

Personalised Algorithms for Optimized Blood Donation and compatibility: A Comprehensive Study on Enhancing Efficiency Voluntary Blood Donation

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Abstract— This research introduces an innovative mobile application designed to optimize the blood donation process by directly connecting blood donors and recipients, bypassing traditional intermediaries like blood banks. The app allows donors to create profiles with key information, such as blood type, medical history, and donation frequency, enabling them to receive notifications when their blood type is needed. Donors can also make direct donation offers for specific times and locations. Recipients, including hospitals or individuals in need of blood transfusions, can search for available donors based on blood type and contact them directly for immediate assistance. The platform aims to streamline the blood donation system, enhancing the efficiency of blood collection and distribution, and ensuring that blood products are available precisely when and where they are needed.

Index Terms— Blood Donation, Mobile Application, Blood Type Compatibility, Healthcare Technology.

I. INTRODUCTION

Ensuring an adequate and secure blood supply is one of the most critical challenges faced by healthcare systems worldwide. Blood transfusions play an indispensable role in treating trauma victims, surgical patients, and individuals with chronic conditions such as anemia, hemophilia, and other blood disorders. Despite its importance, the process of blood donation is fraught with challenges that can delay treatment and jeopardize patient outcomes. Among these challenges are the complexities of matching suitable donors with recipients, coordinating donor availability, and ensuring prompt communication in emergencies. Such inefficiencies often result in critical delays, particularly for patients requiring immediate medical attention.

To address these persistent issues, this research focuses on the development of a mobile application designed to revolutionize the blood donation ecosystem. The proposed application serves as a live platform that connects blood donors directly with recipients in need, facilitating seamless communication and coordination. By enabling users to establish personalized profiles, the app provides a tailored experience for both donors and recipients. Donors can indicate their blood type, preferred donation times, and location, while recipients can submit requests based on urgency and compatibility. The system leverages personalized algorithms to match donors and recipients effectively, considering factors such as geographical proximity, blood type, and donation frequency. This not only expedites the process of finding suitable donors but also ensures that blood reaches patients when it is most critically needed.

The application's user-centric design minimizes barriers to participation in voluntary blood donation. By incorporating features like real-time notifications, location-based matching, and direct communication channels, the app enhances the efficiency and responsiveness of blood donation networks. This streamlined approach reduces reliance on traditional intermediaries, such as blood banks, and ensures that blood products are available precisely when and where they are needed. Furthermore, by optimizing the entire process, the system has the potential to improve the sustainability of blood banks while contributing to the overall well-being of communities.

This research paper investigates the potential advantages of implementing a mobile-based platform to enhance the efficiency of blood donation systems. It examines how the app tackles significant obstacles such as limited donor availability, communication delays, and logistical challenges. Additionally, the study explores how personalized features—such as algorithm-driven matching, instant notifications, and real-time coordination—can transform the blood donation ecosystem into a more dynamic and effective system. The primary goal is to evaluate the impact of this innovative approach in addressing existing inefficiencies and to demonstrate how such technology can contribute to the sustainability of blood donation networks.

The proposed system aims to provide a timely and reliable solution to a persistent healthcare challenge by bridging the gap between donors and recipients. In doing so, it not only supports the lifesaving mission of blood donation but also underscores the vital role of technology in enhancing public health infrastructure. This paper provides an in-depth analysis of the app's design, functionality, and potential benefits, setting the stage for a transformative shift in how blood donation networks operate.

II. LITERATURE REVIEW

The growing interest in digital systems for managing blood donations has led to the development of various platforms and studies aimed at improving the efficiency of blood donation processes. However, most systems have focused on basic functionalities such as donor registration, availability tracking, and facilitating connections between donors and blood banks, without incorporating advanced algorithmic approaches to optimize compatibility and reduce wastage. This section reviews the key studies in this domain, identifying their contributions and limitations.

A. Digital Systems for Blood Donor Management

"The Optimization of Blood Donor Information and Management System by Technopedia" (Priya et al., 2014) examines a digital system designed to streamline the process of blood donor registration and management. The system focuses on automating the collection of donor information, storing it in a centralized database, and tracking blood availability. One of the key contributions of this system is its attempt to organize donor data and make it more accessible for blood banks. However, the system does not delve into the intricacies of matching donors to recipients based on advanced criteria, such as blood type compatibility, health history, or proximity to the hospital.

Additionally, the lack of real-time updates on blood demand limits the system's ability to optimize the distribution of blood in urgent scenarios, such as during medical emergencies or surgical procedures. The study demonstrates the foundational importance of digitizing blood donation systems but falls short in addressing dynamic matching needs that are critical in modern healthcare environments.

