IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

CLABSI Prevention Through AI-Powered Web Application Approach

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Abstract : In this paper, we present a new approach to preventing Central Line-Associated Bloodstream Infection (CLABSI) by integrating artificial intelligence (AI) into a web application developed using the MERN (MongoDB, Express, React, Node.js) stack. Our system combines data collection and surveillance, enabling healthcare professionals to input infection-related data through the web application. The application processes and analyzes this data using machine learning models to predict and identify potential CLABSI risks. By automating the surveillance process, the AI-powered web application offers an efficient and proactive solution for early detection and prevention of CLABSI, ultimately improving patient safety in healthcare settings.

Keywords: CLABSI, machine learning, web application, healthcare, prediction, prevention, data collection, data processing, healthcare-associated infections.

I.INTRODUCTION

Central Line-Associated Bloodstream Infections (CLABSI) is a type of infection that can occur in healthcare settings, particularly due to the use of central lines. Preventing HAI CLABSI is a crucial aspect of healthcare as it ensures the safety of patients. This requires strict adherence to infection control protocols, including proper hand hygiene, the use of sterile techniques during catheter insertion and maintenance, and regular monitoring and surveillance to promptly identify any signs of infection.

By focusing on prevention strategies and implementing evidence-based practices, healthcare organizations can reduce the occurrence of HAI CLABSI. This not only improves patient outcomes but also helps in reducing healthcare costs and promoting overall healthcare quality.

Symptoms of CLABSI include fever or chills, elevated heart rate, low blood pressure, redness or tenderness at the catheter insertion site, drainage at the catheter site, fatigue and weakness, confusion, or altered mental status.[9]

It's important to keep in mind the limitations of preventing CLABSI. One of the biggest challenges is that cases may be underreported due to differing definitions and surveillance methods across healthcare facilities.

To prevent CLABSI, healthcare facilities can implement various measures. One of the most effective measures is the use of electronic surveillance systems that utilize data analytics and machine learning to quickly identify potential cases of CLABSI. These systems can also trigger alerts for prompt intervention.

Additionally, electronic health records (EHRs) can facilitate the documentation of catheter-related information, including insertion and maintenance details, and enable healthcare providers to monitor patient data and identify trends that may indicate infection. Finally, remote monitoring of patients with central lines can ensure timely detection of complications or signs of infection, allowing for prompt intervention.

In the future, these technologies may be used to identify high-risk patients, promoting safer care through personalized infection prevention.

NEED OF THE STUDY

Central Line-Associated Bloodstream Infections (CLABSIs) are a significant threat to patient safety in healthcare settings. They can cause severe complications, prolonged hospital stays, and increased healthcare costs. Despite the implementation of infection prevention guidelines, CLABSIs remain a substantial challenge, requiring innovative approaches for early detection and prevention.[9] This study explores the development and implementation of an AI-powered web application that integrates data collection and surveillance for CLABSI prevention.

Traditional manual surveillance methods are often time-consuming and may not provide real-time insights into infection risks. Therefore, there is an urgent need for a more efficient and proactive solution that can predict and identify CLABSI risks, allowing healthcare professionals to take timely preventive measures.

Integrating AI and machine learning into a web application has the potential to simplify the surveillance process, lower the incidence of CLABSIs, and improve patient outcomes. By addressing this need, healthcare institutions can enhance patient safety, optimize resource allocation, and significantly reduce the burden of CLABSIs, making this study a crucial contribution to the healthcare industry.

Nursing-sensitive indicators or measures reflect the structure, process, and outcomes of nursing care. Nursing care structure is affected by the supply of nursing staff, the skill level of the nursing staff, and the education of nursing staff. Process indicators measure aspects of nursing care, such as assessment, intervention, and registered nurse job satisfaction. Patient outcomes that are determined to be nursing sensitive are those that improve if there is a greater quantity or quality of nursing care.[9]

The main aim is the discussion about various decision parameters, features, attributes, etc that are held into consideration while choosing an algorithm and their importance. It was stated that neural networks predict with a greater efficiency followed by decision tree and naïve bayes[4]

II. RELATED WORK

The importance of following established guidelines for preventing CLABSI and the role they play in reducing infection rates have been highlighted by several studies. These guidelines include hygiene practices, proper catheter care, and the need for early detection.[9]

Manual surveillance systems for CLABSIs are resource-intensive and often provide retrospective data, making it difficult to take real-time preventive measures.[3] There is a clear need for more efficient and automated surveillance methods.

The use of artificial intelligence in healthcare has shown promise in various applications, including predictive modeling for infectious diseases.[6] AI's ability to process vast amounts of data and identify patterns makes it a valuable tool for improving patient outcomes.

