MEDICAL SUPPLY CHAIN MANAGEMENT SYSTEM

CASE STUDY: PEOPLE›S MEDICAL STORE FREETOWN

BY

MOHAMED I. SANKOH **FODAY SAMUEL KANU** **FATMATA SESAY**

1920015 **1920080** **1920200**

Dissertation Submitted to

CENTRAL UNIVERSITY

DEPARTMENT OF COMPUTER SCIENCE AND BUSINESS INFORMATION TECHNOLOGY

In partial fulfilment of the requirement

For the award of Degree of

BACHELOR OF SCIENCE HONS IN COMPUTER SCIENCE AND BUSINESS INFORMATION TECHNOLOGY

SUPERVISOR

MR. DAVID SAPUNKA

13TH JANUARY, 2024

ACKNOWLEDGMENT

In the name of Allah, the Most Gracious, the Most Merciful.

We express our deepest gratitude to the Almighty Allah, who bestowed upon us the strength, wisdom, and perseverance to navigate through the challenges encountered during the development of this project. His guidance has been our constant source of inspiration and support.

We would like to extend our heartfelt thanks to our parents, friends, and the entire family for their unwavering encouragement, understanding, and continuous support throughout the course of this project. Their confidence in us has been our main motivator and has helped us finish successfully.

Special appreciation goes to our supervisor, Mr. David Sapunka, for his invaluable guidance, mentorship, and insightful feedback. His expertise and dedication played a pivotal role in shaping the project and enhancing its quality.

We also acknowledge the Head of Department, Mr. Isaac Muckson Sesay, for his leadership and support. Our gratitude extends to the entire staff at Central University, particularly the Technical Science Department, for their encouragement, assistance, and guidance.

This project would not have been possible without the collective effort, encouragement, and support from these individuals and entities. We are sincerely thankful for their contributions to our academic journey.

DECLARATION

We, the undersigned members of the group, hereby declare that the project entitled "Medical Supply Management System," submitted in partial fulfillment of the requirements for the award of a Bachelor's degree in Computer Science and Business Information Technology at Central University, has been developed by us as a group and has not been submitted for any other degree or qualification.

We affirm that this project represents our own work, and all contributions from external sources have been properly acknowledged and cited. Any ideas, text, or work of others that have been incorporated into this project are appropriately referenced.

Furthermore, we acknowledge that this project has not been previously submitted and approved for the award of a Bachelor's degree or any other qualification at this or any other university.

By signing below, we confirm our understanding of the academic integrity policies and regulations of Central University and affirm the originality and authenticity of this group project.

Group Members	**Signature**	**Date**
Mohamed I. Sankoh:	……………………….	………………….
Foday Samuel Kanu:	……………..………….	…………………
Fatmata Sesay:	…………………………	………………….

APPROVAL

Supervisor's Name	**Signature**	**Date**
Mr. David Sapunka	……………………….	…………………..

LIST OF ACRONYMS

MSMS: Medical Supply Management System

EHR: Electronic Health Record

SOP: Standard Operating Procedure

MoHS: Ministry of Health and Sanitation

Usaid: United States Agency for International Development

MSCMS: Medical Supply Chain Management System

COVID-19: Coronavirus Disease 2019

SCM: Supply Chain Management

WHO: World Health Organization

AI: Artificial Intelligence

PSC: Pharmaceutical Supply Chain

HIPAA: Health Insurance Portability and Accountability Act

IoT: Internet of Things

HIT: Health Information Technology

HIMSS: Healthcare Information and Management Systems Society

SRS: Software Requirements Specification

UI: User Interface

HTTP: Hypertext Transfer Protocol

HTTPS: Hypertext Transfer Protocol Secure

HTML: HyperText Markup Language **CSS:** Cascading Style Sheets

RAM: Random Access Memory

ERD: Entity-Relationship Diagram

VS Code: Visual Studio Code

IDE: Integrated Development Environment

ABSTRACT

The efficient flow of goods and services in a firm is critical to getting products and services to customers. As a result, management must create and execute well-structured supply chain management procedures and functions through efficient coordination and activity organization in order to maximize corporate operations.

This research work addresses the critical need for an innovative solution in the healthcare sector through the development and implementation of a web-based Medical Supply Chain Management System (MSCMS) with specific to the People's Medical Store in Freetown, Sierra Leone. It enables a real-time inventory tracking, and the optimization of supply chain management system processes, and also enhances overall healthcare operations.

The research utilized various techniques like interviews, observation, focus groups, and document sampling, along with an incremental software development approach, to adapt to the changing needs of the healthcare industry. This resulted in a conceptual framework with business analytics arrangement, enhancing service delivery and meeting the software development perspective as describe early in the project development stage. In this study, the researchers focus solely on the protocols and processes involved in the medical supply chain management, as well as their alignment with the ecological sustainability viewpoint. Hence, it recommends further research to strive in combing cutting-edge technology to enable the full actualization of artificial intelligence's capacity, which will result to a paradigm shift in medical supply operational activities and functions.

Supply Chain Management Corporate Operations Innovation in Healthcare

Optimization of Processes

Incremental Software Development

Service Delivery Enhancement

Software Development Perspective

Ecological Sustainability

Artificial Intelligence (AI)

Incremental Software Development Approach

Capacity of Artificial Intelligence

Operational Activities

TABLE OF CONTENTS

CHAPTER THREE
System Design Specifications

CHAPTER FOUR
System Analysis and Design

CHAPTER FIVE
System Implementation and Testing

CHAPTER SIX
Conclusion, Lessons Learnt
and Recommendations for Future Enhancement

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE
Introduction

Chapter Summary

This chapter provides an introduction to the dissertation on the Medical Supply Management System (MSMS). It outlines the background, justifies the study by highlighting the challenges in traditional medical store management, and presents the research study aims, objectives, and research questions. It also acknowledges the study limitations, scope and defines key terms.

Finally, it outlines the structure of the dissertation, with chapter demarcations that guide the reader through the forthcoming comprehensive exploration of Medical Supply Management System development, implementation, and evaluation in the context of healthcare settings.

1.0. Background of the Study

In the fast-paced world of healthcare, medical supply management plays a critical role in ensuring the seamless availability and distribution of essential medications and medical supplies through the use of a robust information system management function an operation. With effective and efficient management of inventory and supply chain processes, patient care logistic and services delivery is enhance resulting to reduce medical error and also the optimization of cost.

Medical supply management involves the procurement, storage, distribution, and utilization of essential medical resources, such as pharmaceuticals, surgical instruments, and medical equipment. The proper functioning of a healthcare system heavily relies on an efficient and reliable supply chain for these critical items.

The impact of poor medical supply management can be a crucial challenge in healthcare management and service delivery operation. Shortages of critical medical supplies can compromise patient care, increase healthcare costs, and even lead to adverse patient outcomes (Carenzo et al., 2020; Stergachis et al., 2020). As such, the effective management of medical supplies has gained increasing attention from healthcare administrators, policy makers, and researchers. Hence, call for the need for researchers, policy makers, and administrators to examine, develop suitable polices, to be implemented by administrators to better enhance healthcare giving operation.

However, many medical stores still rely on manual and the desktop computer base systems, leading to challenges such as stock outs, overstocking, supply chain inefficiencies, and compromised patient safety. The manual system, which involves maintaining records on paper and using basic spreadsheets, has a considerable amount of draw backs such as; time-consumption, prone to errors, and security false to name but few. Besides, the issue of data accusation, real-time processing, accessibility and availability hinders the store's ability to make informed business decisions and respond promptly to changing market demands.

The effective management of medical stores is paramount in the healthcare industry. The Peoples Medical Store which is one among the leading pharmaceutical enterprise in Sierra Leone is not an exception to that.

In that respect, this research work is quest to develop and deploy a web base medical supply management system in order to provide real-time inventory tracking, to reduce challenges in the accusation, processing and delivery of service so as to maintain accurate stock levels within People Medical store.

1.1 Justification of the Study

The People medical store is faced with the challenge of generating, processing, stocking and delivery of product, because of inadequate management of stock record such as stock overflow, shortages, expire medication, resulting to financial losses.

Initially the enterprise uses the traditional base information system management procedures in tracking records and delivery. This approach was time consuming erroneous an exposes to a number of security issues and other related challenges, such as inconsistency and data integrity. The management is currently utilizing a desktop base approach with the use of excel in managing the enterprise records but however they seem not be adequate enough.

In that respect the researchers have intended to develop and deploy a fully automated medical supply management system towards addressing the problem.

1.2. Study Aim

The aim of this project is to develop and deploy a comprehensive medical supply management system, to address the challenges and inefficiencies faced by traditional manual systems in managing medical stores. The system will aim at streamline and optimize various aspects of the store's operations, to provide real-time visibility into stock levels, helping track stock outs and overstock situations to enhanced product management, increase data accuracy and security.

1.3. Objectives

I. To investigate the management procedures, use in medical supply chain management system.

II. To examine the effect of inventory management, regulatory compliance, patient safety, and data security within the medical supply chain management system.

III. To identify possible insight for successful design, development and implementation of medical supply chain management system architecture.

1.4. Scope of the Study

The scope of this research work focus on the design development and implementation of a web base medical supply chain management system at the Peoples medical store in Freetown Sierra Leone.

This study gives premium attention to it Medical Supply Management System structure operation and procedure which encompass the automation of inventory control, tracking medication quantities, expiration dates, and restock alerts seeking to optimize stock levels and provide insight for stock overflow and under stocking. It also covers bill generation and payment processing, insurance claims, and managing financial transactions related to medications and healthcare products through a web base approach in ensure user friendly data exchange and interoperability.

1.5. Study Limitations

While conducting this research on the Medical Supply Management System, several limitations were encountered that impacted the research process and outcomes. One of the significant constraints was related to financial resources. The costs associated with printing essential documents and transportation for visiting supervisors posed challenges. Limited funding affected the ability to conduct extensive field visits and collect in-depth data, potentially limiting the comprehensiveness of the study.

Time constraints also played a pivotal role in shaping the research scope and depth. Balancing the demands of developing the Medical Supply Management System while concurrently working on the dissertation presented a challenge. The time allocated for research activities was limited, impacting the depth of analysis and exploration possible within the study. This constraint potentially restricted the comprehensive understanding of certain aspects of the Medical Supply Management System, which could have been further explored given more time.

Furthermore, internet access emerged as a significant limitation. Limited or unreliable internet connectivity hindered the researchers' ability to access up-to-date literature, online databases, and research materials critical for conducting a thorough literature review. This constraint restricted the breadth and depth of the literature reviewed, potentially influencing the context in which the Medical Supply Management System was explored.

1.7. Chapter Demarcations

Chapter 2: Literature Review: A comprehensive review of relevant literature on medical store management, information technology in healthcare, and related topics.

Chapter 3: System Methodology: Details on the research design, data collection methods, and data analysis techniques used in this study.

Chapter 4: System Analysis and Design: A description of the design and development of the Medical Store Management System (MSMS).

Chapter 5: System Implementation and Testing: Focuses on the practical execution of the designed Medical Supply Management System, encompassing the deployment of software, hardware, and comprehensive testing procedures to ensure functionality, reliability, and adherence to user requirements.

Chapter 6: Conclusion and Future Directions: Summarizes the study, provides conclusions, and outlines potential areas for future research.

Appendices: Supporting materials, such as images of the system, code and technical documents.

References: A comprehensive list of references used throughout the dissertation.

CHAPTER TWO
Literature Review

Chapter Summary

This chapter draws attention to the existing state of the art literature material on medical supply chain management processes and procedures. It aims at providing a comprehensive understanding and broaden the researchers understanding within the study domain.

This chapter is stratified into three facet to keep the researchers in line with the study hypothesis. These include procedures in medical supply chain systems, the effect of inventory management in medical supply system and the possible insight for successful design, development and implementation of medical supply chain architecture.

Lastly, the study provides a conceptual framework of a web-based medical supply chain management system.

2.0. Introduction

Medical supply management in the healthcare industry is a complicated and vital activity that has a direct influence on patient care, operational efficiency, and overall healthcare results. The medical supply chain system's growth is deeply intertwined into the fabric of healthcare delivery, illustrating a path from manual inventory management to highly complex, technology-driven procedures. This study of the literature provides an in-depth examination of the historical history, present condition, and future tendencies of medical supply chain systems, providing light on the important aspects influencing their design, development, and implementation.

Medical supply chain management has its origins in a period when manual methods predominated. In the 1960s and 1970s, healthcare institutions depended on paper-based inventory control systems, ordering supplies the old-fashioned way. The development of computerized systems in the 1980s heralded a new era of efficiency and precision in medical supply management in the following decades (Kros and Brown, 2016). They further mentioned that the integration of supply chain management into larger Enterprise Resource Planning systems in the late 1990s and early 2000s constituted a watershed moment. This integration aimed to simplify operations across several healthcare divisions in order to develop a more unified and integrated approach to resource management. In the 2000s, advanced technologies, notably Radio-Frequency Identification, rose to prominence, enabling real-time tracking and laying the groundwork for improved visibility and data-driven decisionmaking.

Medical supply chain systems have grown into sophisticated ecosystems typified by interoperability, cloud-based solutions, and powerful data analytics in the modern day. Integration with Electronic Health Records (EHR) and other healthcare systems is now required, allowing for a more smooth flow of information and a more patient-centric supply chain. Scalability is provided by cloud-based infrastructures, allowing healthcare businesses to effectively respond to changing needs (Prashant, 2021).

Sierra Leone's healthcare supply chain has been operating its logistics management of health commodities using the 2010 version of SOP Manual Logistics Management of Health Commodities. The Ministry of Health and Sanitation (MoHS) has adopted different structures, technologies, and tools to improve the logistics system. However, some of the roles and responsibilities of the various players coordinating these structures, technologies, and tools to make a meaningful change in the logistics system were obsolete and not structured. Hence, supply chain activities over the years were done mainly on an ad hoc basis, while very few were done in an organized manner. Over time, several assessments conducted, identified the need for an integrated supply chain that links users, managers, suppliers, and donors from end to end (Usaid, 2023).

This literature review aims to give a comprehensive overview of medical supply chain systems' historical history, current condition, and future routes. This review sets the stage for a deeper exploration of specific aspects influencing the design, development, and implementation of effective medical supply chain systems in the healthcare landscape by delving into key milestones, technological advancements, contemporary challenges, and future trends.

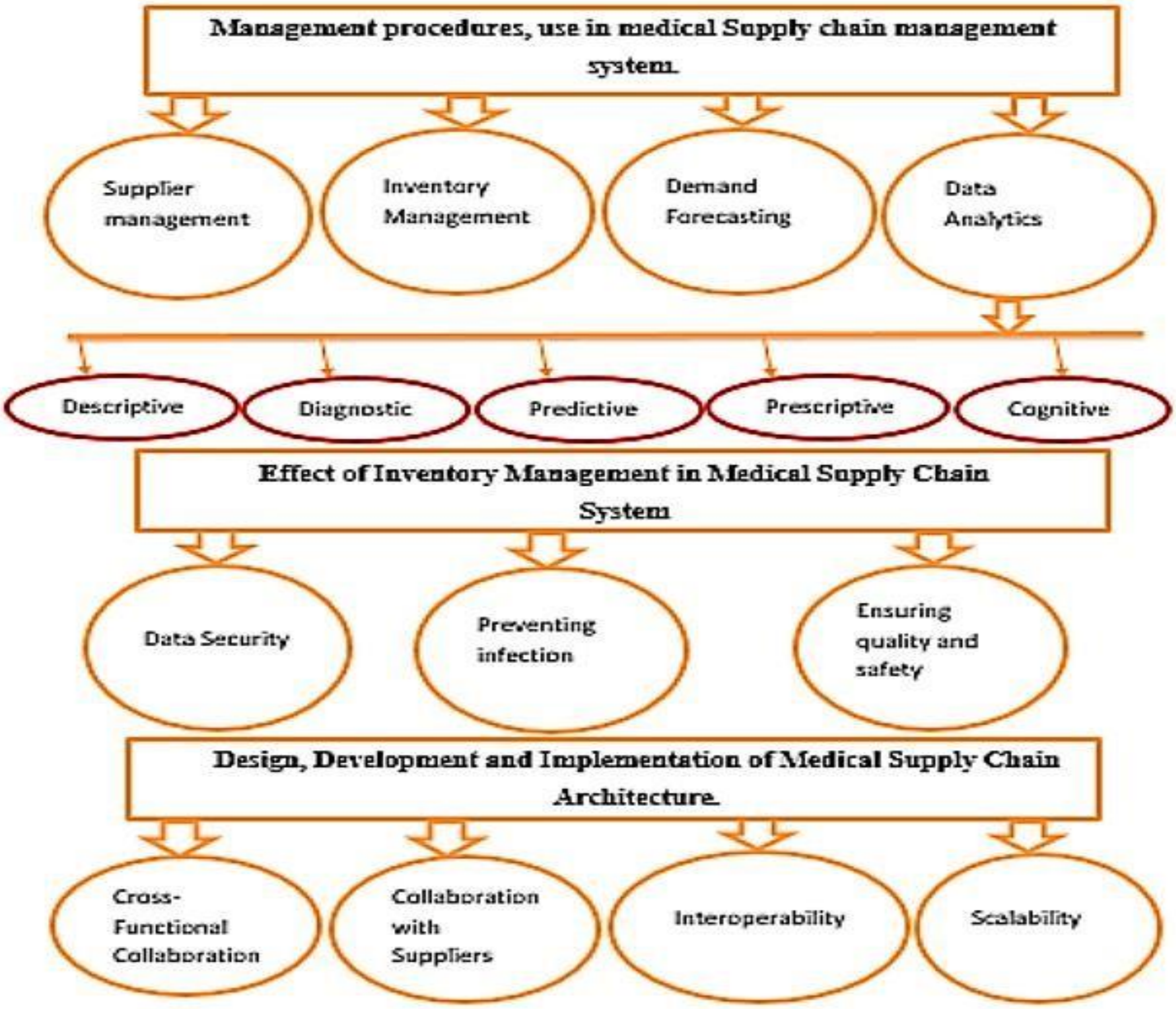


Figure 2.1 Study review thematic diagram of the medical supply chain management system

Source: Study Activity (October 2023)

2.1. Management Procedures, Use in Medical Supply Chain System.

A supply chain is a network of organizations, people, activities, information, and resources involved in the creation and distribution of a product or service to the end consumer. According to Handfield, R., & Linton, T. (2022) described supply chain as it encompasses the entire process of sourcing raw materials, transforming them into finished products, and delivering those products to the end-users. Supply chains are a fundamental part of business operations and play a crucial role in meeting customer demands efficiently.

According to Frolovs, G (2022), Healthcare supply chain involves obtaining resources, managing supplies, and delivering goods and services to providers and patients. She further explain that to complete the process, physical goods and information about medical product and services usually go a number of independent stakeholders including manufacturers, insurance companies, hospitals, providers, group purchasing organizations and several regulatory agencies.

In addition, medical healthcare is traditionally defined as the delivery of treatment and services to people in need of medical attention. Shou, Y., Shao, J., Lai, K., Kang, M., Park, J. (2019) mentioned that the industry's performance is heavily dependent on a complex network of companies working to design, produce, deliver, and manage a wealth of health and medical related products and services hence, healthcare management has attracted increasing attentions from both researchers and practitioners.

In line with Jacqueline LaPointe, (2022) research, she mention four main factors that influence the procedures of medical supply chain management, which are supplier management, inventory management, demand forecasting and data analytics.

2.2.1. Supplier management

As supply chains grow more complex, businesses need reliable ways of evaluating how their suppliers contribute to overall business success. Piramathu and

Zhou, (2016) mentioned that Supplier management is the process that ensures maximum value is received for the money that an organization pays to its suppliers. Because these supplies play a part in the smooth running of an organization, it is important for both supplier and organization to engage properly and effectively.

LaPointe.J, (2022) emphasize that supplier management refers to the process in which a business captures, stores, updates, and analyses all supplier data in a single location. This data takes the form of critical trading information, as well as necessary accreditations and certifications required to trade with the buyer.

According to Frolovs,G (2022) argue that It is a foundational responsibility for any medical device company to have reliable and top-class suppliers so that your products and services are of the highest industry standards, and, will match or exceed customers' expectations. He further express that a strong relationship with suppliers is critical because suppliers should be selected based on quality, reliability, and the ability to meet regulatory standards and also a diversified supplier base can also mitigate risks related to single-source dependencies.

2.2.2. Inventory Management

An inventory management system (or inventory system) is the process by which you track your goods throughout your entire supply chain, from purchasing to production to end sales. It governs how you approach inventory management for your business. If you are holding a lot of inventory in your business, you need to stay efficient and maintain healthy margins by so doing an effective inventory management system exists to help you achieve this. According to Alfonso-Lizarazo, et al. (2022) mentioned that in the medical world, shortages of inventory can cost lives. The understandable reaction is to order more than you need to be safe, but these ties up much-needed capital, and risks stock write-offs as expiry dates come around (SOS, 2023) argues.

Inventory management in the healthcare system is complicated because it is connected to many factors. Saha & Ray, (2019) further mentioned that, the factors affecting inventory management in healthcare are the demand and supply of inventory items, nature of healthcare inventory items, type of inventory item and storage facility, nature of the inventory distribution system, replenishment policy, service level growth, patient medical conditions, physician prescribing behavior, the criticality of inventory items, and interactions among parties.

