Mechanical Engineering Department

ME7194D Project (Part 1)

Inventory Management and Demand Forecasting of Medicines in a Healthcare Centre

UNDER THE GUIDENCE OF PROFESOR R. SRIDHARAN

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Inventory Management and Forecasting Demand of Medicines in a Healthcare Centre

Efficient inventory management and accurate demand forecasting are crucial in healthcare centers to ensure timely availability of medicine and improve patient care.

By Sourabh Ghaghre

Outlines

- Overview
- Research Review
- Problem Statement
- Research Question
- Research Objective
- Research Gap
- Methodology
- References

Importance of Inventory Management in Healthcare

Optimized Supply Chain

Effective inventory management helps healthcare centers **streamline their supply chain, reducing costs and improving efficiency.**

Reduced Wastage

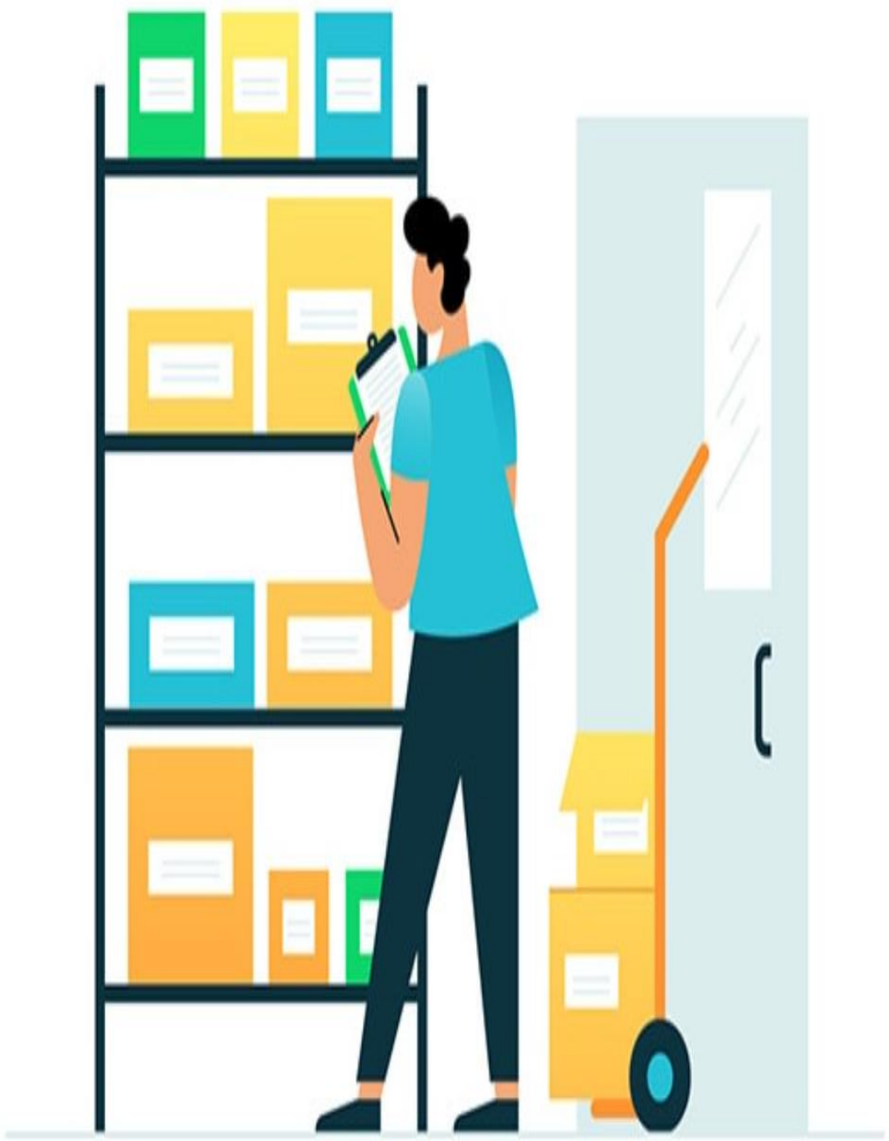
Proper inventory control ensures optimal utilization of medicine, minimizing wastage and **maximizing cost savings**.

Emergency Preparedness

By managing inventory levels, healthcare centers can be **well-prepared for emergencies and unexpected spikes in demand.**

Enhanced Patient Safety

Efficient inventory management safeguards patient safety by ensuring the **availability of critical medications when needed**.



Challenges Faced in Managing Medicine Inventory

1

Expiry Dates

It is important to closely monitor medicine inventory to ensure that patients do not receive expired products.

2

Changing Demand

Fluctuating demand patterns and evolving healthcare needs require adaptability in managing medicine inventory.

3

Supply Chain Complexity

Managing diverse suppliers, ensuring product quality, and maintaining accurate records pose challenges in inventory management.

Benefits of Effective Inventory Management and Demand Forecasting

Reduced Costs

Optimized inventory levels and accurate demand forecasting lead to cost savings through minimized overstocking and wastage.

Improved Patient Care

Efficient inventory management ensures timely availability of medicine, leading to enhanced patient safety and care.

Minimized Stockouts and Overstocking

Proper inventory control prevents stockouts that could disrupt patient treatment and avoids excess inventory storage costs.

Forecasting Demand

1

Methods of Demand Forecasting

Statistical models, expert opinions, and historical data analysis aid in accurate estimation of future medicine demand.

2

Factors Influencing Demand for Medicine in Healthcare

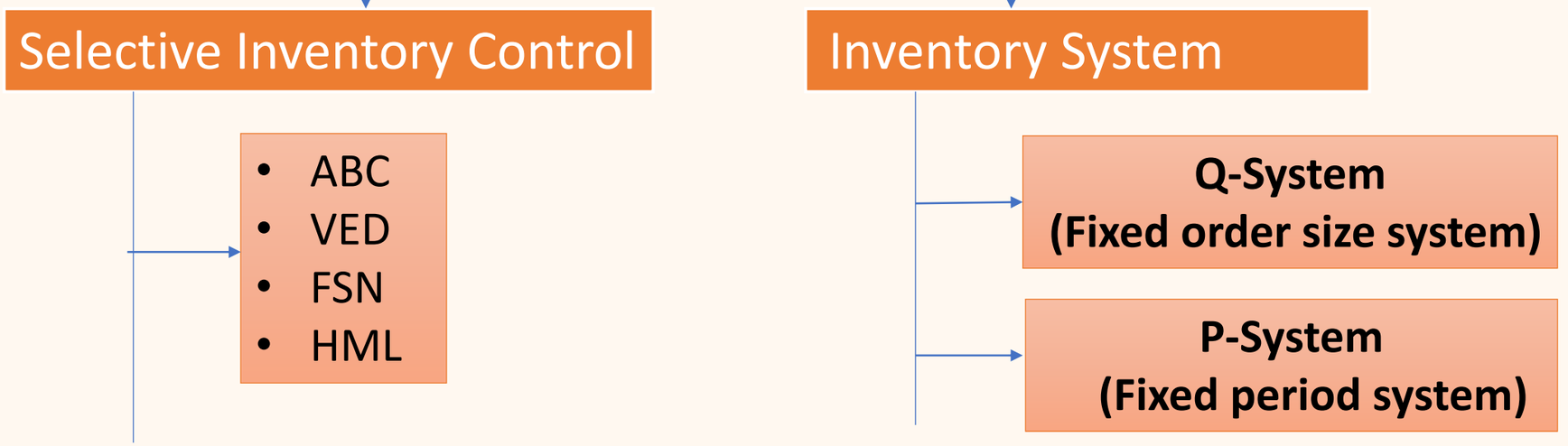
The demand for medicine is influenced by various factors such as demographic shifts, disease prevalence, healthcare policies, and technological advancements.