Recent studies have explored the use of machine learning models to predict infectious diseases, including CLABSIs. These models analyze patient data to identify individuals at higher risk, providing an opportunity for early intervention.[7]

Some research has focused on developing web applications for healthcare surveillance. These applications provide user-friendly interfaces for data collection and real-time tracking, improving the overall efficiency of infection control.[5]

The development of AI algorithms that can accurately identify healthcare-associated infections (HAIs) from various data sources, such as electronic health records (EHRs), laboratory results, and patient demographics, has shown promising results. However, more research is needed to create AI algorithms that can be widely implemented in healthcare facilities.[8]

The integration of the MERN stack with MLA for real-time prevention and detection of central line-associated bloodstream infections (CLABSI) is an area that requires further exploration.

The research highlights the importance of data quality, indicating that better dataset training produces more efficient output models and vice versa. Additionally, it emphasizes the flexibility of REST APIs that facilitate data transfer between clients and servers.[5]

III. RESEARCH METHODOLOGY

The proposed system follows the MVC model, with the client tier written in JavaScript, HTML, and CSS using ReactJS with Redux as the framework. This tier is responsible for user interaction and provides access to the web application's functions. The application server, which acts as a bridge between the client tier and the database tier, is implemented using NodeJS and ExpressJS. The controller serves HTML pages to the user's device, accepts HTTP requests, and responds appropriately. Finally, the database tier is hosted on MongoDB.[5]

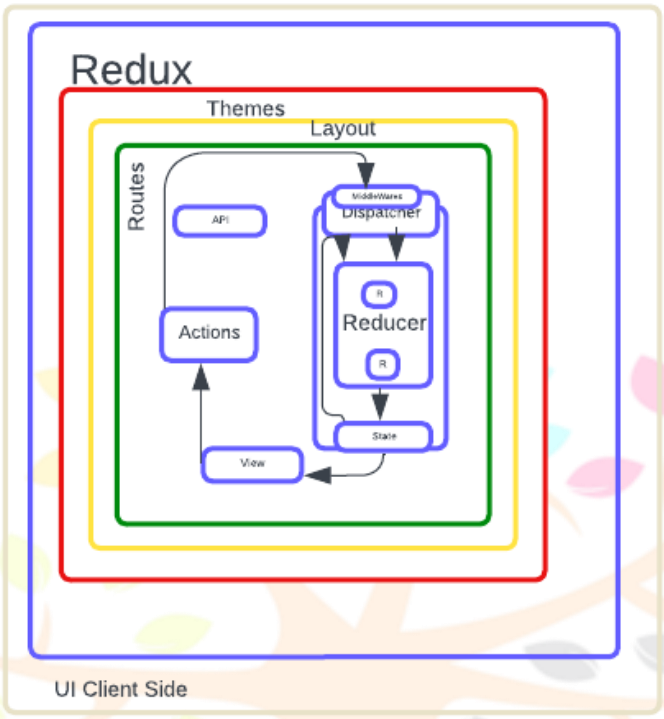

Figure 1.Front End System

Redux is a library for managing state in JavaScript applications. When building a MERN stack front-end, Redux is commonly used to manage the state of the application. It offers a predictable and centralized way to handle the state of your application, which makes it much easier to manage and update data.

When it comes to client-side routing in a React application, the React Router is a popular library used for defining and managing routes. With React Router, you can create single-page applications with multiple views and navigate between them without the need for full-page reloads.

In the context of libraries like Redux, actions, and reducers are responsible for handling the dispatching of actions and state changes. A reducer is a pure function in Redux that specifies how the application's state changes in response to actions. It takes in the current state and an action as input and returns a new state.

Views are responsible for rendering the user interface and displaying data to the user. They are typically composed of JSX and can be simple components or complex, nested structures.

Middleware simplifies development by modularizing concerns and adding functionality without tight coupling to routes or components.

3.1MERN STACK

The proposed system aims to prevent and detect Central Line-Associated Bloodstream Infections (CLABSIs) in healthcare facilities. It consists of four modules: the Doctor Module, Admin Module, Common Module, and Nurse Module, each serving specific functions to enhance the system's overall effectiveness.[5]

The system architecture involves a training model process and running the Django server to predict CLABSI patient analysis using the Django server.