In this context, different researchers have developed optimization models for solving healthcare inventory problems. Settanni et al., (2017) affirms that mathematical models allow the assessment and identification of the main metrics that measure the possible outcomes of targeted transformation situations and can be manipulated to make solutions. Also he argues that a mathematical model of the medical supply chain should allow the analytical assessment of its present and alternative scenarios in terms of structural and behavioral characteristics, in response to fluctuations in patient needs, market demands, and resource availability in which from a practical perspective, future medical supply chain models should be constructed to make accurate predictions about the future need to meet patient demand.

Franco and Alfonso-Lizarazo, et al. (2022) proposed two different mathematical models evaluated over real data and simulated scenarios in a pharmacyhospital echelon under demand uncertainties. The first model determines the replenishment dates over a planning horizon that result in cost reduction, while the second model determines an acceptable expiration date that helps the hospital to minimize the number of expired medicines and inventory levels. Similarly, Franco, C. (2020). also developed a simulation model to evaluate medical supply chain costs in Colombian hospitals. The model was adjusted and verified based on real data in the clinic to represent the behavior of the final cost of medicines. Their research concluded that the final cost of medicines is fluctuating and is affected by different factors.

In addition, Goodarzian et al. (2020) also proposed model aims to optimize the production, distribution, allocation, location, ordering, inventory, and transportation of pharmaceutical products utilizing multi-modal transportation. Using such a model facilitates healthcare management and leads to patient satisfaction. Also Goodarzian, Kumar, and Ghasemi (2021) have proposed a model and heuristic method to solve the medical supply chain system problems and to reduce the total cost and the delivery time of pharmaceutical supply to the hospital and pharmacy, while improving the reliability of the transportation system. They further note that, due to the growing demand for medicines during the pandemic, forecasting the demand for medicines is important to minimize cost, offer a timely service to patients, and prevent medicine shortages.

Therefore, Goodarzian, Ghasemi, et al. (2021) presented a simulation method that had been used to estimate the quantity of the required medicines demand. Additionally, Goodarzian, Taleizadeh, et al. (2021) developed a multi-objective, multi-product, and multi-echelon mathematical formulation called Sustainable Medical Supply Chain Network during the COVID-19 pandemic and the simulation approach has been used to calculate the demand distribution function of the required medicines. Also, Goodarzian, Wamba, et al. (2021) presented a green medicine supply chain management network design to reduce the total costs and environmental impacts by considering the environmental influences related to the establishment of pharmacies and hospitals.

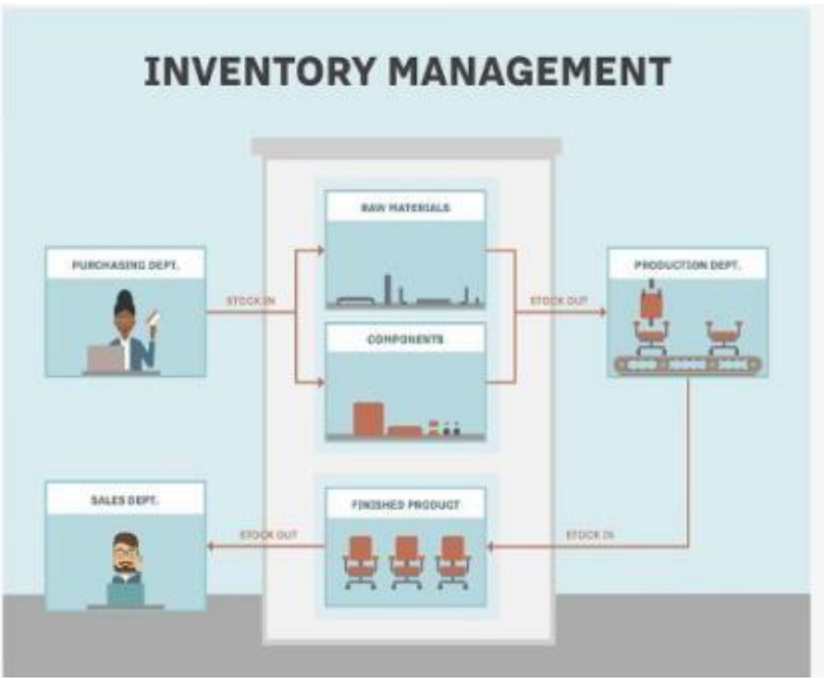


Figure 2.2 An inventory management process
Source: Retrieved from: https://www.mccmdclinic.org/4-basic-steps-to-hospitalinventory-management-process/

2.2.3. Demand Forecasting.

Forecasting is an important component that can affect the operation of a medical supply chain. As defined by Merkuryeva et al., (2019), demand forecasting is the process of estimating the future need for a product or service based on the current condition of the environment and previous data in order to plan and manage enterprises. However, Haszlinna Mustaffa and Potter (2009) and Merkuryeva et al. (2019) observed that effective demand forecasting in the pharmaceutical business is difficult since there is no exact data on drug use. Furthermore, Zhao et al., (2022) contend that forecasting is a critical component for decision-makers to guarantee proper planning and inventory control. As a result, more estimations that are precise can benefit the Supply Chain in terms of lowering inventory costs, satisfying demand, and improving customer satisfaction. Indeed, the healthcare industry is required to manage the supply successfully to reduce the cost and work efficiently.

In addition, inefficient inventory management, such as poor forecasting can lead to excessive loss and spoilage of the product they further argue. The study conducted by Awad et al. (2016) identified the four causes of unsuccessful medicine supply in Jordan: supply and demand imbalance, distribution factors, regulatory issues, and human factors. Plus, their study recognized the possible medical supply related causes of supply and demand imbalance such as unexpected need due to pandemic infections; supply disruption of raw material or final product; the addition of new uses for currently approved medicines; and demand increases due to political issues in the area. Likewise, Polater and Demirdogen (2018) found that supply chain flexibility has a mediation effect between demand forecasting, SC integration, supplier performance, and patient responsiveness at public hospitals. They also maintained that Medical supply chain stakeholders should have accurate demand forecasting to meet the stable and uncertain demand to achieve flexible Supply Chain and patient satisfaction.

Indeed, LaPointe, (2022) agreed that demand forecasts are considered a foundation of all medical supply chain management and pharmaceutical logistics decisions Thus, pharmaceutical industries need to focus on demand forecasting and inventory management to attain better SC performance and further improvement.

2.2.4. Data Analytics

Alotaibi and Mehmood (2018) stated that transferring drugs and medical equipment under suitable environmental conditions is critical in the medical industry; data gathered in their RFID-based system helps guarantee safety is monitored and quality assurance is enhanced in the process. Similarly, Sadeghi et al., (2020) underline the importance of data analytics since it gives pharmaceutical organizations with data-backed insights, such as the ability to conduct in-depth competitive research and monitoring, as well as enhance in-house operations. They go on to say that, this helps medical enterprises keep ahead of market trends, find new products and markets, and optimize production processes and procedures.

They further argue that, the amount of data generated in healthcare is growing at an incredible rate and the sector has not been able to proficiently utilize data management and analysis in order to interpret data effectively. As a result, healthcare administrators risk becoming overwhelmed by an avalanche of irrelevant information. According to Ayyub Salau (2022), he said, “Healthcare supply chain management spends almost one-third of total operating expenditures in healthcare institutions”. He also mentioned that Data analytics aids in the improvement of day-to-day operations and the provision of improved patient care by utilizing existing data to analyze trends and perform predictive modelling.

Moreover, World Health Organization WHO, (2021) aims to enhance billions of people's health by 2023 by reforming data governance and standards, boosting country capacity, and leveraging partnerships to acquire, analyze, and use data. Analytics in healthcare is rapidly being considered as the industry's future. Also, Sadeghi and Musolu,(2020) said that data is acquired for business operations of healthcare services; additionally, huge amounts of health data is obtained, kept, and analyzed in order to enhance procedures and processes of healthcare supplies and services. In a similar vein according to the Global Innovation Index (2019), just over half of hospitals lack a data governance or analytic strategy, and 97% of hospital data is underutilized. Data inaccuracy is a concern to consider during Health care data analytics as it is compiled from multiple sources and in varied forms (Rehman, Naz and Razzak, 2020) maintained.

The attributes of data analytics for a sector is determined by the industry's stage of growth Khalifa (2018) argues. He further stated that, data analytics has made significant advances in healthcare for evaluating massive amounts of data and getting new perspectives. He grouped it into five categories: descriptive, diagnostic, predictive, prescriptive, and discovery analytics in healthcare sector.

2.2.5. Descriptive analytics

He moved on to affirmed that, descriptive analytics will allow healthcare providers to learn from their previous experiences and understand the link between variables and how it affects future outcomes. Descriptive analytics is the capacity to quantify occurrences and report on them in a human-readable manner. It is the first step in converting big data into meaningful insights, and there is a lot to be discovered from this tier of analytics.

2.2.6. Diagnostic analytics

This takes an informed healthcare supply chain with insights on determining why something occurred. Extensive examination and guided analysis of existing data using tools such as visualization methods is required to find the fundamental causes of an issue and give insights into understanding the nature and effect of problems (Khalifa, 2019) further expressed.

2.2.7. Predictive analytics

He goes on to maintain that, using predictive analytics on investigations helps Healthcare stakeholders focus on essential information while also providing insight into which pathways are likely to produce the highest performance. Predictive health analytics is more sophisticated than basic descriptive analytics in such that, it emphasizes the utilization of information, which better insight and understand rather than plain data. Besides, it analyses existing data and indicators to forecast future performance, which enhance supply chain. Predictive modelling in pharmaceuticals aids in the identification of new prospective medications with a higher chance of being developed and authorized effectively. Adapting Predictive analytics results assists pharmaceutical producers in optimizing costs and inventory, reducing shortages, and increasing transparency in the manufacturing process.

2.2.8. Prescriptive analytics

This is another crucial analytic tool which goes beyond just predicting a future occurrence He further argues that, it goes beyond offering the ability to find a solution which has to do with performance prediction and the use of complex algorithms to discover the best answers to supply chain integration.

Furthermore, it necessitates such a flawless and thoroughly integrated data analytics infrastructure that only a few healthcare firms are capable of engaging in this ultimate data application on a relevant or large scale. Prescriptive analytics is also, used in health analytics to enhance the outcomes of cancer, AIDS, and tuberculosis (Raghupathi et al., 2019) maintained. As a result, proactive judgments are made to find medication from pharmaceuticals for an unknown disease, based on patients' medical circumstances, which improves the services and delivery of healthcare (Poornima and Pushpalatha, 2020).

2.2.9. Cognitive analytics

This utilizes artificial intelligence capabilities. It is among the most outstanding modern analytic; which applies human-like intelligence to specific tasks and combines a variety of intelligent technologies, including semantics, artificial intelligence algorithms, deep learning and machine learning

Ayyub (2022), also put forward that, overall, data analytics in the healthcare supply chain has the potential to revolutionize how healthcare practitioners employ advanced technology to acquire insight from clinical and other data sources and make well-informed decisions. Data analytics in healthcare may then be coupled with analytical software to anticipate medical outcomes and enhance overall patient care quality. However, the necessary analytical tools and procedures may help to improve and accelerate the supply chain integration process, as well as give results for evaluating enormous datasets in the healthcare sector to improve quality management.

Figure 2.3 *Types of data analytics*

Source: Retrieved from: https://soulpageit.com/5-types-of-data-analytics-and-theirprominence/

2.3. Effect of Inventory Management in Medical Supply Chain System

In line with Qiu, Y.; Qiao, J.; Pardalos, P.M. (2019), inventory management is connected with the procedure of requesting, storing, and utilizing an institution's inventory. This involves the management of primary products, components, as well as end products. It also consists of warehousing and processing such items. However, Muller, M, (2019) depicted it as a systematic approach to sourcing, storing, and selling inventory, that is both finished goods (products) and raw materials (components). A supply chain, on the other hand, is composed of stages that are either indirectly or directly involved in accomplishing a customer's request (Ageron, B.; Benzidia, S.; Bourlakis, M. 2018). According to Moons, K.; Waeyenbergh, G.; Pintelon, L. (2019), it involves the producer, supplier, transport operators, warehousing, retailers, third party logistics providers, and lastly, the customer. Moons et al. noted that the supply chain is responsible for ascertaining that there is an adequate connection of hospitals, operations, and the revenue cycle.

Zwaida, T,A.; Pham, C; Beauregard, Y. (2021) mentioned that, Health care institutions across the globe are in search of methods that will prove effective in improving the efficiency of operations, that is inventory management, while reducing expenditures that will in no way affect medical care and services. Bradley, R.V.; Esper, T.L.; In, J.; Lee, K.B.; Bichescu, B.C.; Byrd, T.A. (2020), illustrated that the material requirements for the provision of health care delivery are multifarious, generating a complex distribution network of relationships from the distributor to the customer. Likewise, Qiu, Y.; Qiao, J.; Pardalos, P.M. (2019) noted that health care budgets are very stringent, and thus, health care providers are attempting to optimize their inventory management, which will eventually lead to a reduction of the costs incurred whilst providing health care.

Additionally, Zwaida,T,A.; Pham, C; Beauregard, Y. as referenced Kritchanchai et al. in (2021) noted that an effective supply chain management is one that intends to optimize the full value created as opposed to the profit produced in a specific supply chain. He further argues, the medical supply chain sometimes referred to as the Pharmaceutical Supply Chain (PSC), is intricate and comprised of numerous organizations that perform various but sometimes-superimposed roles in the contraction and distribution of drugs. Qiu et al. in (2019) highlighted three factors that could influence the effect of inventory management in medical supply chain system these are: data security, preventing infection and ensuring quality and safety.

2.3.1. Data security

Qiu et al. in (2019) stated that data security is any type of preventative measure that helps secure and protect data and healthcare institution process a hug amount of sensitive information. This invaluable data attracts the attention of attackers and cyber attackers on medical facilities. According to Altynpar, E.; Bestaieva, D. (2023) stated that data security in healthcare refers to the measures and practices implemented to protect sensitive patient information, known as electronic protected health information. Tripathi, M. (2021) argued that, securing healthcare data is a shared responsibility that requires collaboration among healthcare organizations, technology providers and policymakers to create a culture of data protection. He moved on to emphasized that, this involves in ensuring the confidentiality, integrity and availability of this data to prevent unauthorized access, disclosure or alteration.

2.3.2. Preventing infection

In healthcare settings, infection prevention is a paramount concern, and effective medical supply inventory management plays a crucial role in mitigating the risk of healthcare-associated infections. The ministry of health and sanitation of Sierra Leone (2019) emphasize the important of improving health worker and patient hygiene conditions, appropriate management of potentially infectious patients including use and availability of personal protective equipment, improved healthcare waste management and the safe use of injections, invasive devices, and blood transfusions.

In ensuring compliance with regulatory standards, such as Good

Manufacturing Practices and Good Distribution Practices, is foundational to infection prevention. Tietjan, L.; Bossemeyer,D; McIntosh,N. (2021) Literature emphasizes the importance of adhering to strict sterilization practices for medical supplies to eliminate microbial contamination. Studies by Curless, S.; Forrester, L.; Trexler, P. (2018) underscore the correlation between compliance with sterilization protocols and reduced rates of surgical site infections. Also Proper segregation and storage of medical supplies within inventory systems significantly contribute to infection prevention. Michael,S.; Veeraraghavan,B,Dr. (2019) highlight the importance of separating sterile and non-sterile items within the inventory to prevent crosscontamination. They also argues that efficient inventory management systems that facilitate organized storage and easy retrieval of supplies have been shown to reduce the risk of infections associated with improper handling.

In addition, Collaboration with suppliers is crucial in maintaining a high standard of quality for medical supplies. Research by Madhumathi,J.; Walia,K. (2021) emphasizes the need for establishing strong partnerships with suppliers who adhere to rigorous quality control measures. They further note that supplier collaboration, coupled with robust quality assurance protocols, contributes to infection prevention by minimizing the risk of defective or substandard products entering the supply chain.

Furthermore, the utilization of data analytics in medical supply inventory management extends beyond demand forecasting. Shaban,S.B.; Macbeth,D. (2021) propose the integration of data analytics tools to monitor infection rates correlated with specific medical supplies. This proactive approach allows healthcare facilities to identify patterns, track potential sources of contamination, and implement preventive measures in real-time.

The human element in medical supply inventory management is serious to infection prevention. Studies by Tropea,J. (2023) emphasize the need for comprehensive training programs for healthcare staff involved in inventory handling. She also heighted that human factors such as hand hygiene, aseptic techniques, and adherence to infection control protocols significantly contribute to preventing healthcare-associated infections.

2.3.3. Ensuring quality and safety

Qiu et al. in (2019) argues that ensuring the quality and safety of medical supply inventory is paramount in delivering effective and secure healthcare services. They further mentioned the importance of adherence to rigorous regulatory standards, such as Good Manufacturing Practices and Good Distribution Practices, serves as a fundamental pillar in ensuring the quality of medical supplies. The literature of Mutomba,M.; Mica,A.; Green,L., (2013) consistently underscores the correlation between regulatory compliance and the assurance of product safety and efficacy. By strictly adhering to these standards, healthcare organizations can establish a baseline for quality control within their supply chains.

In addition, the integration of advanced traceability systems, including technologies like Radio-Frequency Identification (RFID) and barcoding has emerged as a critical component in enhancing the quality and safety of medical supply inventory. Moons,k.; Waeyenbergh,G.; Pintelon,L .(2019) Highlight the role of these technologies in providing real-time visibility into the supply chain, allowing for quick identification and removal of compromised products during recalls or quality issues.

Furthermore, Continuous monitoring and surveillance of medical supply inventory are vital for early detection of potential quality issues. Real-time monitoring facilitated by Internet of Things (IoT) devices and analytics tools allows for proactive identification of anomalies, such as temperature excursions or damage, reducing the risk of compromised supplies reaching patients (Peters et al., 2023). This emphasis on real-time surveillance aligns with a preventive approach to maintaining quality and safety.

Human factors, including staff training and adherence to protocols, play a critical role in ensuring the quality and safety of medical supply inventory. Comprehensive training programs, covering aspects such as proper handling, storage, and disposal procedures, are highlighted in the literature (Wang.Q,; Chan.Z. 2022). The human element is considered a linchpin in preventing errors that could compromise the safety and efficacy of medical supplies.

2.4. Design, Development and Implementation of Medical Supply Chain Architecture.

Designing, developing, and implementing an effective medical supply chain management system architecture is a multifaceted challenge that requires careful consideration of technological, logistical, and regulatory factors. Recent research by Altynpar, E.; Bestaieva, D. (2023) highlights the pivotal role of advanced technologies in enhancing the architecture of medical supply chain management systems. Qiu, Y.; Qiao, J.; Pardalos, P.M. (2019) emphasize the use of Internet of Things (IoT) devices, Radio-Frequency Identification (RFID), and Artificial Intelligence for real-time tracking, monitoring, and predictive analytics. Such integration not only improves visibility across the supply chain but also facilitates more accurate demand forecasting. Research by Raghupathi et al., (2019) discusses how blockchain ensures transparency, traceability, and security by creating an immutable and decentralized ledger. This not only mitigates the risk of counterfeit drugs but also provides a secure platform for data sharing among stakeholders.

Dynamic and adaptive governance models are essential for the ongoing success of medical supply chain management systems. Mason.C, (2017) argue for governance structures that facilitate continuous improvement, incorporating feedback from users, monitoring performance metrics, and adapting to changes in the external environment. This approach ensures the sustainability and relevance of the system over time. He moved on to group some of the factors of designing and developing a medical supply chain system. These are; Cross-functional collaboration, Collaboration with suppliers, interoperability and scalability.

2.4.1. Cross-Functional Collaboration

He argues that in involving stakeholders from various departments, including procurement, logistics, healthcare providers, and IT, in the design and development process ensures that the architecture aligns with the specific needs of each group. The successful design and development of a medical supply chain management system architecture demand a comprehensive understanding of the diverse needs and intricacies inherent in healthcare operations. He further specify that, engaging stakeholders across disciplines can tailor the architecture tailored to align with specific operational requirements and ensure a cohesive, interoperable, and efficient system.

A key facet of cross-functional collaboration involves integrating perspectives from procurement departments. Muller.M, (2019) argue that by involving procurement specialists early in the design phase, the system can be optimized for efficient sourcing, cost-effectiveness, and supplier relationship management. He further lamented that Collaboration with vendors and suppliers is highlighted, emphasizing the importance of mutual understanding and interoperability to streamline procurement processes.

In addition, Cross-functional collaboration extends to logistics and distribution teams, who play a pivotal role in the timely and secure delivery of medical supplies. Beldek.T, (2019) stress the need for a collaborative approach that considers logistics challenges, warehouse management, and transportation requirements. By incorporating insights from logistics experts, the system architecture can better address issues such as route optimization, inventory visibility, and real-time tracking.

