"Optimizing Pharmacy Inventory A Four-Month Analysis of Seasonal Trends and DemandPatterns"

A Mid-term report for the BDM Capstone Project

Name : Mohd Shad

Email : 23f3004148@ds.study.iitm.ac.in

Roll No. : 23f3004148

IITM Online BS Degree Program,
Indian Institute of Technology,
Madras, Chennai Tamil Nadu, India, 600036

Executive summary

This mid-term analysis of Kareema Medical Store focuses on optimizing inventory management and boosting profitability based on sales data from September 1, 2024, to November 22, 2024. The store, serving a 10–12 km radius in Chandpur, Uttar Pradesh, faces challenges including frequent stockouts, overstocking, and dead stock, leading to revenue losses and operational inefficiencies.

Key findings highlight that 20% of SKUs generate nearly 60% of total revenue, with Antibiotics, NSAIDs, and Vitamins contributing the most. Seasonal demand spikes (e.g., Vitamins in winter, NSAIDs during flu season) were observed, underscoring the need for dynamic inventory planning. Conversely, low-demand categories like Weight-Loss and Vaccines contribute minimally and inflate holding costs.

Stockouts were frequent in high-demand items like Zerodol SP and BROZEET LS Syrup, while overstocking occurred in Antacids and low-performing SKUs. ABC analysis identified 114 dead-stock SKUs, potentially saving ₹1,766/month if liquidated.

Proof of Originality

2.1 Business Verification

To establish the authenticity of this project, the following documents and media have been collected as evidence of primary data collection and real-time interaction with Kareema Medical Store, Chandpur, Uttar Pradesh

2.1.1 IMG_20250206_161509.jpg _TAP TO OPEN

- (Entrance of Abrar Memorial Hospital, affiliated with Kareema Medical Store)

2.1.2 Inventory & Stock Verification, Real-Time Inventory Snapshots:

- **IMG_20250206_162057.jpg**(Captured to validate stock levels, inventory…
- **IMG_20250206_162035.jpg** …..movement, and storage conditions.)
- **IMG_20250206_162044.jpg**
- IMG_20250206_162015.jpg

2.1.3 Data Collection Process

- Live Data Entry & Reports Captured from Marg ERP:
  - IMG_20250206_174313281.jpg IMG_20250206_174319109.jpg
  - IMG_20250206_162011.jpg
  - HM (2).pdf RAW DATA (I got data similar to this format for sales of SKUs)

Google Sheet (Collected Data – Sep to Nov 2024):

- Access Sales & Inventory Data Sheet (Shared for review and verification.) sep - nov

2.1.4 Interaction & Business Validation

- Interview with Pharmacist & Manager (Mohd Umar):

  - VID-20250206-WA0037~2.mp4 Interaction Video *(Manager discusses inventory challenges and stock management practices.)*
  - Official Verification Letter from Kareema Medical Store:

Metadata

3.1 Firm Overview & Data Collection

The pharmacy remains open every day from 9 AM to 8 PM, catering to both routine and emergency medical needs. For this analysis, data was collected over a five-month period from September 1, 2024, to February 2, 2024. The primary data sources include sales records extracted from the Marg ERP system, detailing medicine names, therapeutic categories, stock levels, purchase records, sales figures, and dumped stock. Additionally, an Annual Ledger Report was used to compare sample data with full-year financial performance. To validate stock movement and inventory conditions, real-time inventory snapshots were provided by the store owner.

- Dataset has 3 sheets Mainly 2 sheets (sales_data), (time_seriesdata) and that Statical sheet is for validation of our calculation.

3.2 Dataset Summary & Key Variables

- The sales Variables name are stored in 'KAREEMA MEDICAL STORE (**Sales_Data)** row 1'

Variable Name	Data Type	Relevance
SKUs	Categorical	Identifies most and least sold SKUs.
Therapeutic Tag(Medicine Category)	Categorical	Groups medicines by purpose (e.g., Antibiotics, NSAIDs) for demand analysis. Helps in ABC classification.
OPEN_QTY(Opening Stock)	Numerical	Initial inventory count, indicating available stock at the beginning of the period.
Purchase value (₹)	Numerical	Total cost of received stock, used for purchase-to-sales ratio calculations.
CLOSING_QTY (Closing Stock)	Numerical	Determines remaining stock.
ISSUE_QTY(Sales Quantity)	Numerical	Measures product demand.
Revenue (₹)	Numerical	Measures overall business performance and SKU profitability.
Dump/Waste Stock (Qty)	Numerical	Tracks expired/unsold medicines.

