Web Based Predictive Inventory Healthcare Management System Using Eclat Algorithm and Hierarchical Clustering

Rhonnel S. Paculanan, Isagani Mirador Tano, Christian Escoto, Paula Joy Dela cruz, Bucaling Gatan Redentor Jr., May Anne Ong Laciste

Quezon City University Philippines

DOI: https://doi.org/10.51584/IJRIAS.2024.912023

Received: 03 December 2024; Accepted: 06 December 2024; Published: 07 January 2025

ABSTRACT

Governments and health care decision-makers must encourage the creation of effective and efficient healthcare systems in view of the alarming rise in global health care expenditures and the rising demand for medical facilities (Ahmadi-Javid, Jalali, and Klassen, 2017). The efficient management of inventory resources is crucial to the clinics' capacity to provide timely, high-quality healthcare via online clinics. According to Luciano et al. (2023), inventory management systems are essential in the medical industry because they prevent shortages of crucial medical supplies and needless purchases of excess inventory, both of which could jeopardize patient care. In urgent care centers, machine learning can assist in predicting patient flow (Maddigan & Sušnjak, 2023). This research has shown that using ensemble-based models instead of time-series forecasting is more likely to yield reliable performance results. Furthermore, in situations without contracts, the forecast analysis validated the predictive power of certain transactional parameters, like the volume and frequency of prior transactions. By using the Hierarchical Clustering technique to find trends in patient visits and help manage supply levels in the clinic, the current study attempts to give an overview of a web-based clinic demand forecasting system. The project's goals are to provide a clinical information system that can forecast healthcare service supply and demand, optimize resource use to raise patient care standards and operational effectiveness, and provide a single system that can be tailored to various healthcare settings. To fully satisfy the needs of this investigation, the project used a triangulated strategy. With the quantitative approach, 50 respondents were given surveys and questionnaires to complete to gather numerical data. To understand users' experiences with a particular system, the qualitative approach mainly focuses on obtaining information through focus groups, interviews, and answering open-ended questions. Primary data from system administrators and users, as well as secondary data from books, websites, and articles, make up the methods used to obtain the data. When creating the system, the project adheres to the Agile Software Development Life Cycle (SDLC) process, which includes several phases such as planning, analysis, design, development, testing, implementation, and maintenance. Within the database's structure, data scalability, security, and consistency are also preserved. The system was evaluated using ISO 25010, which uses a 4-point Likert-type scale, weighted mean, and percentage analysis to evaluate five perspectives: robustness, usability, effectiveness, and reliability. Both the user and technical respondents expressed satisfaction with the system's use and portability. With an average mean score of 3.21 overall, users gave these aspects positive ratings. With an overall mean score of 3.28, technical responders commended portability and performance efficiency. These results demonstrate that, the system is reliable and meets the needs of its users. Its focus on adaptability and usability makes it a useful tool for managing visitor data, which enhances the user experience.

Keywords: healthcare, Hierarchical Clustering, Agile Software Development, Eclat algorithm

INTRODUCTION

Due to the alarming rise in world health care expenditures and the increased need for health facilities, it is critical for both governments and health care decision-makers to encourage the establishment of efficient and effective healthcare systems (Ahmadi-Javid, Jalali, and Klassen, 2017). The basic competence of the healthcare system is the treatment and care of the patients. The basic objective has always been to avail of highly qualified and experienced physicians and surgeons, well-trained nurses and medical staff with

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue XII December 2024

developed facilities and infrastructure, recent medical technology, high quality medicines and other medical and surgical supplies (De Vries, 2011). Nonetheless, in recent times, the emphasis has shifted to the management aspect of healthcare systems. Healthcare management systems comprise capacity management, resource management systems, inventory demand management, scheduling, and other operational activities as a minimum. Brailsford & Vissers (2011).

The clinics' ability to deliver quality health care on website-based clinics on time is highly reliant on the effective management of inventory resources. Luciano et al. (2023), inventory management systems are critical in the medical field as they help avoid stock outs of required medical supplies and unnecessary expenditures of excess stock, which would compromise patient care. This paper seeks to assess the extent to which the Hierarchical Clustering Method, a powerful machine learning technique, can improve patient demand forecasts for web-based clinics that face challenges of rapid and volatile demand. In contrast to traditional healthcare administration, nurses and caregivers of web-based clinics do not need patients to have established connections or booked appointment beforehand (Martínez et al., 2020). This brings about another layer of demand forecasting challenges because patient behavior becomes much more volatile and difficult to predict (Martínez et al., 2020).