Moreover, Human-centric design principles are paramount in ensuring the acceptance and usability of the system among healthcare providers. Ageron and Benzidia (2018) emphasize the importance of involving healthcare professionals in the design and development process. Their input can guide the creation of intuitive interfaces, workflow integration, and features that align with the unique demands of patient care, ultimately contributing to the system's successful adoption. The collaboration with IT professionals is essential for creating a robust and secure medical supply chain management system architecture. Lapointe, J. (2017) highlight the significance of aligning the architecture with existing IT infrastructure, ensuring seamless integration with electronic health records and other information systems. In addition, collaboration with IT experts is crucial for addressing data security concerns and implementing encryption protocols to safeguard sensitive information.

Furthermore, Effective communication between various departments is crucial for the success of the medical supply chain management system. Saha & Ray, (2019) stress the need for cross-functional teams to collaboratively design workflows that seamlessly connect different stages of the supply chain. This collaborative approach ensures that data flows efficiently between procurement, logistics, healthcare providers, and other stakeholders, minimizing delays and optimizing the overall supply chain process. Cross-functional collaboration plays a pivotal role in ensuring compliance with regulatory standards. Poornima and Pushpalatha, (2020) argue for the establishment of cross-functional oversight committees that bring together representatives from different departments. This collaborative governance structure can systematically address regulatory requirements, monitor compliance, and ensure that the system architecture aligns with industry-specific regulations.

2.4.2. Collaboration with Suppliers

Foster collaboration with suppliers, encouraging them to integrate with your system. This enables streamlined communication, automatic order processing, and better visibility into the supply chain. The integration of supplier systems into the medical supply chain management architecture is recognized as a key driver for efficient communication (Bhattacharya, J.2023). Chakraborty and Dobrzykowski (2014) highlight that seamless communication between healthcare providers and suppliers minimizes delays, reduces errors, and enhances the overall responsiveness of the supply chain. By fostering integration, organizations can establish a real-time exchange of information, leading to improved coordination and timely decisionmaking. Mejia,F and langabeer (2016) emphasize that integrating supplier systems allows for automated order placements, acknowledgments, and updates. This not only reduces manual intervention but also ensures that inventory levels are accurately tracked, preventing stock outs and streamlining the replenishment process.

Collaboration with suppliers contributes significantly to enhancing visibility into the supply chain. Changhee and Kim (2019) discuss that integrating supplier data provides organizations with a comprehensive view of the entire supply chain ecosystem. This visibility extends beyond internal operations, allowing stakeholders to monitor supplier performance, track shipments in real-time, and proactively address potential disruptions. Khuntia,J. (2022) argue that suppliers, being close to the manufacturing and production processes, possess valuable insights. When integrated into the system architecture, this shared data enhances the accuracy of demand forecasts, enabling organizations to optimize inventory levels and respond effectively to fluctuating market conditions.

In addition, to ensure effective collaboration, the establishment of standardized data protocols is essential. Konyalioglu,K.A. (2016) advocate for the adoption of common data formats and communication standards. This standardization simplifies the integration process, ensuring compatibility between disparate systems and facilitating a more efficient and error-free exchange of information.

The collaborative relationship with suppliers extends beyond transactional processes to include proactive issue resolution and continuous improvement. Lapointe, J. (2017) discuss the importance of jointly addressing challenges, such as quality issues, supply disruptions, and changes in regulatory requirements. Collaborative problem solving fosters a resilient supply chain and sets the foundation for ongoing improvements in the system architecture.

2.4.3. Interoperability

Interoperability is a cornerstone in the design and development of a comprehensive medical supply chain management system architecture. According to Mason.C. (2023) describe interoperability as “the ability of different information technology systems and software applications to communicate, exchange data, and use the information that has been exchanged.” Healthcare Information and Management Systems Society (HIMSS) (2021) asserts that, data exchange schema and standards should allow for the sharing of data among healthcare community participants irrespective of which applications or vendors they use. Interoperability, according to HIMSS, enables HIT systems to transcend organizational boundaries and promote effective healthcare delivery.

Collaboration with laboratory systems is a critical aspect of interoperability in healthcare supply chains. (Tripathi, M. 2021) highlight the importance of integrating medical supply chain data with laboratory systems to facilitate the efficient management of diagnostic supplies. Real-time data exchange between the supply chain and laboratories supports timely procurement, reduces delays in testing processes, and enhances overall diagnostic service delivery. Prasad.M. (2023) also noted that by having access to their complete medical information, including past diagnoses, treatments, and medications, providers can make well-informed decisions and avoid unnecessary tests or procedures.

Interoperability with pharmacy systems is paramount for effective medication management within healthcare supply chains. Tripathi, M. (2021) stress that integrating supply chain data with pharmacy systems enables accurate tracking of medication orders, inventory levels, and expiration dates. This integration ensures that medications are readily available when needed, minimizing the risk of medication errors and enhancing patient safety. Continuum. (2020), also mention that it reduced paperwork for employees and eliminating the need for manual data entry are significant advantages of healthcare interoperability.

In addition, interoperability should not only enable data exchange but also ensure consistency and accuracy across different healthcare systems. Prasad,P.(2023) emphasize the importance of aligning data definitions, coding standards, and data governance practices to maintain the integrity of information as it traverses between supply chain, EHR, laboratory, and pharmacy systems. This consistency is crucial for informed decision-making and care continuity. Continuum (2020) stress the need for collaboration with suppliers, encouraging integration and interoperability. This collaborative approach streamlines communication, automates order processing, and enhances visibility across the entire supply chain. Interoperability ensures seamless data exchange between different components of the healthcare ecosystem. Interoperability is not just a technical requirement but also a strategic imperative in the design and development of a medical supply chain management system architecture.

2.4.4. Scalability

Designing a system to be scalable to accommodate future growth and evolving healthcare needs is also important. According to Joby,A. (2019), Scalability allows the architecture to expand without requiring a complete overhaul. Scalability is a critical dimension in the design and development of an effective medical supply chain management system architecture. A scalable architecture ensures that the system can expand seamlessly without necessitating a complete overhaul, providing the agility required to meet the dynamic demands of the healthcare landscape.

Bridgwater,A. (2022) highlight that scalability is fundamental in addressing the dynamic nature of healthcare demand. As healthcare needs evolve, a scalable system architecture allows for the flexible addition of resources, modules, or functionalities. This adaptability is crucial for accommodating changes in patient populations, variations in medical product demand, and shifts in healthcare delivery models. Mukherjee,S.; Bhole,K. and Sonawane,D. (2019) emphasize the importance of designing systems with modular components. This modular approach allows for incremental growth, where specific modules or functionalities can be added without disrupting the overall system. Such modularity not only facilitates scalability but also streamlines the integration of new technologies or features.

In addition, Charif,b,A & Zomahoun,V. (2022) discuss how cloud computing offers elasticity, allowing the system to dynamically scale resources up or down based on demand. Cloud-based solutions provide a cost-effective and efficient way to accommodate varying workloads, ensuring that the system can handle increased data volumes and processing requirements. Scalability is closely tied to future-proofing the system against technological changes (Clifford, G.2015). Ngongoni,N.C. (2022) advocate for a technology-agnostic approach, designing architectures that are not overly reliant on specific technologies or platforms. This approach enables easier integration with emerging technologies, ensuring that the system remains adaptable to innovations without necessitating a complete reengineering.

Furthermore, in addressing the increasing volume of healthcare data, Zamboni,K. (2019) highlight the importance of scalable data storage and processing capacities. A scalable architecture accommodates the growing data requirements of the medical supply chain, whether it be in terms of transactional data, real-time tracking information, or analytics for demand forecasting. This scalability supports efficient data management and analysis. Interoperability is integral to scalability, as discussed by Jedrzejowska,M. (2022) Ensuring that the system can seamlessly integrate with other healthcare systems and technologies supports collaborative growth. Interoperability allows for the incorporation of new partners, technologies, or data sources, fostering an ecosystem where the medical supply chain can expand collaboratively with other components of the healthcare infrastructure.

Scalability requires proactive capacity planning and continuous performance monitoring. Greenhalgh,T. (2019) argue for the implementation of tools and processes that assess system performance in real-time. This proactive approach enables organizations to identify potential scalability challenges before they affect operations, ensuring a responsive and well-prepared system. A scalable architecture is not just a technical necessity but also a strategic imperative for ensuring the longevity, adaptability, and sustained effectiveness of medical supply chain systems.

2.5. Business Analytics into Medical Supply Chain System Conceptual Framework.

Below depict a conceptual framework of medical supply chain with business analytics. A supply chain is like a delicate, well-oiled machined. All cog must function in harmony, or else the entire system goes out of balance. In this day and age of intense competition, hard deadline and demanding customers, medical supply companies need to be efficient and intelligent with their supply chain management. It is not easy keeping track of the multiple factors that affect every step on Medical supply chain. It is a colossal task to ensure steady flow of event occurs. That is why it is essential to incorporate Business analytics in Medical supply chain system. Business analytics can now use the power of data and its much valuable application to create a seamless Medical supply chain.

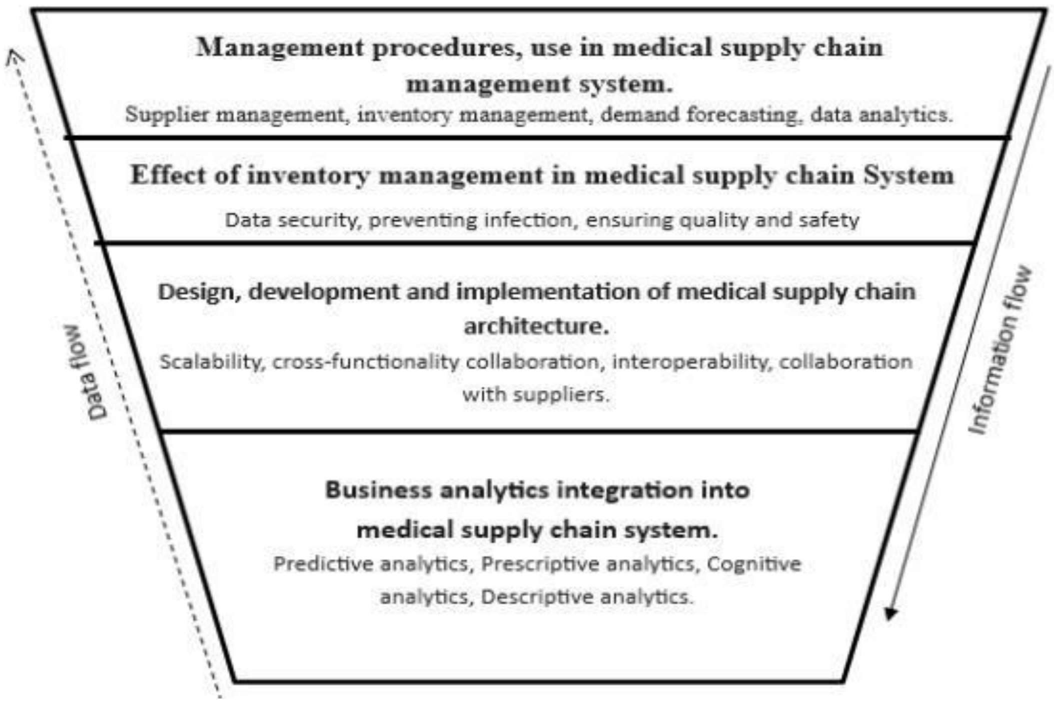


Figure 2.4 Conceptual framework with business analytics in medical supply chain system**.**

Source: Study Activities (2023).

In conclusion, a survey of this literature on medical supply chain management systems reveals a dynamic environment epitomise by constant growth, technology improvements, and a rising acknowledgement of the vital role that effective supply chain management plays in healthcare. The synthesis of several research highlights numerous major themes and insights that help to provide a thorough picture of the present status and future orientations of medical supply chain systems. An effective medical supply chain requires careful management across several areas - sourcing, procurement, warehousing, inventory control, and logistics - to maintain the flow of products to hospitals, pharmacies, clinics and other healthcare access points.

Besides, this literature highlights a progressive shift towards the adoption of advanced technologies such as data analytics, to enhance visibility, accuracy, and efficiency in medical supply chains. Furthermore, it also encourages a culture of continuous improvement and learning within medical supply chain management and feedback mechanisms, performance monitoring, and a proactive approach to addressing challenges contribute to the ongoing refinement and optimization of supply chain operations. With strategic foresight and coordinated action across the end-to-end supply chain, the global medical product supply ecosystem can achieve greatly enhanced transparency, flexibility, and reliability to fulfil the ultimate mission – delivering the best possible healthcare to those in need.

CHAPTER THREE
System Design Specifications

Chapter Summery

This chapter lays the foundation for the development of a robust Medical Supply Management System (MSMS) by addressing key components such as study research methodology, software development approach, and system architecture. It underscores the importance of a systematic research methodology, employing factfinding approaches like interviews, observation, focus group discussions, *comparative analysis, and document sampling to comprehensively understand the nuances of the medical supply chain. The iterative and incremental software development approach is introduced, emphasizing adaptability to dynamic healthcare requirements.*

The chapter details the phases of the iterative and incremental product development process, from initial planning to testing and evaluation, ensuring continuous refinement based on stakeholder feedback. Additionally, the Software Requirement Specification (SRS) is highlighted as a critical document guiding the development of the MSMS, defining both functional and non-functional requirements.

The client-server system architecture is explored in the context of MSMS, clarifying the roles of clients and servers for seamless communication and data management. The chapter introduces three essential system modules—Stock Module, Stock History Module, and Invoice Module each contributing distinct functionalities to the overall MSMS. The integration and collaboration tools, including Visual Studio Code, Localhost, Google Chrome, and MySQL, are discussed for their roles in creating a cohesive and efficient development environment.

3.0. Study Research Methodology

Research methodology refers to the systematic, theoretical, and analytical analysis of the methods applied in a field of study. When studying medical supply chain management systems, clearly outlining the research methodology is crucial for evaluating supply chain procedures and identifying opportunities for optimization (Naseem et al., 2022).

There are several important components in developing a robust research methodology for assessing medical supply chains. Firstly, researchers must determine appropriate data collection tools and analysis methods that align with the research aims and context (Lalwani, 2019). Common approaches include surveys, interviews, observational studies, and field experiments. The methodology should outline target sample sizes for reliable statistical testing. It also needs to justify quantitative versus qualitative approaches as suitable for capturing in-depth insights versus generalizable trends.

Secondly, medical supply chain research necessitates multiple perspectives, calling for multi-method designs. For example, Lalwani (2019) adopted a mixedmethods approach combining optimization modeling with cluster analysis of survey data to examine flows of essential medicines. This enabled evaluating both technical components like distribution systems and human elements like supplier behaviors. Finally, the methodology should embed rigorous validity and reliability checks of findings. Medical supply chains are complex; thus, data triangulation from diverse sources strengthens accuracy. Detailed documentation of assumptions, limitations, and ethical considerations also bolsters credibility (Naseem et al., 2022).

3.1. Fact-Finding Approaches:

To develop a thorough understanding of the medical supply chain ecosystem, various fact-finding approaches are employed. These approaches include interviews with healthcare professionals and supply chain stakeholders, direct observation of current supply chain processes, focus group discussions involving different participants in the medical supply chain, comparative analysis of existing systems, and document sampling from relevant healthcare sources. These methodologies are consistent with the principles of qualitative and quantitative research that aim to collect diverse data sources for a holistic view of the medical supply chain (Panneerselvam, 2014).

3.1.1. Interviews:

The researcher conducts in-depth interviews with various stakeholders like doctors, hospital administrators, logistics partners, etc. across the medical supply chain. Whether structured, semi-structured or open-ended in nature, the interviews help the researcher gather qualitative insights from different perspectives about onground practices, relational dynamics, pain points and improvement needs.

3.1.2. Observation:

By embedding themselves directly within healthcare provider settings, the researcher is able to unobtrusively observe actual supply chain processes like procurement, inventory management and distribution as they unfold in real-time. This enables the researcher to identify process bottlenecks first-hand through direct observation.

3.1.3. Focus Group Discussions:

The researcher brings together a diverse set of 10-12 medical supply chain practitioners from roles across the ecosystem into a common forum. This could include pharmaceutical executives, inventory analysts and purchasing managers. Moderating open discussions helps elicit a range of opinions about potential issues and interventions based on their specialized experience.

3.1.4. Comparative Analysis:

The researcher thoroughly benchmarks current medical supply chain systems against established best practices by carrying out comparative audits. This allows accurate diagnostics of process limitations ripe for performance improvements grounded in data-driven gap assessment.

3.1.5. Document Sampling:

By comprehensively analyzing various operational documents like distribution logs, utilization trends and inventory records, the researcher is able to quantify contextual factors and augment other qualitative findings towards formulating databacked management system enhancement recommendations.

3.2. Software Development Approach:

In the context of a Medical Supply Chain Management System, the software development approach plays a pivotal role in shaping the technological framework of the solution. The iterative and incremental methodology is commonly employed to accommodate the dynamic nature of healthcare requirements.

According to Mitropoulos et al. (2019), the iterative approach allows for continuous refinement and adjustment of the system based on feedback from healthcare professionals and end-users, ensuring that the medical supply chain management system (MSCMS) remains adaptable to evolving healthcare needs. The software development approach aligns with the overarching goal of creating a responsive and user-centric system that addresses the unique challenges of medical supply chain management.

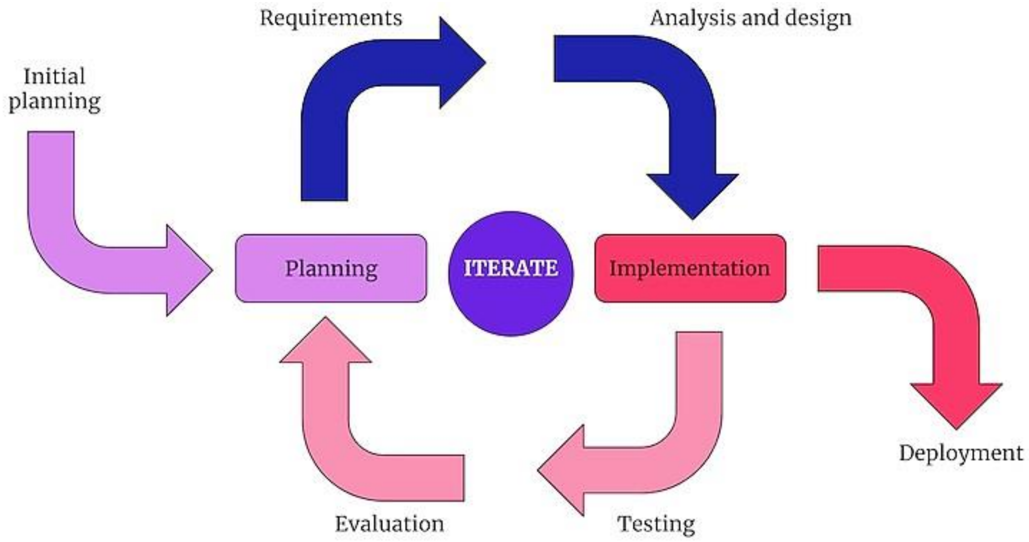


Figure 3.1 -Project Development Life Cycle for Medical Supply Management
Source: Suhasini Gadam. (2023): https://blog.logrocket.com/productmanagement/what-is-iterative-incremental-development-process-examples/

3.2.1. Initial Planning:

In the initial planning phase, the overall goals and objectives of developing an MSCMS are outlined. Stakeholders, including healthcare professionals, administrators, and IT experts, come together to define the scope, purpose, and expected outcomes of the system. Critical considerations during this phase include identifying key functionalities required for effective medical supply chain management, understanding the unique challenges of the healthcare sector, and establishing a high-level roadmap for the development process.

3.2.2. Planning:

Building upon the initial planning, this phase involves detailed project planning for the MSCMS. Key activities include defining project timelines, allocating resources, identifying potential risks, and establishing milestones. The planning phase also involves prioritizing features based on their importance to the medical supply chain, considering regulatory requirements, and incorporating feedback from stakeholders. A comprehensive project plan guides subsequent iterations, ensuring a systematic and well-organized development process.

3.2.3. Requirements Analysis and Design:

In the requirements analysis and design phase, detailed specifications for the MSCMS are developed. This involves a thorough examination of functional and nonfunctional requirements, considering aspects such as inventory management, order processing, user interfaces, and system scalability.

The design phase encompasses architectural design, defining the structure of the system, and creating prototypes or wireframes. The goal is to have a clear blueprint that guides the subsequent implementation phase.

3.2.4. Implementation:

During the implementation phase, the actual coding of the MSCMS takes place. The development team translates the design specifications into executable code. Given the iterative nature of the process, implementation is performed incrementally, focusing on specific features or modules in each iteration. This allows for continuous testing and refinement throughout the development lifecycle.

3.2.5. Testing:

Testing is a crucial aspect of each iteration in the development process. In the context of the MSCMS, testing involves verifying the functionality of the system, ensuring that it meets the specified requirements. This includes functional testing to validate features like inventory tracking, order processing, and reporting, as well as non-functional testing to assess system performance, security, and reliability. Stakeholders actively participate in testing, providing valuable feedback that informs the refinement process.

3.2.6. Evaluation and Development:

After testing, the system undergoes evaluation to assess its performance against predefined criteria. Stakeholders evaluate the system's alignment with their needs, and feedback is collected. This feedback loop informs the next development cycle, guiding further enhancements and refinements. The development phase involves making necessary adjustments based on stakeholder feedback, updating features, and adding new functionalities identified during evaluation.

