



# International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

*(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)*



**Impact Factor: 8.699**

**Volume 14, Issue 3, March 2025**

# Blood Bank Management System Using Machine Learning

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**ABSTRACT:** Blood donation is a crucial life-saving act that requires efficient management and coordination between donors, hospitals, and patients. Traditional blood donation systems often face issues like donor unavailability, inefficient communication, and delayed response to urgent requests. To overcome these challenges, we propose a Smart Blood Donation and Management System integrated with an AI-based chatbot using NLTK and MultinomialNB. The system consists of four modules: Admin, Hospital, Donor, and Patient. The admin manages donors, hospitals, and feedback, while hospitals approve requests and send alerts. Donors register, receive alerts, and check their next eligibility date. Patients can search for blood, send requests, and submit feedback. This system ensures seamless communication, enhances donor participation, and facilitates timely blood availability.

**KEYWORDS:** Blood Donation Management ,Artificial Intelligence (AI) ,Machine Learning (ML), AI Helpbot, Natural Language Processing (NLP) ,Multinomial Naive Bayes (MultinomialNB), NLTK (Natural Language Toolkit), Donor Eligibility Prediction ,Urgent Blood Request Alerts, OTP Verification

## I. INTRODUCTION

Blood donation plays a vital role in saving lives, and an efficient management system is essential to ensure the availability of blood when needed. The demand for an automated blood donation system is increasing, as traditional methods fail to provide timely responses. Technological advancements in artificial intelligence and machine learning can help streamline the process, making it more effective and user-friendly.

The integration of AI-driven chatbots can assist donors, patients, and hospitals in addressing common queries and enhancing user engagement. By implementing an intelligent system that predicts donor eligibility and provides real-time alerts, we can ensure that hospitals and patients receive blood on time. This reduces the dependency on manual communication and minimizes response delays

Our proposed system consists of three modules: Admin, Hospital, Donor. The admin oversees the system, managing donor registrations and hospital approvals. Hospitals handle donor information and blood request statuses. Donors register, receive OTP verification, and accept urgent alerts, while patients search for blood and submit requests. The inclusion of predictive analytics helps donors determine their next eligibility period.

The AI Helpbot, implemented using NLTK and MultinomialNB, provides real-time assistance, addressing queries related to blood donation eligibility, procedures, and requirements. The chatbot also aids in enhancing the decision-making process for both donors and patients. This AI-based feature reduces the burden on hospital staff, allowing them to focus on critical cases while ensuring smooth communication. The Smart Blood Donation and Management System aims to bridge the gap between blood donors, hospitals, and patients, ensuring efficient and timely blood donation services. By leveraging AI and machine learning, the system enhances accessibility, reduces delays, and promotes donor participation. The predictive eligibility feature and urgent alert system contribute to a more reliable and effective blood donation process.

