consolidated into broader management categories.

Category I

Usually includes the most important combinations such as AV, AE, BV and CV.

Category II

Includes intermediate-priority combinations.

Category III

Generally, includes lower-cost and lower-criticality items.

The exact grouping may vary according to institutional policy.

The value of the matrix is that it prevents the hospital from making decisions based solely on cost. A low-cost but vital medicine can receive a higher priority than its ABC classification alone would suggest.

Research from secondary-level hospitals has shown that ABC-VED can allow closer supervision of a relatively small group of medicines while maintaining availability of clinically important items. [6]

Recent Indian studies continue to support the use of ABC-VED for prioritizing medicines and improving inventory control. [14]

Another recent tertiary-care study reported that integrating expenditure and criticality helped identify high-priority medicines requiring closer monitoring. [17]

ABC-VED-FNS AND OTHER COMBINED APPROACHES

ABC-VED analysis can be extended by adding other characteristics.

ABC-VED-FNS incorporates financial value, criticality and movement characteristics.

FNS refers broadly to:

- Fast-moving
- Non-moving
- Slow-moving

Combining multiple dimensions can provide a more detailed understanding of inventory behaviour.

A cross-sectional study examining ABC-VED-FNS analysis demonstrated how information from combined matrices can support operational decision-making in pharmaceutical inventory management. [7]

Such approaches are particularly useful when a hospital faces both overstocking and stock-out problems because they can identify medicines that are expensive, critical and slow-moving.

HML ANALYSIS

HML classifies items according to unit cost:

- **H – High cost**
- **M – Medium cost**
- **L – Low cost**

Unlike ABC analysis, which uses annual consumption expenditure, HML focuses on the unit price of an item.

HML can be useful for identifying high-unit-cost medicines that may require:

- Restricted access.
- Additional authorization.
- Stronger storage controls.
- Individual monitoring.
- Frequent reconciliation.

For example, a medicine with a high unit price but very low annual consumption might not become an A item in ABC analysis but could still deserve special attention through HML analysis.

FSN ANALYSIS

FSN classification considers the rate of movement of medicines.

Fast-moving

Frequently issued medicines.

Slow-moving

Medicines with relatively low consumption.

Non-moving

Medicines that have not been issued or consumed for a defined period.

FSN analysis is especially useful for identifying stock that has remained in the pharmacy for long periods.

Non-moving medicines should be reviewed to determine whether they should be:

- Transferred to another department.
- Returned to the supplier where possible.
- Included in a revised formulary.
- Used before expiry.
- Reduced in future procurement.

SDE ANALYSIS

SDE classification considers procurement difficulty:

- **S – Scarce**
- **D – Difficult**
- **E – Easy**

This method can help identify medicines for which procurement is difficult because of limited suppliers, manufacturing problems, regulatory restrictions or geographical constraints.

SDE analysis becomes particularly useful when procurement lead time is long or uncertain.

ECONOMIC ORDER QUANTITY

Economic Order Quantity, or EOQ, attempts to determine an order quantity that balances ordering and holding costs.

The traditional formula is:

$$EOQ = \sqrt{(2DS/H)}$$

Where:

- **D** = annual demand
- **S** = ordering cost per order
- **H** = annual holding cost per unit

The traditional EOQ model assumes relatively stable demand and other simplified conditions. Hospital pharmacies may not always meet these assumptions because medicine demand can be unpredictable.

Nevertheless, EOQ can provide a useful starting point for purchasing decisions.

Research examining drug supply management has demonstrated the practical relevance of EOQ together with minimum–maximum stock systems for improving cost-efficient supply. [8]

MINIMUM-MAXIMUM STOCK SYSTEM

In a minimum–maximum system, a minimum stock level and maximum stock level are established for each medicine.

When stock reaches or approaches the minimum level, replenishment is initiated.

The maximum level represents the upper amount that should normally be maintained after replenishment.

This approach is particularly useful when:

- Consumption is relatively predictable.
- Procurement lead time is known.
- Storage capacity is limited.
- Standardized ordering procedures are required.

The minimum–maximum method should be periodically reviewed because demand patterns and lead times can change.

REORDER LEVEL

The reorder level is the stock level at which a new order should be placed.

A simplified concept is:

Reorder Level = Expected Lead-Time Demand + Safety Stock

For example, if a hospital consumes 100 units per week and supplier lead time is two weeks, the expected lead-time demand would be approximately 200 units. A safety stock could then be added according to the variability of demand and supply.

The actual formula should be adapted to the hospital's demand pattern and service requirements.

SAFETY STOCK AND BUFFER STOCK

Safety stock is maintained to protect against uncertainty.