- Explanation of Categories used for classification of medicines
- The sales items have been organized into Fifteen primary categories for the purpose of analysis. These categories are as follows:

Category	**Purpose**	**Medicines used eg.**
Antibiotic	Treat bacterial infections	L-CIN 250 (Levofloxacin), AUGXETIL-250 (Cefuroxime)
NSAID	Reduce pain, inflammation, and fever	ETORICA 60 (Etoricoxib), NAPROSYN SR (Naproxen)
Antacid	Neutralize stomach acid to treat acidity, heartburn, or GERD	ACILOC 150 (Ranitidine), 1-AL (Aluminium Hydroxide)
Vitamin	Address nutritional deficiencies or boost immunity	ZINCOVIT-CL (Zinc + Vitamins), EVION-400 (Vitamin E)
Bronchodilator	Open airways to treat asthma, COPD, or bronchitis	ASTHALIN (Salbutamol), TELEKAST-5 (Montelukast)
Probiotic	Restore gut flora balance and treat diarrhea or IBS	DAROLAC CAP (Saccharomyces Boulardii), ECONORM (Probiotics)
Antihistamine	Block histamine to treat allergies, itching, or allergic rhinitis	AVIL (Pheniramine), CASPA (Cetirizine)
Analgesic	Relieve pain (e.g., headaches, muscle pain, post-surgical pain)	CALPOL-120 (Paracetamol), COMBIFLAM (Ibuprofen +

		Paracetamol)
Saline	Rehydrate or clean wounds	DRAWIN (ORS), SRS 3 ML (Saline Solution)
Antispasmodic	Relieve muscle spasms in the gut, urinary tract, or uterus	DROTIKIND-M (Drotaverine), SPASMOPRIV (Antispasmodic)
Antiepileptic	Treat seizures or epilepsy	CLONAFIT-0.50 (Clonazepam), EPSOLIN (Phenytoin)
Antiseptic	Prevent infection by killing or inhibiting microorganisms	DETTOL (Antiseptic), MACBERY (Chlorhexidine)
Antidepressant	Treat depression or anxiety disorders	POXL 100 (Paroxetine), TRYPTOMER 25MG (Amitriptyline)
Hormone	Regulate hormonal imbalances (e.g., fertility, thyroid, or corticosteroids)	LUPI-HCG 5000 (Human Chorionic Gonadotropin)
Decongestant	Relieve nasal congestion	NOZY-NS DROP (Nasal Decongestant)

- The classification of medicines **Therapeutic Tags** are stored in 'KAREEMA MEDICAL STORE **(Sales_Data)** Column D1'

3.3 DATASET SIZE

Dataset dimensions having **311 total rows** and **15 total columns** This dataset contains product inventory information with:• A header row in row 1 • 310 data records in rows 2-311
• 15 attributes per record including company, SKU, quantities, and values

4. Descriptive Statistics

After data processing and cleansing, the following is a concise overview of the dataset using **descriptive statistics**. These key metrics highlight important aspects of **sales performance, stock levels, and financial impact**, ensuring data-driven insights for inventory optimization and demand forecasting.

Descriptive statistic measure	**Descriptive statistic definition**
Sum	The total value
Mean	The average value
Standard Error	The variability of mean, across multiple samples drawn from the same population.
Median	The middle value when arranged in ascending order
Standard Deviation	The measure of spread of values from mean in single sample.
Minimum	The smallest value.
Maximum	The largest value.