3

Importance of Accurate Demand Forecasting

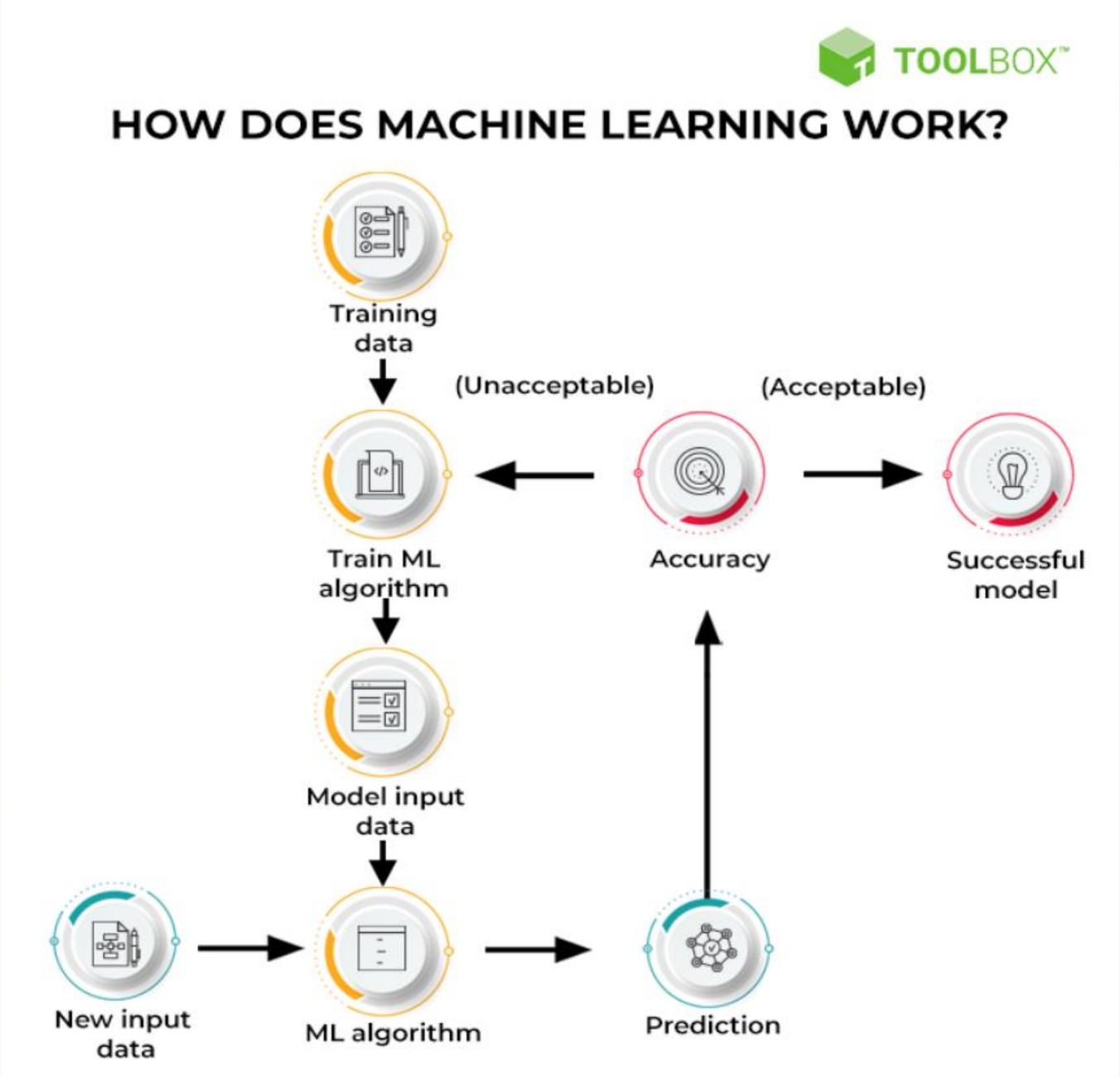
Precise demand forecasting reduces stockouts, wastage, and costs, ensuring optimal medication availability for patient needs.

Methods of Inventory Management



Inventory Management and Forecasting Demand of Medicine in Healthcare Centre by using Machine Learning

The effective management and accurate forecasting of medicine demand are crucial for healthcare centers. **Learn how machine learning can revolutionize this process.**



