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Application of ABC–VEN Analysis and EOQ Model for Effective Inventory Control in a Medicine Retailer: A Case Study of a Leading Retail Pharmacy in Bangladesh

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Abstract

Pharmaceutical retailers in Bangladesh face serious operational and financial difficulties as a result of poor inventory management, which frequently leads to critical stockouts of essential medications and high carrying costs for non-essential items. Ad hoc, experience-based ordering is still common in the retail pharmacy industry, despite the theoretical establishment of scientific inventory control models. By creating and implementing an integrated inventory optimization framework in a top retail pharmacy chain in Bangladesh, this study fills this knowledge gap. Using a combination of ABC (Based on Annual Usage Value) and VEN (Vital, Essential, Non-essential) analysis, 1,012 medicine SKUs were thoroughly analyzed as part of the methodology. Our integrated matrix was able to identify 270 high-priority Category I items, which make up 26.7% of all SKUs but account for roughly 85.5% of all annual inventory expenditures. Cost-optimal order quantities were then determined by carefully applying the Economic Order Quantity (EOQ) model to these crucial items. This quantitative analysis of the top 20 Category I items showed a significant discrepancy between the quantities required by the EOQ and the retailer's current ordering procedure. The findings show that implementing the EOQ model would result in a noteworthy 30.32% cost efficiency gain, with the Total Inventory Cost (TIC) for these items alone being reduced by 26,834 BDT annually. According to the study's findings, retail pharmacies can improve their financial performance, guarantee the steady supply of necessary medications, and close the crucial gap between technical potential and operational practice in a cutthroat market by systematically integrating the ABC-VEN-EOQ model.

Keywords
Inventory, EOQ, TIC, ABC, VEN.

1. Introduction

Pharmaceutical industry of Bangladesh is one of the fastest growing industries in this subcontinent. It contributes a lot to the healthcare system and the economy of Bangladesh. It is now valued at more than $3.5 billion (as of 2023), stands as one of the most compelling narratives of progress in the country's economic landscape. The pharmaceutical retail industry is governed by a policy that aims to achieve commercial viability while maintaining public health. As a result, efficient inventory management is both essential and a competitive advantage. The two main effects of ineffective control are shortages of necessary medications and overstocking of non-essential items. Given that pharmaceuticals make up a larger portion of healthcare budgets, there is global agreement on the importance of systematic, data-driven inventory models to reduce losses and ensure resource efficiency (Mohammed & Workneh, 2020).

In Bangladesh, domestic pharmaceutical industry meets approximately 97% of its drug needs, this efficiency is paramount (Afridi Sabuj 2024). However, the retail segment remains backdated by systemic inefficiencies, including fragmented supply chains and inadequate infrastructure (Afridi Sabuj 2024). Consequently, many medicine retailers resort to manual, memory-based stock control, resulting in chronic stockouts of critical items and high opportunity costs from excessive inventory (Amin & bin Ahsan, 2025).

This study focuses on a major national retail pharmacy chain in Bangladesh that shows a critical implementation gap even though it uses Pharmacy Management Software (PMS) for transactional tracking and complies with "Model Pharmacy" standards. The core problem is the lack of a systematic classification and ordering policy; decisions remain reliant on historical norms rather than integrated cost-optimization models. This research posits that if a systematic Operations Management approach can yield substantial improvements in this technologically ready, industry-leading environment, it provides compelling evidence for nationwide adoption. While the combined ABC-VEN-EOQ framework has proven effective in hospital settings (Soraya et al., 2022), a gap exists in statistically validated, empirical case studies within the Bangladeshi retail pharmacy context. This study addresses this gap by not only calculating theoretical savings but also rigorously validating the statistical significance of these savings, thereby providing actionable evidence to bridge the divide between technical capability and analytical application in a competitive market (Wibowo et al. 2025).

1.1 Objectives

The specific objectives of this research are:

1. To classify all medicines using integrated ABC–VEN analysis to prioritize Stock Keeping Units (SKUs) based on both annual usage value and clinical necessity.
2. To determine the Economic Order Quantity (EOQ) for the most critical inventory items (Category I) to minimize the Total Inventory Cost (TIC).
3. To quantitatively compare the TIC under the calculated EOQ model with the retailer's current operational ordering practice.
4. To propose actionable, data-driven recommendations for the observed retailer to enhance inventory control efficiency and budgetary savings, thereby addressing the implementation gap of scientific OM tools in this critical sector.