Uncertainty may result from:

- Unexpected increases in demand.
- Supplier delays.
- Transportation interruptions.
- Seasonal variation.
- Emergency admissions.
- Changes in prescribing patterns.

However, safety stock should not become an excuse for uncontrolled overstocking.

Recent work on buffer-stock management has emphasized segmentation as a method for reducing unnecessary buffer levels while maintaining availability. [9]

The ideal safety-stock level therefore represents a balance between service reliability and inventory cost.

PROCUREMENT MANAGEMENT

Procurement is one of the most important stages in the inventory cycle.

Good procurement requires:

1. Correct medicine selection.
2. Accurate quantification.
3. Appropriate supplier selection.
4. Quality assurance.
5. Competitive pricing.
6. Appropriate delivery schedules.
7. Reliable documentation.
8. Monitoring of supplier performance.

WHO's operational principles for good pharmaceutical procurement emphasize systematic procurement practices covering management, selection and quantification, financing and competition, supplier selection and quality assurance. [10]

Procurement should therefore be based on reliable consumption information rather than intuition alone.

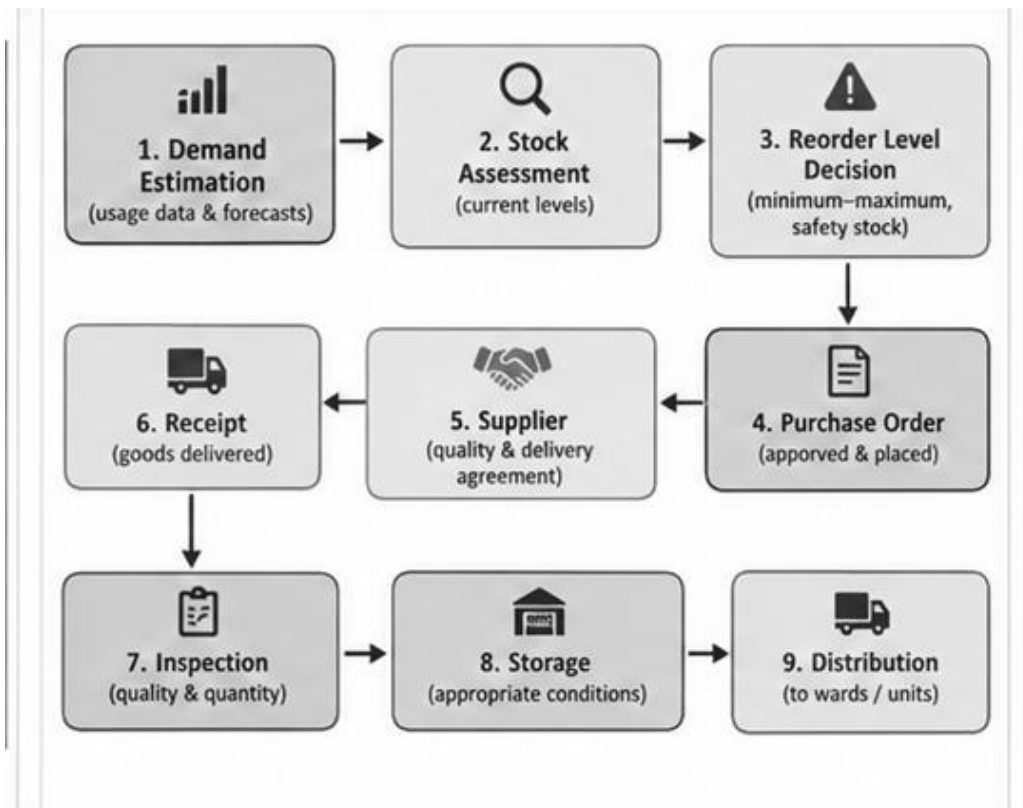


Figure 05: Pharmaceutical Procurement and Replenishment Process

Procurement should consider:

- Historical consumption.
- Current stock.
- Pending orders.
- Lead time.
- Seasonal demand.
- Disease patterns.
- Formulary changes.
- Budget.
- Expiry dates.
- Supplier reliability.

QUANTIFICATION OF MEDICINES

Quantification estimates the quantity of medicines required during a particular period.

Two common approaches are:

Consumption-based quantification

Uses historical consumption data.

Morbidity-based quantification

Uses expected disease burden and standard treatment requirements.

A combination may be appropriate when historical data are incomplete or when major changes in service utilization are expected.

Accurate quantification prevents both shortages and excessive procurement.

ROLE OF DRUG AND THERAPEUTIC COMMITTEE

The Drug and Therapeutics Committee plays an important role in medicine selection, formulary management and rational medicine use.