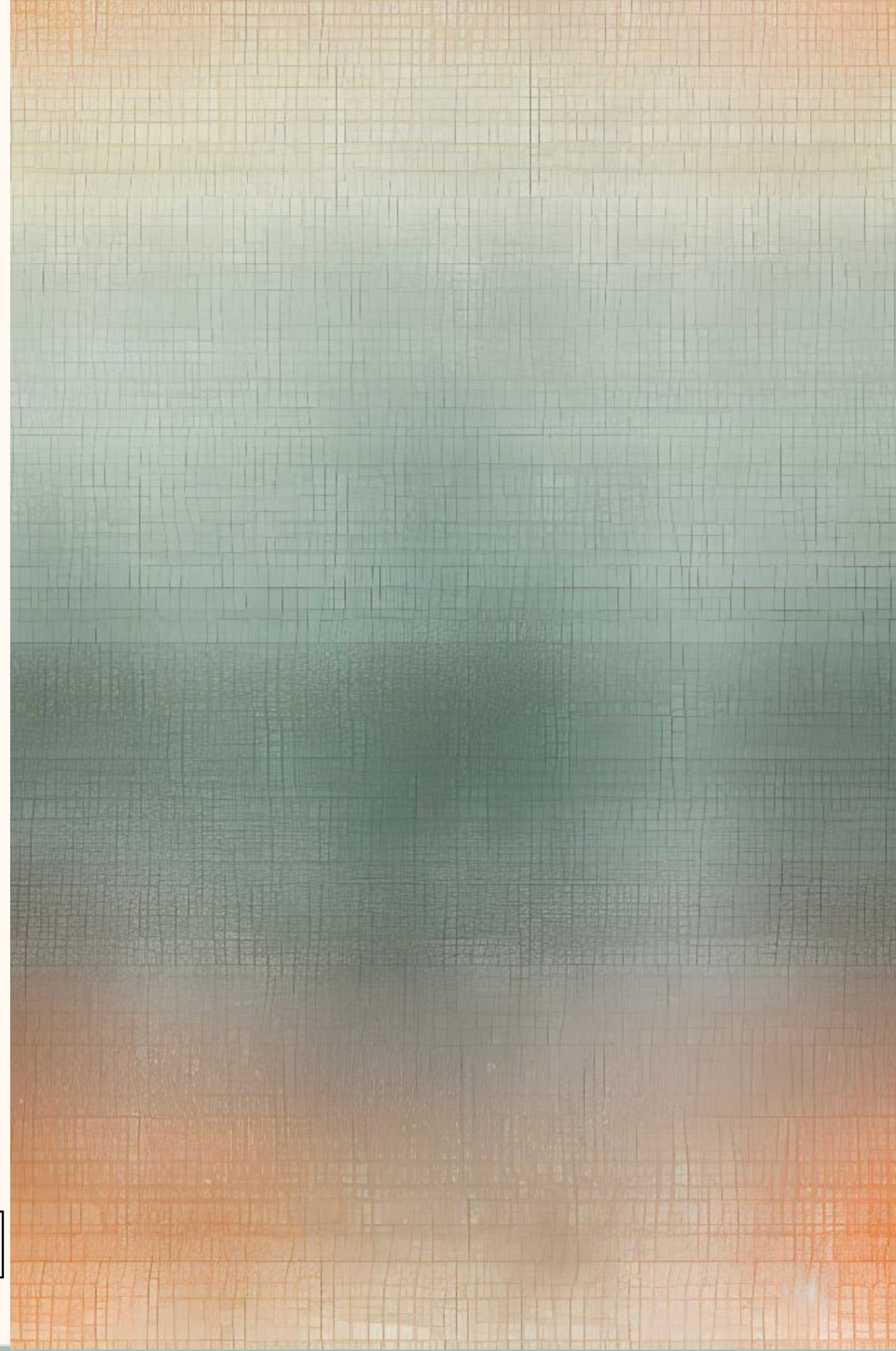
Source https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-ml/

Data Collection and Preprocessing Techniques

Explore the various techniques used for collecting and preprocessing data, including data cleaning, normalization, and feature engineering.

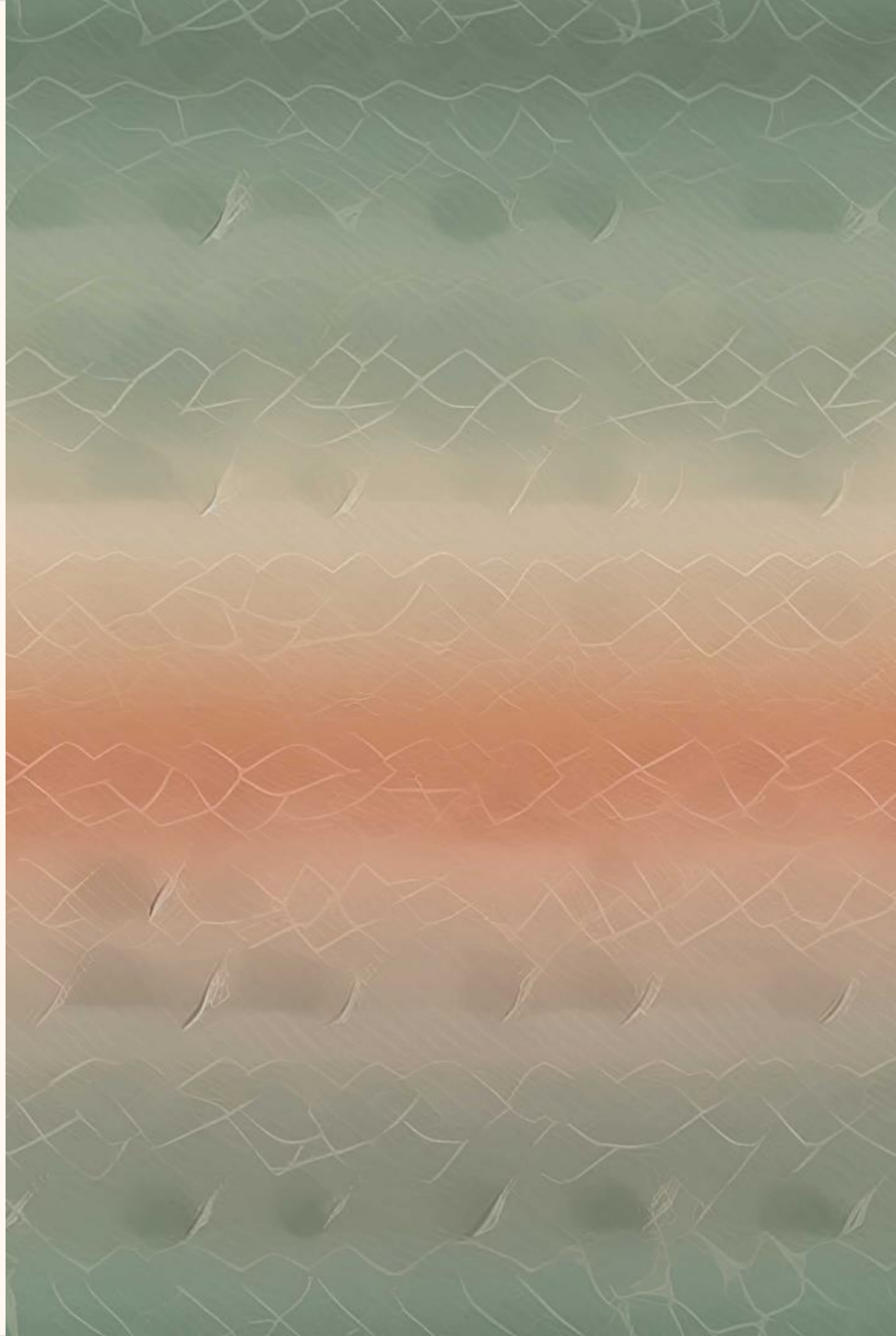
Tentative Machine Learning Algorithms for Inventory Management and Forecasting of Medicine Demand