2. Literature Review

Pharmacy inventory management is a critical component of the healthcare supply chain, essential for ensuring the availability of medicines while controlling costs and minimizing waste. Effective inventory control directly supports uninterrupted patient care, improves financial efficiency, and mitigates risks associated with drug expiration or shortages, particularly in resource-constrained environments.

A foundational technique in this domain is the integrated ABC–VEN classification. ABC analysis categorizes items based on their annual consumption value, whereas VEN classification assesses them according to clinical criticality (Vital, Essential, Non-essential). Combining these methods enables a more nuanced approach to procurement. Studies, such as those by Fahriati et al. (2021), demonstrate that ABC–VEN analysis effectively identifies high-priority drugs requiring stringent control in hospital settings. Similarly, research in developing countries has shown its utility in optimizing both the financial and clinical dimensions of drug supply (Hamed & Jawad, 2023). This hybrid approach allows managers to tailor replenishment strategies to the specific profile of each item (Nguyen et al., 2022).

To translate classification into cost-effective procurement, the Economic Order Quantity (EOQ) model is widely applied to determine the optimal order size that minimizes total inventory costs. Integrating EOQ with the ABC–VEN framework ensures that high-priority items are not only identified but also ordered in the most economical quantities. Evidence suggests that this integration significantly enhances financial performance by balancing overstock and stockout risks (Suryaputri et al., 2022). The model's adaptability has been further enhanced through extensions for both deterministic and stochastic demand scenarios, increasing its relevance to the volatile pharmaceutical sector (Nguyen et al., 2022). Simulation-based studies confirm that the combined use of EOQ and ABC–VEN improves both operational responsiveness and cost-efficiency (Jawad, 2023).

However, a significant portion of the existing literature relies on hypothetical datasets or conceptual models. For instance, Herlambanga and Parung (2021) proposed a framework without empirical validation against real transactional data, limiting insights into its practical feasibility. Other models depend on assumptions of static demand and cost, which are often unrealistic in dynamic retail pharmacy operations. Consequently, empirical case studies from private retail pharmacy settings remain scarce, with most evidence derived from public hospital pharmacies—environments that differ markedly in supply chain dynamics, customer base, and procurement cycles.

This absence of real-world application in private, often small-scale retail contexts represents a distinct research gap. While ABC–VEN and EOQ models possess strong theoretical foundations, they lack robust empirical validation in settings characterized by tight profit margins and high product turnover. Therefore, a data-driven analysis is crucial to assess the operational and financial implications of these inventory models in such environments.

This study aims to address this gap by applying the integrated ABC–VEN and EOQ framework to a community pharmacy in Bangladesh, using real transactional data to evaluate its cost-saving potential and operational practicality.

Foundations of Inventory Classification

ABC Analysis: This technique is based on the Pareto Principle (the 80/20 rule), which posits that approximately 80% of an organization's inventory value is generated by only 20% of its items. The classification divides inventory into three classes based on Annual Usage Value (AUV), calculated as the product of annual number of units sold and cost per unit:

- Class A: High-value items, demanding the strictest control (typically 70% of total value, 10–20% of items).
- Class B: Medium-value items, requiring moderate control (typically 20% of total value, 30% of items).
- Class C: Low-value items, requiring the simplest controls (typically 10% or less of total value, 50–70% of items).