The committee may include physicians, pharmacists, nurses, administrators and other relevant professionals.

Its responsibilities can include:

- Formulary development.
- Medicine selection.
- Evaluation of new medicines.
- Development of prescribing policies.
- Monitoring medicine utilization.
- Supporting medication safety.
- Reviewing adverse drug reactions.
- Promoting rational use.

A nationwide survey of hospital Drug and Therapeutics Committees demonstrated their involvement in drug selection and prescribing-related policies, with pharmacists represented within these structures. [13]

For inventory management, formulary decisions are important because unnecessary duplication of medicines can increase stock complexity and expenditure.

ESSENTIAL MEDICINES AND INVENTORY PLANNING

Essential medicines should receive appropriate priority because they address major healthcare needs.

The WHO Model List of Essential Medicines is intended to guide countries and health systems in selecting medicines according to disease burden, evidence of efficacy and safety, and comparative cost-effectiveness. [20]

Essential medicines should be available in appropriate dosage forms, of assured quality and in sufficient quantities.

Inventory planning should therefore integrate the hospital formulary with relevant essential-medicine policies.

STORAGE OF PHARMACEUTICAL PRODUCTS

Proper storage is essential for maintaining pharmaceutical quality.

Storage conditions should consider:

- Temperature.
- Humidity.
- Light.
- Cleanliness.
- Ventilation.
- Security.
- Pest control.
- Segregation.
- Expiry dates.
- Product integrity.

WHO guidance on good storage practices emphasizes appropriate storage conditions and organizational controls intended to preserve pharmaceutical quality during storage. [11]

Medicines should be stored according to their specific requirements rather than according to convenience.

STOCK ROTATION

Stock rotation prevents older stock from remaining unused while newer stock is issued.

Two important principles are:

FIFO

First In, First Out

The product received first is issued first.

FEFO

First Expiry, First Out

The product with the earliest expiry date is issued first.

For pharmaceutical products, FEFO is generally particularly useful because expiry dates may differ even between batches received at different times.

Regular physical inspection is necessary to identify products approaching expiry.

EXPIRY AND WASTAGE MANAGEMENT

Medicine wastage can occur due to:

- Overstocking.
- Poor forecasting.
- Low demand.
- Changes in treatment guidelines.
- Product discontinuation.
- Damaged packaging.
- Improper storage.
- Short remaining shelf life at receipt.

A pharmacy should maintain an expiry-monitoring system.

Medicines approaching expiry can be identified through:

- Monthly expiry reports.
- Electronic alerts.
- Physical shelf checks.
- Near-expiry labels.
- Departmental redistribution.

The goal should not simply be to dispose of expired medicines but to identify why the medicines became excess stock in the first place.

STOCK-OUT MANAGEMENT

A stock-out occurs when a required medicine is unavailable.

Potential causes include:

- Inaccurate forecasting.
- Delayed procurement.
- Supplier failure.
- Unexpected demand.
- Inadequate safety stock.
- Poor stock records.
- Budget constraints.

- Distribution problems.

Stock-outs should be recorded and analysed rather than treated as isolated events.

For each stock-out, the pharmacy should ask:

1. Was the medicine forecast correctly?
2. Was the reorder point appropriate?
3. Was the purchase order placed on time?
4. Did the supplier deliver on time?
5. Was stock available elsewhere in the hospital?
6. Was the stock record accurate?
7. Was there unexpected demand?

INVENTORY RECORDS

Accurate records are essential for inventory control.

Records may include:

- Stock registers.
- Bin cards.
- Goods-received notes.
- Issue vouchers.
- Purchase orders.
- Expiry records.
- Batch records.
- Electronic transaction histories.
- Stock-adjustment records.

Every receipt and issue should be recorded promptly.

The difference between physical stock and recorded stock can be caused by:

- Data-entry errors.
- Unrecorded issues.
- Damaged products.
- Expiry.
- Theft or pilferage.

- Incorrect counting.
- Duplicate entries.

Regular reconciliation helps identify these problems.

INVENTORY AUDITING

Inventory auditing compares records with physical stock.

Audits may be:

- Periodic.
- Monthly.
- Quarterly.
- Annual.
- Cycle-count based.

High-value or high-criticality medicines should generally receive more frequent monitoring.

A hospital pharmacy should also investigate repeated discrepancies rather than simply correcting the numerical difference.

INVENTORY TURNOVER

Inventory turnover measures how frequently inventory is consumed or replaced during a specified period.