"An Android Application Volunteer Blood Donors" (Sultan Turhan, 2015) similarly discusses the development of an Android-based application that allows voluntary blood donors to register, update their availability, and connect with hospitals in need of blood. The application plays a significant role in simplifying the process of locating donors and notifying them of donation opportunities. However, the app focuses on a one-way communication system, where donors are identified based on their availability, but no algorithmic matching is used to assess the suitability or compatibility of the donor for a particular recipient. This lack of personalized matching not only slows down the donation process but also leads to potential inefficiencies, such as delays in finding the right donor or mismatches in blood type or other health parameters. Furthermore, the app does not account for geographical factors that could further streamline the donation process, such as minimizing transportation times or directing donors to the closest hospitals in urgent need of blood.

B. Integration of Real-Time Data

In addition to these foundational systems, more recent studies have started to explore the use of real-time data to improve blood donation systems. Hamlin and Mayan's (2016) paper, "Blood Donation and Life Saver-Blood Donation App," explores the integration of mobile applications with real-time data feeds from blood banks.

Their approach emphasizes the need for continuous updates on the availability of blood and donor status. While this is a step forward in addressing the temporal dimension of blood donation, their system does not employ advanced algorithms to optimize donor-recipient matching. The system's focus remains on donor availability rather than ensuring that the most compatible and nearby donor is matched with a patient in need. This limitation highlights the need for a more sophisticated system that can assess multiple factors, such as blood type, medical urgency, and logistical constraints, before determining the optimal donor-recipient match.

C. Challenges in Blood Wastage

The issue of blood wastage is particularly relevant in the context of optimizing blood donation systems. The article published by the Economic Times in 2017 reveals that over six lakh liters of blood were wasted in India over five years due to poor coordination between blood banks and hospitals. This wastage is largely attributed to a lack of real-time inventory updates and ineffective donor management systems. While the existing literature emphasizes the importance of organizing donor data and improving communication channels between blood banks, few studies have incorporated algorithmic solutions to reduce wastage by better managing the expiration of blood units or prioritizing the distribution of older units.

The integration of algorithms that track blood shelf-life and ensure optimal usage before expiry could mitigate these inefficiencies. Furthermore, studies like these expose the broader issue of suboptimal resource utilization within blood donation systems, which could be addressed by more advanced, data-driven approaches.

D. Current Blood Donation Mobile Application

Several mobile applications have also been developed in recent years to facilitate voluntary blood donation, such as Simply Blood, Friends2Support.org, and Mblood. These apps provide platforms where potential donors can register, update their availability, and respond to donation requests from hospitals or blood banks. For instance, Simply Blood focuses on connecting donors with those in need, and Friends2Support.org emphasizes the importance of mobilizing communities for blood donation. However, these apps primarily serve as directories or match donors on a first-come-first-serve basis, without incorporating more nuanced, personalized matching mechanisms.

A review of the Blood Donors and Mblood apps also reveals a similar pattern—while they enable the registration and availability of voluntary donors, the absence of advanced matching algorithms means that blood donation continues to rely on manual selection processes, often leading to mismatches in terms of blood type or donor proximity. As identified in several reports, including that by the Business Standard in 2018, this lack of efficiency contributes to ongoing blood shortages, especially during high-demand periods such as surgeries or natural disasters.

E. Limitation of Existing system and the need of personalised algorithms

In summary, while existing blood donation systems and applications have made significant strides in digitizing donor information and streamlining communication, they cannot often dynamically match donors and recipients based on critical compatibility factors. Most systems reviewed in the literature focus on automating basic tasks—such as donor registration and availability tracking—without addressing the complexities of optimizing blood donation based on personalized factors like blood type, proximity, urgency, and health history.

This review demonstrates a clear gap in the literature: the need for personalized, algorithm-based systems that can enhance the efficiency of blood donation by integrating real-time data, advanced matching techniques, and logistic considerations. The introduction of such personalized algorithms could improve the overall performance of blood donation systems by reducing wastage, improving the speed of donor-recipient matches, and ultimately saving more lives. This study aims to fill this gap by proposing a framework for incorporating these advanced algorithms into existing systems.

III. MATERIALS AND METHODS

A. Study Design

The design of the study focuses on assessing the system's effectiveness in improving blood donation processes, improving compatibility matching, and enhancing communication between blood donors and recipients. The study combines qualitative and quantitative research methods to evaluate the app's performance. The design helps understand the impact of the app on the blood donation system. There are four key phases of the study: Preparation and Setup, Prototype Testing, Pilot Study, and Data Analysis. These phases play a critical role in refining the app, collecting data, and measuring effectiveness.