For Overall Sales Data:

Descriptive Statistics	*purchase value*	*OPEN_QTY*	*OPEN_VALUE*	*ISSUE_QTY*	*ISSUE_VALUE*	*CLOSING_VALUE*	*DUMP_QTY*	*REVENUE*
Sum	280,456.12	261,640.00	475,125.39	33,883.00	373,941.49	460,130.09	87,578.00	93,485.37
mean	904.70	863.50	1,532.66	171.99	1,206.26	1,484.29	579.99	301.57
standard error	122.42	571.94	837.88	34.94	163.23	841.93	522.83	40.81
median	141.31	7.00	210.00	27.00	188.41	168.25	7.00	47.10
standard deviation	2,155.48	9,955.64	14,752.35	490.40	2,873.97	14,823.78	6,424.59	718.49
minimum	0.00	-472.00	-3,095.04	-1.00	0.00	-3,095.04	1.00	0.00
maximum	19,258.42	140,954.00	218,478.70	5,094.00	25,677.89	219,425.75	78,828.00	6,419.47
Zero revenue								
Descriptive Statistics	*purchase value*	*OPEN_QTY*	*OPEN_VALUE*	*ISSUE_QTY*	*ISSUE_VALUE*	*CLOSING_VALUE*	*DUMP_QTY*	*REVENUE*
Sum	0.00	326.00	17,392.02	-1.00	0.00	18,734.99	1,780.00	0.00
mean	0.00	2.91	152.56	-1.00	0.00	164.34	20.00	0.00
standard error	0.00	6.71	46.45	0	0.00	46.61	3.57	0.00
median	0.00	2.00	79.33	-1.00	0.00	88.01	6.00	0.00
standard deviation	0.00	71.06	495.93	0	0.00	497.69	33.67	0.00
minimum	0.00	-472.00	-3,095.04	-1.00	0.00	-3,095.04	1.00	0.00
maximum	0.00	162.00	2,140.02	-1.00	0.00	2,140.02	162.00	0.00

4.1 Key Performance Indicators:

1. Revenue & Value Metrics:

- Total Revenue Generated: ₹93,485.37
- Total Purchase Value: ₹280,456.12
- Average Revenue per SKU: ₹301.57
- Significant value spread (SD: ₹718.49) indicates diverse product pricing

2. Inventory Movement Analysis:

- Total Issues: 33,883 units
- Average Issue Quantity: 172 units per SKU
- High inventory variation (Open Qty SD: 9,955)
- Substantial dump quantity: 87,578 units

3. Critical Observations:

- Value Chain Efficiency:
- Purchase Value to Revenue ratio shows 33.3% realization
- High closing value (₹460,130.09) suggests significant inventory holding
- Operational Concerns:
- Negative minimum values indicate stockouts
- Maximum single-item revenue: ₹6,419.47
- Large standard deviations suggest volatile demand patterns

4. Zero-Revenue Products:

- Concerning indicators:
- 1,780 units in dump quantity
- ₹17,392.02 locked in opening value
- Negative issue quantities suggesting return flows

4.2 Statistical Analysis of Top 5 Therapeutic Categories (Contributing 62% of Total Revenue)

This section presents the performance analysis of the five highest revenue-generating therapeutic categories at Kareema Medical Store, which collectively contribute 62% of total revenue. The analysis is based on sales quantity, revenue, and inventory efficiency to understand demand patterns and stock performance. Key metrics : progressive% = Cumulative revenue,

Therapeutic Tag	Metric	Sum	Mean	Median	Std Dev	Std Error	Min	Max	Progressive %
Antibiotic	Quantity	4196	46	18	96	10	-3	555	19
Antibiotic	Revenue	6419	70	21	159	17	0	807	19
Antibiotic	Dump Quantity	147	2	0	10	1	0	89	19
NSAID	Quantity	8632	360	247	387	79	-2	1414	31
NSAID	Revenue	5883	245	91	386	79	0	761	31
NSAID	Dump Quantity	100	4	0	20	4	0	100	31
Antacid	Quantity	3466	173	165	162	36	-28	514	42
Antacid	Revenue	2550	127	112	157	35	0	436	42
Antacid	Dump Quantity	28	1	0	6	1	0	28	42
Vitamin	Quantity	1027	27	20	52	8	-2	312	53
Vitamin	Revenue	4401	116	39	237	38	0	1056	53
Vitamin	Dump Quantity	587	15	0	44	7	0	230	53

Bronchodilator	Quantity	531	66	150	89	32	-6	189	62
Bronchodilator	Revenue	3043	380	213	421	149	0	831	62
Bronchodilator	Dump Quantity	0	0	0	0	0	0	0	62

The **statistical analysis** of Kareema Medical Store's inventory data highlights trends related to **demand fluctuations, stockouts, and capital allocation**, aligning with the identified problem areas.