A simplified formula is:

Inventory Turnover = Annual Consumption Value / Average Inventory Value

Higher turnover may indicate efficient use of stock, but extremely high turnover may also indicate insufficient safety stock.

Conversely, low turnover may indicate overstocking, low demand or poor formulary management.

Therefore, inventory turnover should always be interpreted together with stock-out and expiry indicators.

COST CONTAINMENT

Cost containment does not mean simply purchasing the cheapest product.

A medicine with a low acquisition price may create higher costs if:

- It has poor quality.
- It has unreliable supply.
- It expires quickly.
- It requires special storage.
- It causes repeated emergency procurement.

Similarly, purchasing large quantities solely to obtain a lower unit price may be inappropriate if the medicine has low demand.

Economic evaluation should therefore consider total inventory cost.

Historical hospital studies have demonstrated the usefulness of economic analysis for identifying groups of medicines requiring stringent management and expenditure monitoring. [27]

HOSPITAL INTERNAL SUPPLY CHAIN

The pharmacy is part of a larger hospital supply chain.

The internal chain may include:

Supplier → Central Store → Pharmacy → Ward/Department → Patient

Delays or errors at any stage can affect medicine availability.

Hospital supply-chain performance therefore depends on coordination between procurement, stores, pharmacy, clinical departments, finance and administration.

A literature review of internal hospital supply chains emphasized the importance of performance measurement for identifying inefficiencies and controlling supply-chain costs. [16]

Inventory control should therefore not be treated as the responsibility of the pharmacy alone.

DIGITAL INVENTORY MANAGEMENT

Digital technologies are increasingly being incorporated into hospital pharmacy.

Examples include:

- Pharmacy information systems.
- Electronic inventory systems.
- Barcode scanning.
- Automated dispensing systems.
- RFID.
- Electronic procurement.
- Cloud-based dashboards.
- Automated expiry alerts.
- Electronic stock reconciliation.

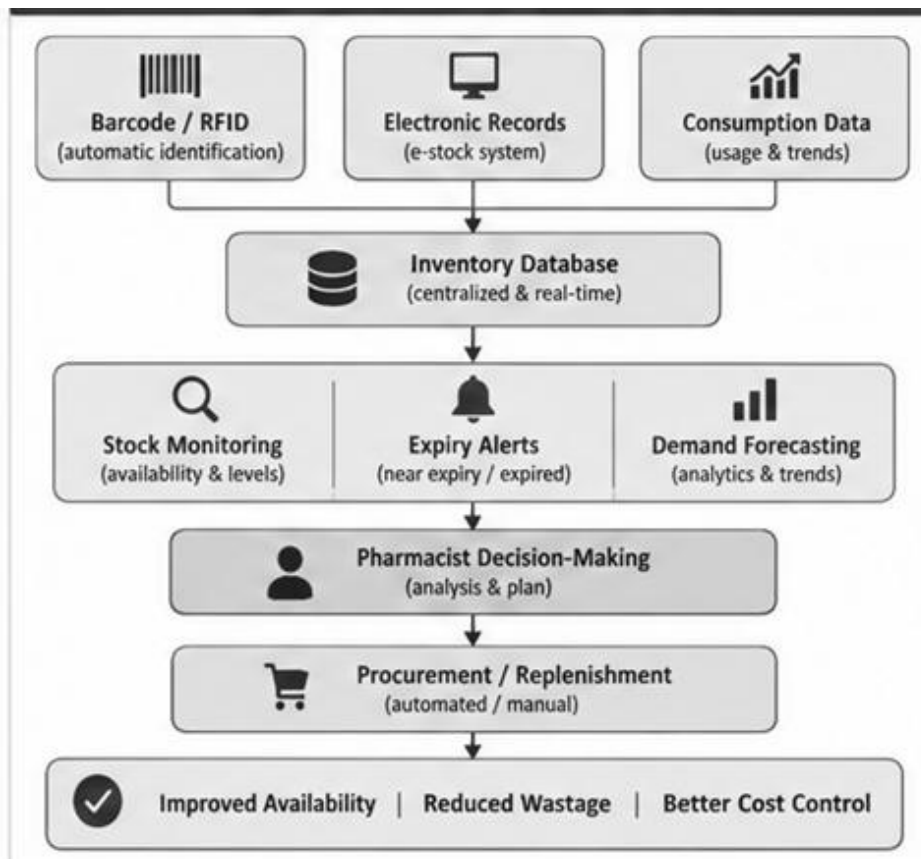


Figure 06: Integrated Digital Inventory-Control Framework for Hospital Pharmacy

A recent systematic review of digital technologies in hospital pharmacy reported their relevance to efficiency, safety and inventory management. [15]

Digital systems can provide real-time or near-real-time information about:

- Current stock.
- Consumption.
- Pending orders.
- Expiry.
- Supplier performance.
- High-value medicines.
- Stock-out risk.