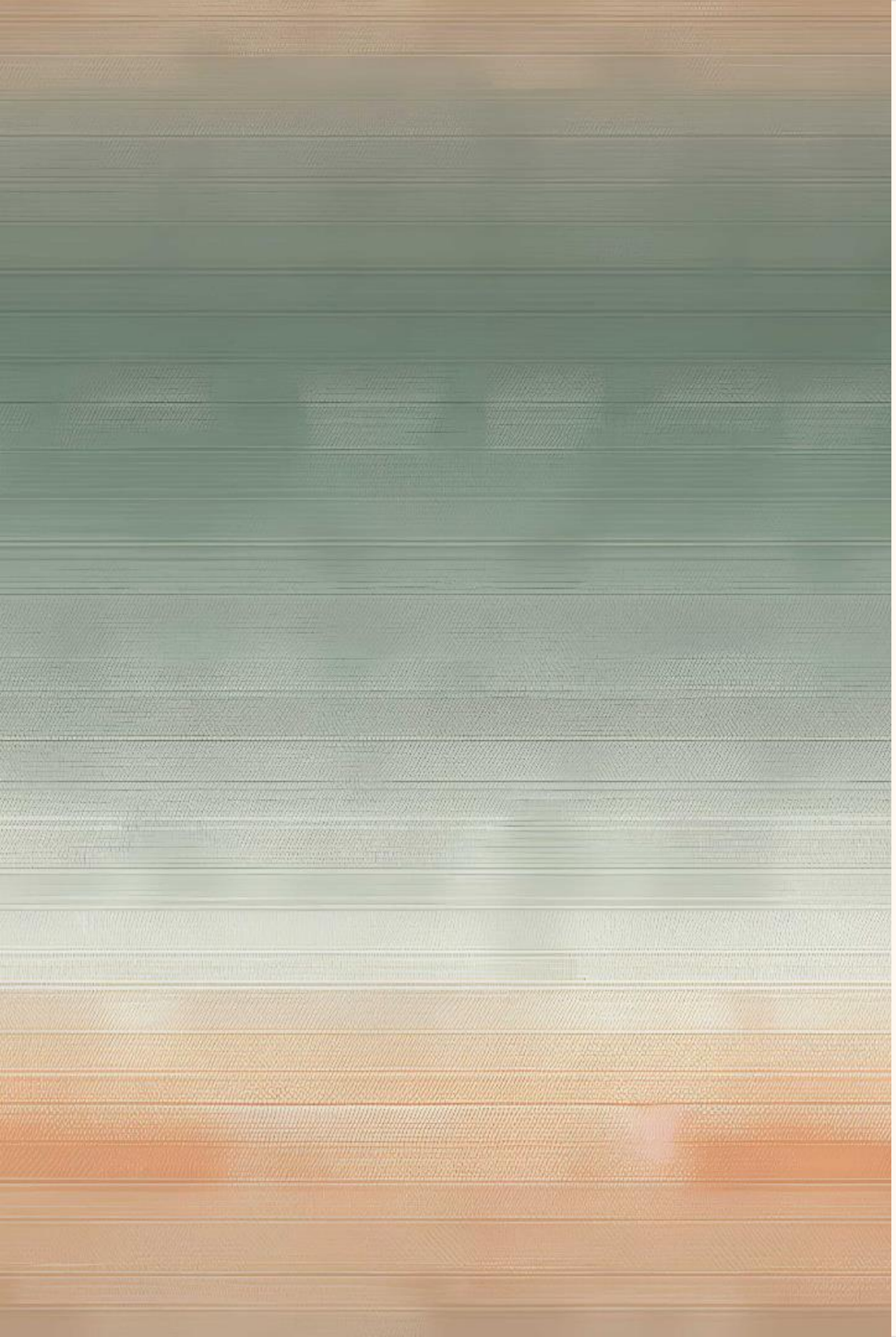
machine learning algorithms used for inventory management and forecasting medicine demand, such as **regression, time series analysis, and neural networks.**



Real-life Application of ML for Medicine Demand Forecasting

Discover real-life applications where machine learning has been successfully implemented to **forecast medicine demand, optimizing inventory and preventing shortages**.