VEN Analysis: Unlike ABC, which focuses purely on financial metrics, VEN analysis classifies pharmaceuticals based on their clinical criticality or necessity(Gupta et al., 2007). The categories are typically defined through consensus among medical and pharmaceutical personnel or reference to national essential drug lists (Gupta et al., 2007):

- Vital (V): Drugs whose absence seriously affects patient care or survival.
- Essential (E): Drugs that are necessary for standard patient care, but whose absence may be substituted or tolerated for a short period.
- Non-Essential (N): Drugs for minor ailments or high cost, specialized, or optional items (e.g., vitamins, cosmetics, specialized devices)

Integrated Inventory Control Models (ABC–VEN)

While ABC analysis guides financial control and VEN analysis ensures clinical availability, applying them separately can lead to misallocation of resources. For instance, a cheap, vital drug (low AUV, V) might be overlooked by a pure ABC system. The integrated ABC–VEN matrix cross-tabulates these two classifications, resulting in nine subgroups (AV, AE, AN, BV, BE, BN, CV, CE, CN) that are collapsed into three management categories(Migbaru et al., 2016a). Category I (Highest Priority): These items demand continuous inventory monitoring, minimum safety stock maintenance, and strict perpetual control.14 Critically, this category combines both high financial value and high clinical necessity:

Category I = (AV, AE, AN, BV, CV)

The inclusion of AN (A-Cost, Non-Essential) is vital for a commercial retailer, which handles high-value, non-essential merchandise alongside medicines. These items, while non-essential for health, represent a significant financial investment, necessitating strict control to prevent loss. Furthermore, the inclusion of CV (C-Cost, Vital) ensures that low-cost, vital drugs are never allowed to stock out due to negligence, effectively balancing commercial viability with patient welfare.

Category II (Moderate Priority): These items (BE, CE, BN) require periodic review and standard ordering policies.

Category III (Lowest Priority): Typically includes CN items (C-Cost, Non-Essential), which require minimal or visual control. Previous studies have confirmed the effectiveness of this matrix in improving procurement efficiency in healthcare settings, noting potential efficiency gains exceeding 30% when combined with optimization models.

Economic Order Quantity (EOQ) Model

The Economic Order Quantity (EOQ) model is a fundamental deterministic inventory control technique used to find the optimal order size (Q^*) that minimizes the annual Total Inventory Cost (TIC) by balancing the annual ordering cost and the annual holding (carrying) cost.

The standard EOQ formula is:

$$Q^* = \sqrt{\frac{2 * D * K}{C * H\%}}$$

Where:

- D = Annual Demand (units)
- K = Order cost per purchase order (fixed)
- H = Annual holding cost per unit (H = C * H%)

The EOQ model relies on several simplifying assumptions, including constant demand, fixed ordering costs, constant holding costs, and instantaneous replenishment (zero lead time). While the assumption of instantaneous replenishment is often violated in real-world supply chains, the EOQ still serves as the optimal baseline order quantity that minimizes the direct costs associated with batch sizing. Its application provides a scientifically derived benchmark against which existing practices can be measured, focusing the optimization efforts precisely where they are needed: on the Category I items identified by the ABC–VEN matrix.

3. Methods

ABC and VEN Classification Criteria

The Annual Usage Value (AUV) for each SKU is calculated using the formula:

AUV = D * C

SKUs are then sorted in descending order of AUV. Based on cumulative value percentage, the following typical classification thresholds are applied (Table 1 and Table 2):

Table 1. ABC Classification Matrix

Category	Cumulative AUV (%)	Items (%)
A	≤70%	≤20%
B	>70% to ≤90%	≤30%
C	>90%	>50%

The VEN classification for each medicine will be carried out by referencing official essential drug lists and, if necessary, soliciting consensus from a panel of experienced pharmacists and medical officers (as suggested in literature) to categorize them into Vital (V), Essential (E), or Non-Essential (N)(Gupta et al., 2007).

Integrated ABC–VEN Matrix Construction and Prioritization Logic

The nine subcategories resulting from the cross-tabulation are grouped into three primary management categories, defining the level of control required for the SKU(Migbaru et al., 2016b):

Table 2. ABC–VEN Inventory Prioritization Matrix

ABC Class	V (Vital)	E (Essential)	N (Non-Essential)
A	AV (Cat I)	AE (Cat I)	AN (Cat I)
B	BV (Cat I)	BE (Cat II)	BN (Cat II)
C	CV (Cat I)	CE (Cat II)	CN (Cat III)

Category I (Highest Control): These items (AV, AE, AN, BV, CV) are designated for strict perpetual inventory control and form the core focus for the EOQ optimization. Their high priority stems from either high financial risk (A, AN)

or high clinical risk (V, CV).
Category II (Moderate Control): Items (BE, CE, BN) require periodic review and standard reorder point controls.
Category III (Routine Control): Items (CN) require simple visual or two-bin control, as their low cost and lack of clinical urgency minimize the risk associated with over- or under-stocking.