However, digitalization is effective only when data are accurate and staff are trained to use the system.

BARCODE AND RFID TECHNOLOGIES

Barcode systems can reduce manual data-entry requirements.

A barcode can be scanned during:

- Receipt.
- Storage.
- Dispensing.
- Issue.
- Return.
- Stock verification.

RFID can provide automated identification of tagged items and may improve tracking in large inventories.

The principal advantages include:

- Improved traceability.
- Faster transactions.
- Reduced manual entry.
- Better stock visibility.
- Improved reconciliation.

Implementation cost, infrastructure requirements and staff training must nevertheless be considered.

DATA ANALYTICS AND FORECASTING

Inventory systems generate valuable data.

Data can be analysed to identify:

- Seasonal consumption.
- Fast-moving medicines.
- Slow-moving medicines.
- Non-moving stock.
- High expenditure.
- Frequent stock-outs.
- Expiry patterns.
- Supplier delays.

Forecasting can use historical consumption and other variables to estimate future demand.

Healthcare inventory modelling literature has emphasized the need to account for the special characteristics and uncertainties of healthcare demand when designing inventory models. [29]

Forecasting should therefore be treated as a decision-support process rather than a perfectly accurate prediction.

ABC-XYZ ANALYSIS

ABC-XYZ analysis combines financial importance with demand variability.

ABC considers expenditure.

XYZ considers demand predictability or variability.

For example:

- **AX:** high-value and relatively predictable demand.
- **AZ:** high-value but highly variable demand.
- **CX:** low-value and predictable demand.
- **CZ:** low-value and unpredictable demand.

Recent evidence from a public tertiary cancer hospital in India has demonstrated the application of ABC-XYZ analysis to drug availability and wastage management. [12]

This method can be particularly useful for high-cost medicines whose demand is difficult to predict.

MULTI-CRITERIA INVENTORY ANALYSIS

Traditional ABC analysis uses expenditure as its principal criterion. However, hospital inventory decisions may depend on multiple factors.

Potential criteria include:

- Cost.
- Clinical criticality.
- Consumption.
- Lead time.
- Supplier reliability.
- Shelf life.
- Storage requirements.
- Substitutability.
- Disease burden.

Recent research has examined the integration of ABC-VED with multi-criteria analysis to improve drug inventory prioritization. [19]

Multi-criteria methods may be particularly useful in complex hospital systems where no single parameter adequately represents inventory importance.

INVENTORY CONTROL IN RESOURCE-LIMITED SETTINGS

Resource limitations make efficient inventory management even more important.

Hospitals with limited budgets may experience:

- Procurement delays.
- Limited storage capacity.
- Manual records.
- Staff shortages.
- Supplier dependency.
- Inadequate forecasting.

A study of a secondary-level hospital in North India demonstrated that ABC-VED could be applied to prioritize inventory management even outside large tertiary-care institutions. [6]

The lesson is that inventory control does not necessarily require sophisticated software. Basic classification, accurate records and disciplined review can produce meaningful improvements.

INVENTORY PROBLEMS IN NEWLY ESTABLISHED HOSPITALS

New hospitals may face special inventory challenges because historical consumption data are limited.

Potential problems include:

- Uncertain demand.
- Incomplete formulary development.
- Rapid changes in service capacity.
- Inexperienced procurement teams.
- Inadequate stock-control procedures.
- Excessive initial procurement.

A study of a recently established national institute in Eastern India highlighted the importance of identifying medicines requiring stringent control and addressing pharmacy inventory-management problems during institutional development. [22]

New hospitals should therefore establish inventory policies at an early stage rather than waiting for major stock problems to occur.

INVENTORY MANAGEMENT IN PUBLIC HEALTH FACILITIES

Public-sector facilities often operate under procurement rules, budgetary constraints and centralized purchasing systems.

A study from West Arsi Zone evaluated pharmaceutical inventory management using approaches including ABC-VEN and FSN-XYZ analysis, illustrating how multiple inventory techniques can be used to assess pharmaceutical availability and management performance. [23]

Another analysis using ABC–VEN demonstrated the usefulness of combining financial and criticality dimensions for pharmaceutical inventory prioritization. [24]

These studies reinforce the principle that inventory management should combine quantitative and qualitative information.

RECENT EVIDENCE FROM INDIAN HOSPITALS

Recent Indian research continues to demonstrate the relevance of ABC–VED.