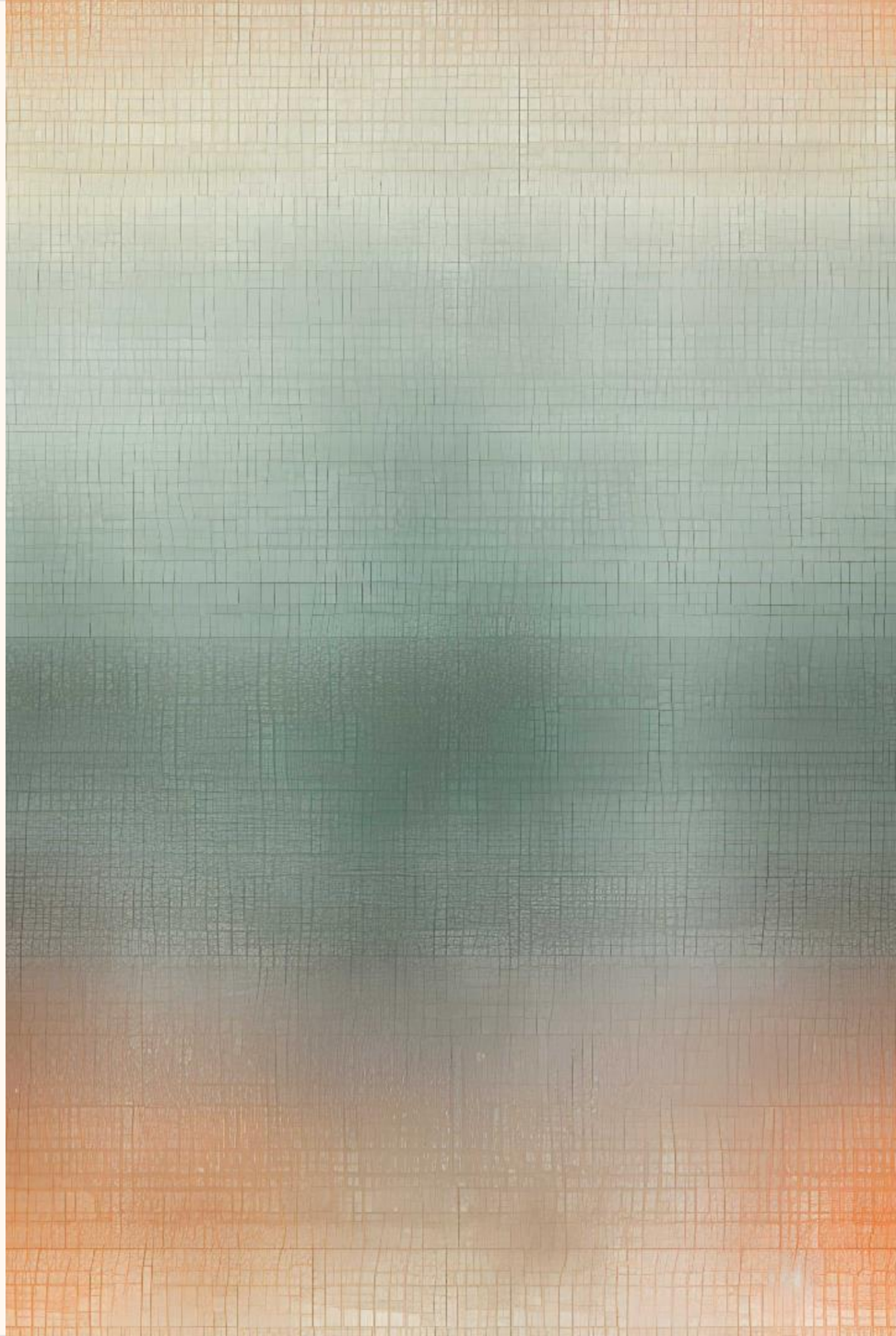


Evaluation Metrics for Model Performance

Learn about the evaluation metrics used to assess the performance of machine learning models in inventory management and medicine demand forecasting, including **RMSE, MAPE, and accuracy**.

Challenges and Limitations in Implementing ML for Inventory Management

Explore the challenges and limitations faced when implementing machine learning for inventory management and medicine demand forecasting**, including data quality, scalability, and interpretability.**



Litreature Review

Literature Review Contd.

Author Name (year)	Title of the work/Journal Name	Objective of work
George et al.(2023)	Inventory Management and Pharmaceutical Supply Chain Performance of Hospital Pharmacies in Bahrain: A Structural Equation Modeling Approach / ***SAGE Open***	To investigate the effect of inventory level control on the pharmaceutical supply chain performance of hospital pharmacies in Bahrain.

Findings from the work

- Structural equation model (SEM) is a statistical modeling technique used .
- Pharmaceutical supply chain performance was improved by using appropriate inventory level control methods such as batch control and stock review and having suitable replenishment decisions such as lead time management.

Gaps identified/Scope for future work

Future research could explore other factors that affect the pharmacy supply chain, such as regulations, physician preferences, price, **technology**, and economic factors.

Literature Review Contd.

Author Name (year)

Ahmadi et al. (2022)

Title of the work/Journal Name

Intelligent inventory management approaches for perishable pharmaceutical products in a healthcare supply chain / ***Computers and Operations Research***

Objective of work

The study aims to develop and assess Intelligent Inventory Management (IIM) approaches for perishable pharmaceutical products in a healthcare supply chain.

Findings from the work

- The demands for the products in the hospitals are assumed to be uncertain. To this end, intelligent inventory management (IIM) approaches are developed by utilizing two reinforcement learning (RL) techniques to find the near-optimal inventory policies for the problem of interest.
- The computational results indicate that the IIM policies outperform periodic review (R,s, S) policies in terms of lower total cost, reduced inventory shortage risk, higher service levels for patients, and lower product expiration risk.

Gaps identified/Scope for future work

Future research may explore extensions to multi-product systems and alternative reinforcement learning techniques.

The terminology used in the above paper

- **Two reinforcement learning techniques** are used specifically **Q-learning (QL) and Deep Q-network (DQN) algorithms.**

- **Policies used-**

1.***R***: Reorder Point:

2.***S***: Order-Up-To Level:

3.***S*:** Order Quantity:

- The policy (R, s, S) dictates that when the inventory level falls to the reorder point (*R*), a new order is placed for an amount (*S*) to bring the inventory level back up to the order-up-to level (*s*). These policies are part of **periodic review systems, where inventory levels are reviewed at fixed intervals, and orders are placed periodically based on the review outcomes**.

- **Multi-product systems** in inventory management research is essential for addressing the complexities inherent in real-world supply chains, optimizing resource allocation, and developing strategies that are applicable across diverse industry settings.

Literature Review Contd.

Author Name (year)	Title of the work/Journal Name	Objective of work
Franco et al. **(2017)**	A Structured Review of Quantitative Models of the Pharmaceutical Supply Chain / ***Complexity***	• The aim of this review is to identify and provide a structured overview of quantitative models in the pharmaceutical supply chain. • The researchers reviewed 46 papers

Findings from the work	Gaps identified/Scope for future work
• The review identifies three major research topics: network design, hospital inventories, and optimization of pharmaceutical supply chain networks. • "The challenges faced by pharmacies include lack of inventory control, excess inventory levels, frequent stock outages, costly emergency deliveries, increased labor requirements, workflow interruptions, expensive work, and missed contract compliance,".	• The review suggests that future research should include uncertainty aspects and consider real pharmaceutical supply chains. • Future research on this topic should focus on coordinating various medicines and developing powerful algorithms to handle a large number of items.

Literature Review Contd.

Author Name (year)	Title of the work/Journal Name	Objective of work
Zwaida et al.(2021)	Optimization of Inventory Management to Prevent Drug Shortages in the Hospital Supply Chain / ***Applied Sciences***	To mitigate the risk of shortages and ensure sustainable operations, the study aims to develop an efficient inventory management solution for the Hospital Supply Chain (HSC).

Findings from the work

- The application of deep reinforcement learning optimally determines drug refill quantities in each timeslot.

Literature Review Contd.

Author Name(year)

Oliveira et al (2021)

Title of the work/Journal Name

Lead Time Forecasting with Machine Learning Techniques for a Pharmaceutical Supply Chain/***23rd International Conference on Enterprise Information Systems (ICEIS 2021)***

Objective of work

Utilizing machine learning regression algorithms for Forecasting purchasing lead times.

Findings from the work

- Compared support vector machines, random forests, linear regression, and k-nearest neighbors on a very large collection of examples provided by a large company with headquarters in Italy.
- SVM is giving good results among.

Gaps identified/Scope for future work

Adopt Deep learning and neural networks for future work on complex and nonlinear data.

Literature Review Contd.

Author Name (year)

Kelle et al.(**2018**)

Title of the work/Journal Name

Pharmaceutical supply chain specifics and inventory solutions for a hospital case / ***Operations Research for Health Care***

Objective of work

Analyzing current managerial approaches, exploring stakeholder goals, and focusing on operational decisions while optimizing allocation policies and providing tactical decision support tools for enhanced management practices.

Findings from the work

- Operational decisions were optimized using reorder point and order up to levels based on an allocation policy, reducing emergency and daily refilling workload.
- The research illustrated relationships between these tradeoffs and key performance indicators at a local care unit.