The iterative and incremental nature of this development process means that these phases are not strictly linear; they are revisited and refined in subsequent iterations. Each cycle brings the MSCMS closer to its final form, with continuous improvement based on user feedback and changing requirements. This approach ensures that the system remains adaptable and responsive to the dynamic nature of the medical supply chain environment.

3.3. Software Requirement Specification (SRS)

The Software Requirement Specification (SRS) is a critical document that serves as a blueprint for the development of the Medical Supply Chain Management System (MSCMS). It outlines the functional and non-functional requirements of the system, providing a comprehensive understanding of what the software should accomplish and how it should perform in the context of managing medical supplies within healthcare facilities.

In order to address the difficulties associated with medical inventory and distribution management, the SRS will essentially map out the major workflows that the system is intended to support, such as demand planning, inventory optimization, procurement processing, and supplier integration. An organized overview of the system architecture and data landscape will be provided by describing the individual modules, the database schema, and how they are interconnected. In order to provide intuitive, role-based accessibility, prototyped screen blueprints, navigation flows, and UI element specifications will also be used to express the requirements for the humancomputer interface.

3.3.1. Functional Requirements:

Within the context of Medical Supply Chain Management System, the SRS's functional requirements outline the system's fundamental functions. These consist of functions for order processing, demand forecasting, inventory management, and reporting. For example, the SRS might describe how the system can automatically create orders based on demand analysis, track the amount and dates of the medical supplies, and provide stakeholders with real-time reports. In order to guarantee that the MSCMS satisfies the operational demands of healthcare practitioners and optimizes the medical supply chain, these functional requirements are essential.

3.3.2. Non-functional Requirements:

Non-functional requirements outlined in the SRS address the performance, security, and usability aspects of the MSCMS. Given the sensitive nature of medical supplies, the system must adhere to stringent security standards to protect patient data and ensure the integrity of the supply chain. Non-functional requirements may specify performance metrics such as response times, system reliability, and scalability to accommodate the dynamic nature of healthcare environments. Usability requirements ensure that the MSCMS is user-friendly for healthcare professionals who may have varying levels of technical expertise.

3.3.3. System Constraints:

The SRS identifies any constraints that may impact the development and deployment of the MSCMS. This could include limitations in hardware resources, budget constraints, or specific technological dependencies. Understanding these constraints is vital for making informed decisions during the development process and ensuring that the final MSCMS aligns with practical and logistical considerations.

3.4. Purpose of the System

The purpose of the Medical Supply Chain Management System (MSCMS) is to streamline and optimize the complex processes involved in managing the flow of medical supplies within healthcare organizations. This purpose encompasses various objectives aimed at enhancing efficiency, reducing costs, ensuring regulatory compliance, and ultimately improving patient care.

The Medical Supply Chain Management System aims to provide real-time tracking and monitoring of medical supplies, from procurement to usage. This ensures that healthcare facilities maintain optimal inventory levels, preventing shortages or excesses that can impact patient care.

3.5. Scope of the Developed System

The scope of the Medical Supply Chain Management System (MSCMS) outlines the boundaries, functionalities, and objectives that the system is designed to address. It defines what aspects of the medical supply chain will be covered and what features will be included. This includes functionalities for tracking and monitoring the entire lifecycle of medical supplies, from procurement and storage to distribution and usage within healthcare facilities.

3.6. System Architecture

The client-server system architecture is a model where the responsibilities and tasks related to processing, storage, and access to data are divided between two types of entities: clients and servers. In the context of a Medical Supply Management System (MSMS), this architecture is designed to efficiently handle the complexities of managing medical supplies within a healthcare environment.

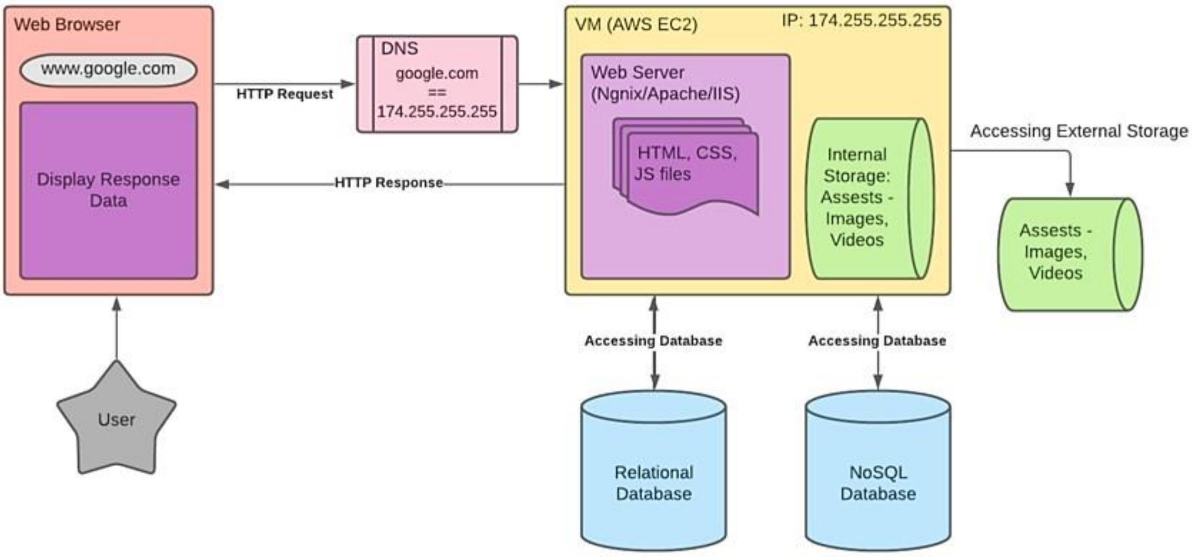


Figure 3.2 -Real-time web application architecture with a single user

Source: Viplove Prakash. (2021): [Deploy a web application in production in just six steps | by Viplove Prakash | Medium]

3.6.1. Clients:

- User Interfaces: Clients in the Medical Supply Management System context are devices used by healthcare professionals or administrators. These devices, such as computers or mobile devices, host user interfaces that allow users to interact with the system. The interfaces are designed to be user-friendly and provide functionalities for tasks such as order placement, inventory checking, and data analysis.

3.6.2. Server:

- Centralized Database: The server side of the architecture hosts a centralized database that stores crucial data related to medical supplies, inventory, orders, and other relevant information. This centralization ensures data consistency and integrity across the entire system. It acts as a single source of truth for the MSMS.

- Security Measures: Security protocols and measures are implemented on the server side to safeguard sensitive medical and supply chain data. This includes access control, encryption, and authentication mechanisms to protect against unauthorized access. Centralized security ensures a uniform and robust approach to data protection.
- Communication with Clients: Communication between clients and the server occurs through established protocols, such as HTTP or HTTPS. This facilitates the exchange of data, requests, and responses, ensuring seamless connectivity between devices and the central server.

3.7. System Environment

The System Environment for the Medical Supply Management System (MSMS) encompasses both hardware and software configurations essential for its effective operation. In terms of hardware, the system requires specifications that support seamless functionality, including servers to host the centralized database, computing devices for users, and networking infrastructure to facilitate communication. On the software front, the medical supply management system (MSMS) relies on a technology stack comprising Python Django, HTML, CSS, JavaScript, Boostrap, and MySQL database.

3.7.1. Hardware Specification

Hardware specifications detail the infrastructure required to host the MSMS. This includes servers, storage systems, networking components, and IoT devices. The chapter provides insights into the hardware choices made to support the system's functionalities, ensuring optimal performance and reliability.

i. Laptop computer
ii. Intel or AMD processor with minimum 1.5GHz speed and above.
iii. RAM: 4GB and above iv. Hard Disk: 80GB and above

3.7.2. Software Specification

The software specification outlines the technologies, programming languages, and frameworks employed in the development of the medical supply management system (MSMS). This section explores the rationale behind the software choices, emphasizing the need for compatibility, security, and scalability within the healthcare environment.

i. Python as a programming language
ii. Django as a framework for the development
iii. MYSQL as a database tool for the system
iv. Html, CSS, JavaScript & Bootstrap for the front-end development
v. Google Chrome browser for testing and accessing the application

3.8. Software Features

In the context of the Medical Supply Management System (MSMS), the emphasis on software features aligns with the overarching goals of the project development methodology. The software features are designed with careful consideration of user-friendliness, system efficiency, flexibility, reliability, maintainability, portability, and integrity. This approach ensures that the medical supply management system (MSMS) is not only responsive to the dynamic needs of healthcare professionals and administrators but also prioritizes a user-centric experience.

3.9. System Modules

The developer of this project Medical Supply Management System (MSMS), makes use of Python Django, MySQL. There are three modules in it, which are Stock Module, Stock History Module, and invoice module represent distinct components designed to fulfill specific functionalities within the overall system. Let's relate these modules to their potential roles in managing medical supplies:

3.9.1 Stock Module:

- Inventory Management*:* The stock module is responsible for managing the inventory of medical supplies. It allows users to view current stock levels, add new supplies, and update existing stock information.
- Supply Management: Healthcare professionals can make medical supplies through this module, triggering updates to the inventory.

3.9.2. Stock History Module:

- Activity Tracking*:* The Stock History Module keeps a record of all stockrelated activities. This includes details of stock additions, removals, and any other changes made to the inventory.
- Audit Trail*:* Users can review the history of stock transactions, providing transparency and accountability in the supply chain.

3.9.3. Invoice Module:

- Invoice Generation: The Invoice Module generates invoices for orders placed by healthcare professionals. It includes details such as itemized lists, and quantities
- Customer details: The module may track customer's status and due dates for invoices, within the supply chain.

3.10. Integration and Collaboration:

These modules collectively contribute to a comprehensive Medical Supply Management System, allowing for seamless integration and collaboration between different aspects of the supply chain.

3.10.1. Python Django*:*

The backend framework, Django, is likely used to develop the logic and functionalities related to stock management. This includes handling stock levels, updating inventory, and processing stock-related transactions. Python Django framework serves as the backbone, ensuring the efficient processing of data and interactions between the various modules.

3.10.2. HTML, CSS, JavaScript, Bootstrap:

These technologies contribute to the development of the user interface of different modules. HTML structures the content, CSS styles the presentation, JavaScript enhances interactivity, and Bootstrap provides a responsive design for seamless user experience.

3.10.3. Visual Studio Code (VS Code):

VS Code serves as an integrated development environment (IDE) for developers working on the medical supply management system (MSMS). It provides a platform for coding, debugging, and version control. Developers can write, edit, and organize code efficiently, thanks to VS Code's features like syntax highlighting, autocompletion, and integrated Git support.

3.10.4. Development Server:

Localhost refers to the local server on a developer's machine used for testing and development before deploying to a live environment. During Medical Supply Management System development, localhost is the environment where developers can run and test the application without affecting the live system.

3.10.5 Browser for Frontend Testing:

Google Chrome is commonly used to test the frontend of the MSMS. Developers can use Chrome's Developer Tools to inspect and debug the application's frontend code.

CHAPTER FOUR
System Analysis and Design

Chapter Summary

This chapter delves into the critical aspects of the development of the Medical Supply Chain Management System (MSCMS). The initial focus is on the System Development Feasibility Analysis, a comprehensive assessment that evaluates the potential of the MSCMS to meet functional needs, provide economic benefits, and seamlessly integrate with existing technologies within the healthcare sector.

In the Functional Feasibility section, researchers conduct a meticulous examination of the medical supply management system (MSCMS) capabilities to address the dynamic needs of healthcare professionals and administrators. Economic Feasibility involves a thorough financial analysis to evaluate the cost-effectiveness of implementing the MSCMS. The chapter also explores Technical Feasibility, where researchers examine the compatibility of the MSCMS with existing technology infrastructure within healthcare environments.

Moving on to System Design, researchers embark on the critical phase of shaping the blueprint for the MSCMS, ensuring its technical soundness and usercentric approach. The chapter details the creation of Data Design Diagrams, Database Design, and System Output Design. These elements provide a visual guide for comprehending the intricate data architecture and presenting information to endusers in a clear, user-friendly manner. The logical view includes Activity Diagrams, Use Case Diagrams, Data Flow Diagrams, Entity Relationship Diagrams, and Sequence Diagrams. The chapter concludes by highlighting the significance of these design components in laying the groundwork for the subsequent stages of MSCMS development.

4.0. System Development Feasibility Analysis

The System Development Feasibility Analysis provides a comprehensive understanding of the Medical Supply Chain Management System (MSCMS) potential to address functional needs, deliver economic benefits, and integrate seamlessly with existing technologies. This analysis is instrumental in guiding decision-making processes and determining the strategic alignment of the MSCMS within the healthcare sector. This analysis encompasses three critical dimensions: Functional Feasibility, Economic Feasibility, and Technical Feasibility.

4.0.1. Functional Feasibility:

Researchers conducting the System Development Feasibility Analysis begin by focusing on functional feasibility, assessing the medical supply chain management system (MSCMS) capacity to effectively meet the identified functional requirements. In the intricate landscape of medical supply chain management, this involves a meticulous examination of the system's capabilities to address the dynamic needs of healthcare professionals and administrators. The feasibility analysis aims to ensure that the MSCMS comprehensively supports key functionalities such as supplies processing, demand forecasting, inventory management, and reporting. By conducting a thorough functional feasibility assessment, researchers ascertain that the system aligns precisely with the specific operational requirements of medical supply chains, ultimately enhancing overall efficiency and effectiveness.

4.0.2. Economic Feasibility:

In the economic feasibility dimension, researchers delve into the financial aspects to evaluate the cost-effectiveness of implementing the medical supply chain management system (MSCMS). This involves a detailed financial analysis, encompassing development costs, operational expenses, and potential return on investment. Specifically tailored to the medical supply management system, the economic feasibility study assesses factors like software development, hardware procurement, training, and maintenance costs. Through a comprehensive cost-benefit analysis, researchers determine whether the benefits derived from the MSCMS, such as improved inventory control and streamlined processes, justify the associated costs. This thorough economic feasibility assessment ensures that the implementation of the system aligns with the financial goals of healthcare organizations and provides sustainable economic value.

4.0.3 Technical Feasibility:

In technical feasibility, researchers examine carefully the compatibility of the medical supply chain management system (MSCMS) with existing technology infrastructure within healthcare environments. This involves an in-depth analysis of hardware, software, and networking requirements. The technical feasibility study ensures that the proposed system can seamlessly integrate into the healthcare ecosystem, leveraging existing technologies while minimizing potential disruptions. Researchers assess whether the MSCMS aligns with industry standards, scalability needs, and security protocols. Addressing technical feasibility is crucial for ensuring the system's interoperability, adaptability, and efficient performance within the complex healthcare IT landscape. This systematic approach to technical feasibility enables researchers to guide decision-making processes and determine the strategic alignment of the MSCMS within the healthcare sector.

4.1. System Design

This comprehensive System Design phase lays the groundwork for the subsequent stages of development, ensuring that the MSCMS is not only technically sound but also user-centric and capable of delivering meaningful, actionable information to enhance the efficiency of medical supply chain management.

4.1.1. System Development Overview:

Researchers embark on the critical phase of System Design, shaping the blueprint for the Medical Supply Chain Management System (MSCMS) to align seamlessly with the identified requirements and objectives. This phase is a pivotal bridge between conceptualization and implementation, where the theoretical framework of the system takes tangible form.

4.1.2. Data Design Diagrams:

In crafting the data design diagrams, researchers employ various modelling techniques to visually represent the structure and flow of information within the MSCMS. Techniques such as Entity-Relationship Diagrams (ERDs) are instrumental in defining the relationships among different data entities, such as medical supplies, inventory levels, and procurement transactions. These diagrams serve as a visual guide, aiding both developers and stakeholders in comprehending the intricate data architecture that underlies the efficient functioning of the system. Below are some key aspects of the proposed project design in logical view:

I. Activity diagram
II. Use case diagrams
III. Data Flow diagrams, level 0 and 1
IV. Entity Relationship Diagram
V. Sequence Diagrams

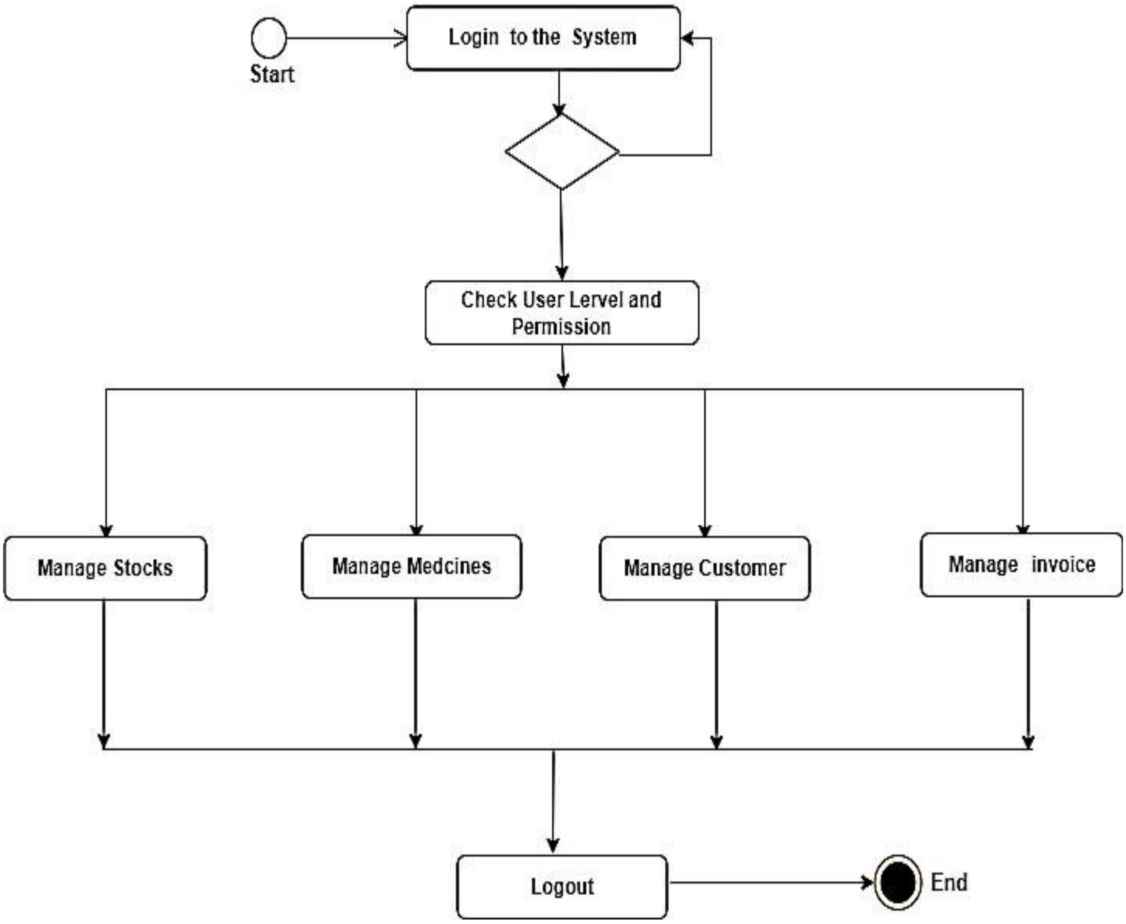


Figure 4.1 -Medical Supply Management System Activity Diagram
Source: Study activity (January, 2024).

Activity Diagrams

Activity diagrams are used to model the flow of activities in a system. The above activity diagram illustrates the flow of activities in the Medical Supply Management System. These diagrams showcase the sequence of activities, decision points, and parallel tasks, offering a clear depiction of the supply chain operations.