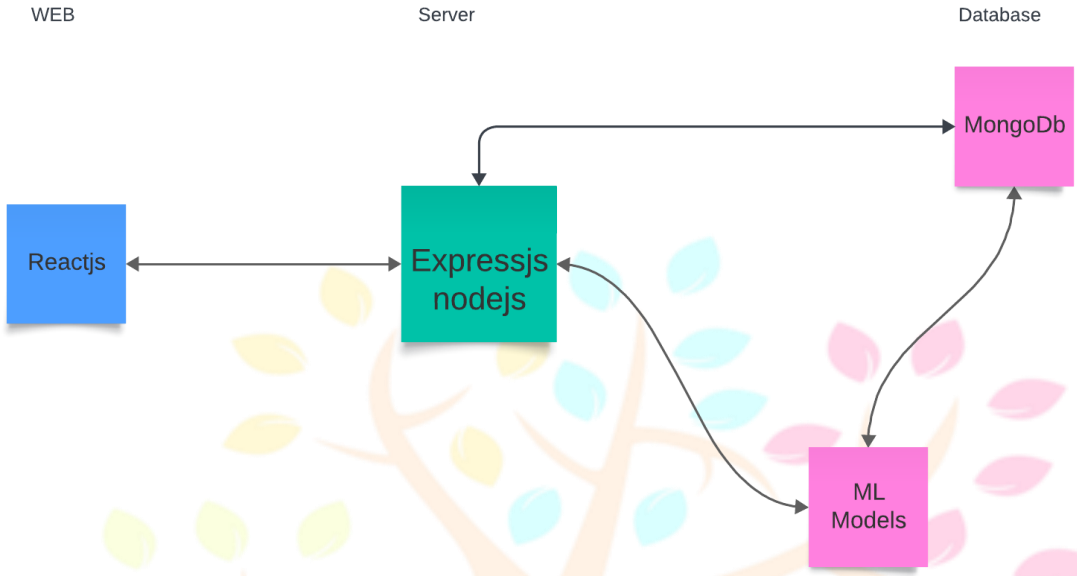

Figure 2. System Architecture

3.1.1 Doctor Module

A crucial part of the proposed system is the 'Doctor Module', which plays a key role in managing doctors and patients. This module provides healthcare professionals with the necessary tools to handle patient data, make diagnoses, and establish treatment plans. Additionally, it includes features that enable the analysis of patient data, such as identifying potential cases of CLABSI.

3.1.2 Admin Module

The Admin Module is a vital component that complements the Doctor Module and performs a crucial role in managing the system. It assists in the administration of healthcare facilities by managing users, configuring the system, and overseeing data. Although it does not directly analyze patient data, it is essential for ensuring the smooth operation and security of the application.

3.1.3 Common Module

The Common Module acts as the main interface that patients, healthcare providers, and administrators use to interact with the system. It comprises the home, about us, and contact us interfaces. Besides, it offers some patient data analysis features that allow users to access healthcare-related information and resources, leading to the prevention of CLABSI.

3.1.4 Nurse Module

The Nurse Module is an essential component of patient management. Its main responsibility is to handle patient care, monitoring, and data input. By enabling nurses to input crucial patient information, the module offers early detection of CLABSIs.

The proposed system is a web application powered by machine learning. It has the potential to significantly improve the detection of CLABSI cases. The MERN stack (MongoDB, Express, React, Node.js) is utilized to ensure scalability, flexibility, and

responsiveness. Additionally, the integration of trained models for CLABSI prediction is facilitated by the use of TensorFlow, a powerful machine-learning framework.

3.2 Machine Learning

The proposed system integrates a trained machine-learning model within a Django server. This Python server handles user requests and manages responses from the Node server, facilitating effective data analysis and interaction with the machine learning component.[4]

The primary goal of the system is to improve patient outcomes and promote a healthier population by enhancing CLABSI detection and prevention. It streamlines healthcare processes, supports medical professionals in decision-making, and empowers patients to take an active role in managing their health. The integration of machine learning and web technologies is a significant step forward in healthcare innovation, promising to save lives, reduce healthcare costs, and enhance overall patient care quality.

The machine learning model uses a decision tree, random forest, KNN, and native Bayes algorithms, providing maximum accuracy. This trained model is used in the system to detect and prevent CLABSI.