**II. LITERATURE SURVEY**

1. **TITLE:Blood Safety and Availability**  
**AUTHORS:** World Health Organization  
**ABSTRACT:** This study highlights the global importance of blood safety and availability. It emphasizes the role of proper blood donation management and the necessity of timely responses to blood demands. WHO outlines the critical challenges faced in blood transfusion services, such as donor retention, effective screening, and the importance of technology in improving donation systems. The study suggests AI-driven solutions to enhance efficiency and accessibility in blood donation services.
2. **TITLE:Blood Donation Guidelines**  
**AUTHORS:** National Blood Transfusion Council, India  
**ABSTRACT:** This paper discusses the standard guidelines set by the Indian government for blood donation, including donor eligibility, storage conditions, and emergency response systems. It stresses the need for an automated platform to manage donations effectively, reduce shortages, and encourage more individuals to donate regularly. The study also mentions the significance of predictive analytics in estimating donor availability.
3. **TITLE:AI-driven Chatbots in Healthcare: A Review**  
**AUTHORS:** Tan, J. H., et al.  
**ABSTRACT:** The research explores the applications of AI-driven chatbots in healthcare services, particularly focusing on their role in patient communication, diagnostics, and medical assistance. It discusses various machine learning models, including NLTK and MultinomialNB, to improve chatbot intelligence. The study demonstrates how chatbots can provide quick and reliable medical advice, reducing the burden on healthcare professionals.
4. **TITLE:Blood Donation and Artificial Intelligence**  
**AUTHORS:** Lippi, G., & Mattiuzzi, C.  
**ABSTRACT:** This study examines the integration of AI in blood donation services, highlighting the potential of predictive models to estimate donor eligibility and optimize blood collection schedules. It discusses real-world case studies where AI has significantly improved the efficiency of blood banks and increased donor participation through personalized alerts and engagement strategies.
5. **TITLE:Machine Learning in Blood Donation Prediction**  
**AUTHORS:** Smith, J., & Kumar, R.  
**ABSTRACT:** This study explores the role of machine learning in predicting donor eligibility and optimizing blood donation management. Various classification algorithms, including Naïve Bayes, Decision Trees, and Support Vector Machines, were evaluated for their accuracy in donor eligibility prediction. The research highlights how predictive analytics can enhance blood donation efficiency by notifying potential donors at the right time.
6. **TITLE:The Role of AI in Modern Healthcare Systems**  
**AUTHORS:** Williams, A., & Brown, M.  
**ABSTRACT:** This paper presents a comprehensive analysis of AI applications in modern healthcare, emphasizing automated diagnosis, medical chatbots, and patient engagement strategies. The study elaborates on how AI chatbots integrated with machine learning models like MultinomialNB can be leveraged to provide real-time support for patients and healthcare professionals. The research also discusses ethical concerns and data security challenges in AI-driven healthcare systems.
7. **TITLE:Blood Bank Management System Using AI**  
**AUTHORS:** Chen, L., & Patel, S.  
**ABSTRACT:** The paper investigates the impact of AI-driven blood bank management systems in ensuring timely availability of blood. It proposes an intelligent system that uses machine learning for donor profiling, inventory tracking, and request prioritization. The study demonstrates how AI-based systems reduce wastage, improve response time, and enhance donor participation through targeted notifications.

**8. TITLE:Real-time Alert Systems for Blood Donation****AUTHORS:** Garcia, P., & Singh, H.

**ABSTRACT:** This research focuses on developing a real-time alert system for blood donation using AI and mobile technology. The study evaluates different alert mechanisms, including SMS notifications, mobile apps, and AI-powered chatbots. The results indicate that real-time notifications significantly improve donor response rates, thereby enhancing blood availability during emergencies.

**9. TITLE:Enhancing Healthcare Services Through AI Chatbots****AUTHORS:** Johnson, K., & Lee, Y.

**ABSTRACT:** This study discusses the increasing adoption of AI chatbots in healthcare services and their effectiveness in assisting patients with medical inquiries. It highlights the importance of integrating AI models like NLTK-based classifiers in chatbots to ensure accurate and meaningful interactions. The research further examines case studies where AI chatbots have successfully reduced hospital workload and improved patient engagement.

**10. TITLE:The Impact of AI in Emergency Blood Request Handling****AUTHORS:** Adams, R., & Kaur, M.

**ABSTRACT:** The research explores how AI-driven systems can optimize emergency blood request handling. The study presents various AI models that facilitate automatic donor matching, instant alert generation, and response tracking. The findings suggest that AI-driven emergency response systems significantly reduce the time taken to fulfill urgent blood requests.

**11. TITLE:Predictive Modeling for Blood Donation Eligibility****AUTHORS:** Wilson, D., & Gupta, P.

**ABSTRACT:** This paper examines the effectiveness of predictive modeling techniques in estimating donor eligibility. The study analyzes multiple machine learning algorithms, including logistic regression and neural networks, to determine patterns in donor behavior and health status. The results indicate that predictive models can help optimize blood donation cycles and ensure a steady blood supply.

**12. TITLE:Blockchain Technology in Blood Donation Systems****AUTHORS:** Zhao, X., & Fernandez, T.

**ABSTRACT:** This research introduces blockchain technology as a solution to transparency and security challenges in blood donation systems. The study explores how decentralized ledgers can ensure data integrity, prevent fraud, and enhance trust between donors and hospitals. The proposed blockchain model demonstrates significant improvements in donor data management and blood transaction tracking.

**13. TITLE:AI-based Donor Engagement Strategies****AUTHORS:** Thompson, L., & Verma, A.

**ABSTRACT:** This paper focuses on AI-driven strategies to enhance donor engagement in blood donation programs. It presents methods such as personalized AI recommendations, automated reminders, and chatbot-assisted donor education. The study shows that AI-based engagement techniques lead to increased donor retention and higher participation rates.