Gaps identified/Scope for future work

- Investigate the correlation between items in the inventory.
- Provide quantitative support for negotiations between pharmacy administrators and medical doctors, analyzing the cost vs. product variety tradeoff.

The terminology used in the above paper

"**cost vs. product variety tradeoff**" involves finding the right balance between offering a diverse range of products to meet customer needs and keeping operational costs at an optimal level. It's a strategic decision-making process that aims to maximize customer satisfaction and profitability while minimizing unnecessary expenses.

Literature Review Contd.

Author Name (year)

Uthayakumar et al. **(2013)**

Title of the work/Journal Name

Pharmaceutical supply chain and inventory management strategies: Optimization for a pharmaceutical company and a hospital / ***Operations Research for Health Care***

Objective of work

The aim is to achieve the specified hospital customer service level (CSL) target while minimizing the overall cost of the supply chain.

Findings from the work

- used a Lagrangian multiplier algorithmic approach to determine the optimal lot size, lead time, and total number of deliveries from a pharmaceutical company to a hospital in a production cycle.
- The study improves current inventory management policy in health care and offers managerial support via the decision support tool developed.

Gaps identified/Scope for future work

Hospitals would like to avoid these emergency orders if possible because they are very costly.

Problem Statement

In the healthcare sector, effective inventory management and accurate demand forecasting for medicines are critical components that directly impact patient care, operational efficiency, and financial sustainability. The current state of affairs within our healthcare center reveals several challenges that demand immediate attention and interventions. It is proposed to apply selective inventory control techniques for determining appropriate inventory policies. Further, a predictive model can be built to determine medicine demand based on disease occurrence.

Research Questions

- How to classify the medicines using selective inventory control techniques?
- Which Machine Learning algorithm is best for demand prediction?
- What is the precision of the prediction model?

Research Objectives

- To improve medicine inventory management using inventory control policies.
- To forecast the demand for medicines based on disease occurrence by applying machine learning algorithms.
- To identify the best machine learning algorithms.

Research Gap

- There are fewer research studies available on the forecasting of medicine demand in healthcare organizations.
- The literature reports only a few studies that have explored the application of supervised, unsupervised machine learning algorithms, and time series algorithms in the context of medicine demand forecasting.

Methodology:

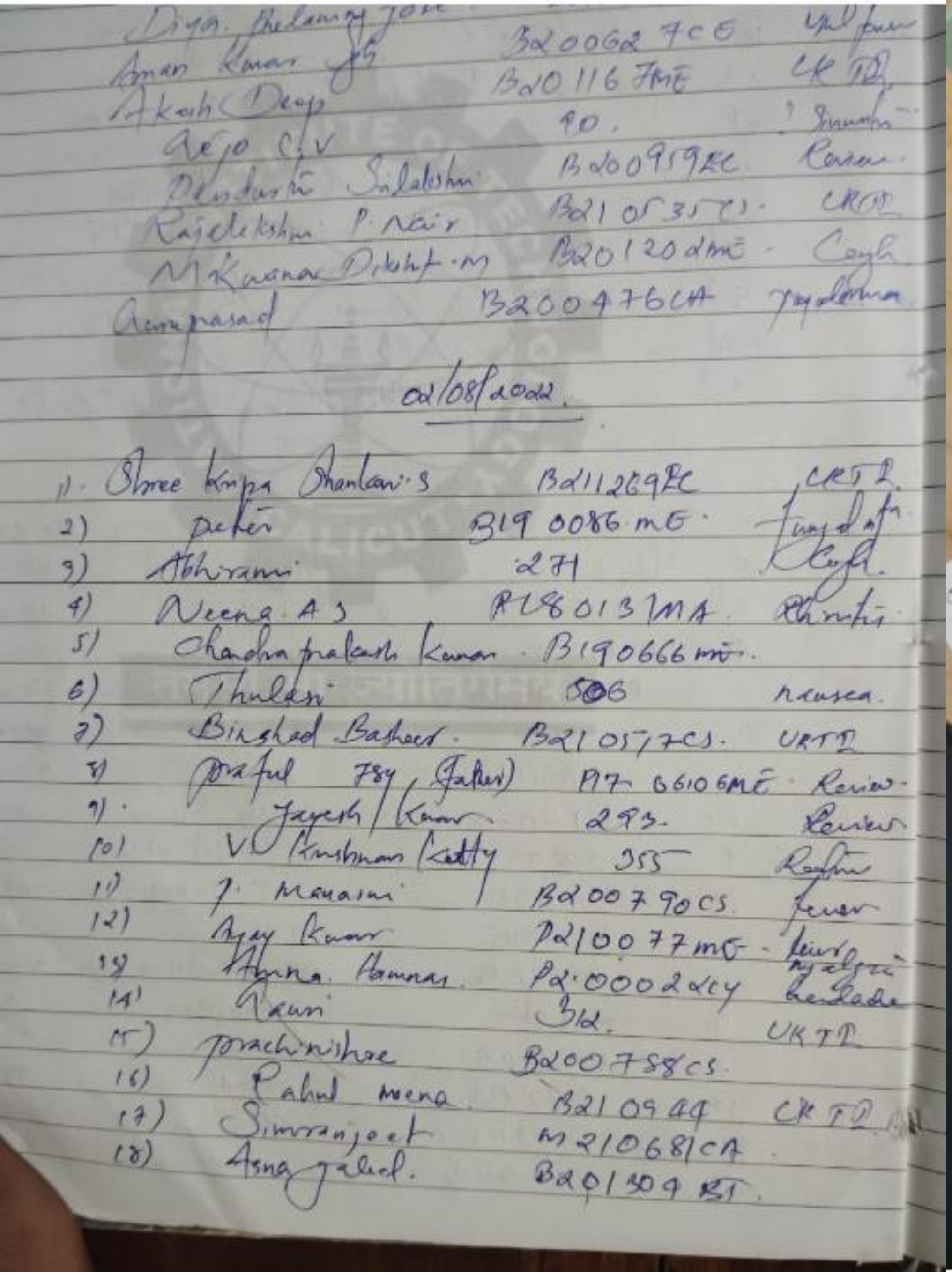
1. **Data Collection**: Gather historical data on sales, inventory levels, and other relevant factors.
2. **Data Preprocessing**: Clean and preprocess the data, handling missing values and outliers.
3. **Feature Engineering**: Extract relevant features from the data, such as seasonality, trends, and promotional events.
4. **Model Selection**: Choose appropriate machine learning models, such as time series, unsupervised machine learning or ANN.
5. **Model Training**: Train the selected model using the prepared dataset.
6. **Model Evaluation**: Assess the performance of the model using evaluation metrics like RMSE or MAE.
7. **Forecasting:** Use the trained model to predict future demand and optimize inventory levels.
8. **Monitoring and Refinement**: Continuously monitor the model's performance and refine it as needed.