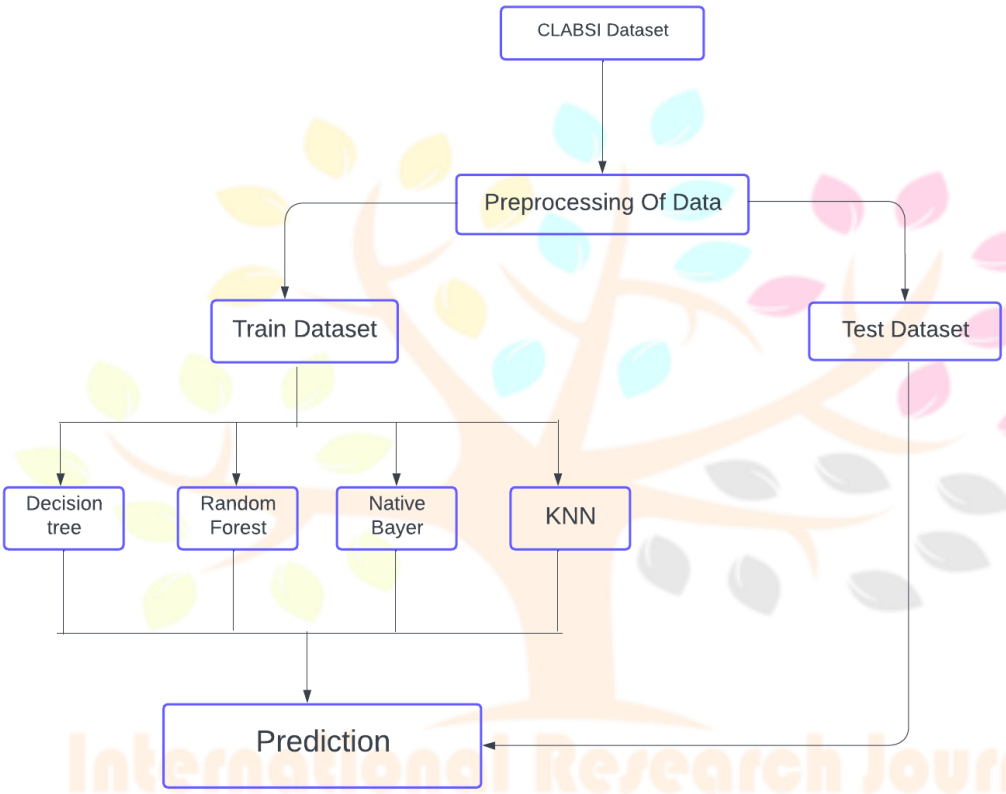

Figure 3.Machine learning Model Architecture

3.2.1 Decision Tree Algorithm

Decision Tree is a highly adaptable classification technique used for pattern recognition and classification of complex image problems.

3.2.2 Random Forest Algorithm

The Random Forest algorithm is a type of machine learning algorithm that falls under the supervised learning technique. It is used to solve both classification and regression problems in machine learning. The technique works by combining multiple classifiers to solve complex problems, which results in an improved performance of the model. This approach is known as ensemble learning. [6]

3.2.3 Native Bayes Algorithm

The Naive Bayes classifier relies on Bayes' theorem, which assumes the independence of predictors. This makes it easy to build and useful for very large datasets, as there's no need for complicated iterative parameter estimation.

3.2.4 K-Nearest Neighbours Algorithm

K-Nearest Neighbours is a supervised learning technique that allows us to classify new data by guessing its similarity to existing data points. The algorithm stores and classifies all available data based on similarity, and then assigns a new data point to the category that is most similar to the existing categories. This means that any newly appearing data can be easily classified into a suitable category using the K-NN algorithm.

IV. DISCUSSION

The proposed web application powered by AI can predict and intervene early. By combining machine learning and artificial intelligence, the system is capable of analyzing patient data in real-time to identify those at high risk of Central Line-Associated Bloodstream Infections (CLABSIs). This early warning system allows for timely intervention, which is crucial for reducing the incidence of CLABSIs and improving patient outcomes.

The user-centric disease risk assessment component empowers individuals to actively participate in their healthcare management. Users can assess their risk of CLABSIs and other diseases by providing their health information. This aspect not only fosters greater engagement in healthcare decision-making but also encourages users to take preventive measures and seek early intervention when necessary.

The application ensures that CLABSIs are identified promptly, reducing the impact on patient health and overall healthcare costs. Protecting patient confidentiality and privacy is paramount in the design and operation of our web application. This ensures that the application adheres to the highest standards of data protection and ethical practice.

When it comes to processing speed, Naive Bayes and k-NN are your go-to algorithms for high-velocity data streams. However, if you prioritize predictive accuracy and have enough computational resources.[4]

Random Forest can be a strong contender due to its ability to provide high accuracy and robustness. On the other hand, if interpretability is essential, and you need a model that can be easily explained to non-technical stakeholders. Decision trees may be the best choice.[7]

The most accurate prediction model for high real-time datasets should be determined through experimentation and testing. Try multiple algorithms and evaluate their performance using metrics such as accuracy, precision, recall, and F1-score.[6]

V.CONCLUSION

Central line-associated bloodstream infections (CLABSIs) are a grave complication resulting from central line placement.[9] These infections can cause significant morbidity and mortality, thereby increasing healthcare costs. However, AI-powered web applications can assist healthcare providers by providing them with tools to identify patients at high risk of infection and implement preventive measures, thus preventing CLABSIs.

The scope of work details our strategic process - from data collection and cleaning, to model development, and practical AI implementation.

VI.ACKNOWLEDGMENT

The completion of this survey paper on CLABSI Prevention Through AI-Powered Web Application Approach. While it's impossible to list everyone who played a part, we express our gratitude to the Director of GTU-GSET Dr. S. D. Panchal, Dr. S. K. Hadia, Prof. Mahesh Panchal, and Prof. Soniya Jain for their invaluable guidance and support.

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