1. High-Revenue Categories & Demand Variability

- **Antibiotics (19.02% of total revenue)** display high demand fluctuations, with a **standard deviation of 96 units**, indicating inconsistent consumption patterns.
- **NSAIDs (12.42% of total revenue)** exhibit the highest **volatility (SD: 387 units)**, correlating with seasonal health trends such as flu outbreaks.
- The **mean (46) and median (18) for Antibiotics** indicate a skewed distribution, suggesting that a few high-selling SKUs dominate overall sales, while others contribute minimally.

2. Inventory Inefficiencies & Waste Management

- **Negative minimum stock values** across categories confirm instances of **stockouts**, reinforcing the unpredictability in demand.
- **Vitamin supplements reported the highest wastage**, with **587 units dumped**, signifying surplus stock or slow-moving products.
- The **progressive revenue contribution analysis** reveals that a small set of products accounts for a majority of sales, aligning with the **Pareto principle** observed in inventory management.

3. Capital Allocation & Stock Optimization

- **Five therapeutic categories contribute 62% of total revenue**, reinforcing the concentration of sales within a limited set of products.
- **114 SKUs generated zero revenue** during the analyzed period, highlighting capital investment in products that did not contribute to sales.

Detailed Explanation of Analysis Method

5.1 Data Collection & Sources

Data collection was a significant challenge due to restricted access to the Marg ERP system, which was linked to multiple hospitals and stores. Extracting data in a usable format required multiple visits to the medical store for validation and manual verification.

- Primary Data Sources:
  - Sales & Inventory Reports (Sept 1, 2024 – Feb 2, 2025) extracted from Marg ERP.

- Annual Ledger Report for financial comparison with sample data.
- Stock Verification through real-time inventory snapshots.

- Data Extraction & Structuring:
  - Raw data was obtained in PDF format, requiring conversion using PyPDF2 (Python) to extract tabular data.
  - The extracted data was cleaned and formatted into a structured dataset with 311 rows and 15 columns, focusing on relevant attributes like SKU, stock levels, purchase & sales quantity, revenue, and wastage.

5.2 Data Preprocessing & Cleaning

To ensure accuracy and consistency in the dataset, data preprocessing involved the following steps:

Missing Value Treatment

- Replaced missing values (‘-’) with numerical zero for uniform analysis.
- Standardized empty cells for consistent computations.
- Verified negative values in stock and sales data to confirm if they indicated returns or manual adjustments.

Numerical Standardization

- Converted floating-point values to integers for inventory quantities.
- Applied standardized rounding protocols across all financial metrics.
- Standardized currency formats for financial calculations.

Data Validation & Cross-Verification

- Stock Flow Validation: Ensured the logical consistency of inventory movements (Opening Stock → Purchases → Sales → Closing Stock).
- Revenue Accuracy Check: Cross-validated revenue with sales quantity and applicable GST rates.
- Category Verification: Ensured proper mapping of therapeutic categories for each SKU.

5.3 Analytical Framework & Methods Used

A structured statistical approach was adopted to address inventory management challenges and extract meaningful insights:

- **1. Categorical Analysis by Therapeutic Classification**

  Method Used: Therapeutic category-based grouping with progressive revenue contribution analysis

Justification for Selection: Categorizing inventory by therapeutic function provides superior insights compared to alternative approaches because:

- Medications in the same therapeutic class experience similar demand patterns (e.g., all bronchodilators spike during respiratory illness seasons)
- Prescription behavior follows therapeutic logic rather than brand preference
- This aligns with how medical professionals make prescription decisions

Alternative Methods Considered:

- Brand-based Analysis: Would fracture insights across multiple brands treating the same conditions
- Price-tier Analysis: Would group unrelated medications with different demand drivers
- Supplier-based Grouping: Would obscure therapeutic patterns critical for anticipating demand

Our therapeutic classification approach directly addresses the problem statement's observation that "seasonal and viral health trends cause frequent stockouts" by revealing which therapeutic categories are most affected by seasonality.