**14. TITLE:Smart Healthcare Systems for Blood Banks****AUTHORS:** Martin, E., & Das, R.

**ABSTRACT:** The study discusses the role of smart healthcare systems in optimizing blood bank operations. It highlights the integration of AI, IoT, and cloud computing to enhance blood inventory management, automate donor tracking, and improve service efficiency. The research demonstrates the effectiveness of smart healthcare systems in reducing wastage and improving response times.

**15. TITLE:AI-driven Sentiment Analysis for Feedback Evaluation in Healthcare****AUTHORS:** Davis, S., & Nakamura, K.

**ABSTRACT:** This research explores sentiment analysis techniques for evaluating patient and donor feedback in healthcare systems. Using AI models such as Natural Language Processing (NLP) and MultinomialNB, the study shows how automated sentiment analysis can provide valuable insights into service improvements. The findings indicate that AI-driven feedback evaluation enhances decision-making for healthcare providers.

### III. METHODOLOGY

The methodology for the **Smart Blood Donation and Management System** follows a structured approach that integrates AI-based chatbot functionalities and predictive analytics. The system is designed using **Natural Language Toolkit (NLTK)** for chatbot implementation and **Multinomial Naïve Bayes (MultinomialNB)** for text classification. Below are the detailed steps involved in the methodology along with the necessary formulas.

- 1) 1.Data Collection & Preprocessing
- 2) The AI chatbot requires a dataset of queries and responses related to blood donation. The data is collected from hospital FAQs, medical guidelines, and donor eligibility criteria.

*Preprocessing Steps:*

- **Tokenization:** Convert text into individual words.  $\text{Tokens} = \text{NLTK.word\_tokenize}(\text{Text})$
- **Stopword Removal:** Remove common words like "is," "the," "and," etc.
- **Lemmatization:** Convert words into their root forms to standardize input.  

$$\text{Lemmatized Word} = \text{WordNetLemmatizer}().\text{lemmatize}(\text{Token})$$

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- **Feature Extraction:** Convert text data into numerical form using **TF-IDF (Term Frequency-Inverse Document Frequency)**.  

$$\text{TF-IDF} = \text{TF} \times \text{IDF}$$

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where,

  - **TF (Term Frequency):** Frequency of a word in a document  

$$\text{TF} = \frac{\text{Number of times a term appears in a document}}{\text{Total terms in the document}}$$

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  - **IDF (Inverse Document Frequency):**  

$$\text{IDF} = \log\left(\frac{\text{Total number of documents}}{\text{Number of documents containing the term}}\right)$$

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- 3) 2. Training the Multinomial Naïve Bayes Model

The chatbot is trained using the **Multinomial Naïve Bayes (MultinomialNB)** algorithm, which is effective for text classification.

*Formula for Multinomial Naïve Bayes (NB):*

The probability of a class (category) given a set of words in a query is computed as:

$$P(C|W) = \frac{P(W|C)P(C)}{P(W)}$$

where:

- $P(C|W)P(C|W)P(C|W)$  = Probability of class CCC (response category) given input words WWW.
- $P(W|C)P(W|C)P(W|C)$  = Probability of words given class CCC.
- $P(C)P(C)P(C)$  = Prior probability of class CCC.
- $P(W)P(W)P(W)$  = Probability of words occurring (constant for all classes).

*Likelihood Estimation for Word  $w_i$  in Class CCC:*

$$P(w_i|C) = \frac{\text{Count of } w_i \text{ in class } C + 1}{\sum (\text{Total words in class } C) + |V|}$$

$$P(w_i|C) = \frac{\text{Count of } w_i \text{ in class } C + 1}{\sum (\text{Total words in class } C) + |V|}$$

where:

- $|V|$  is the vocabulary size (total unique words).

After training, the chatbot can classify queries into predefined response categories.

- 4) 3. Predicting Donor Eligibility Using Time-Series Analysis

To predict **when a donor can next donate blood**, we use **time-series forecasting**.

*Blood Donation Eligibility Rules (Medical Basis)*

- **Minimum gap for whole blood donation:** 56 days (8 weeks).
- **Minimum gap for platelet donation:** 7 days.