A study conducted in public health facilities in Puducherry used ABC–VED analysis to identify medicines requiring different levels of inventory control. [14]

A recent tertiary-care study from Gondia also demonstrated that ABC–VED could identify high-expenditure and high-criticality groups requiring stringent management. [18]

A study in North Maharashtra similarly reported the usefulness of ABC, VED and ABC–VED approaches for evaluating annual drug expenditure and prioritizing inventory. [25]

Another recent study from Jharkhand identified high-value and clinically important medicines as requiring continuous attention and highlighted the importance of strengthening digital stock management and proactive procurement. [17]

Together, these findings suggest that ABC–VED remains relevant even as hospital inventory systems become increasingly digital.

ABC–VED VERSUS SINGLE INVENTORY METHODS

No inventory method is universally sufficient.

Method	Primary basis	Major purpose
ABC	Annual expenditure	Financial control
VED	Clinical criticality	Patient-care priority
HML	Unit cost	High-cost item monitoring
FSN	Movement	Identify slow/non-moving stock
SDE	Procurement difficulty	Supply-risk management
EOQ	Order economics	Optimize order quantity
Minimum–Maximum	Stock level	Replenishment control
ABC–VED	Cost + criticality	Integrated prioritization
ABC–XYZ	Cost + variability	Demand-based prioritization

ABC–VED is particularly valuable because it integrates two important hospital priorities: money and clinical importance.

PRACTICAL INVENTORY-CONTROL FRAMEWORK

A practical hospital pharmacy inventory-control system can be organized into the following stages:

Step 1: Establish the formulary

Define medicines that the hospital routinely requires.

Step 2: Collect consumption data

Use reliable historical records.

Step 3: Calculate annual consumption value

Apply ABC analysis.

Step 4: Determine clinical criticality

Classify medicines using VED.

Step 5: Develop ABC–VED matrix

Identify high-priority categories.

Step 6: Establish minimum and maximum levels

Set replenishment parameters.

Step 7: Determine safety stock

Consider demand and supply variability.

Step 8: Establish reorder levels

Incorporate lead time.

Step 9: Develop procurement schedules

Use consumption and stock data.

Step 10: Apply FEFO

Prioritize medicines approaching expiry.

Step 11: Conduct regular physical verification

Compare physical and recorded stock.

Step 12: Monitor key performance indicators

Track stock-outs, expiry, inventory turnover and record accuracy.

Step 13: Review the system

Modify stock levels according to changing demand.

KEY PERFORMANCE INDICATORS

Hospital pharmacies can use several indicators to evaluate inventory performance.

Stock-out rate

Measures how often required medicines become unavailable.

Inventory accuracy

Measures agreement between physical stock and recorded stock.

Expiry rate

Measures the proportion or value of stock lost because of expiry.

Near-expiry stock

Identifies medicines approaching expiry.

Emergency purchase rate

Indicates how frequently medicines must be procured urgently.

Supplier delivery performance

Measures the proportion of orders delivered on time.

Inventory turnover

Assesses the rate at which stock is consumed.

Carrying cost

Estimates the cost associated with holding inventory.

Order fulfilment rate

Measures how successfully required quantities are supplied.

Performance measurement is important because a hospital cannot determine whether its inventory policy is effective without measurable indicators. [16]

HUMAN FACTORS IN INVENTORY MANAGEMENT

Even the most advanced inventory system depends on people.

Common human factors include:

- Inadequate training.
- Poor communication.
- Incorrect data entry.
- Failure to record issues.
- Failure to inspect stock.
- Ignoring expiry alerts.
- Inadequate handover.
- Poor adherence to SOPs.

Staff should therefore receive regular training in:

- Inventory classification.
- Stock documentation.
- FEFO.
- Storage requirements.

- Expiry management.
- Reconciliation.
- Procurement procedures.
- Electronic inventory systems.

Training should be practical and periodically evaluated.

PHARMACIST'S ROLE IN INVENTORY CONTROL

The pharmacist plays a central role in pharmaceutical inventory management.

Responsibilities may include:

1. Forecasting medicine requirements.
2. Participating in procurement.
3. Reviewing supplier performance.
4. Maintaining stock records.
5. Conducting physical verification.
6. Monitoring expiry.
7. Ensuring appropriate storage.
8. Implementing FEFO.
9. Performing ABC-VED analysis.
10. Monitoring stock-outs.
11. Coordinating with clinical departments.
12. Supporting formulary management.
13. Monitoring high-value medicines.
14. Supporting medication safety.
15. Training pharmacy personnel.

Pharmacists should therefore be involved not only in dispensing but also in strategic inventory decisions.