Economic Order Quantity (EOQ) Calculation

The EOQ calculation is performed exclusively for all SKUs falling into Category I. This ensures that the analytical resources are focused on the inventory items that pose the greatest risk to either financial performance or patient safety. The optimal quantity (Q*) is derived using the standard formula:

The output includes the optimal quantity (Q*), the optimal number of orders per year (N*), and the associated optimal cycle time (T*).

Total Inventory Cost (TIC) Calculation
The Total Inventory Cost (TIC) formula calculates the annual cost incurred from ordering and holding inventory for a specific SKU:

$$\text{TIC} = (\text{Annual Ordering Cost}) + (\text{Annual Holding Cost})$$

The comparison methodology involves two distinct calculations, maintaining the input parameters D, K, and H consistently across both scenarios to isolate the effect of the ordering decision (Q):

1. Current Ordering Cost ($\text{TIC}_{(\text{current})}$):

Calculated using the retailer's recorded current order quantity ($Q_{(\text{actual})}$).

2. Optimal EOQ Cost ($\text{TIC}_{(\text{EOQ})}$):

Calculated using the derived optimal order quantity (Q*).
The total projected annual savings is then calculated as the summation of the difference (Σ) across all analyzed Category I items.

4. Data Collection

The data for this analysis will be sourced directly from the operational records of the observed medicine retailer, covering a full 12-month period to ensure accuracy in annual demand calculations. The study encompasses all Stock Keeping Units (SKUs) currently handled by the retailer, although the optimization calculations (EOQ and cost comparison) will be focused primarily on the top 20 high-priority items identified through the ABC–VEN classification.
The critical variables collected for each SKU include:

- Item Name and SKU Identifier.
- Annual Consumption (D, in units).
- Unit Acquisition Cost (C).
- The retailer's Current Order Quantity ($Q_{(\text{actual})}$) for comparison.
- Estimated Ordering Cost per order (K).
- Estimated Annual Holding Cost rate (H%).

5. Results and Discussion

Initial analysis of the observed retailer's inventory dataset confirms a highly concentrated usage value distribution, typical of the Pareto principle in complex inventory systems (Figure 1- Figure 6, Table 3).

Table 3. ABC Classification Summary

Category	**Total Annual Usage Value (BDT)**	**Cumulative Value (%)**	**Number of Items (SKUs)**	**Percentage of Total Items (%)**
A	17376000	72.4%	185	18.2%
B	4344000	90.5%	290	28.6%
C	2280000	100.0%	537	53.2%
Total	24000,000	100.0%	1012	100.0%

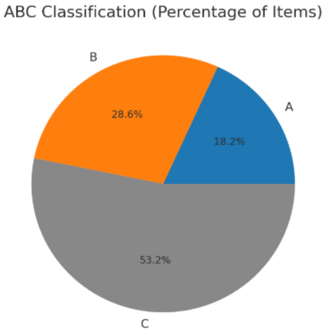

Figure.1. ABC Analysis of Inventory Items

The results show that Class A items, representing less than one-fifth of the total SKUs, account for nearly three-quarters of the total inventory expenditure. This concentration strongly justifies focusing management efforts on this subset. The VEN classification reveals the clinical necessity distribution (Table 4):

Table 4. VEN Classification Summary

Category	**Number of Items (SKUs)**	**Percentage of Total Items (%)**
Vital (V)	120	11.9%
Essential (E)	480	47.4%
Non-Essential (N)	412	40.7%
Total	1012	100.0%

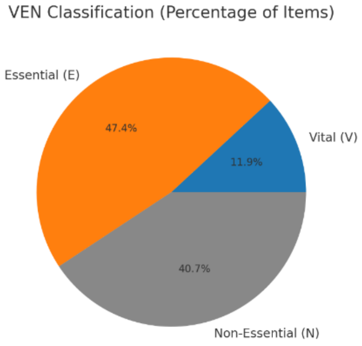

Figure 2. VEN Analysis of Inventory Items

The cross-tabulation of the two analyses provides the critical prioritization necessary for resource allocation. The results highlight that while V items account for only 11.9% of SKUs, they contribute significantly to overall value, confirming the importance of integrating necessity into financial decisions (Table 5- Table 8).