- **2. Statistical Analysis Framework**

Method Used: Multi-metric descriptive statistics with variance analysis

Justification for Selection: For pharmaceutical inventory, understanding variability is more critical than central tendency alone since:

- Stock-outs have health consequences beyond lost sales
- Demand spikes for categories like antibiotics can be sudden and dramatic
- Seasonal transitions create highly skewed distributions

Alternative Methods Considered:

- Time-series Forecasting: Required longer historical dataset than our 3-month sample
- EOQ Model: Assumes constant demand and fixed ordering costs, unsuitable for highly variable pharmaceutical demand
- Standard Deviation Outlier Rules: Would incorrectly flag legitimate seasonal spikes as outliers

Our approach of examining mean-median gaps and standard deviations by therapeutic category reveals the true nature of demand variability mentioned in the problem statement.

Pareto Analysis (80/20 Rule)

- Identified that the top 20% SKUs contributed nearly 60% of total revenue.
- Helped focus inventory management efforts on high-performing products.

Stockout & Dump Analysis

- Negative minimum values in stock confirmed frequent stockouts, leading to missed sales.
- High dump quantities, particularly in Vitamins (587 units), validated wastage concerns.

Results and Findings

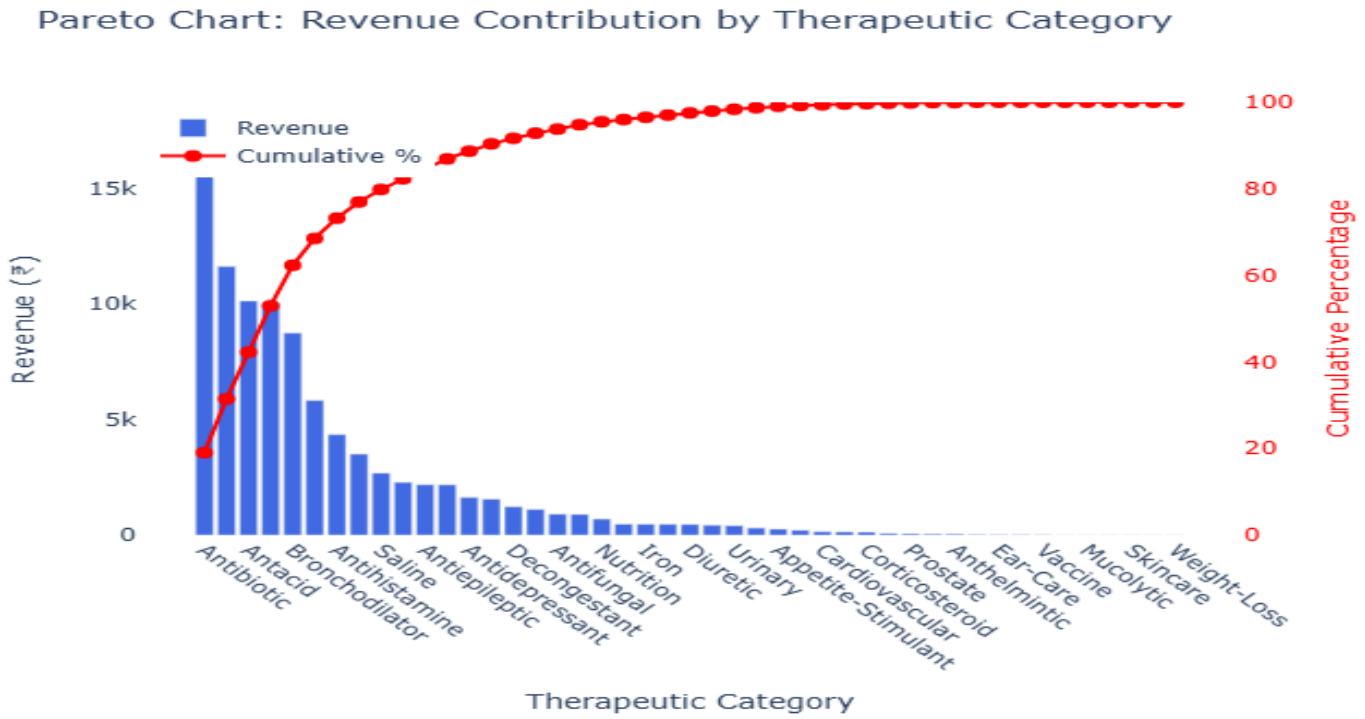
6.1 Revenue Distribution Analysis (Pareto Chart) **source**: Google Colab