Machine learning can help anticipate the patient flow in case of urgent care clinics (Maddigan & Sušnjak, 2023). Such studies have demonstrated that the use of ensemble-based models is more likely to produce robust performance outcomes than standard approaches utilizing time-series forecasting. Moreover, the analysis of forecasts also confirmed the predictive capability of some transactional attributes, such as the amount and frequency of previous transactions, in circumstances where there are no contracts. The current study aims at providing an overview of a web-based clinic demand forecasting system by employing the Hierarchical Clustering technique to identify patterns in the patients' visits and aid in the control of stock levels within the clinic.

The study aims to design and implement a clinical information system that uses advanced data mining techniques to predict healthcare demand and supply. The main objective lies in the improvement of healthcare resource management and decision making within the healthcare sector. The system is devised to improve patient care, optimal resource allocation, and efficient operational functioning of healthcare facilities.

In addition, the study's objective is to enhance decision-making by enabling healthcare managers with tools that can forecast requirements for medication, inpatient beds, and medical personnel and seeks to enhance resource accessibility for the patients by minimizing unnecessary delays.

Data collection is the process of collecting large amount of health care data from hospitals and clinics which includes records of patients, resources used and their historical demand. The Eclat algorithm is applied in the implementation of the algorithm to mine association rules in data while patients and resources are clustered using Hierarchical Clustering for precision in forecasting. With a user-friendly dashboard designed for healthcare administrators, the system has been validated using data from various healthcare providers.

The main aim is a working clinical information system that can predict both supply and demand in healthcare services, effective resource utilization that leads to higher standards of patient care and operational efficiency, and one system that can be customized to fit several healthcare environments.

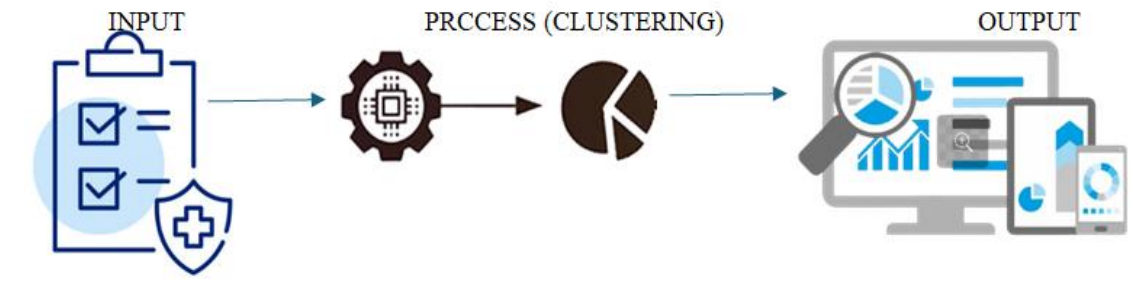

Figure 1: Conceptual Framework

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue XII December 2024

Conceptual Framework

The framework integrates Eclat Algorithm and Hierarchical Clustering to analyze clinical data, predict demand, and optimize healthcare inventory management. The system transforms patient data into actionable insights to streamline appointments, manage medicine inventory, and generate patient reports.

1. Input Layer

Clinical Data

The system begins with data collection from patient-related processes, including Patient data (demographics, medical history and diagnoses and Appointment schedules and frequencies) and

Clinical Process Data (Treatment details, Consumables used)

2. Process Layer

Analysis and Prediction

The input data is processed through two core analytical techniques: Eclat Algorithm and Hierarchical Clustering.

Step 1: Data Preprocessing

Standardization:

Normalize data for compatibility across algorithms (Transaction Formation) ; Convert clinical data into transaction records (e.g., items used during a patient visit).

Step 2: Eclat Algorithm (Association Rule Mining)

Objective: Identify relationships between inventory items and patient treatments with the Input binary transaction data such as patient information extract frequent itemset that will have a patterns of inventory usage tied to specific patient treatments or diagnoses.

Step 3: Hierarchical Clustering (Behavioral Grouping)

Objective: Group patients and behaviors to uncover trends and demand patterns.

3. Output Layer: Decision-Making Insights

The processed data yields actionable insights to optimize healthcare operations such as Appointments that predict and schedule appointments based on patient clusters and historical trends; Medicine Inventory to forecast inventory demand using frequent itemset from Eclat and cluster-based trends. and Patient Reports that generate personalized patient reports highlighting the treatment histories and future needs.

The project employed a triangulated approach to fulfill the requirements of this study in an exhaustive manner. The quantitative method consists of obtaining numerical information via the use of surveys and questionnaires which were administered to 50 respondents. The qualitative approach primarily focuses on gathering information through interviews, undertaking focus groups, and replying to open-ended questions to comprehend user ‘s experiences of a given system. The techniques employed in data collection comprise of primary data sourced from system users and administrators and libraries where books, websites and articles are used as secondary sources. The project follows the Agile Software Development Life Cycle (SDLC) methodology in developing the system which incorporates various stages including planning, analysis, design, development, testing, implementation, and maintenance. The consistency, security as well as the scalability of data are also maintained within the framework of the database. The system was assessed based on ISO 25010

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue XII December 2024

which evaluates five perspectives including functionality, reliability, usability and effectiveness as well as robustness, aided by percentage analysis, weighted mean, and a 4-point Likert-type scale. Respondents include 30 users and 20 technical professionals, with feedback ensuring a holistic evaluation of the system.