QUALITY ASSURANCE AND PHARMACEUTICAL STANDARDS

Inventory control must always be linked with product quality.

A low-cost product is not useful if its quality is uncertain.

Quality assurance should include:

- Approved suppliers.
- Receipt inspection.

- Batch verification.
- Expiry verification.
- Appropriate storage.
- Temperature monitoring.
- Documentation.
- Quarantine of questionable products.
- Appropriate disposal.

The Indian Pharmacopoeia serves as an important reference for pharmaceutical standards in India. [21]

Thus, inventory control should be designed to protect both availability and quality.

SUPPLY-CHAIN RISK MANAGEMENT

Pharmaceutical supply chains are vulnerable to disruption.

Potential risks include:

- Supplier failure.
- Manufacturing shortages.
- Transportation disruption.
- Regulatory changes.
- Natural disasters.
- Epidemics.
- Sudden demand increases.
- Financial constraints.

Hospitals can reduce vulnerability by:

- Identifying critical medicines.
- Maintaining appropriate safety stock.
- Monitoring supplier performance.
- Developing alternative suppliers where appropriate.
- Establishing emergency procurement procedures.
- Reviewing high-risk products regularly.

A recent Asia-Pacific systematic review identified continuing variability in inventory practices and persistent medicine-shortage challenges across healthcare systems. [30]

EMERGENCY AND DISASTER INVENTORY

Emergency medicines require special inventory policies.

Examples include medicines used for:

- Resuscitation.
- Trauma.
- Poisoning.
- Anaphylaxis.
- Severe infections.
- Major bleeding.
- Critical care.

Emergency stocks should be:

- Clearly identified.
- Easily accessible.
- Regularly checked.
- Protected from unauthorized use.
- Replenished immediately after use.
- Monitored for expiry.

Emergency stock should not be excluded from routine inventory audits.

FINANCIAL AND CLINICAL MANAGEMENT

The fundamental challenge in hospital inventory management is balancing cost with patient care.

If inventory is too low:

Stock-outs → Treatment interruption → Emergency procurement → Increased operational pressure

If inventory is too high:

Overstocking → Capital tied up → Expiry → Wastage → Increased cost

The optimum system therefore aims for an appropriate inventory level rather than the lowest possible inventory.

Healthcare inventory modelling research similarly emphasizes the need to balance inventory-related cost with service-level requirements. [29]

INVENTORY CONTROL POLICY

Every hospital pharmacy should have a written inventory-control policy.

The policy should define:

- Inventory classification methods.
- Procurement responsibilities.
- Stock-level determination.
- Reorder points.
- Safety-stock principles.
- FEFO.
- Storage requirements.
- Stock verification.
- Expiry monitoring.
- Stock-out reporting.
- Emergency procurement.
- Disposal.
- Documentation.
- Key performance indicators.
- Review frequency.

The policy should be periodically reviewed because hospital demand and supply conditions change.

ROLE OF STANDARDIZED SUPPLY-CHAIN SYSTEMS

A structured pharmaceutical management system should integrate:

Selection → Quantification → Procurement → Storage → Distribution → Use → Monitoring

Management Sciences for Health's MDS-3 provides a comprehensive framework for managing access to medicines and health technologies, including pharmaceutical supply-chain and management considerations. [28]

Such frameworks demonstrate that inventory control should be considered part of the larger medicines-management system.

SUSTAINABILITY IN HOSPITAL INVENTORY

Inventory management also has an environmental dimension.

Excessive purchasing may produce:

- Expired medicines.
- Packaging waste.
- Disposal requirements.
- Unnecessary transportation.

Sustainable inventory management can reduce waste through:

- Better forecasting.
- Smaller but appropriate order quantities.
- FEFO.
- Redistribution.
- Return mechanisms.
- Digital monitoring.
- Appropriate disposal.

Economic efficiency and environmental sustainability can therefore reinforce each other when waste is minimized.

FUTURE PERSPECTIVES

The future of hospital pharmacy inventory management is likely to involve increasing use of digital and analytical technologies.

Potential developments include:

Artificial intelligence

AI systems may identify demand patterns and predict stock-out risk.

Predictive analytics

Historical consumption, seasonal trends and clinical activity can be combined to forecast demand.

Automated replenishment

Inventory systems may generate purchase recommendations when stock reaches predetermined thresholds.

Real-time dashboards

Pharmacy managers may monitor stock, expiry and expenditure continuously.

RFID and advanced tracking

Automated identification can improve visibility of medicine movement.

Multi-criteria decision support

Financial, clinical, logistical and supply-risk factors can be incorporated into inventory prioritization.