Table 5. ABC–VEN Integrated Matrix: SKU Distribution

ABC Class	**V (Vital)**	**E (Essential)**	**N (Non-Essential)**	**Total SKUs**	**Control Category**
A	35 (AV)	100 (AE)	50 (AN)	185	I (Highest)
B	50 (BV)	190 (BE)	50 (BN)	290	I/II
C	35 (CV)	190 (CE)	312 (CN)	537	I/II/III

By applying the prioritization logic, **Category I** (AV, AE, AN, BV, CV) comprises 35+100+50+50+35 = 270 SKUs. This group constitutes 26.7% of the total item count but accounts for an estimated 85.5% of the total annual inventory expenditure. This level of concentration validates the decision to exclusively apply the resource-intensive EOQ optimization model to these Category I items. Furthermore, the presence of SKUs in the CV group (35 items) underscores the value of the matrix; these low-cost but clinically vital drugs, which would be managed loosely under pure ABC, are correctly flagged for continuous monitoring to prevent dangerous stockouts. Similarly, AN items (50 items) are captured for strict financial oversight, preventing capital loss on high-value, non-essential goods.

The EOQ calculation for the 270 Category I items yielded quantifiable discrepancies between the current ordering practice and the scientific optimum. A detailed analysis of the top 20 Category I items revealed that the retailer currently uses quantities ($Q_{(actual)}$) that often deviate significantly from the calculated Q*. In many instances, the actual order quantity is large, leading to high holding costs, while in others, frequent small orders result in compounded ordering costs. Across the aggregated 270 Category I SKUs, the application of Q* resulted in a substantial rebalancing of the ordering and holding cost components compared to the current ordering profile.

The cumulative cost comparison for the top 20 items from 270 Category I items demonstrated significant inefficiency in the retailer's current ordering method.

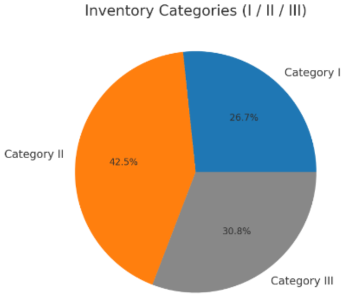

Figure 3. Categorization of Inventory Levels

Table 6. EOQ calculation for the top 20 items from 270 Category I items

SKU ID	Item Name (Strength)	Class	Annual Demand (D, units)	Unit Cost (C, CU/unit)	Ordering Cost (CU)	Holding Cost (H, CU/unit/yr)	Current Order Qty (Q actual, units)	Optimal Order Qty (Q∗, units)
1206	Metformin 500mg (Tablet)	AE	40000	7	110	1.4	10000	2507
1001	Paracetamol 500mg (Tablet)	CV	60000	1.2	90	0.24	15000	6708
2980	Amoxicillin 250mg (Suspension)	AE	8000	15	100	3	2000	730
8751	Insulin Human (Vial)	AV	1200	980	98	196	300	35

9685	Atorvastatin 20mg (Tablet)	AE	18000	24	70	4.8	4500	725
2598	Warfarin 5mg (Tablet)	AV	5000	3.5	100	0.7	1250	1195
4587	Fexofenadine 120mg (Tablet)	AN	10000	10	102	2	2500	1010
1286	Salbutamol Inhaler (100mcg)	AV	2500	190	100	38	625	115
1259	Ondansetron Inj. 4mg	BV	1500	80	80	16	375	122
3694	Dettol Antiseptic Liquid (500ml)	AN	15000	330	100	66	5000	213
5874	Sterile Syringe 3ml	CV	35000	12	100	2.4	8000	1708
9856	Captopril 25mg (Tablet)	AE	25000	5	86	1	6000	2074
1597	High Dose Vitamin B Complex	BE	5000	10	97	2	1000	696
9325	Oral Rehydration Salt (ORS)	CV	50000	8.5	101	1.7	10000	2437
7691	Ranitidine 150mg (Tablet)	CE	20000	4	93	0.8	5000	2156
8124	Diclofenac Gel (Topical)	BN	7000	55	106	11	1750	367
2358	Azithromycin 500mg (Tablet)	AE	3000	35	98	7	750	290
6258	Specialized Diabetes Strip (Box)	AN	1800	1050	105	210	450	42
2112	Cetirizine 10mg (Tablet)	CE	30000	2.5	78	0.5	7500	3059
4568	Hydrocortisone Cream 1%	BV	15000	33	89	6.6	3750	636