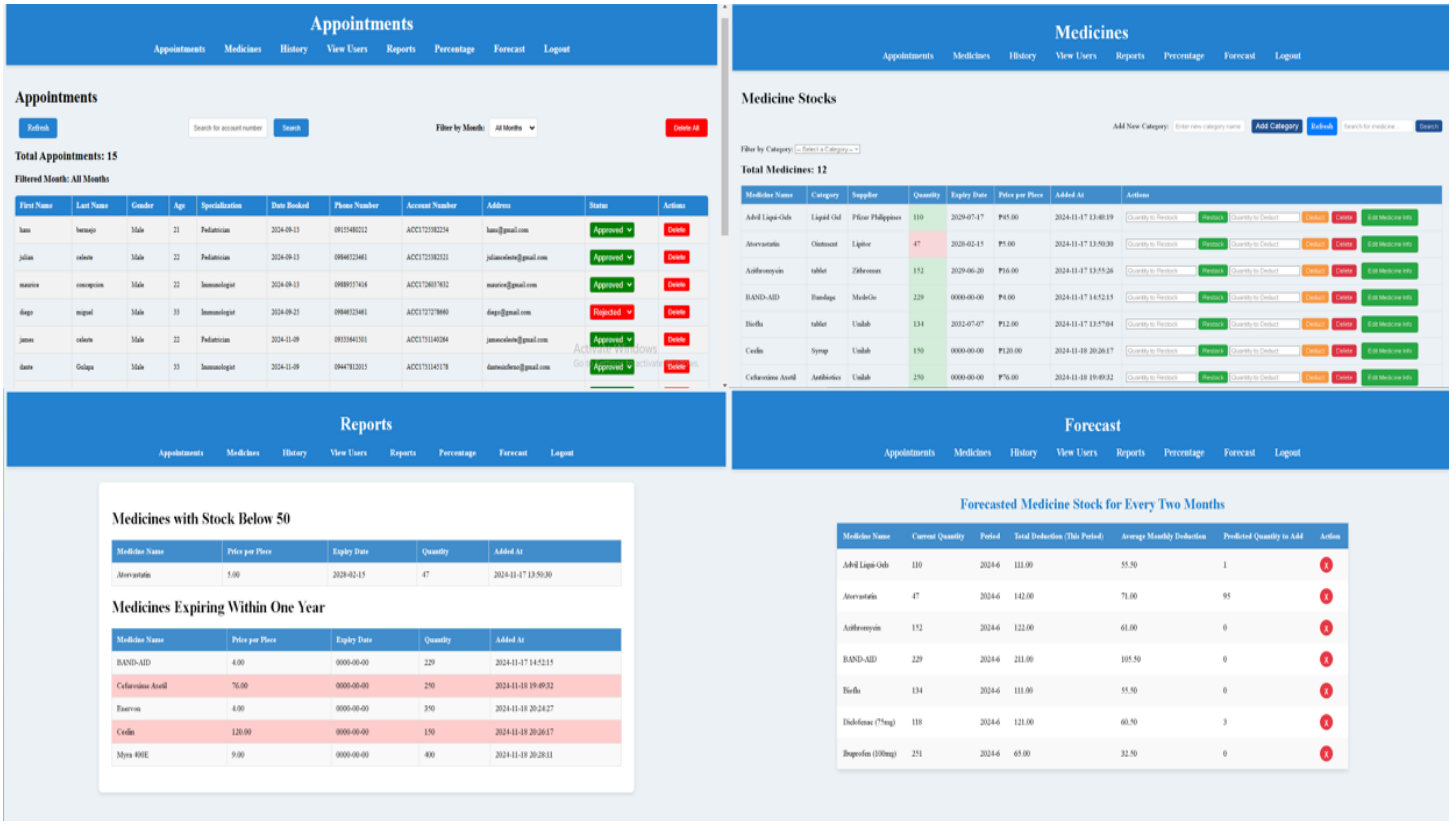

Figure 2: Some screen shot from the Web based predictive Inventory healthcare management system using Eclat algorithm and Hierarchical Clustering

On the left upper portion of the figure shown the appointments that have been booked, and you can select them in 3 options: approved, rejected, or pending. It also has an archive action that will go to the history webpage. and it also has a search navigation for easy usage and refresh.