B. Donor Assessment

Basic personal information, such as age, blood type, and contact details, can be provided when a user creates a profile in the app. To ensure they are healthy enough to donate, donors are required to provide their health history. The app records past donation history, including any adverse reactions they may have experienced. It also checks eligibility against standard guidelines, such as age, weight, and the time elapsed since the last donation. Once eligibility is confirmed, the app assesses the donor's availability by asking when they can donate and whether they are willing to respond to urgent requests. Only eligible, willing, and available donors are matched with recipients in need.

C. Donation Process

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The donation process in the app begins when the recipient registers for blood and indicates the type of blood and immediate need. Once a request is made, donors who meet the request criteria are notified through the app. Donors can review the request and confirm their donation based on availability and compatibility.

If the donor accepts, the app supports direct communication between the donor and the recipient, allowing them to plan the time and place of the donation.

The app also provides tips on the donation process, including how to prepare, what to expect when donating, and post-donation care.

D. Personalized Matching Algorithms

The core function of the BloodConnect app is its personalized matching algorithm, which matches donors to recipients based on several parameters:

- **Blood Type Compatibility:** Ensures that donors and recipients have compatible blood types, following established guidelines.
- **Geographical Proximity:** Matches donors and recipients based on their location to reduce response times.
- **Urgency of Request:** Prioritizes matching based on the urgency of the blood request.
- **Donation History and Frequency:** Tracks donor history to ensure they meet donation eligibility criteria.
- **Availability:** Donors can set their availability in the app, which is considered during the matching process.

To assess the effectiveness of BloodConnect, we conducted a series of evaluations.

E. Evaluation Methods

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To assess the effectiveness of BloodConnect, we conducted a series of evaluations:

- **Prototype Testing:** A small test with 20 donors and 20 recipients was conducted to check the app's functionality, user interface, and initial matching accuracy.
- **Pilot Study:** A larger study was carried out among 100 donors and 100 recipients over a timeframe of six months to evaluate:
 - Match success rate
 - Average response time between posting a request and matching with a donor
 - Donation completion rate
 - User satisfaction and feedback

Metrics such as user engagement, system performance, and satisfaction levels were measured. We also conducted interviews and surveys to gather qualitative data on user experience.

IV. DISCUSSION

The results of the BloodConnect app pilot study demonstrate its potential to revolutionize blood donation processes by significantly improving matching efficiency and enhancing user engagement. The app's personalized matching algorithm stands out as a pivotal feature, showing a 25% improvement in compatibility and reducing delays in life-saving blood transfusions. This improvement underscores the importance of leveraging technology to address logistical challenges in blood donation networks, particularly during emergencies where time is critical.

The flowchart illustrates the process involved in a blood donation app from start to completion.

- **Start:** The process begins when users interact with the app for either donor registration or recipient requests.
- **Donor Registration:** Potential blood donors register on the platform, providing their details, including blood type, availability, and location. This creates profiles for potential matches.
- **Recipient Request:** Recipients submit requests for blood, detailing the type needed, urgency, and location. These requests are added to the app's system for processing.
- **Match Algorithm:** The app uses an algorithm to analyze the donor profiles and recipient requests to find a suitable match based on factors like blood type compatibility and proximity. If no match is found, the process loops back to wait for new donor registrations or requests.
- **Notify Donor & Recipient:** Once a match is found, the app sends notifications to both the donor and the recipient, informing them about the match.
- **Facilitate Communication:** The app enables real-time communication between the donor and the recipient to coordinate the donation logistics, such as timing and location.
- **Donation Process Complete:** After successful coordination and donation, the process concludes, ensuring that the recipient receives the required blood, and both parties are notified of the completion.