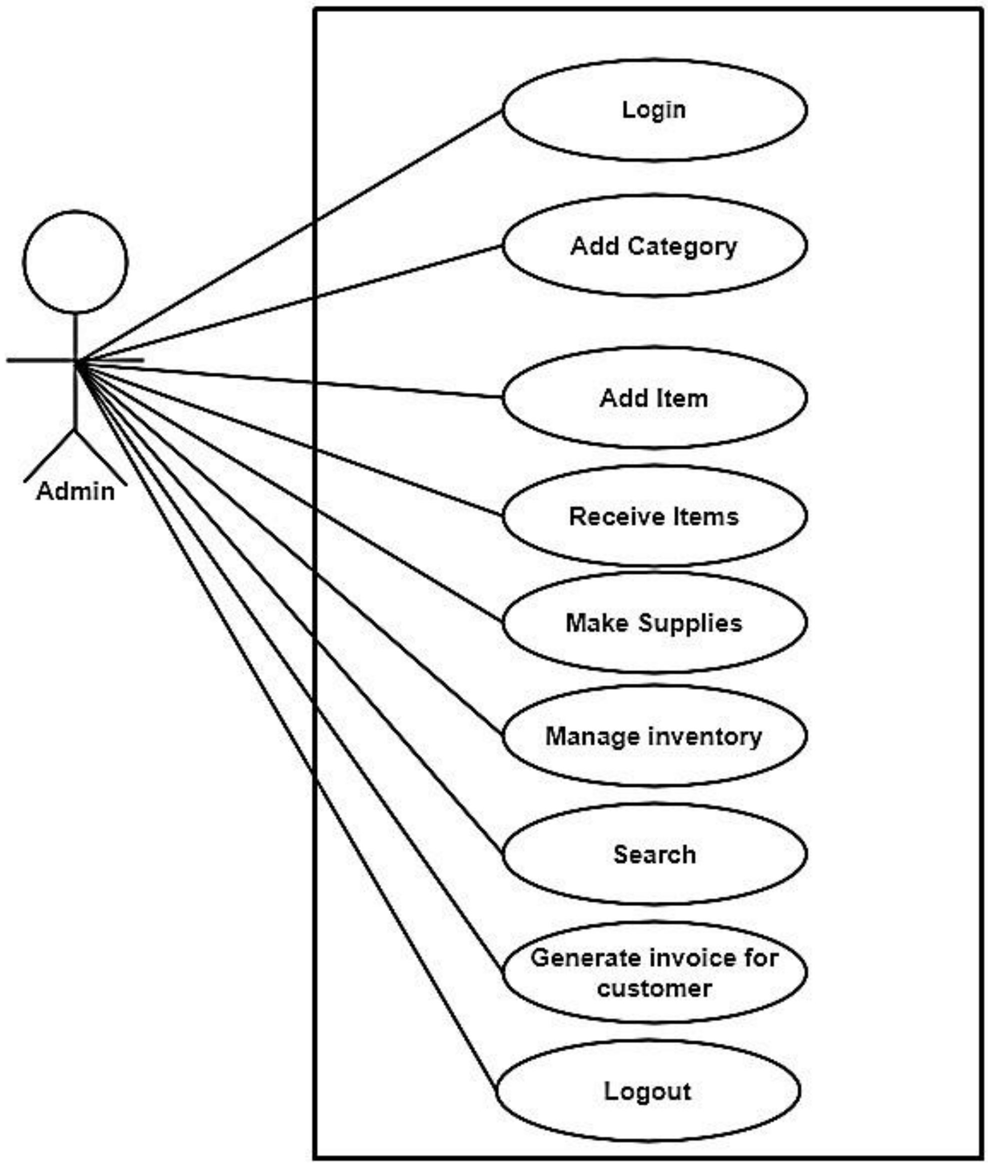


Figure 4.2 -Medical Supply Management System Use Case Diagram
Source: Study activity (January, 2024).

Use Case Diagram

Use case diagrams are used to model the interactions between actors and the system. The above use case diagram illustrates the interactions between actor and the Medical Supply Management System.

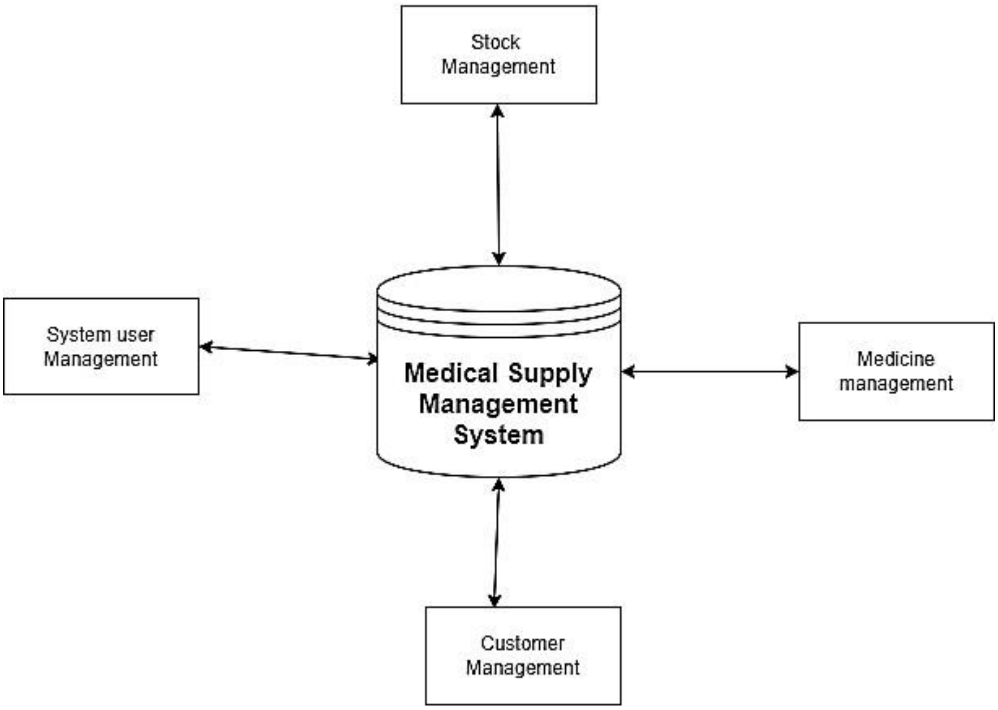


Figure 4.3 - Level-Zero Data Flow Diagram for Medical Supply Management System Source: Study activity (January, 2024).

Level Zero Data Flow Diagram

The level zero data flow diagram provides an overview of the entire Medical Supply Management System.

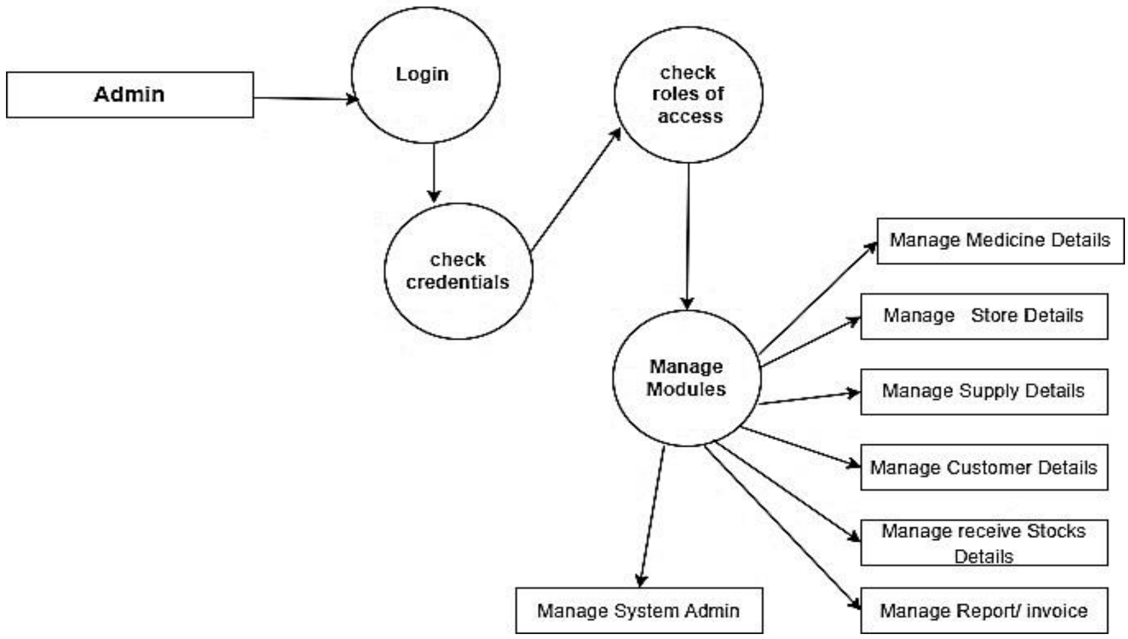


Figure 4.4- Level-One Data Flow Diagram for Medical Supply Management System
Source: Study activity (January, 2024).

Level One Data Flow Diagram

The level one data flow diagram provides a detailed view of the system. The above level one data flow diagram illustrates the detailed view of the Medical Supply Management System.

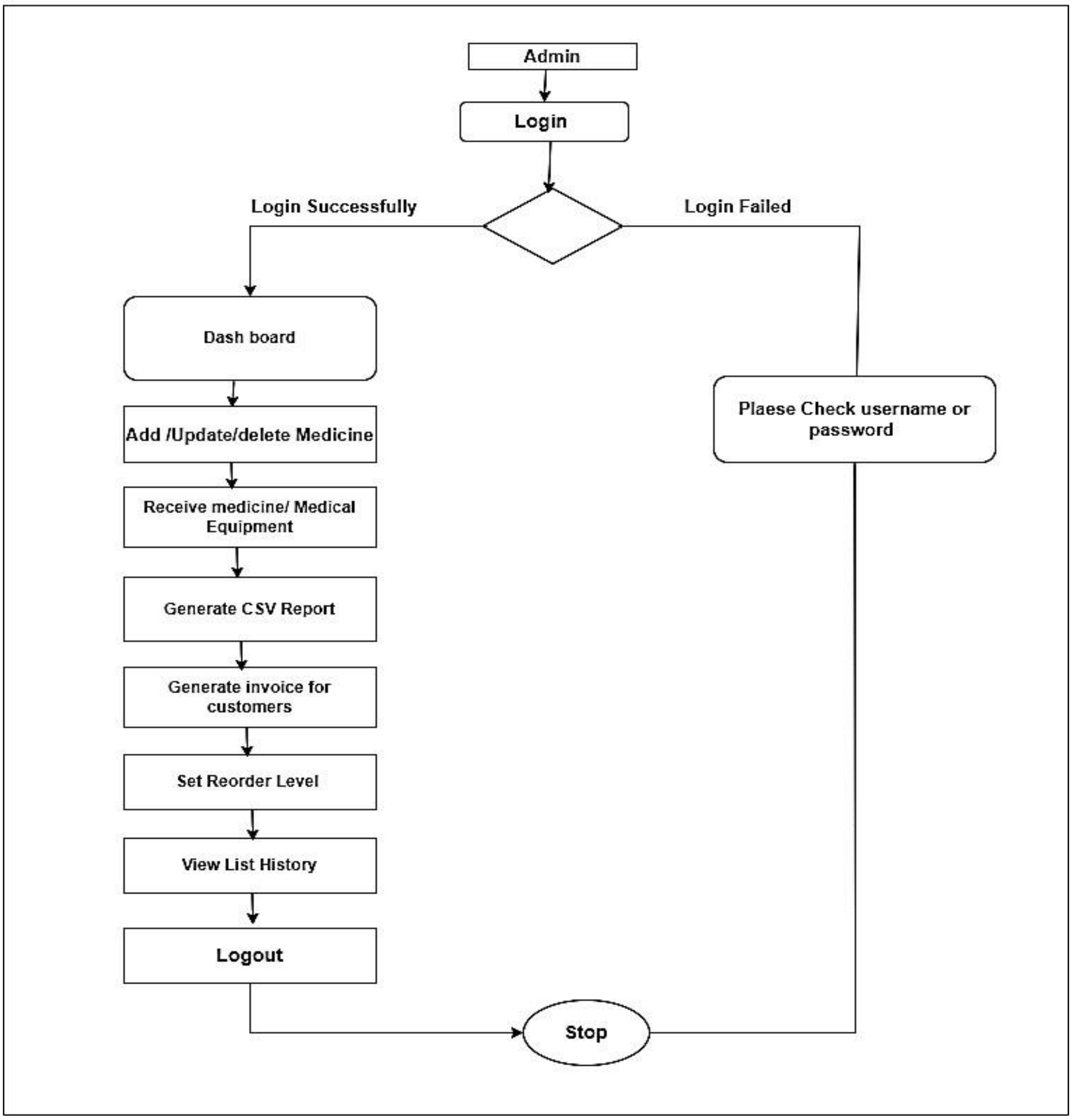


Figure 4.5- Level-Two Data Flow Diagram for Medical Supply Management System
Source: Study activity (January, 2024)

Level Two Data Flow Diagram

The level two data flow diagram provides a more detailed view of the Medical Supply Management System.

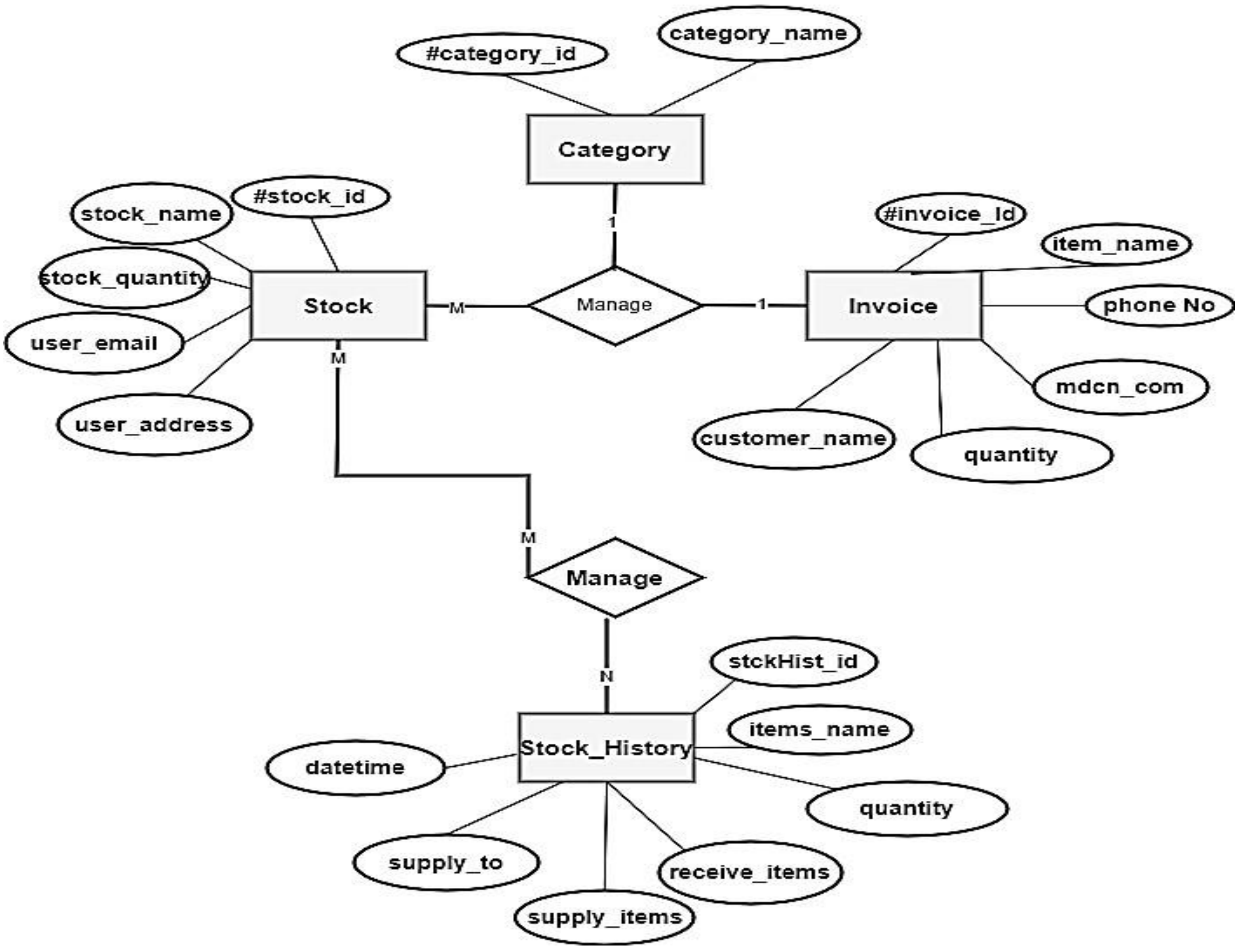


Figure 4.6 - Medical Supply Management System Entity Relationship Diagram (ER-diagram) Source: Study activity (January, 2024).

Entity Relationship Diagram

The entity relationship diagram is used to model the relationships between entities in a Medical Supply Management System,

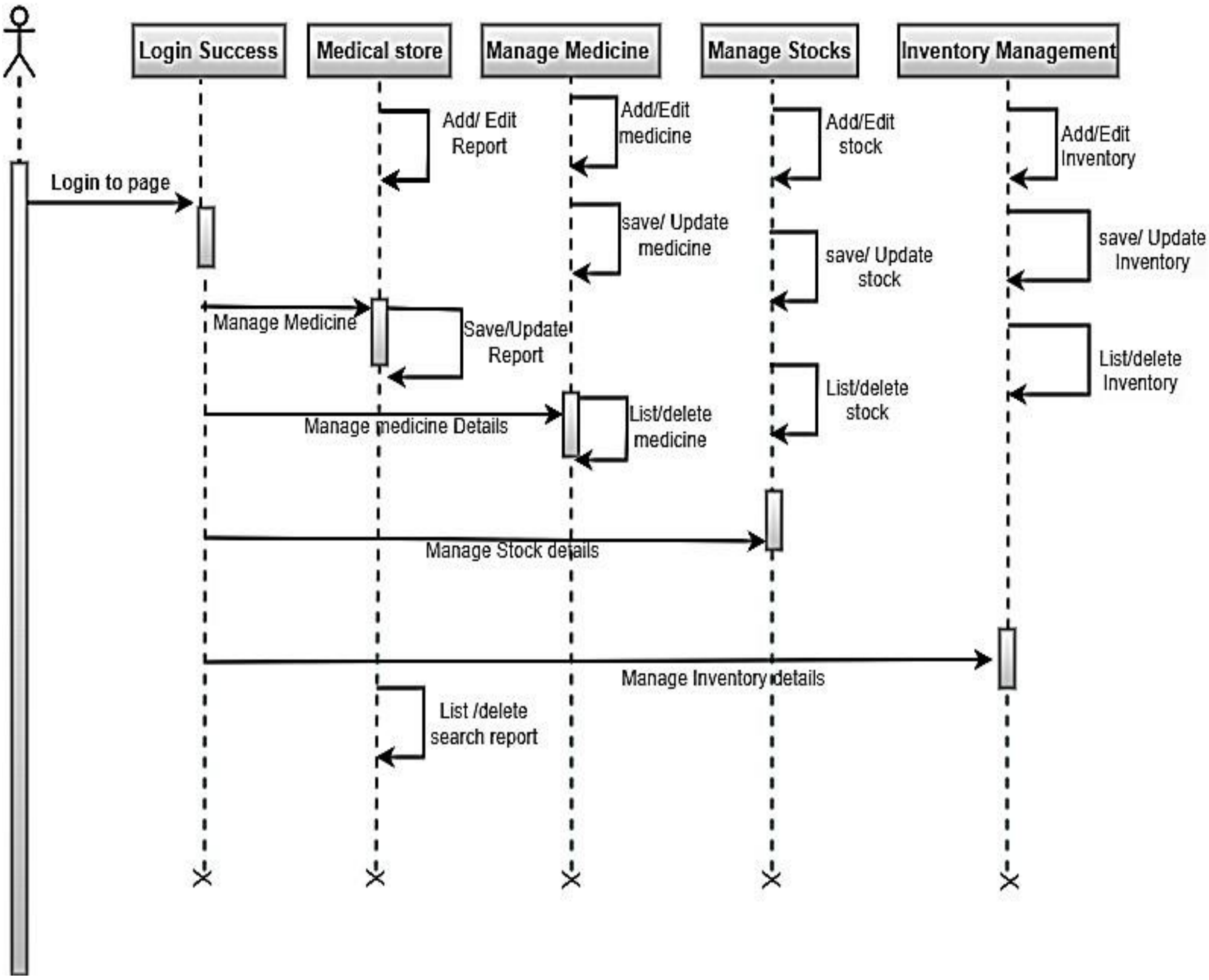


Figure 4.7 - Medical Supply Management System Sequence Diagram
Source: Study activity (January, 2024)

Sequence diagrams are used to model the interactions between objects in a system. The above sequence diagram illustrates the interactions between objects in the Medical Supply Management System.

4.2. Database Design:

Building upon the data design, the database design phase involves the specification of the database structure that will house and manage critical information.

This includes defining tables, establishing relationships, and determining data types. Researchers employ relational database management systems, like MySQL, to ensure robust data organization, retrieval, and manipulation. The objective is to create a database schema that optimally supports the functionalities of the MSCMS, facilitating seamless data storage, retrieval, and integrity.