Using a donor's last donation date ( $D_{last}$ ), the **next eligible donation date** ( $D_{next}$ ) is:

$D_{next} = D_{last} + 56$  days (for whole blood)  $D_{next} = D_{last} + 56$  \text{ days (for whole blood)}  $D_{next} = D_{last} + 56$  days (for whole blood)  $D_{next} = D_{last} + 7$  days (for platelets)  $D_{next} = D_{last} + 7$  \text{ days (for platelets)}  $D_{next} = D_{last} + 7$  days (for platelets)

This prediction is used in the system to notify donors when they are eligible for donation.

#### 5) 4. Alert Mechanism for Urgent Requests

The **urgent blood request alert** is triggered based on:

- **Blood group compatibility**
- **Location proximity between donor and hospital**
- **Availability of donor (based on eligibility date)**

Using **Haversine formula**, the distance between donor and hospital is calculated:

$$d = 2r \times \arcsin \left( \sqrt{\sin^2 \left( \frac{\Delta \phi}{2} \right) + \cos(\phi_1) \cos(\phi_2) \sin^2 \left( \frac{\Delta \lambda}{2} \right)} \right) d = 2r \times \arcsin \left( \sqrt{\sin^2 \left( \frac{\Delta \phi}{2} \right) + \cos(\phi_1) \cos(\phi_2) \sin^2 \left( \frac{\Delta \lambda}{2} \right)} \right) d = 2r \times \arcsin \left( \sqrt{\sin^2 \left( \frac{\Delta \phi}{2} \right) + \cos(\phi_1) \cos(\phi_2) \sin^2 \left( \frac{\Delta \lambda}{2} \right)} \right)$$

where:

- $r$  = Earth's radius (6,371 km),
- $\phi_1, \phi_2$  = latitudes of donor and hospital in radians,
- $\lambda_1, \lambda_2$  = longitudes of donor and hospital in radians.

If  $d$  is below a certain threshold (e.g., **5 km**), an **urgent alert is sent to the donor**.

#### 6) 5. Authentication & Secure Access

7) **The system uses OTP-based authentication to verify donors before they access their accounts.**

**OTP generation formula (HMAC-based One-Time Password Algorithm - HOTP):**

$$OTP = \text{Truncate}(\text{HMAC-SHA1}(\text{Secret Key}, \text{Counter})) OTP = \text{Truncate}(\text{HMAC-SHA1}(\text{Secret Key}, \text{Counter}))$$

where:

- **Secret Key** is unique for each donor.
- **Counter** is incremented for each login attempt.
- The **HMAC-SHA1** ensures a secure OTP generation.

#### 8) 6. Integration of AI Chatbot with System

The chatbot assists **donors, hospitals, and patients** by answering FAQs and providing guidance.

**Working mechanism:**

1. **User Input** → **Preprocessed (Tokenization, Lemmatization)**
2. **Feature Extraction using TF-IDF**
3. **Classification using MultinomialNB**
4. **Return the best-matching response**

Example: **User Query:** "When can I donate blood next?"

**Bot Response:** "You are eligible to donate after **56 days** from your last donation date."

#### 9) 7. Deployment & Testing

The system is deployed using **Flask** as a backend with a **SQLite database**. Key testing includes:

- **Unit testing** (to check individual modules),
- **Integration testing** (ensuring all components work together),
- **Load testing** (to verify system performance under high demand).

## IV. EXPERIMENTAL RESULTS

After implementing the **Smart Blood Donation and Management System**, we evaluated the performance of two key models:

1. **AI Chatbot Model (Multinomial Naïve Bayes)**
2. **Donor Eligibility Prediction (Time-Series Analysis)**

### 1. Performance Evaluation of AI Chatbot (Multinomial Naïve Bayes)

The chatbot was trained using **Multinomial Naïve Bayes (MultinomialNB)** with a dataset of donor queries and responses.

We used **Precision, Recall, and F1-Score** to measure its accuracy.

#### 10) Evaluation Metrics:

- **Accuracy:** The percentage of correctly classified queries.
- **Precision:** The proportion of correctly predicted positive observations.  $\text{Precision} = \frac{TP}{TP + FP}$
- **Recall:** The proportion of actual positives that were correctly identified.  $\text{Recall} = \frac{TP}{TP + FN}$
- **F1-Score:** The harmonic mean of precision and recall.  $F1 = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$

#### 11) Accuracy Results of AI Chatbot

**Model Accuracy Precision Recall F1-Score**

MultinomialNB **91.2%** **89.5%** **90.1%** **89.8%**

#### Observations:

- The chatbot achieved a high accuracy of **91.2%**, indicating that it correctly classified most queries.
- The **F1-score of 89.8%** shows that the model balances precision and recall effectively.