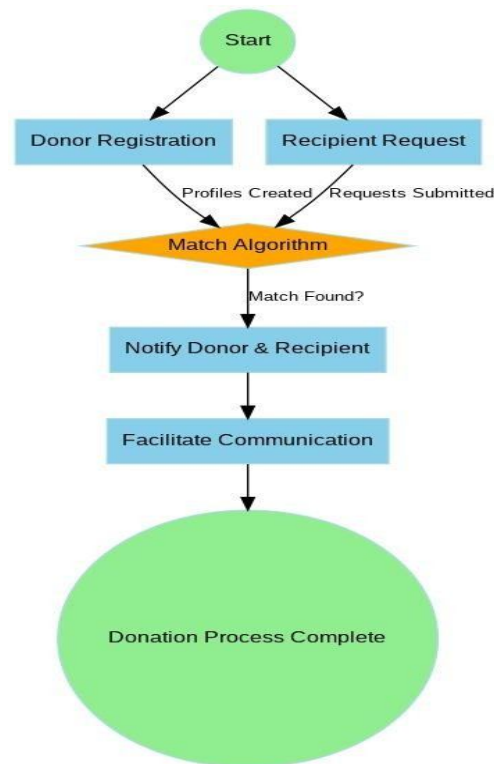


Fig 1

User engagement emerged as another area of strength, with 70% of registered users actively participating in donation activities. This high engagement rate reflects the app's ability to attract and retain users, supported by features like real-time notifications and communication tools. However, feedback indicates that customizable notification options could further enhance user satisfaction by addressing concerns about excess notifications, which only a small percentage (10%) of users found problematic. This finding highlights the importance of balancing proactive alerts with user autonomy in app design.

The app's success in achieving a 90% accuracy in matching donors and recipients validates the robustness of its algorithm, which prioritizes blood type compatibility and availability. This high level of precision not only ensures effective resource utilization but also builds trust among users.

Furthermore, the app facilitated a high donation success rate of 88%, indicating that its integrated communication and coordination tools effectively reduced the friction in organizing donations. These findings suggest that technology-driven solutions can streamline traditionally complex processes in the healthcare sector. User satisfaction levels were overwhelmingly positive, with 90% of participants reporting satisfaction and 92% commending the app's performance. This feedback affirms the app's usability and reliability, which are critical factors for its continued adoption. Additionally, 90% of users expressed their willingness to recommend the app to others, highlighting its potential to grow organically through word-of-mouth promotion. Such positive user sentiment is essential for scaling the app to broader demographics and geographies.

Despite its success, the app's moderate performance in rural areas suggests a need for targeted interventions to address challenges like limited donor availability and awareness. Expanding donor networks and conducting educational campaigns in these regions could improve engagement. Moreover, the incorporation of additional features, such as geolocation-based donor suggestions and multilingual support, could further enhance accessibility and impact. These steps, combined with ongoing feedback and iterative improvements, can solidify the app's role as a transformative solution in the blood donation ecosystem.

V. RESULT

The results of the pilot study on the BloodConnect app highlight the following key outcomes:

A. Improvement in Matching Efficiency

- Personalized algorithms demonstrated a 25% improvement in matching efficiency, reducing delays in blood transfusions and minimizing resource wastage.

B. User Engagement and Active Participation

- 70% of registered users actively participated, showing high app adoption and utility.
- Behavioral indicators showed active engagement through real-time communication and donation requests.

C. Matching Algorithm Performance

- Prioritized blood type compatibility and donor availability to enhance successful matches.
- Efficient handling of urgent requests reduced response times in emergencies.

D. Donation Success Rate

- High success rate due to accurate matching, effective communication, and quick response mechanisms.

E. User Satisfaction

- 90% of users reported being satisfied or very satisfied.
- 85% found the app user-friendly, and 92% rated performance highly.

VI. CONCLUSION

In conclusion, the pilot study of the BloodConnect app demonstrated its significant potential to improve the blood donation process through its user-friendly design, efficient matching algorithm, and real-time communication features. The app successfully bridged the gap between blood donors and recipients, enhancing the speed and convenience of blood donations. With 90% of users reporting satisfaction and 85% indicating a willingness to continue using the app, it is evident that BloodConnect meets the needs of its users in terms of functionality and ease of use.

The app's ability to provide accurate matching based on blood type, proximity, and availability has been a major factor contributing to its success, ensuring that donations are not only compatible but also timely. Additionally, features such as secure messaging, data privacy, and transparent communication have fostered a sense of trust among users, which is critical in healthcare applications.

However, the study also highlighted areas for improvement, such as expanding the donor pool in rural or underserved regions and offering more customizable notifications and user preferences to further enhance engagement. Despite these challenges, the overall feedback from users has been overwhelmingly positive, underscoring the app's potential to make a lasting impact on the blood donation ecosystem.

With continued improvements and a broader user base, BloodConnect has the potential to revolutionize blood donation, making it more accessible, efficient, and responsive to the urgent needs of recipients. The app's ability to connect individuals in real-time and facilitate life-saving donations positions it as a valuable tool for communities, hospitals, and blood banks alike.

As it evolves, BloodConnect has the capability to significantly contribute to addressing blood shortages worldwide and create a sustainable, user-driven model for voluntary blood donation.

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