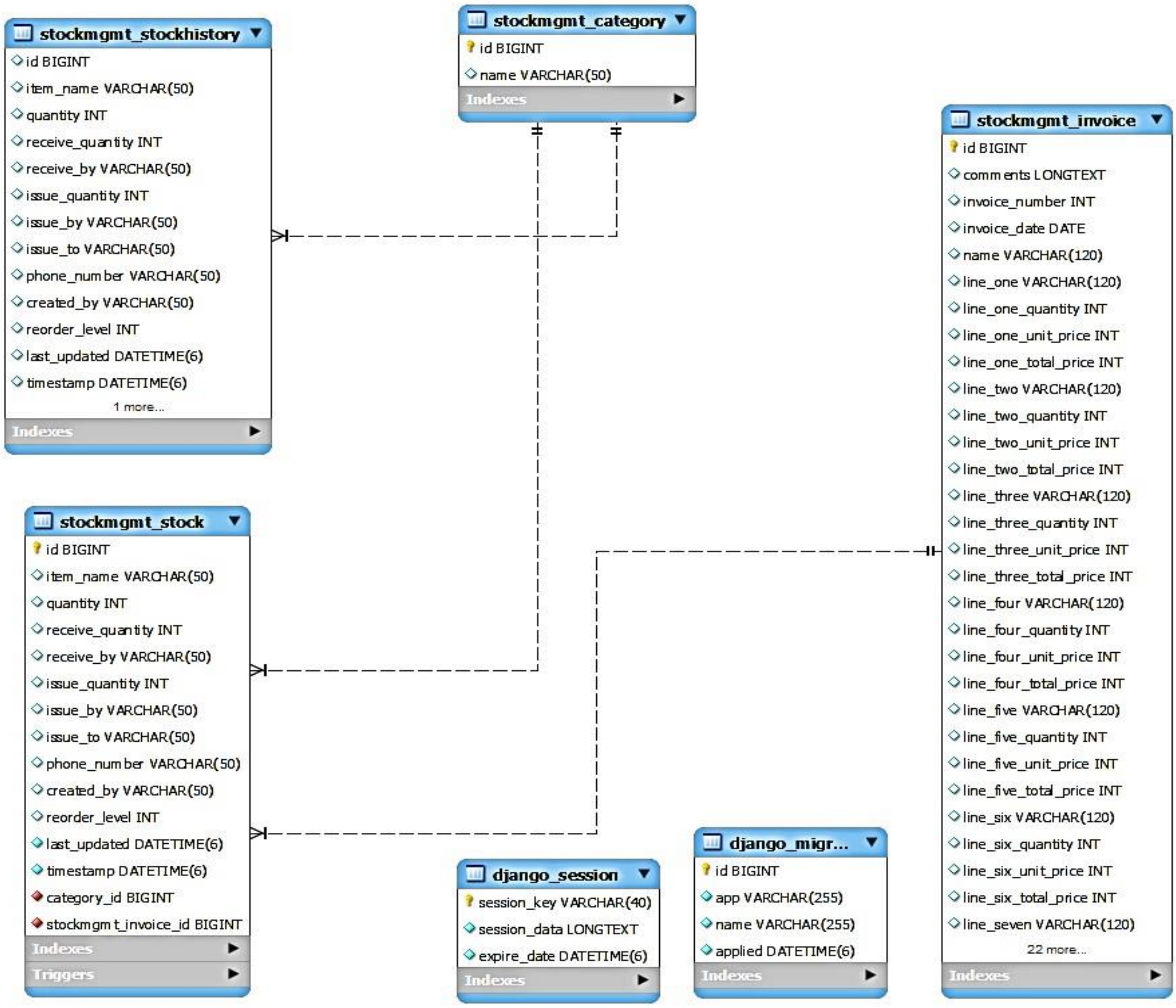


Figure 4.8 - Database Table and Relationships

Source: Study activity (January, 2024).

Table 4.1 MySQL Stock Table Structure

id	item_name	quantity	receive_quantity	issue_quantity	reorder_level	last_updated
9	Infusion pumps	81	1	0	0	2023-10-17 10:57:13.326343
12	Babcock	0	0	0	0	2023-10-17 11:16:42.279825
13	Ring cutter	0	0	0	0	2023-10-17 11:23:14.186202
15	Panadol	5	0	45	2	2023-10-19 19:50:21.037898
NULL	NULL	NULL	NULL	NULL	NULL	NULL

Source: Study activity (January, 2024).

Table 4.2 MySQL Category Table Structure

id	name
1	Medicine
2	Medical Devices
3	Personal Care Products
4	Baby and Child Care Products
5	First Aid Supplies
6	Medical Tests and Kits
7	Surgical Supplies
8	Respiratory Supplies
9	Dietary Foods
10	Hygiene Products
NULL	NULL

Source: Study activity (January, 2024).

Table 4.3 MySQL Stock History Table Structure

id	item_name	quantity	receive_quantity	issue_quantity	issue_to	last_updated
1	Panadol	60	6	NULL	NULL	2023-10-02 01:11:59.652507
1	Panadol	50	NULL	10	Makeni	2023-10-02 01:17:30.402446
2	Malcure	42	30	0	NULL	2023-10-08 17:44:59.461732
1	Panadol	40	0	10	Freetown	2023-10-02 01:29:05.812366
2	Malcure	42	30	0	NULL	2023-10-08 17:44:59.461732
1	Panadol	140	100	0	NULL	2023-10-02 01:32:50.903370
1	Panadol	40	0	100	Freetown	2023-10-02 01:46:11.340581
1	Panadol	140	100	0	NULL	2023-10-02 01:59:29.229286
7	Mask	350	0	150	Mile 91	2023-10-02 02:18:33.380781
2	Malcure	42	30	0	NULL	2023-10-08 17:44:59.461732
2	Malcure	42	30	0	NULL	2023-10-08 17:44:59.461732
8	TM	700	0	0	NULL	2023-10-02 14:57:54.388056
9	Temp	130	70	0	NULL	2023-10-02 21:43:46.424884
10	Crime	628	0	10	admin	2023-10-08 17:46:51.270218

Source: Study activity (January, 2024).

Table 4. 4 MySQL Invoice Table Structure

id	comments	invoice_number	invoice_date	name	line_one	line_one_quantity
1		1	2023-10-30	Mile 91 Health Center	Panaldor	50
2		2	2023-10-31	Bo Community Health Care	Panaldor	2
3		3	2023-10-31	MOHAMED IBRAHIM SANKOH	Panaldor	2
4		4	2023-10-31	MOHAMED IBRAHIM SANKOH	Panaldor	3
5		5	2023-10-31	Mohamed	Panaldor	50
NULL	NULL	NULL	NULL	NULL	NULL	NULL

Source: Study activity (January, 2024).

4.3. System Output Design:

The System Output Design is focused on defining how information processed within the medical supply chain management system (MSCMS) will be presented to end-users. Researchers consider the diverse needs of healthcare professionals, administrators, and other stakeholders when designing the system's output format. Reports, dashboards, and alerts are structured to provide actionable insights, aiding decision-making processes. The design emphasizes clarity, user-friendliness, and relevance, ensuring that the system's output aligns with the information needs of different users across the medical supply chain.

CHAPTER FIVE
System Implementation and Testing

Chapter Summary

This chapter delves into the crucial phases of System Implementation and Testing within the development lifecycle of the Medical Supply Chain Management System (MSCMS). System implementation is highlighted as the transformative process turning theoretical designs into practical, executable code. Key aspects, including coding and development, database creation, integration of system components, user interface development, testing procedures, refinement, documentation, and deployment, are explored. The emphasis is on the quality of coding, database functionality, integration, and rigorous testing to ensure a reliable and effective system that addresses the intricate challenges of managing medical supplies in healthcare settings.

System testing, a critical phase, is multifaceted, covering various dimensions to ensure the robustness and user-friendliness of the medical supply chain management system (MSCMS). Test case specifications outline conditions and expected outcomes, guiding meticulous testing. Front-end testing focuses on the user interface, including unit testing, functional testing, integration testing, and system testing. Performance testing evaluates responsiveness, scalability, and stability. Backend testing ensures seamless integration with the database, validating data storage accuracy and overall efficiency. Schema testing involves a detailed examination of the database structure, *covering table and column testing, index testing, trigger testing, stored procedure testing, and database server validation testing. Additional tests encompass user acceptance testing, user training effectiveness, and security and maintenance testing*

5.0. System Implementation

System implementation is the process of transforming a theoretical design into a practical reality. This involves converting architectural blueprints into executable code. System implementation is a critical phase in the development lifecycle of the Medical Supply Chain Management System (MSCMS). This phase involves translating the detailed design specifications into a functional system that can be integrated into the healthcare environment.

The successful implementation of the medical supply chain management system (MSCMS) marks a significant milestone, bringing the envisioned medical supply chain management solution to life. The focus on coding quality, database functionality, integration, and testing contributes to a reliable and effective system that addresses the complex challenges of managing medical supplies in healthcare settings.

5.0.1. Coding and Development:

During the implementation process, developers engage in coding activities to create the software components outlined in the design phase. In the case of medical supply chain management system (MSCMS), this includes modules such as stock management, supply processing, inventory tracking, and reporting. The coding is guided by industry best practices, coding standards, and the specific requirements of the medical supply chain domain.

5.0.2. Database Creation:

The database structure designed in the previous phase is implemented during system implementation. This involves creating tables, defining relationships, and establishing data constraints. For MSCMS, the database plays a crucial role in managing information related to medical supplies, inventory levels, supplies, and other relevant data points.

5.0.3. Integration of System Components:

Different modules and components developed during coding are integrated to create a cohesive system. Integration ensures that each part of the medical supply chain management system (MSCMS) interacts seamlessly with others, and data flows smoothly across various functionalities. This phase is crucial for establishing a comprehensive and unified medical supply chain management solution.

5.0.4. User Interface Development:

The user interface is a key component of medical supply chain management system (MSCMS), as it is the point of interaction for healthcare professionals and administrators. The implementation phase includes the development of a user-friendly interface that facilitates easy navigation and efficient use of the system. The design principles focus on clarity, simplicity, and alignment with user requirements.

5.0.5. Testing During Implementation:

Testing is an integral part of the implementation process. Developers conduct unit testing to verify the correctness of individual modules, ensuring that each component functions as intended. The testing process helps identify and rectify any errors or bugs early in the development cycle.

5.0.6. Refinement and Optimization:

Continuous refinement and optimization are undertaken during the implementation phase. Developers assess the system's performance, identify areas for improvement, and make necessary adjustments. This iterative process ensures that the medical supply chain management system (MSCMS) meets quality standards and is aligned with user expectations.

5.0.7. Documentation:

Comprehensive documentation is created during implementation to provide insights into the system's architecture, functionalities, and coding practices. This documentation serves as a valuable resource for future maintenance, updates, and potential expansions of the medical supply chain management system (MSCMS).

5.0.8. Deployment:

After successful implementation and testing, the medical supply chain management system (MSCMS) is deployed to the live environment. Deployment involves configuring the system to operate in the actual healthcare setting. It includes considerations for data migration, user training, and ensuring that the system is ready for day-to-day operations.

5.1. System Testing

System testing is a critical phase in the development life cycle of the Medical Supply Chain Management System (MSCMS), aiming to ensure the overall functionality, reliability, and performance of the system in a healthcare environment. system testing for the MSCMS is a comprehensive process that spans various dimensions, ensuring that the system is robust, user-friendly, and capable of meeting the complex demands of medical supply chain management in healthcare settings.

5.1.1. Test Case Specifications:

Test case specifications are essential documents that outline the conditions, inputs, and expected outcomes for various scenarios within the medical supply chain management system (MSCMS). These cases cover a range of functionalities such as stock management, supplies, inventory tracking, and reporting. Each test case is meticulously designed to validate specific aspects of the system's behavior.

5.1.2. Front-End Testing Strategy:

Front-end testing focuses on the user interface and user interactions within the medical supply chain management system (MSCMS). It includes several levels of testing to ensure a seamless and user-friendly experience.

- **Unit Testing:** Unit testing involves the examination of individual modules to verify that they perform as intended. For MSCMS, this includes testing functionalities such as receive items, supply items, updating inventory, and generating reports.

- **Functional Testing:** Functional testing assesses the overall functionality of the medical supply chain management system (MSCMS). It ensures that each feature works correctly, meeting the requirements outlined during the design phase. This includes verifying that order processing is accurate, inventory levels are updated in real-time, and reporting functionalities produce meaningful insights.

- **Integration Testing:** Integration testing evaluates the interaction between different modules and components. It ensures that the integrated system operates cohesively, with no disruptions in data flow. Medical Supply Chain Management System (MSCMS) integration testing checks how well stock management integrates with order processing, inventory tracking, and reporting functionalities.

- **System Testing:** System testing provides a comprehensive evaluation of the entire medical supply chain management system (MSCMS). It verifies that the system meets the specified requirements and performs reliably in a real-world healthcare setting. This involves end-to-end testing of key processes, from placing orders to updating inventory and generating reports.

5.1.3. Performance Testing:

Performance testing assesses how well the medical supply chain management system (MSCMS) functions under various conditions. This includes evaluating its responsiveness, scalability, and stability. In a medical supply chain context, performance testing ensures that the system can handle fluctuations in demand, process orders efficiently, and maintain optimal response times.

5.1.4. Back-End Testing:

Back-end testing focuses on the server-side functionalities, including data storage, retrieval, and processing. For MSCMS, it ensures the seamless integration of the database with the front-end functionalities. This involves validating the accuracy of data storage, ensuring data integrity, and assessing the overall efficiency of backend processes.

5.1.5. Schema Testing:

Schema testing involves a detailed examination of the database structure within the medical supply chain management system (MSCMS). This includes testing tables, columns, indexes, triggers, and stored procedures.

- **Table and Column Testing:** Ensures that tables and columns store and retrieve data accurately.
- **Index Testing:** Validates the efficiency of indexing in data retrieval.
- **Trigger Testing:** Verifies the proper functioning of triggers in response to specific events.
- **Stored Procedure Testing**: Evaluates the performance and accuracy of stored procedures.
- **Database Server Validation Testing:** Ensures that the database server performs optimally under different conditions.

5.2. Additional Tests:

- User Acceptance Testing (UAT): UAT involves end-users validating the medical supply chain management system (MSCMS) to ensure it meets their operational needs. It provides insights into user satisfaction and identifies areas for improvement.

- User Training: Testing the effectiveness of user training programs to ensure that healthcare professionals can effectively navigate and utilize the MSCMS.

- Security and Maintenance Testing: Evaluating the system's security measures and assessing its ease of maintenance over time.

CHAPTER SIX
Conclusion, Lessons Learnt and Recommendations for Future Enhancement

Chapter Summery

The dissertation concludes with the successful development and deployment of the Medical Supply Chain Management System (MSCMS), addressing challenges in traditional medical supply management. Recognizing the pivotal role of efficient supply management in healthcare, the web-based MSCMS at the Peoples Medical Store in Sierra Leone enhances inventory control and operational efficiency. Lessons learned underscore the importance of stakeholder collaboration, continuous *improvement, and robust testing for system reliability. Recommendations for future enhancements emphasize continuous monitoring, integration of emerging technologies, collaboration with stakeholders, regular updates, and user training programs to ensure the MSCMS remains innovative, adaptable, and aligned with evolving healthcare needs, thereby contributing to sustained excellence in medical supply chain management.*

6.0. Conclusion

The development and implementation of the Medical Supply Chain Management System (MSCMS) stand as a significant milestone in addressing the challenges of traditional medical supply management. The research identified the critical role of efficient medical supply management in ensuring the seamless availability and distribution of essential resources within healthcare settings. The traditional manual and desktop-based systems, prone to errors and inefficiencies, prompted the need for a comprehensive web-based solution. The MSCMS, designed and deployed at the Peoples Medical Store in Freetown, Sierra Leone, not only streamlines inventory control but also enhances various operational aspects, including tracking medication quantities, received items in the store and other medical supplies.

The study's iterative and incremental development process, guided by a welldefined research methodology, allowed for the continuous refinement of the MSCMS. Stakeholder collaboration, particularly with healthcare professionals, played a pivotal role in tailoring the system to the specific needs of medical supply chain management.

The lessons learned underscore the importance of user feedback, thorough testing, and continuous monitoring for system reliability and adaptability.

6.1. Lessons Learned

Several lessons emerged throughout the development and implementation of the MSCMS. Firstly, understanding the intricate needs of stakeholders, especially healthcare professionals, during the initial planning and requirements analysis phases is crucial. Regular stakeholder engagement and feedback loops ensure that the system remains aligned with evolving healthcare needs.

Secondly, the iterative nature of the development process emphasizes the significance of continuous improvement. The ability to adapt to changing requirements and incorporate real-time adjustments is key to the success of a medical supply chain management system. Lastly, the integration of robust testing procedures at each stage is vital for identifying and rectifying issues early in the development cycle, contributing to the overall reliability of the system.

6.2. Recommendations for Future System Enhancements:

For future enhancements, there are several recommendations for enhancing the MSCMS. Continuous monitoring and evaluation should be embedded in the system's operation to identify emerging trends and address evolving challenges in medical supply chain management.

In future study, the researcher will seek the integration of emerging technologies, such as artificial intelligence and machine learning, can further optimize demand forecasting and inventory management. Collaboration with additional stakeholders, including suppliers and regulatory bodies, could enrich the system's capabilities and ensure broader industry alignment. Regular updates and maintenance will be essential to keep the MSCMS at the forefront of innovation and functionality. Moreover, ongoing user training programs should empower healthcare professionals with the latest tools and insights, ensuring the effective utilization of the system in daily operations.

A:

Research Study Activity Gantt Chat

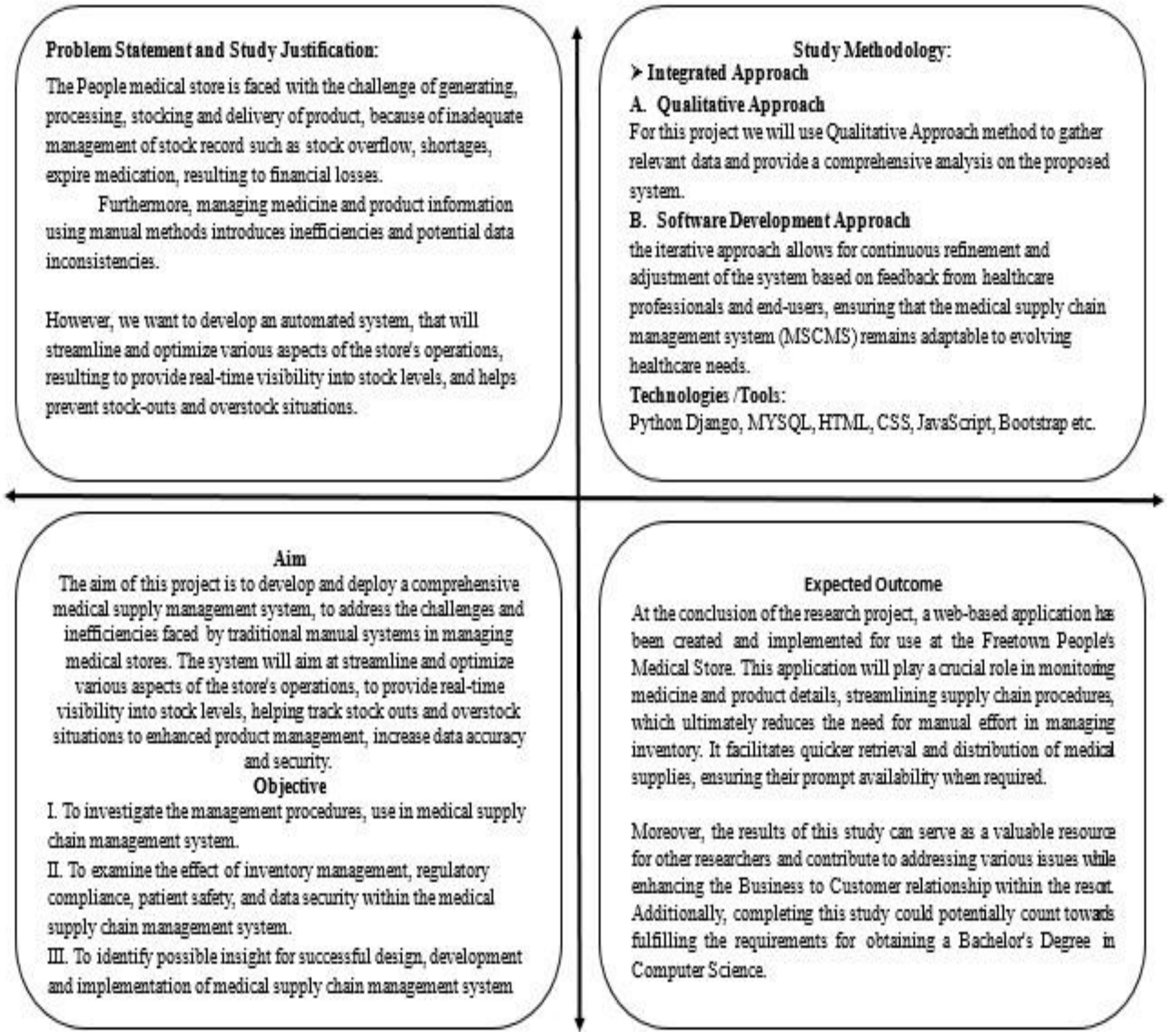
PROJECT NAME: MEDICAL SUPPLY MANAGEMENT SYSTEM															
PROJECT DURATION: 90 DAYS															
PROJECT START DATE: 1/10/2023															
PROJECT END DATE: 31/12/2023															
ACTIVITIES	**DURATION (Days)**	**START**	**END**	**DURATION (WEEKS)**											
				1	2	3	4	5	6	7	8	9	10	11	12
Research/Plan	7	1/10/2023	7/10/2023												
Feasibility Study (Project Definition)	3	8/10/2023	10/10/2023												
System Analysis (Interface Design)	8	11/10/2023	18/10/2023												
System Design (Project Design)	12	18/10/2023	29/10/2023												
Implementation & Testing (Coding)	30	29/10/2023	28/11/2023												
Release & Maintenance (Additional Features)	7	29/11/2023	5/12/2023												
Documentation	23	31/11/2023	31/12/2023												

Source: Study activity (January, 2024).

APPENDIX - B:

Research Study Quad Chart

APPENDIX -



Source: Study activity (January, 2024).

C:

Login Page

Source: Study activity (January, 2024).