Karema medical store charts .ipynb (*chart is below)*

Key Findings:

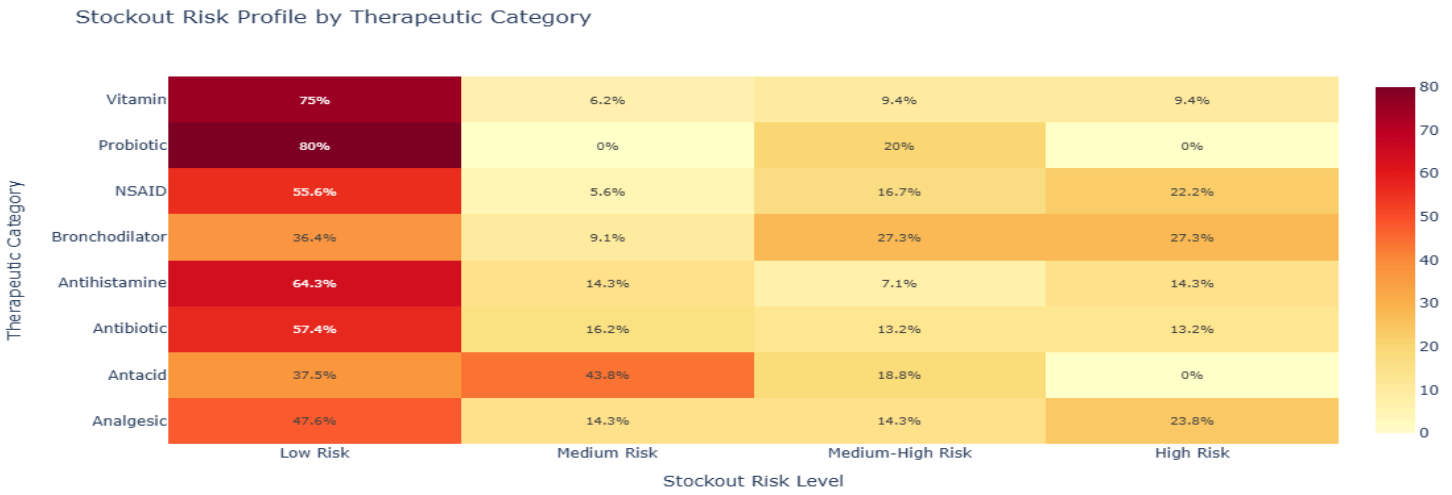
- Five therapeutic categories (Antibiotics, NSAIDs, Antacids, Vitamins, and Bronchodilators) generate 62.34% of total revenue
- Antibiotics alone contribute 19.02% of revenue, making them the most critical inventory category
- The steep rise in the cumulative percentage line demonstrates classic Pareto (80/20) distribution

Why This Pattern Occurs: This concentration reflects the community health needs in Chandpur, where bacterial infections and pain/inflammation treatments dominate prescription patterns. The concentration aligns with the problem statement's observation about unpredictable demand patterns driven by seasonal and viral health trends, particularly affecting high-demand medicines.