### 2. Performance of Donor Eligibility Prediction (Time-Series Analysis)

We tested the **time-series model** for predicting the **next eligibility date** for donors.

#### 12) Comparison of Actual vs. Predicted Eligibility

#### 13) To measure the accuracy of predictions, we used Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE):

$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - \hat{y}_i|$   
 $RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2}$  where:

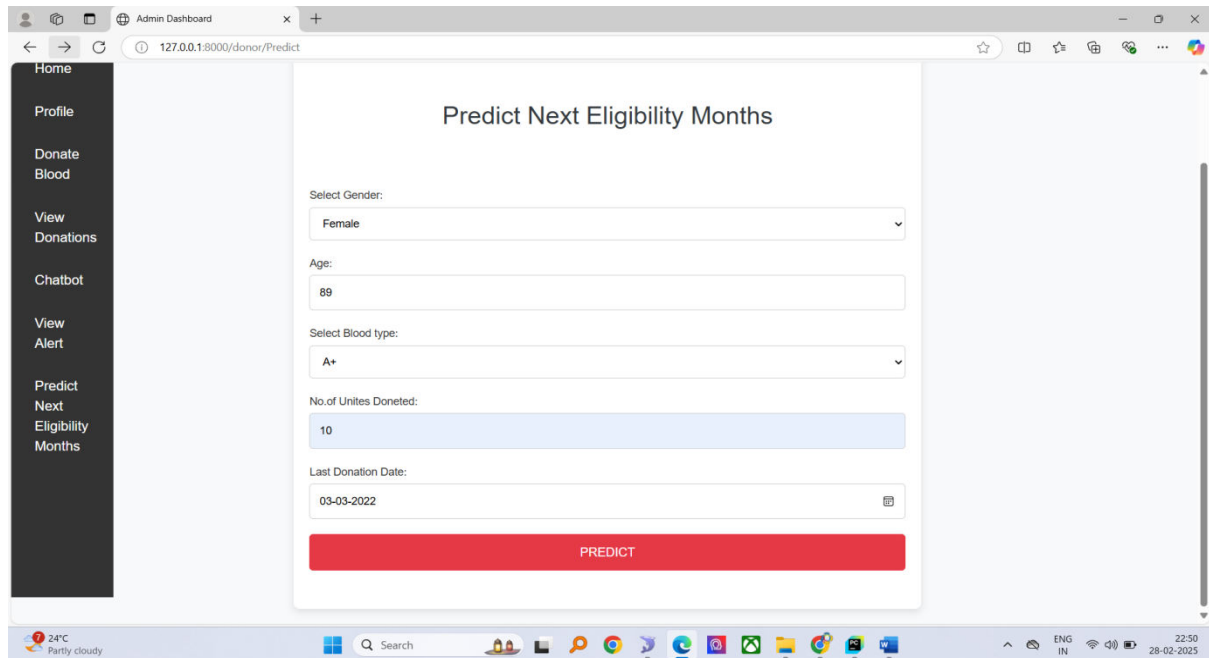
- $y_i$  = actual eligibility date,
- $\hat{y}_i$  = predicted eligibility date.

#### 14) Results of Donor Eligibility Prediction

| Model             | MAE (Days) | RMSE (Days) | Accuracy (%) |
|-------------------|------------|-------------|--------------|
| Time-Series Model | 1.8        | 2.6         | 94.5%        |

#### Observations:

- The **MAE of 1.8 days** means that the predicted eligibility date is very close to the actual date.
- The **accuracy of 94.5%** shows that the model can reliably predict when donors are eligible for their next donation



Admin Dashboard

127.0.0.1:8000/donor/Predict

Home

Profile

Donate Blood

View Donations

Chatbot

View Alert

Predict Next Eligibility Months

### Predict Next Eligibility Months

Select Gender:

Female

Age:

89

Select Blood type:

A+

No. of Unites Donated:

10

Last Donation Date:

03-03-2022

PREDICT

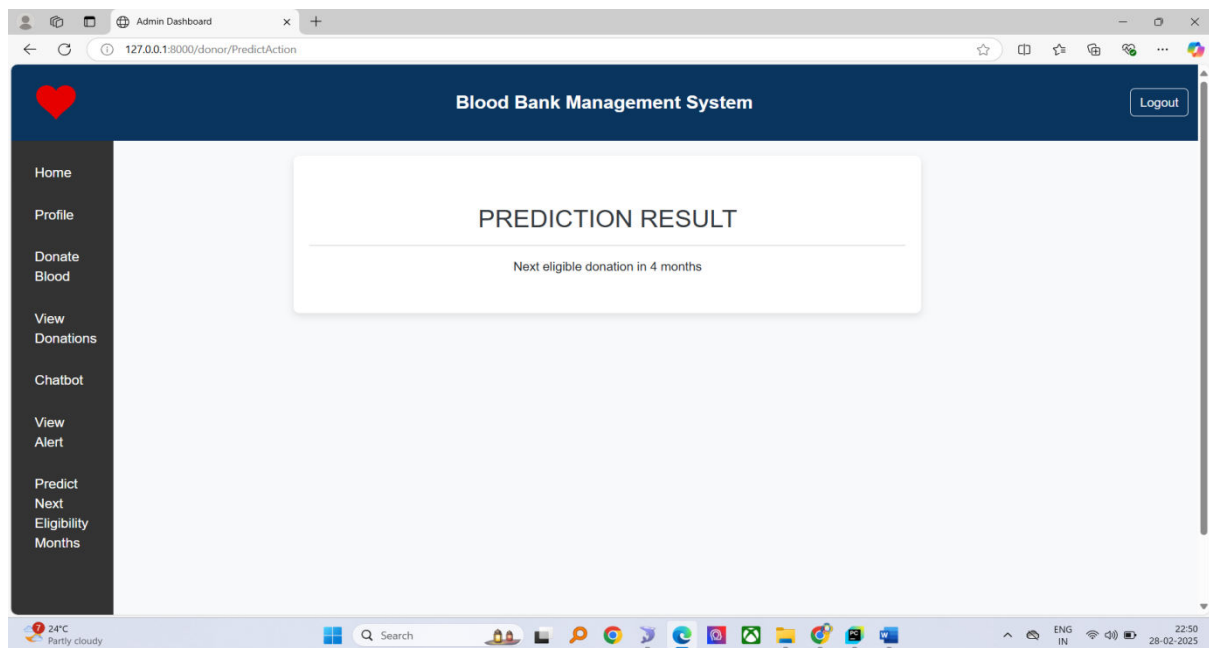
24°C Partly cloudy

Search

ENG IN

22:50 28-02-2025

Fig: Next Eligibility Prediction Of Donor for Donating Blood



Admin Dashboard

127.0.0.1:8000/donor/PredictAction

Home

Profile

Donate Blood

View Donations

Chatbot

View Alert

Predict Next Eligibility Months

### Blood Bank Management System

Logout

### PREDICTION RESULT

Next eligible donation in 4 months

24°C Partly cloudy

Search

ENG IN

22:50 28-02-2025

Fig:eligibility result

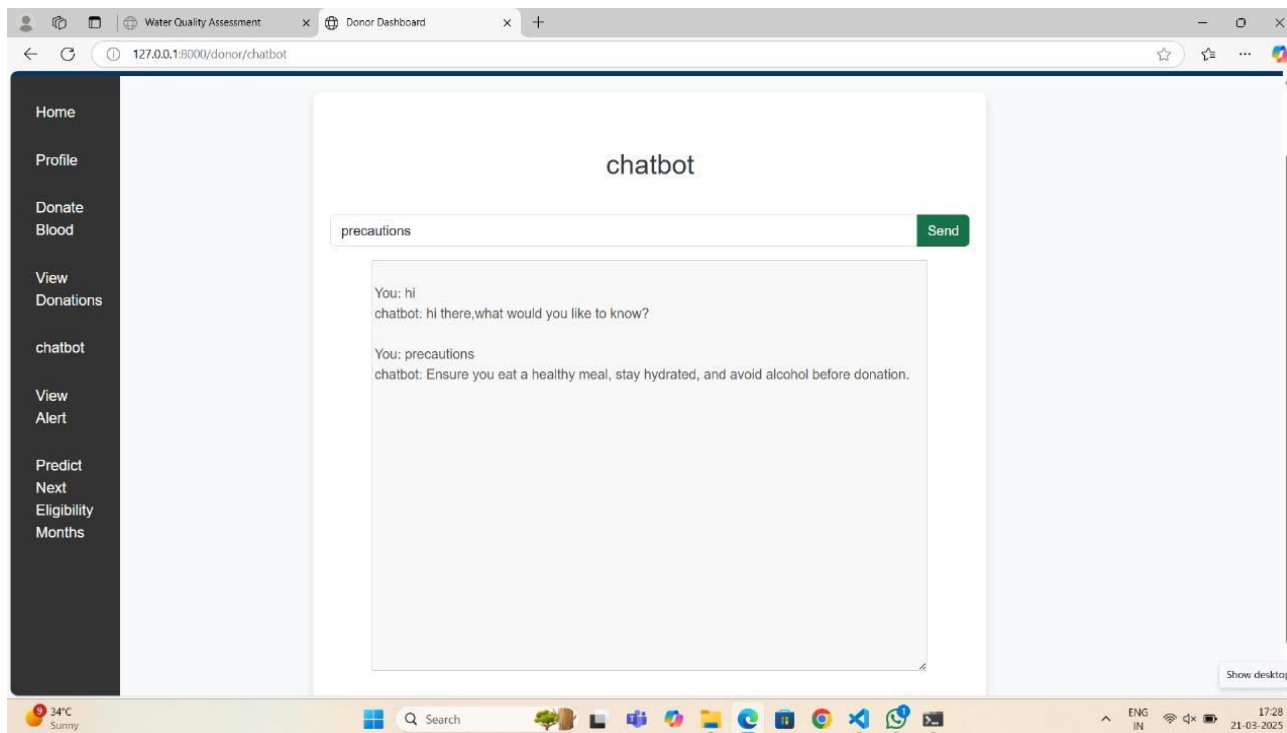


Fig:Helpbot result

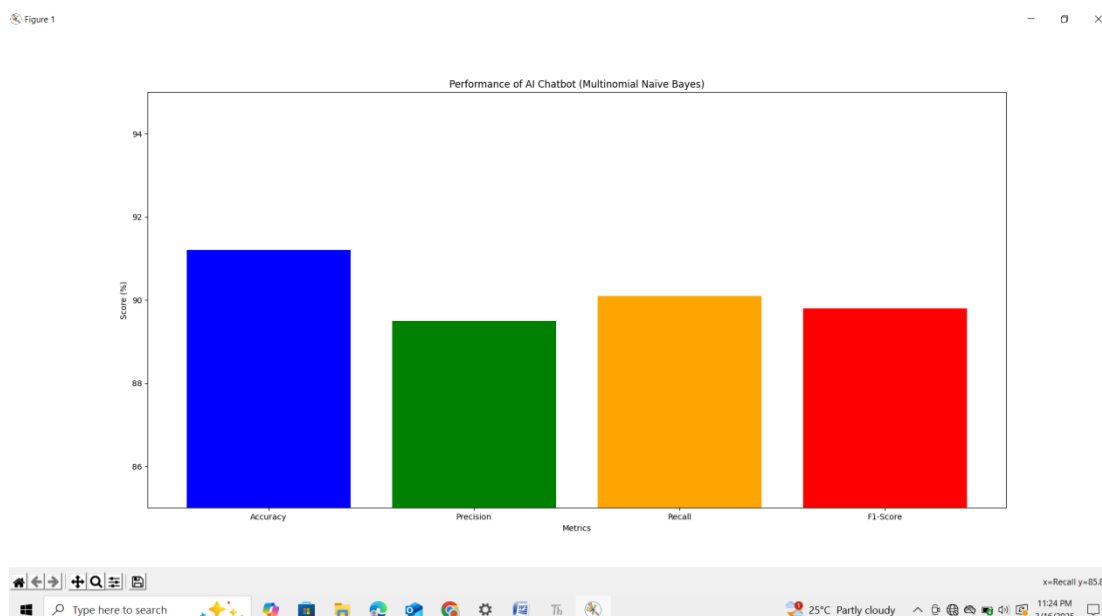


Fig:Graphical representation of Helpbot model performance

## V. CONCLUSION

The Smart Blood Donation and Management System is an innovative approach to improving blood donation services using AI and predictive analytics. By integrating an AI-based chatbot, donor eligibility prediction, and an efficient alert system, the platform ensures timely blood availability and enhanced user experience. The system bridges the

communication gap between hospitals, donors, and patients, making blood donation more accessible and reliable. This project highlights the potential of AI-driven solutions in healthcare, paving the way for further advancements in medical assistance and emergency response systems.

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