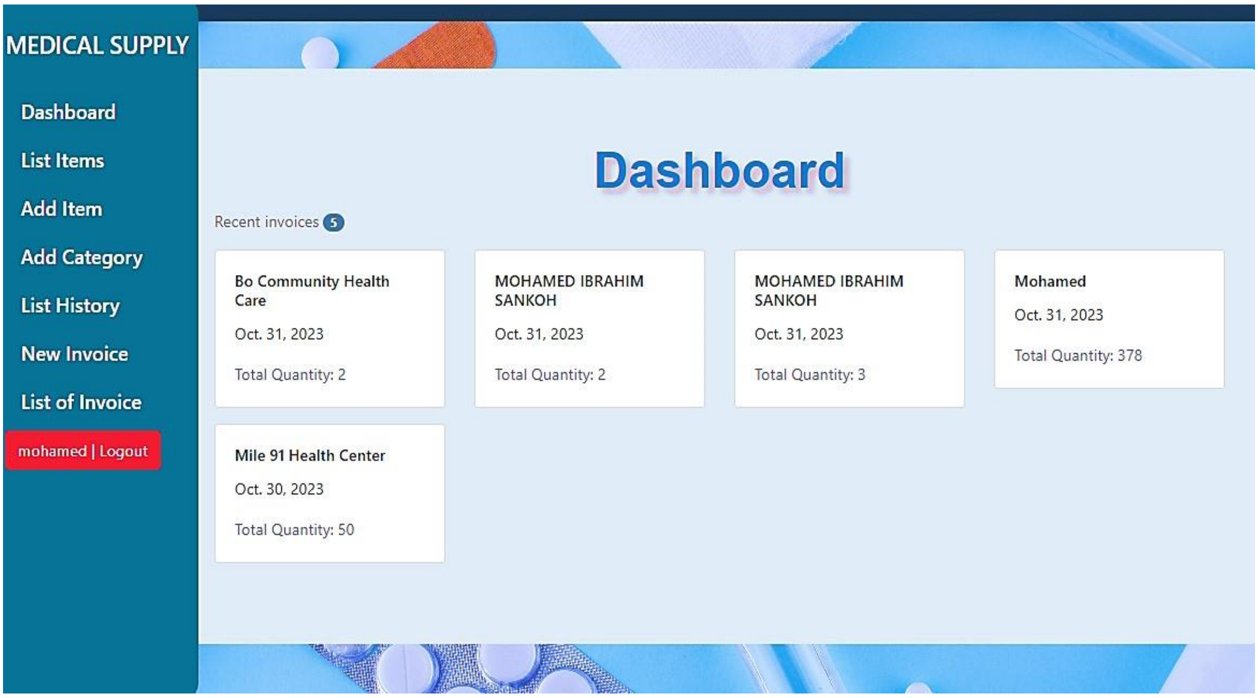
Login Page Code

```
{% block content %}

<div class="container d-flex justify-content-center align-items-center" >

   <form method="post" action="" class="text-center">

      {% csrf_token %}

      {{ form | crispy }}

      <input class="btn btn-primary mt-3" type="submit" value="{% trans 'Log in' %}" />

      <input type="hidden" name="next" value="{{ next }}" />

   </form>

</div>

{% endblock %}
```

APPENDIX -

D:

Dashboard



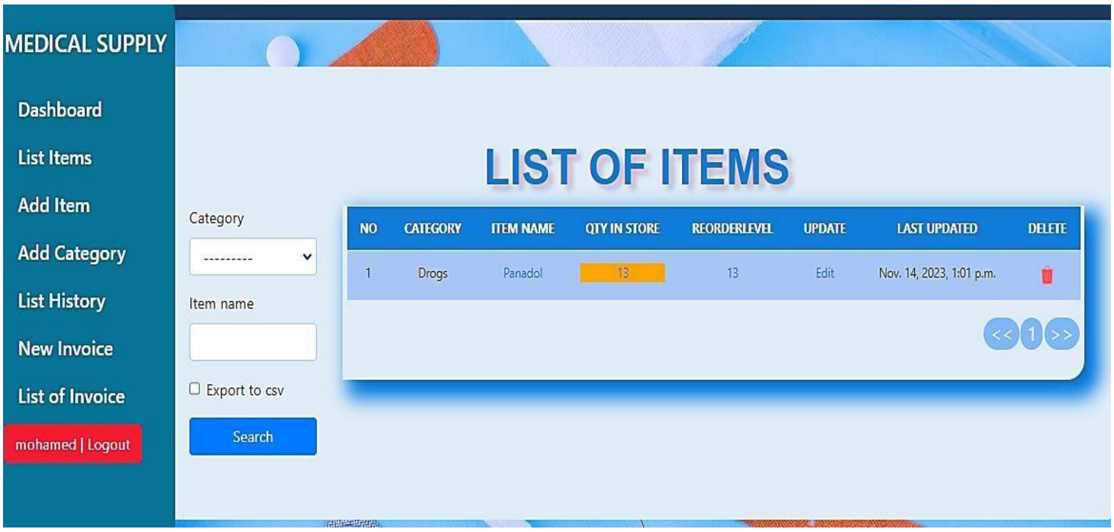
Source: Study activity (January, 2024).

Code for dashboard

```
@login_required def
Dashboard(request):
    form = StockCreateForm(request.POST or None)
total_invoices = Invoice.objects.count()
    queryset = Invoice.objects.order_by('-invoice_date')[:6]
title = Dashboard Page'      context = {
        "title": title,
        "total_invoices": total_invoices,
        "queryset": queryset,
    }
    return render(request, "Dashboard.html",context)
```

E:

List of Items



Source: Study activity (January, 2024).

Code for List Items

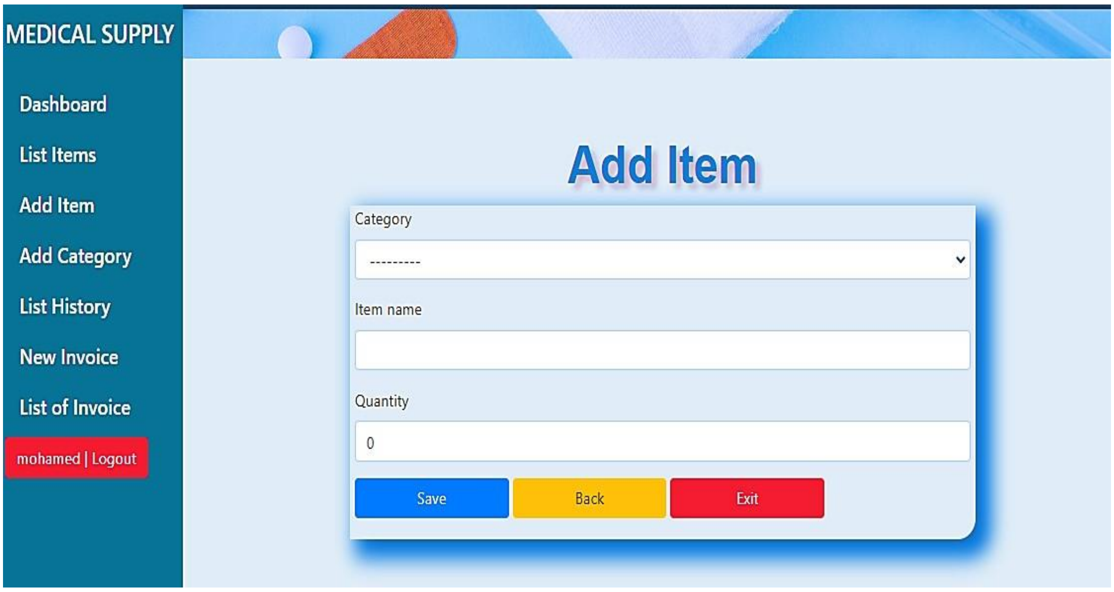
```
@login_required def
list_items(request):
    header = 'LIST OF ITEMS'
    form = StockSearchForm(request.POST or
None)     queryset = Stock.objects.all()     context =
{
        "header": header,
        "queryset": queryset,
        "form": form,
    }
    if request.method == 'POST':
        category = form['category'].value()        queryset = Stock.objects.filter(
#category__icontains=form['category'].value(),
item_name__icontains=form['item_name'].value()
                                        )
if (category != ''):
```

APPENDIX -

```
          queryset = queryset.filter(category_id=category)
if form['export_to_CSV'].value() == True:
          response = HttpResponse(content_type='text/csv')
response['Content-Disposition'] = 'attachment; filename="List of stock.csv"'
writer = csv.writer(response)           writer.writerow(['CATEGORY', 'ITEM
NAME', 'QUANTITY'])           instance = queryset           for stock in instance:
             writer.writerow([stock.category, stock.item_name, stock.quantity])
return response        context = {        "form": form,
      "header": header,
      "queryset": queryset,

}     return render(request, "list_items.html",
context)
```

APPENDIX - F:

Add Item



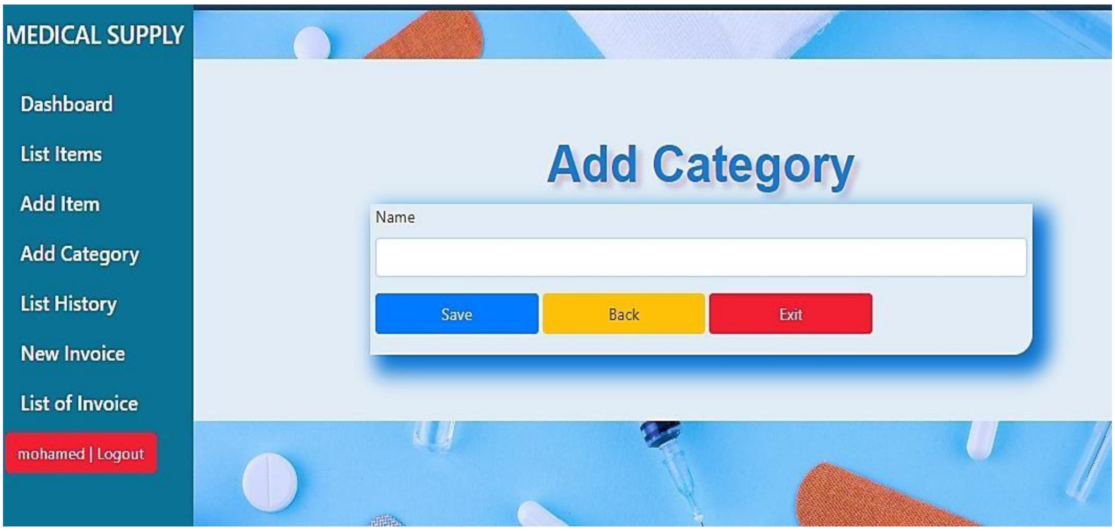
Source: Study activity (January, 2024).

Add Items Code

```
@login_required def
add_items(request):
    form = StockCreateForm(request.POST or None)
if form.is_valid():
        form.save()        messages.success(request,
'Successfully Saved')        return
redirect('/list_items')     context = {         "form":
form,
        "title": "Add Item",
    }
    return render(request, "add_items.html", context)
```

APPENDIX - G:

Add Category



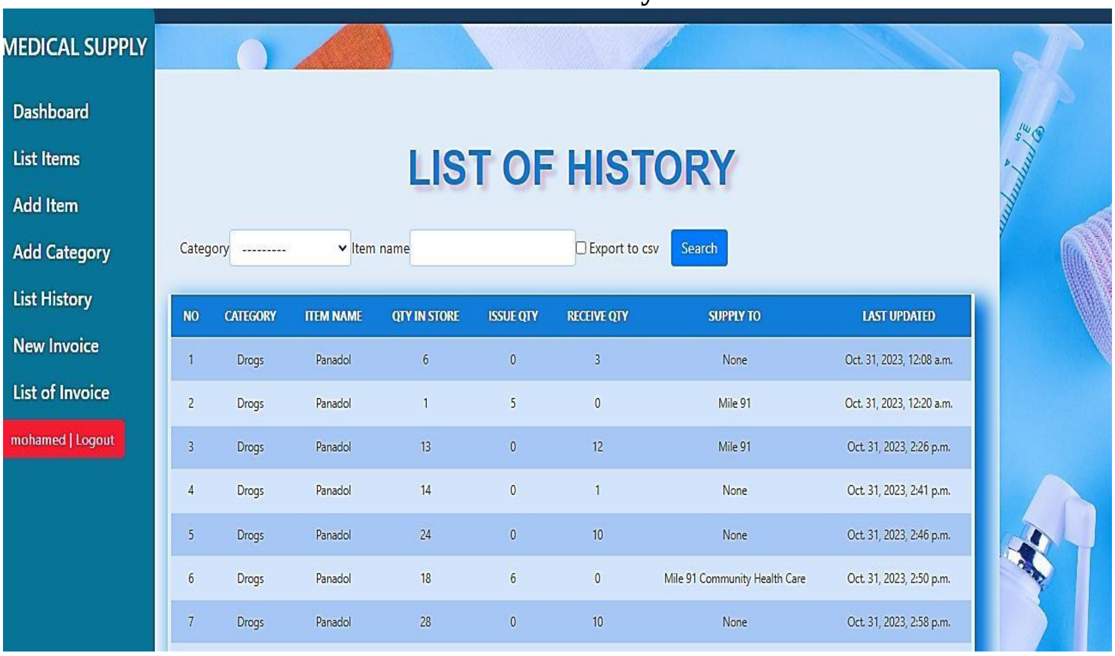
Source: Study activity (January, 2024).

Add Category Code

```
@login_required def
add_category(request):
   form  =  CategoryCreateForm(request.POST  or  None)
if form.is_valid():
      form.save()        messages.success(request, 'Successfully Created')  # Now
'messages' is defined         return redirect('/list_items')     context = {         "form":
form,
      "title": "Add Category",
   }
   return render(request, "add_items.html", context)
```

APPENDIX - H:

List of History



Source: Study activity (January, 2024).

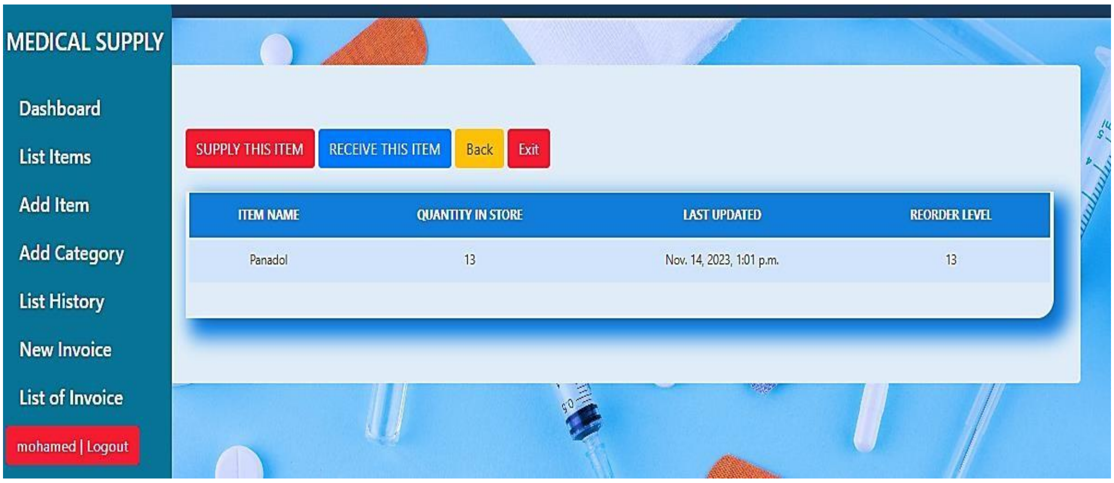
List of History code

```
@login_required def
list_history(request):
    header = 'LIST OF HISTORY'     queryset =
StockHistory.objects.all()     form =
StockSearchForm(request.POST or None)
context = {
        "header": header,
        "queryset": queryset,
        "form": form,
    }
    if request.method == 'POST':
        category = form['category'].value()         queryset =
StockHistory.objects.filter(
item_name__icontains=form['item_name'].value()
                                )

        if (category != ''):
            queryset = queryset.filter(category_id=category)
if form['export_to_CSV'].value() == True:
            response = HttpResponse(content_type='text/csv')            response['Content-
Disposition'] = 'attachment; filename="Stock History.csv"'            writer =
csv.writer(response)            writer.writerow(                ['CATEGORY',
                'ITEM NAME',
                'QUANTITY',
                'ISSUE QUANTITY',
                'RECEIVE QUANTITY',
                'RECEIVE BY',
                'ISSUE BY',
                'LAST UPDATED'])
instance = queryset
```

```
        for stock in instance:
writer.writerow(
[stock.category,
stock.item_name,
stock.quantity,
stock.issue_quantity,
stock.receive_quantity,
stock.receive_by,
stock.issue_by,
stock.last_updated])            return
response

     context = {
"form": form,
     "header": header,
     "queryset": queryset,
  }
  return render(request, "list_history.html",context)
```

APPENDIX - I:

Receive and Supply Items



Source: Study activity (January, 2024).

Receive and Supply Items Code

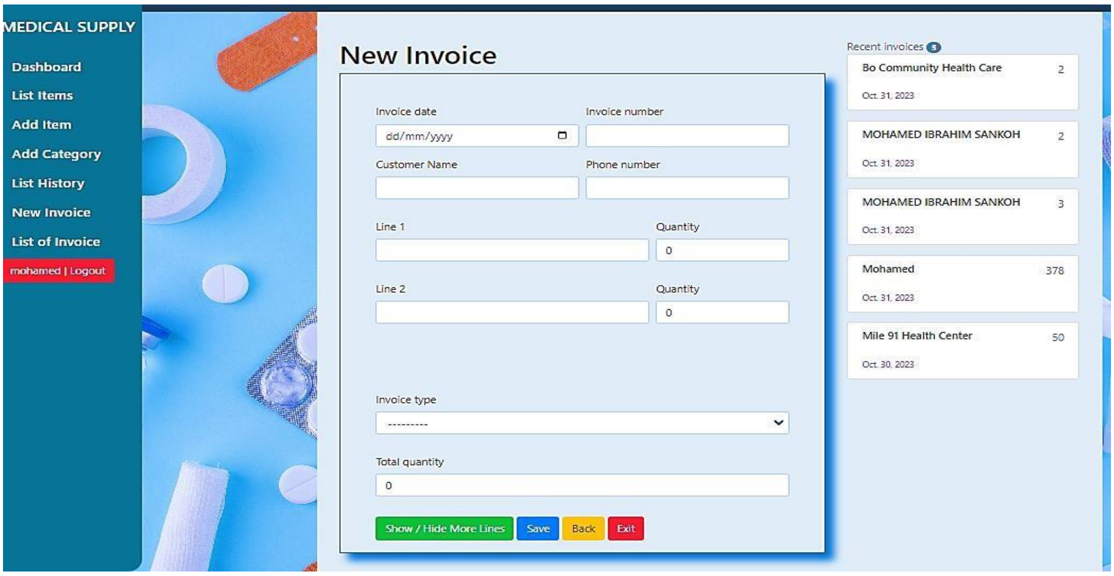
```
@login_required def
issue_items(request, pk):
    queryset = Stock.objects.get(id=pk)     form =
IssueForm(request.POST or None, instance=queryset)

    if form.is_valid():
        instance = form.save(commit=False)

        # Additional validation logic can be added here if needed
        # For example, check if instance.custom_issue_to is valid

        if instance.issue_quantity > instance.quantity:
            messages.error(request, "Sorry! you cannot supply this item. Only " +
str(instance.quantity) + " " + str(instance.item_name) + "s left in Store",
extra_tags='error-message')         else:
            instance.receive_quantity = 0
instance.quantity -= instance.issue_quantity
```

```
            instance.issue_by = str(request.user)

            # Assign the custom_issue_to field value to the issue_to field in the instance
instance.issue_to = instance.issue_to

            messages.success(request,    "SUPPLY    SUCCESSFULLY.    "    +
str(instance.quantity) + " " + str(instance.item_name) + "s now left in Store")
instance.save()

        return redirect('/stock_detail/' + str(instance.id))

    context = {
        "title": 'Issue ' + str(queryset.item_name),
        "queryset": queryset,
        "form": form,
        "username": 'Issue By: ' + str(request.user),
    }
    return render(request, "add_items.html", context)


@login_required def
receive_items(request, pk):
    queryset = Stock.objects.get(id=pk)
    form = ReceiveForm(request.POST or None, instance=queryset)
if form.is_valid():
        instance                    =                    form.save(commit=False)
instance.issue_quantity =0
        instance.quantity += instance.receive_quantity
instance.save()        messages.success(request, "Received
SUCCESSFULLY. " + str(instance.quantity) + " " +
str(instance.item_name)+"s now in Store")

        return redirect('/stock_detail/'+str(instance.id))
        # return HttpResponseRedirect(instance.get_absolute_url())
```

```
context = {
        "title": 'Reaceive ' + str(queryset.item_name),
        "instance": queryset,
        "form": form,
        "username": 'Receive By: ' + str(request.user),
    }
return render(request, "add_items.html", context)
```

APPENDIX - J:

New Invoice



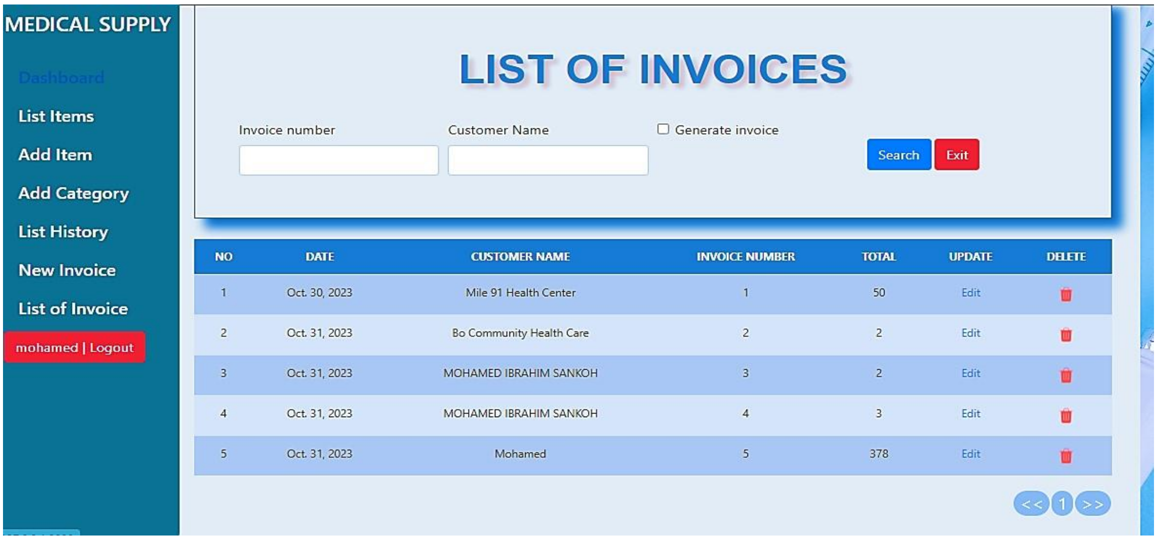
Source: Study activity (January, 2024).