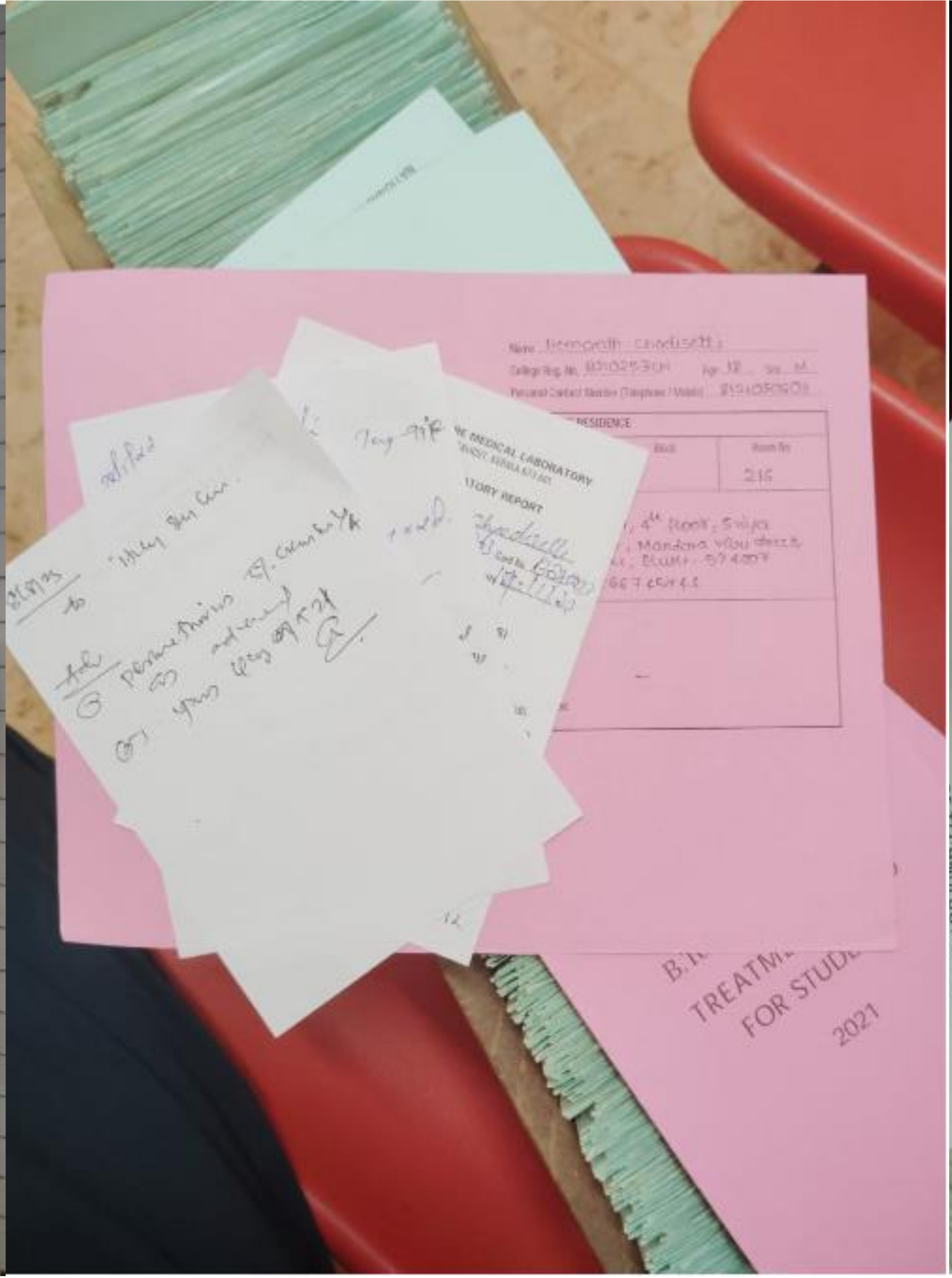
DATA COLLECTION

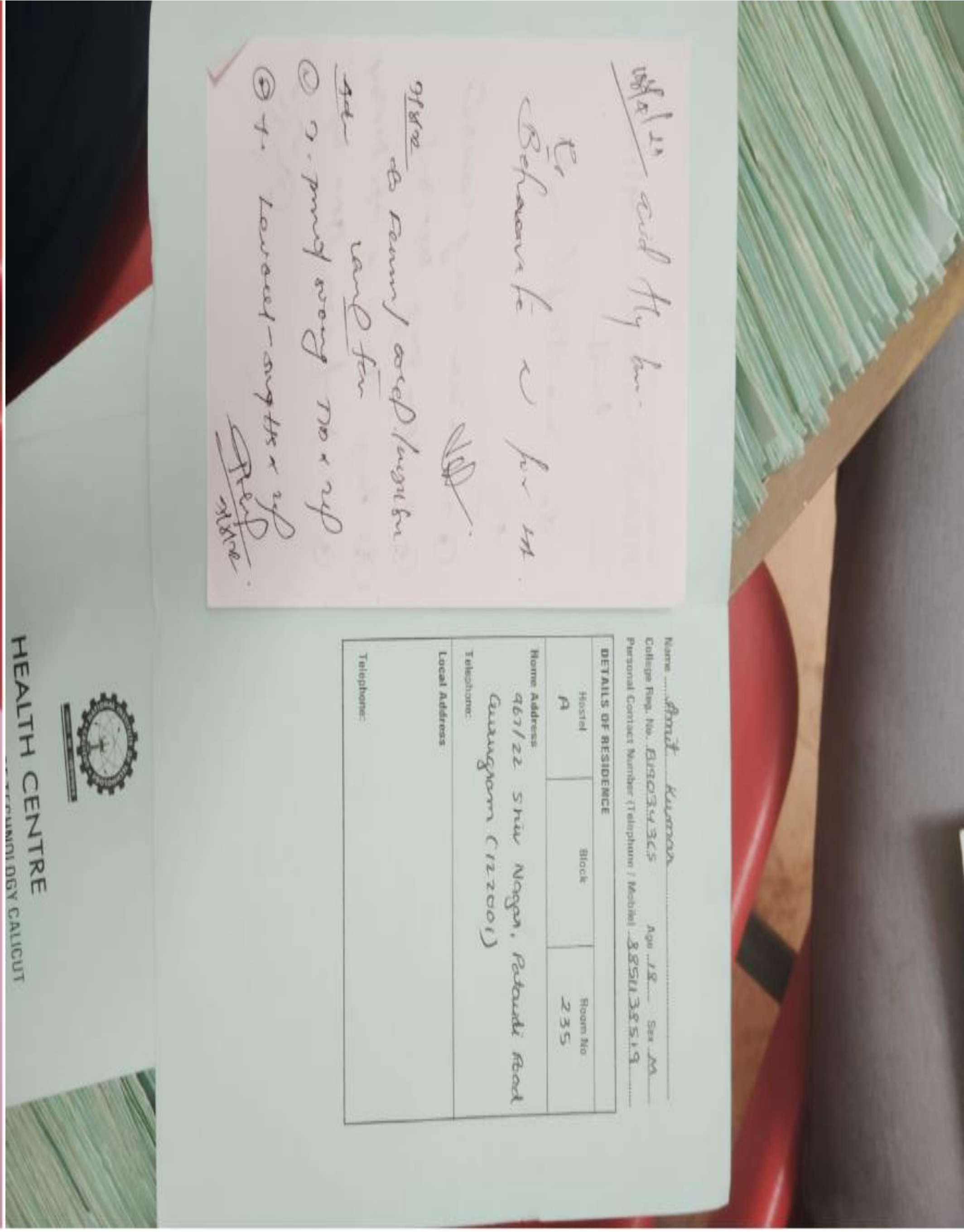
NITC HEALTHCARE CENTRE

DATA VARIABLES

S.NO	VARIABLES	EXAMPLE
1	Roll No.	B200214,M220214,P17215
2	Gender	Male, Female
3	Date	01/08/2022
4	Age	19, 20, 25
5	Diagnosis	Viral Fever, cough, cold, Headache, Upper Respiratory Tract infection, Refer KMCT
6	Medicine Prescribed	Paracetomal, citrazin, Levofloxcin
7	Quantity of Medicine	3*2, 3*1, 3*2







Hospital records photos

Excel Sheet of My Work

ENROLLME	Symptor	DATE	SEX	MP1	QUANTI	MP2	QUANTITY	MP3
B200420	URI	01-08-2022	M	DOLO 650	6	LEVOCET	2	AZEE 500
B201041	VIRAL FEVE	01-08-2022	F	PARACETA	6	LEVOCET	2	
B200205	VIRAL FEVE	01-08-2022	M	DOLO 650	6	LEVOCET	2	
B200515	URI/P	01-08-2022	F	PARACETA	6	MONTEE L	3	AZEE 500
B200395	SINUS	01-08-2022						
B200627	VIRAL FEVE	01-08-2022		DOLO 650	6	LEVOCET	3	
B201167	NA	01-08-2022		NA	NA	NA	NA	NA
B200959	REVIEW/A(	01-08-2022		R	R	R	R	R
B201202	COUGH	01-08-2022						
B200476	REFER DER	01-08-2022		R	R	R	R	R
B200790	FEVER	02-08-2022	F	PARACETA	6	MOX 500	9	
B200788	FOOT PAIN	02-08-2022	F	DOLO 650	9	MOXILAV5	6	
B201304	URI	02-08-2022	M	DOLO 650	9	LEVOCET	3	AZEE 500
B201160	NA	02-08-2022		NA				
B200502	COLD/COU	02-08-2022	M	MONTEE L	2	SYRUP PIR	1	
B200168	SKIN INFEC	02-08-2022	M	CANDID CR	1	LEVOCET	3	
B200365	VIRAL FEVE	03-08-2022	M	PARACETA	6	MOTEE LC	2	
B200270	WOUND D	03-08-2022	F	BETADIN	1	PANTOP D	3	
B200211		03-08-2022	M	ASCORYL S	1	LEVOCET	2	
B201240	VIRAL FEVE	03-08-2022	M	PARACETA	6	LEVOCET P	2	PANTOP D
B200857	URI	04-08-2022	M	DOLO 650	6	MOX 500	9	LEVOCET
B200953	FEVER/COI	04-08-2022	F	DOLO 650	9	LEVOCET	3	
B201179	LEG PAIN	05-08-2022	M	ZERODOL	6	PANTOP D	3	
B200215		05-08-2022						
B200018	WOUND D	05-08-2022						
B200698		05-08-2022						
B200922	EYE PAIN	05-08-2022	M	CIPLOX EYE	1	LEVOCET	2	
B200959	COUGH	05-08-2022						
B200398		06-08-2022						
B200870	COUGH	06-08-2022	F					
B201318	LOOSE MO	06-08-2022	M	ENUFF	6	OME D	3	LEVOCET
B200717	COUGH	06-08-2022						
B201318	LOOSE MO	07-08-2022		REVIEW				