Integration with electronic prescribing

Consumption data can potentially be linked directly to prescribing and dispensing systems.

However, technological development should complement rather than replace professional judgment

DISCUSSION

The literature demonstrates that hospital pharmacy inventory control has evolved from simple stock-recording practices into a multidimensional management discipline.

The fundamental principle remains straightforward: medicines should be available when needed without excessive investment in stock. Achieving this objective, however, requires coordinated decisions throughout the pharmaceutical supply chain.

ABC analysis provides financial prioritization, while VED provides clinical prioritization. The ABC-VED matrix brings these two perspectives together. Multiple studies have demonstrated its usefulness in tertiary hospitals, secondary hospitals and public healthcare facilities. [2]

More recent research has expanded this concept through ABC-XYZ, ABC-VED-FNS and multi-criteria methods. [12] These approaches recognize that hospital inventory is influenced not only by cost and clinical importance but also by movement, demand variability and other operational characteristics.

EOQ and minimum-maximum methods provide quantitative tools for determining replenishment quantities and stock levels. [8] Safety stock protects against uncertainty, while buffer-stock segmentation can prevent unnecessary accumulation. [9]

Procurement must remain linked to quantification and supplier performance. WHO procurement principles emphasize structured procurement processes, appropriate selection and quality assurance. [10]

Storage is equally important. A medicine that is purchased correctly but stored incorrectly can still become unsuitable for use. Therefore, pharmaceutical storage conditions and stock rotation must be incorporated into the inventory system. [11]

Digital technologies offer considerable opportunities. Electronic systems can improve data availability, reduce manual errors and provide alerts for stock levels and expiry. [15] Nevertheless, digital systems cannot compensate for inaccurate data or poorly designed procedures.

The role of the pharmacist is consequently expanding. Pharmacists are increasingly involved in procurement, formulary decisions, data analysis, quality assurance and supply-chain management in addition to dispensing and clinical services.

The literature also indicates that inventory problems are not restricted to developing or resource-limited settings. Hospitals across the Asia-Pacific region experience differences in implementation, medicine shortages and operational constraints despite the availability of inventory-management principles. [30]

RECOMMENDED INVENTORY-CONTROL STRATEGY

A hospital pharmacy seeking to strengthen inventory control can adopt the following practical strategy:

1. Establish a clear formulary

Avoid unnecessary duplication.

2. Collect accurate consumption data

Ensure every receipt and issue is recorded.

3. Perform ABC analysis

Identify high-expenditure medicines.

4. Perform VED analysis

Identify clinically critical medicines.

5. Combine ABC and VED

Give the greatest attention to high-cost and high-criticality medicines.

6. Add FSN/XYZ where necessary

Identify movement and demand variability.

7. Establish minimum and maximum levels

Base them on actual consumption and lead time.

8. Establish safety stock

Protect critical medicines from supply uncertainty.

9. Monitor expiry

Use FEFO and regular expiry reports.

10. Evaluate suppliers

Monitor delivery reliability and product quality.

11. Conduct regular stock audits

Compare physical and electronic records.

12. Monitor KPIs

Track stock-outs, expiry, emergency purchases and inventory accuracy.

13. Use digital tools appropriately

Automate repetitive processes where feasible.

14. Train pharmacy staff

Ensure staff understand SOPs and inventory procedures.

15. Review the system periodically

Inventory policies should change when consumption patterns or supply conditions change.

CONCLUSION

Inventory control is a fundamental component of effective hospital pharmacy practice. Its purpose is not merely to reduce the quantity of medicines stored but to maintain an appropriate balance between medicine availability, clinical necessity and economic efficiency.

ABC analysis provides a useful method for identifying medicines with high financial impact, while VED analysis identifies medicines according to clinical importance. The ABC-VED matrix combines these two perspectives and allows pharmacy managers to focus their resources on medicines that require the greatest attention. Evidence from Indian and international healthcare settings continues to support the value of this approach. [18]

EOQ, minimum-maximum systems, reorder levels and safety-stock calculations provide additional mechanisms for controlling replenishment. Procurement should be based on accurate quantification and supported by supplier monitoring. Storage should protect medicine quality, while FEFO and expiry monitoring should reduce wastage.

The development of electronic inventory systems, barcode technologies, predictive analytics and multi-criteria decision tools provides new opportunities for improving pharmacy inventory management. At the

same time, successful inventory control still depends on accurate data, trained staff, effective policies and professional judgment.

Ultimately, the most effective hospital pharmacy inventory system is one that ensures the right medicine, in the right quantity, of the right quality, at the right time, while using hospital resources responsibly.

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