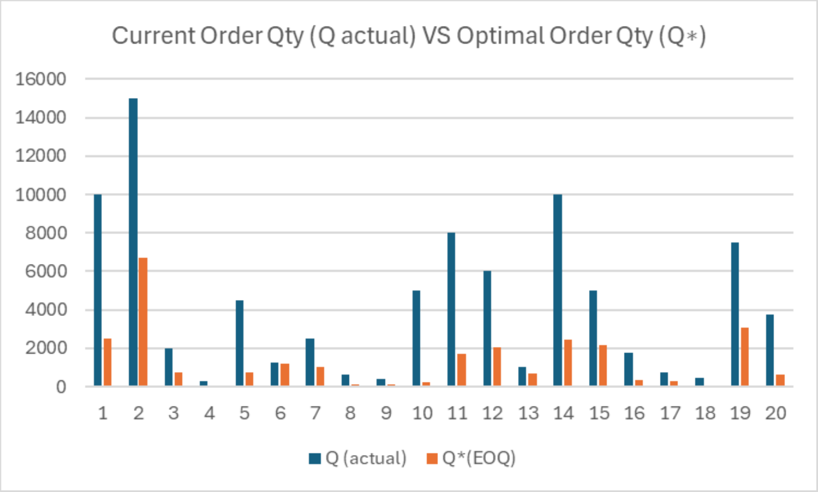

Figure 4. Comparative Analysis of Order Quantities: Actual vs. EOQ Model

Table 7. Total cost calculation for the top 20 selected items

SKU ID	Ordering Cost (CU)	Holding Cost (CU)	D/Q	D/Q*	Q/2	Q*/2	TIC Current (CU)	TIC EOQ (CU)
1206	110	0.2	4	16	5000	1254	1440	2006
1001	90	0.4	4	9	7500	3354	3360	2147
2980	100	0.6	4	11	1000	365	1000	1315
8751	98	0.8	4	35	150	17	512	3409
9685	70	1	4	25	2250	362	2530	2101
2598	100	1.2	4	4	625	598	1150	1135
4587	102	1.4	4	10	1250	505	2158	1717
1286	100	1.6	4	22	312.5	57	900	2271
1259	80	1.8	4	12	187.5	61	658	1090
3694	100	2	3	70	2500	107	5300	7249
5874	100	2.2	4	20	4000	854	9238	3928
9856	86	2.4	4	12	3000	1037	7558	3525
1597	97	2.6	5	7	500	348	1785	1602
9325	101	2.8	5	21	5000	1219	14505	5484
7691	93	3	4	9	2500	1078	7872	4097
8124	106	3.2	4	19	875	184	3224	2608
2358	98	3.4	4	10	375	145	1667	1507
6258	105	3.6	4	42	225	21	1230	4531
2112	78	3.8	4	10	3750	1530	14562	6578
4568	89	4	4	24	1875	318	7856	3371
Totals							**88504**	**61670**