B200222	URI	07-08-2022						
B200475	SKIN DISEA	07-08-2022						
B200273	URI	10-08-2022						
B201029	URI	10-08-2022	M	PARACETA	6	MOX 500	6	LEVOCET
B200012	LEG PAIN	10-08-2022						
B200874	COUGH	10-08-2022	F	LEVOCET	3	ASCORYL S	1	
B200920	COUGH	10-08-2022						
B200030	FEVER/COI	10-08-2022						
B200755	VIRAL FEVE	11-08-2022						
B200028	VIRAL FEVE	11-08-2022						

Vision

Our vision is to ensure efficient inventory management and accurate demand forecasting of medicine in healthcare centre.

Mission

Our mission is to provide healthcare centre with reliable inventory management solutions and demand forecasting techniques to optimize medicine availability.

Goal

Our goal is to minimize medicine stockouts and overstocking, ensuring timely availability of medicines while reducing wastage and costs.

Strategy

We will achieve our goals by implementing advanced inventory management systems, leveraging data analytics and forecasting models and collaborating closely with healthcare centre to understand their specific needs.

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During the healthcare supply chain class, my guide referenced a specific sloka that I would like to review.

“ॐ सर्वे भवन्तु सुखिनः।”	"May all be happy."
"सर्वे सन्तु निरामयाः ।"	"May all be free from illness."
"सर्वे भद्राणि पश्यन्तु ।"	"May all see auspiciousness."
"मा कश्चित् दुःख भाग्भवेत्॥“	"May none suffer."
"ॐ शान्तिः शान्तिः शान्तिः॥"	"Om, peace, peace, peace."

“Every new thing creates two new questions and two new opportunities’’

Jeff Bezos, Founder Of Amazon

THANK YOU

Methods of Inventory Management

1

Just-in-Time (JIT)

Using JIT approach minimizes storage costs and inventory levels by receiving medicine exactly when needed for patient care.

2

Economic Order Quantity (EOQ)

EOQ calculates the optimal order size, considering holding costs and ordering costs, to balance inventory investment.

3

ABC Analysis

Classifying inventory items based on their value and criticality helps prioritize control efforts and optimize stock levels.