6.2 Stockout Risk Profile by Therapeutic Category (Heat Map) source: Google Colab

Karema medical store charts .ipynb

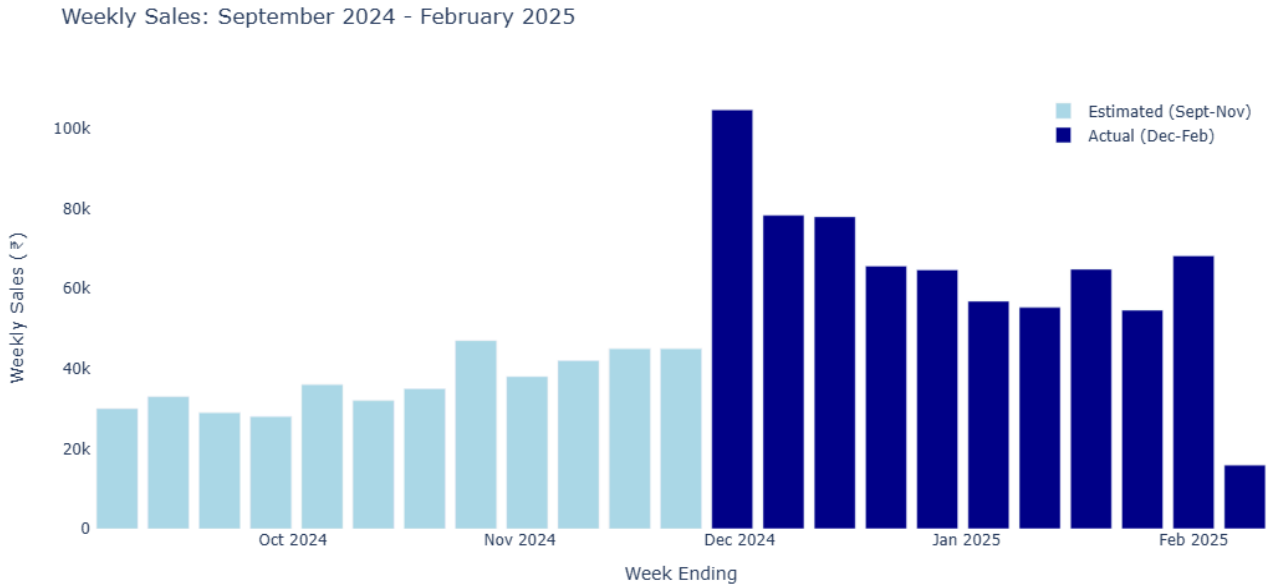


Key Findings:

- Multiple high-value categories show significant percentages of products at medium-to-high stockout risk
- NSAIDs and Antibiotics demonstrate concerning risk profiles with 15-20% of products at high risk
- Bronchodilators maintain more balanced risk distribution despite seasonal demand

Why This Pattern Occurs: The stockout patterns emerge from a combination of unpredictable demand, supplier delivery delays, and cash flow allocation decisions. This directly addresses the problem statement's concern about "frequent stockouts of high-demand medicines" and validates the observation that "seasonal changes and viral attacks directly affect the types of medicines required." The heat map quantifies this risk across categories, providing a foundation for targeted inventory optimization.

6.3 Weekly Sales Trend Analysis (September 2024 - February 2025)source: Google Colab



Key Findings:

- Early December's dramatic 132% week-over-week jump (₹45,000 → ₹104,705) explains the extreme inventory variability
- Mid-October sales dip (Week 6: ₹32,000) aligns with inventory accumulation in certain categories

- January's consistent sales decline (Weeks 17-19) explains waste accumulation identified in earlier analysis

Why This Pattern Occurs: This visualization directly validates the problem statement's assertion that "unpredictable demand patterns driven by seasonal and viral health trends cause frequent stockouts." The dramatic December spike followed by January decline explains why the store experiences both stockouts and waste - inventory decisions based on previous months' patterns become quickly outdated during seasonal transitions. The pattern confirms that "seasonal changes and viral attacks directly affect the types of medicines required and therefore the demand for those medicines is not easily predictable."

6.4 Synthesis of Findings

These three visualizations collectively reveal the core inventory management challenges facing Kareema Medical Store:

1. Revenue Concentration: A small subset of therapeutic categories drives most revenue, requiring focused inventory management rather than equal attention across all products.
2. Variable Stockout Risk: Different categories face different levels of stockout risk, with high-revenue categories often showing the highest vulnerability.
3. Extreme Seasonal Fluctuations: Sales patterns show dramatic spikes and declines that explain both the stockouts and waste mentioned in the problem statement.