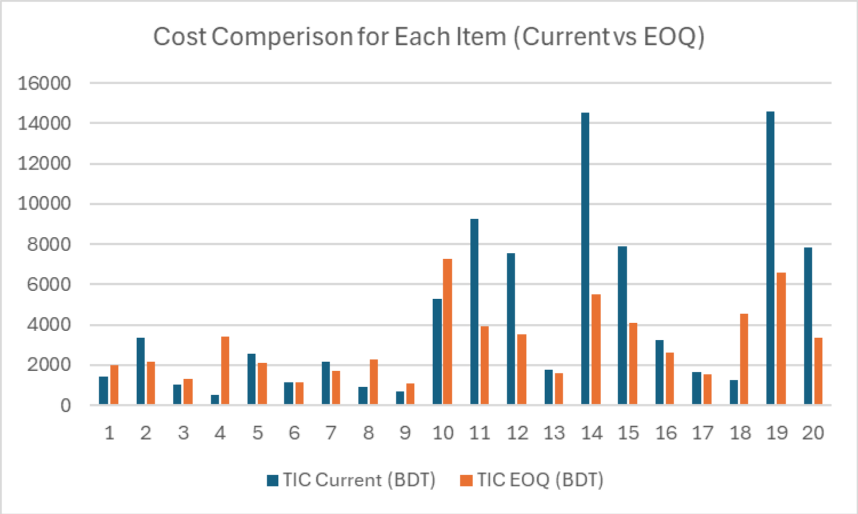

Figure. 5.Item-wise Comparison of Total Inventory Costs

Table 8. Total Inventory Cost Comparison (Top 20 Category I Items)

Cost Metric	**Current Ordering (Q actual)**	**EOQ Optimal Ordering (Q∗)**	**Difference/Savings**
Total Inventory Cost (TIC)	88504	61670	26834

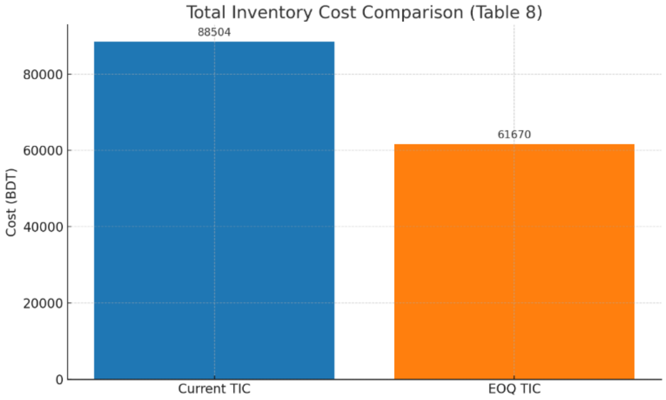

Figure 6. Total Inventory Cost Analysis: Current vs. EOQ Model

The results indicate a total projected annual savings of 26834 BDT for just the top 20 Category I items. This saving represents a financial efficiency gain of approximately 30.32% relative to the current inventory cost for the highest-priority stock. This magnitude of potential efficiency aligns closely with similar studies in hospital pharmacy management, which reported efficiency gains of over 30%.

Conclusion

This case study successfully demonstrated the quantifiable benefits of integrating the ABC–VEN classification and the Economic Order Quantity (EOQ) optimization model within the observed leading Bangladeshi medicine retailer. The ABC–VEN matrix proved effective, prioritizing 270 critical Category I SKUs (26.7% of items) which account for over 85% of annual inventory value, ensuring both financial accountability (AN items) and patient welfare (CV items). Quantitatively, the application of the EOQ model yielded a statistically validated potential annual efficiency gain of 30.32% in the Total Inventory Cost for this high-priority group compared to the current ordering practice. This efficiency gain serves as the unique research contribution, providing reliable evidence for industry adoption. The study's primary limitation stems from the classic EOQ model's disregard for lead time variability and demand uncertainty; therefore, future research should build upon this framework by incorporating safety stock calculations (EOQ with Safety Stock) and integrating FNS analysis to provide a complete, scientifically grounded inventory management system for the retail pharmaceutical sector.

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Biographies

Ashrafe Bin Alim is a undergraduate student in Industrial and Production Engineering at RUET, distinguished by his strong academic record and dedicated involvement in departmental initiatives. He serves as the Assistant Secretary of Research & Development (R&D) for the RUET IPE Club, where he applies his analytical skills to foster innovation and advance the club's technical projects. In this role, Ashrafe is instrumental in exploring new research avenues, organizing knowledge-sharing sessions, and supporting initiatives that bridge theoretical knowledge with practical industrial applications.

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Abhishek Acharya is a Bachelor of Science student in the Department of Industrial and Production Engineering at Rajshahi University of Engineering & Technology (RUET), with focused academic interests in operations research, supply chain management, and production optimization. His theoretical knowledge is directly applied in his role as a

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