New Invoice Code

```
@login_required def

add_invoice(request):

   form = InvoiceForm(request.POST or None)

total_invoices = Invoice.objects.count()     queryset =

Invoice.objects.order_by('-invoice_date')[:6]



   if form.is_valid():

      form.save()        messages.success(request,

'Successfully Saved')        return

redirect('/list_invoice')



   context = {

      "form": form,

      "title": "New Invoice",

      "total_invoices": total_invoices,

      "queryset": queryset,

   }

   return render(request, "entry.html", context)
```

APPENDIX - K:

List of Invoices



Source: Study activity (January, 2024).

List of Invoice Code

```
@login_required def
list_invoice(request):
    title = 'LIST OF INVOICES'     queryset =
Invoice.objects.all()     form =
InvoiceSearchForm(request.POST or None)
context = {
        "title": title,
        "queryset": queryset,
        "form": form,
    }




    if request.method == 'POST':
queryset =
Invoice.objects.filter(invoice_number__icontains=form['invoice_number'].value(),
```

```
                                        name__icontains=form['name'].value()
                                        )
context = {          "form":
form,
        "title": title,
        "queryset": queryset,
    }


    if form['generate_invoice'].value() == True:
        instance = queryset          data_file = instance          num_of_invoices
= len(queryset)          message = str(num_of_invoices) + " invoices
successfully Printed."          messages.success(request, message)

        def import_data(data_file):
invoice_data = data_file               for
row in invoice_data:
                invoice_type = row.invoice_type
invoice_number = row.invoice_number
invoice_date = row.invoice_date                   name
= row.name
                phone_number = row.phone_number

                line_one = row.line_one
                line_one_quantity = row.line_one_quantity
line_one_unit_price = row.line_one_unit_price
line_one_total_price = row.line_one_total_price

                line_two = row.line_two
line_two_quantity = row.line_two_quantity
line_two_unit_price = row.line_two_unit_price
line_two_total_price = row.line_two_total_price
```

```
        line_three = row.line_three
line_three_quantity = row.line_three_quantity
line_three_unit_price = row.line_three_unit_price
line_three_total_price = row.line_three_total_price

        line_four = row.line_four
line_four_quantity = row.line_four_quantity
line_four_unit_price = row.line_four_unit_price
line_four_total_price = row.line_four_total_price

        line_five = row.line_five
line_five_quantity = row.line_five_quantity
line_five_unit_price = row.line_five_unit_price
line_five_total_price = row.line_five_total_price

        line_six = row.line_six
line_six_quantity = row.line_six_quantity
line_six_unit_price = row.line_six_unit_price
line_six_total_price = row.line_six_total_price

        line_seven = row.line_seven
        line_seven_quantity = row.line_seven_quantity
line_seven_unit_price = row.line_seven_unit_price
line_seven_total_price = row.line_seven_total_price

        line_eight = row.line_eight
line_eight_quantity = row.line_eight_quantity
line_eight_unit_price = row.line_eight_unit_price
line_eight_total_price = row.line_eight_total_price

        line_nine = row.line_nine
line_nine_quantity = row.line_nine_quantity
```

```
            line_nine_unit_price = row.line_nine_unit_price
line_nine_total_price = row.line_nine_total_price

            line_ten = row.line_ten
line_ten_quantity = row.line_ten_quantity
line_ten_unit_price = row.line_ten_unit_price
line_ten_total_price = row.line_ten_total_price

            total_quantity = row.total_quantity                     pdf_file_name =
str(invoice_number) + '_' + str(name) + '.pdf'          generate_invoice(str(name),
str(invoice_number),                              str(line_one), str(line_one_quantity),
str(line_one_unit_price),                     str(line_one_total_price), str(line_two),
str(line_two_quantity),                                      str(line_two_unit_price),
str(line_two_total_price), str(line_three),                   str(line_three_quantity),
str(line_three_unit_price),                 str(line_three_total_price), str(line_four),
str(line_four_quantity),                                     str(line_four_unit_price),
str(line_four_total_price),  str(line_five),                   str(line_five_quantity),
str(line_five_unit_price),                      str(line_five_total_price), str(line_six),
str(line_six_quantity),                                        str(line_six_unit_price),
str(line_six_total_price), str(line_seven),                   str(line_seven_quantity),
str(line_seven_unit_price),               str(line_seven_total_price), str(line_eight),
str(line_eight_quantity),                                    str(line_eight_unit_price),
str(line_eight_total_price), str(line_nine),                   str(line_nine_quantity),
str(line_nine_unit_price), str(line_nine_total_price),                     str(line_ten),
str(line_ten_quantity),                                        str(line_ten_unit_price),
str(line_ten_total_price),           str(total_quantity),           str(phone_number),
str(invoice_date),                  str(invoice_type), pdf_file_name)

      def generate_invoice(name, invoice_number,                 line_one,
line_one_quantity, line_one_unit_price, line_one_total_price,
line_two, line_two_quantity, line_two_unit_price, line_two_total_price,
```

```
            line_three, line_three_quantity, line_three_unit_price,
line_three_total_price,                 line_four, line_four_quantity, line_four_unit_price,
line_four_total_price,                 line_five, line_five_quantity, line_five_unit_price,
line_five_total_price,                 line_six, line_six_quantity, line_six_unit_price,
line_six_total_price,                 line_seven, line_seven_quantity,
line_seven_unit_price, line_seven_total_price,                 line_eight,
line_eight_quantity, line_eight_unit_price, line_eight_total_price,
line_nine, line_nine_quantity, line_nine_unit_price, line_nine_total_price,
line_ten, line_ten_quantity, line_ten_unit_price, line_ten_total_price,
total_quantity, phone_number, invoice_date, invoice_type, pdf_file_name):
        pdf_file_name  =  f"{invoice_number}_{name}.pdf"
c = canvas.Canvas(pdf_file_name)




        # image of seal
logo = 'logoarb.png'
        c.drawImage(logo, 50, 700, width=500, height=120)

        c.setFont('Helvetica', 12, leading=None)
        c.drawCentredString(400, 660,  'Invoice No')
invoice_number_string = str('0000' + invoice_number)
        c.drawCentredString(490, 660, invoice_number_string)


        c.drawCentredString(409, 640, "Date:")
        c.drawCentredString(492, 641, invoice_date)


        # c.setFont('Helvetica', 12, leading=None)
        # c.drawCentredString(397, 620, "Amount:")
        # c.setFont('Helvetica-Bold', 12, leading=None)
```

```
    # c.drawCentredString(484, 622, 'D'+total_quantity)


    c.setFont('Helvetica', 12, leading=None)
    c.drawCentredString(80, 660, "To:")
    c.setFont('Helvetica', 12, leading=None)
    c.drawCentredString(150, 660, name)

    c.setFont('Helvetica', 12, leading=None)
    c.drawCentredString(98, 640, "Phone #:")
    c.setFont('Helvetica', 12, leading=None)
    c.drawCentredString(150, 640, phone_number)

    c.setFont('Helvetica-Bold', 14, leading=None)
    c.drawCentredString(310, 580, str(invoice_type))
# c.drawCentredString(110, 560, "Particulars:")
    c.drawCentredString(295, 510,
"___________________________________________________________________________")
    c.drawCentredString(295, 480,
"___________________________________________________________________________")
    c.drawCentredString(295, 450,
"___________________________________________________________________________")
    c.drawCentredString(295, 420,
"___________________________________________________________________________")
    c.drawCentredString(295, 390,
"___________________________________________________________________________")
    c.drawCentredString(295, 360,
"___________________________________________________________________________")
    c.drawCentredString(295, 330,
"___________________________________________________________________________")
    c.drawCentredString(295, 300,
"___________________________________________________________________________")
    c.drawCentredString(295, 270,
"___________________________________________________________________________")
```

```
        c.drawCentredString(295, 240,
"_______________________________________________________")
        c.drawCentredString(295, 210,
"_______________________________________________________")

        c.setFont('Helvetica-Bold', 12, leading=None)
        c.drawCentredString(110, 520, 'ITEMS')
        c.drawCentredString(420, 520, 'QUANTITY')





        c.setFont('Helvetica', 12, leading=None)
        c.drawCentredString(110, 490, line_one)
        c.drawCentredString(420, 490, line_one_quantity)
# c.drawCentredString(330, 490, line_one_unit_price)
        # c.drawCentredString(450, 490, line_one_total_price)
        if line_two !=
'':
            c.setFont('Helvetica', 12, leading=None)
            c.drawCentredString(110, 460, line_two)
            c.drawCentredString(420, 460, line_two_quantity)
# c.drawCentredString(330, 460, line_two_unit_price)
            # c.drawCentredString(450, 460, line_two_total_price)
        if line_three !=
'':
            c.setFont('Helvetica', 12, leading=None)
            c.drawCentredString(110, 430, line_three)
            c.drawCentredString(420, 430, line_three_quantity)
# c.drawCentredString(330, 430, line_three_unit_price)
            # c.drawCentredString(450, 430, line_three_total_price)
```

```
        if line_four != '':
            c.setFont('Helvetica', 12, leading=None)
            c.drawCentredString(110, 400, line_four)
            c.drawCentredString(420, 400, line_four_quantity)
# c.drawCentredString(330, 400, line_four_unit_price)
            # c.drawCentredString(450, 400, line_four_total_price)
        if line_five !=
'':
            c.setFont('Helvetica', 12, leading=None)
            c.drawCentredString(110, 370, line_five)
            c.drawCentredString(420, 370, line_five_quantity)
# c.drawCentredString(330, 370, line_five_unit_price)
            # c.drawCentredString(450, 370, line_five_total_price)
        if line_six !=
'':
            c.setFont('Helvetica', 12, leading=None)
            c.drawCentredString(110, 340, line_six)
            c.drawCentredString(420, 340, line_six_quantity)
# c.drawCentredString(330, 340, line_six_unit_price)
            # c.drawCentredString(450, 340, line_six_total_price)

        if line_seven != '':
            c.setFont('Helvetica', 12, leading=None)
            c.drawCentredString(110, 310, line_seven)
            c.drawCentredString(420, 310, line_seven_quantity)
# c.drawCentredString(330, 310, line_seven_unit_price)
            # c.drawCentredString(450, 310, line_seven_total_price)
        if line_eight !=
'':
            c.setFont('Helvetica', 12, leading=None)
            c.drawCentredString(110, 280, line_eight)
            c.drawCentredString(420, 280, line_eight_quantity)
# c.drawCentredString(330, 280, line_eight_unit_price)
```

References:

Kros, J, F., & Brown, E, C. (2016*). Health care operations and supply chain management: operations, planning and control.* United states of America: Jossey Bass. https://books.google.com.sl/books?hl=en&lr=&id=kji2OziaCsMC&oi=fnd&pg=PR13&dq=medical+supply+chain+books&ots=TV2_fH35sL&sig=t5PDO8a7ci2LomkZ7BexX6D-O2s&redir_esc=y#v=onepage&q&f=false.

Prashant, Y. [supplychainsecretes]. (2021, August 9). *Future healthcare supply chains* [video]. YouTube. https://www.youtube.com/watch?v=xasaqhDpFxw.

Handfield, R., & Linton, T. (2022). *Flow: How the best supply chains thrive.* Toronto: University of Toronto press. https://www.degruyter.com/document/doi/10.3138/9781487538002/html.

Frolovs, G. (2022). *Medical device supplier management process*. Retrieved from: https://www.simplerqms.com/medical-device-supplier-management/ Accessed [November 25 2023].

Shou, Y. et al. (2019). The impact of sustainability and operations orientations on sustainable supply management and the triple bottom line. *Journal of Cleaner Production. 240(*10), https://doi.org/10.1016/j.jclepro.2019.118280.

LaPointe, J. (2022). *Exploring the role of supply chain management in healthcare*. Retrieved from: https://revcycleintelligence.com/news/exploring-the-role-ofsupply-chain-management-in-healthcare Accessed [30 November 2023].

Piramathu, S & Zhou, P (2016). *RFID and sensor network automation in the food industry: Ensuring quality and safety through supply chain visibility*. West Sussex: Wiley Blackwell.

https://books.google.com.sl/books?hl=en&lr=&id=LfelCgAAQBAJ&oi=fnd&pg=PR13&dq=Ensuring+quality+and+safety+in+medical+supply&ots=urjYiKU7qS&sig=WBWNSzoaPQ5j5ekwbttHciuCcDk&redir_esc=y#v=onepage&q=Ensuring%20quality%20and%20safety%20in%20medical%20supply&f=false

Carenzo, L., Costantini, E., Greco, M., Barra, F. L., Rendiniello, V., Mainetti, M., ... Bui, R. (2020). Hospital surge capacity in a tertiary emergency referral centre during the COVID-19 outbreak in Italy. Anaesthesia, 75(7), 928–934. https://doi.org/10.1111/anae.15072

Alfonso-Lizarazo, E. et al. (2022). Prediction of hospital readmission of multimorbid patients using machine learning models. *PLoS ONE*, *17*(12), https://doi.org/10.1371/journal.pone.0279433.

SOS (2023). *Medical Supply Inventory*. Retrieved from: https://www.sosinventory.com/medical-supply-inventory. Accessed (28 October 2023).

Saha, E & Ray, P, K. (2019). Modelling and analysis of inventory management systems in healthcare: A review and reflections. ScienceDirect: *Computers & Industrial Engineering*. *137*, https://doi.org/10.1016/j.cie.2019.106051.

Settanni, E, et al., (2017). Pharmaceutical supply chain models: A synthesis from a systems view of operations research. Elsevier: *Operations Research Perspectives. 4*, 74-95, https://doi.org/10.1016/j.orp.2017.05.002.

Goodarzian F., Hosseini-Nasab H., Muñuzuri J., Fakhrzad M. B. (2020). A multiobjective pharmaceutical supply chain network based on a robust fuzzy model: A comparison of meta-heuristics. *Applied Soft Computing*, *92*, 106331, https://doi.org/10.1016/j.asoc.2020.106331.

Franco C. (2020). A simulation model to evaluate pharmaceutical supply chain costs in hospitals: The case of a Colombian hospital. *Daru*, *28*(1), 1–12 https://pubmed.ncbi.nlm.nih.gov/30565158/.

Goodarzian, F., Kumar V., Ghasemi, P. (2021). A set of efficient heuristics and metaheuristics to solve a multi-objective pharmaceutical supply chain network. *Computers & Industrial Engineering*, *158*, 107389, https://doi.org/10.1016/j.cie.2021.107389.

Goodarzian, F., Ghasemi, P., Gunasekaren, A., Taleizadeh A., Abraham A. (2021). A sustainable-resilience healthcare network for handling COVID-19 pandemic. *Annals of Operations Research*, *312*, 716–825, https://link.springer.com/article/10.1007/s10479-021-04238-2.

Goodarzian, F., Taleizadeh, A. A., Ghasemi, P., Abraham, A. (2021). An integrated sustainable medical supply chain network during COVID-19. *Engineering Applications of Artificial Intelligence*, *100*, 104188. https://pubmed.ncbi.nlm.nih.gov/33619424/.

Goodarzian, F., Wamba, S. F., Mathiyazahagan, K., Taghipour, A. (2021). A new biobjective green medicine supply chain network design under fuzzy enviroment: Hybrid metaheuristics algorithms. *Computers & Industrial Engineering*, *160*, 107535. https://doi.org/10.1016/j.cie.2021.107535

Merkuryeva, G., Valberga, A., Smirnov, A. (2019). Demand forecasting in pharmaceutical supply chains: A case study. *Procedia Computer Science*, *149*, 3–10, https://doi.org/10.1016/j.procs.2019.01.100

Haszlinna Mustaffa, N., Potter, A. (2009). Healthcare supply chain management in Malaysia: A case study. Supply Chain Management: *An International Journal*, *14*(3), 234–243, https://doi.org/10.1108/13598540910954575.

Zhao X., Xie J., Zhang W. J. (2002). The impact of information sharing and ordering co-ordination on supply chain performance. *Supply Chain Management. 7*(1), 24–40, https://doi.org/10.1108/13598540210414364.

Awad H., Al-Zu'bi Z. M., Abdallah A. B. (2016). A quantitative analysis of the causes of drug shortages in Jordan: A supply chain perspective. *International Business Research*, *9*(6), 53–53, https://scholar.google.com/scholar_lookup?title=A+quantitative+analysis+of+the+causes+of+drug+shortages+in+Jordan%3A+A+supply+chain+perspective&author=H.+Awad&author=Z.+M.+AlZu%E2%80%99bi&author=A.+B.+Abdallah&publication_year=2016&journal=International+Business+Research&pages=53-53.

Alotaibi, S. and Mehmood, R. (2018). Big data enabled healthcare supply chain management: Opportunities and challenges. *Conferences Paper*, *224*, https://eudl.eu/pdf/10.1007/978-3-319-94180-6_21.

Sadeghi,S., Vanani, I., Musolu, F. (2020). Big data analytics and its applications in supply chain management. *IntechOpen*, DOI: http://dx.doi.org/10.5772/intechopen.89426.

Khalifa, M. (2019). Health analytics types, functions and levels: *A review of literature*. Netherlands*: IOS Press. 251*, 137-140. https://khalifa.com.au/wpcontent/uploads/2019/02/044-Health-Analytics-Types-Functions-andLevels.pdf.

Salau, A. (2022). Data analytics in healthcare supply chain. *ResearchGate*, https://www.researchgate.net/publication/358904358_Data_Analytics_in_Heal thcare_Supply_chain.

Qiu, Y.; Qiao, J.; Pardalos, P.M. (2019). Optimal production, replenishment, delivery, routing and inventory management policies for products with perishable inventory. *Omega. 82*, 193-204, https://doi.org/10.1016/j.omega.2018.01.006.

Ayyub, S. (2022). Data analytics in healthcare supply chain. *ResearchGate*: DOI:10.13140/RG.2.2.16437.35043.

Mason, C. (2023). *Understand the four levels of interoperability in healthcare*. Retrieved from: https://www.wolterskluwer.com/en/expertinsights/understand-the-four-levels-of-interoperability-in-healthcare.

Rehman, A., Naz, S., Razzak, I. (2020). Leveraging Big Data Analytics in Healthcare Enhancement: Trends, Challenges and Opportunities. Arxiv. https://doi.org/10.48550/arXiv.2004.09010

Alotaibi, S., Mehmood, R. (2018). Big Data Enabled Healthcare Supply Chain Management: Opportunities and Challenges. *Confrences paper:* 224, 207-215, https://doi.org/10.1007/978-3-319-94180-6_21.

Joby, A. (2019). *Scalability*. Retrieved from: https://www.g2.com/glossary/scalability

Naseem, A., Kureshi, N. I., & Abro, M. M. Q. (2022). A systematic literature review and framework development for value creation through medical supply chain integration. Business Process Management Journal. https://doi.org/10.1108/BPMJ-072021-0378

Lalwani, C. S. (2019). Analyzing flows of medicines through African supply chains by combining optimization modeling with cluster analysis of survey data. Production and Operations Management, 28(10), 2359–2378. https://doi.org/10.1111/poms.13058 Panneerselvam, R. (2014). Research methodology. PHI Learning Pvt. Ltd..

Mitropoulos, P., Mitropoulos, I., & Giannikos, I. (2019). Managing medical supply chains with stochastic demand and substitution: An illustrative review. Opera Logistica, 3(1), 7-44.