On the right upper portion of the figure shown the medicine's full information and the timestamp when the medicine is added. and it also has an action for the restock and deduct, and you can also delete and edit the medicine info. and it also has an add category, refresh, filter and search actions

On the left lower portion of the figure shown the medicine reports that have low stocks and a medicine report that shows the medicines that will be expiring within the year and lastly on the right lower portion of the figure shown the forecasted medicine stock for every 2 months with full information about the medicine, like average monthly deductions. And it also has a delete action.

Project Testing: The website was evaluated using the Agile technique as part of the System Development Life Cycle (SDLC). The testing centered on functionality, compliance, and compatibility. Functionality checks guaranteed that all functionalities operated properly and without issues. Performance testing assessed the app's speed on various devices. Compliance guaranteed that the software met industry standards, and compatibility testing confirmed that it operated with the appropriate hardware combinations. This technique assures that website is efficient, dependable, and responsive to user requirements.

Project Evaluation Results: Assessment for the system was done through a dual approach: (1) users and (2) technical groups, which are people who work within the IT industry. The user group analyzes the system based on the usability of the system based on the experience of the users, while the technical group analyzes the technical aspects of the system to ensure that the system is valuable. The evaluation uses the ISO 25010 characteristics to evaluate the system.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue XII December 2024

Table 1: Respondent result ISO 25010 interpretation table

(ISO25010)	RESPONDENTS (50)			
	USERS (30)		TECHNICAL (20)	
	WM	VI	WM	VI
1. FUNCTIONALITY	3.25	A	3.4	A
2. RELIABILITY	3.19	A	3.5	A
3. USABILITY	3.23	A	3.55	SA
4. EFFECTIVENESS	3.22	A	3.5	A
5. ROBUSTNESS	3.15	A	3.28	A
Overall Average Mean	3.21	A	3.28	A

The Table 1 summarizes the user evaluation for all categories based on ISO 25010. User respondents have an overall average mean of 3.21, which is verbally interpreted as “agree,” while technical respondents have an overall average mean of 3.28, which is verbally interpreted as “agree.”. All respondents agree that the system conforms to the above-mentioned ISO 25010 standards. The results signify that the users find the system helpful and reliable.

Data Security: Securing a web-based predictive inventory healthcare management system that employs the Eclat algorithm and hierarchical clustering requires implementing multiple layers of security measures such as the Data Encryption using At-rest Encryption where sensitive data stored in the database using AES-256 are encrypted. Algorithm-Specific Encryption that secure the intermediate datasets used in Eclat and clustering computations, especially when stored temporarily. Authentication wherein strong authentication mechanisms such as multi-factor authentication where implemented and Authorization that permissions to validate before granting access to sensitive inventory data. When it comes to API design, proponents use the endpoints with authentication tokens and implement rate-limiting and input validation to prevent API abuse.

Summary of Findings and Conclusion: The project focuses on developing a "Web-based predictive Inventory healthcare management system using Eclat algorithm and Hierarchical Clustering," which is an inventory management and doctor appointment booking system for medicines that uses high-end data mining techniques, specifically the Eclat algorithm and Hierarchical Clustering, to forecast demand and supply in the healthcare sector. Meanwhile, the primary goal remains to orchestrate simplification in resource management and decision-making in the healthcare industry. This makes the system suited for improving patient care by optimizing inventory and resource allocation, assuring effective appointment scheduling and operations in healthcare institutions. Both the user and technical respondents expressed satisfaction with the system's use and portability. Users rated these aspects positively, with an overall average mean of 3.21. Technical respondents praised performance efficiency and portability, with an aggregate mean of 3.28. These findings show that the system is not only trustworthy, but also well-suited to its users' demands. Its emphasis on usability and adaptability makes it an effective tool for handling visitor information, contributing to a great user experience.

Recommendations: Although the system is receiving great feedback from the audience, there is potential for development. Proponents advocate enhancing the system's user interfaces to make navigation easier. Another recommendation is to integrate the system as a mobile application, which can boost user convenience. IT/Admin suggested adding a notification of the user's booking appointment to the admin dashboard for easier visibility. Improving the system's security is also recommended to ensure that data in the database and user information are not easily compromised.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue XII December 2024

REFERENCES

1. Ahmadi-Javid, Jalali, and Klassen (2017); "Outpatient Appointment Scheduling and Healthcare Operational Management: A Review"
2. Brailsford & Vissers (2011) ealthcare modeling and simulation.
3. De Vries (2011) inventory management, supply chain optimization, or healthcare logistics book
4. Luciano et al. (2023) Medicine Management System: Its Design and Development
5. Martínez et al., (2020); Unprecedented observations of a nascent in situ cirrus in the tropical tropopause layer.
6. P Maddigan, T Susnjak (2023); Chat2VIS: Generating Data Visualizations via Natural Language Using ChatGPT, Codex and GPT-3 Large Language Models. IEEE Access 11 (2023), 45181ś45193