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A Novel Approach to Organize Blood Donation Camp and Blood Unit Wastage Management

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ABSTRACT

In the countries or areas where the supply-demand ratio of blood is not maintained, the medication process is being deteriorated, and this may be as fatal as death of the patients. It is being observed in different areas in different seasons or may be at the time of festival scarcity of blood may happen. On the other hand, if the blood donation camp is organized frequently, there may be a surplus of blood as it has expiry dates. Along with these issues, due to the transportation or mismanagement, blood units are wasted. These problems are addressed in this research work, and methodologies are proposed to determine the most suitable blood bank with respect to the blood donation camp. Further, a demand forecasting algorithm is used both for predicting the blood unit demand of every blood bank and for transferring excess blood units to the blood bank where it is needed the most, and also, for the efficient transportation of the blood units, taxicab geometry-based paths are employed.

KEYWORDS

Blood, Blood Donation, Blood Wastage, Forecasting, Lexicographic Optimization, LSTM, Multi-Objective Optimization, Taxicab Path

INTRODUCTION

Blood is essential for human life. As blood circulates throughout the body it delivers oxygen and nutrients to body cells. If this function stops or does not function properly a lot of problems will occur in the human body, which may even lead to death. Not only about the blood related diseases (hematologic disease) for other issues such as accidents, but operations blood is also required be given

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externally. Although modern medical science has improved dramatically, the production of blood is still not possible. Blood can be given externally by taking the blood from another human body only in the form of a blood donation. To meet this emergency requirement and demand of blood, blood donation camps (Chaudhari et al., 2018; AlZu'bi et al., 2022) play a pivotal role. Recognizing this, countries that prioritize the well-being of their citizens understand the positive impact of organizing well-planned and scientifically driven blood donation camps (Dutta et al., 2018; Luo et al., 2021; Sadri et al., 2021) within their healthcare systems. Numerous studies (Devi et al., 2012; Alexander & Adler, 2020) indicate that in countries such as India, Pakistan, and Bangladesh, only one-third (Devi et al., 2012) of the required blood units are obtained through various blood donation camps. Hence, promoting awareness (Dutta et al., 2018) about blood donation is crucial for every compassionate nation. At the same time, blood donation camps are often organized in a haphazard manner (Sadri et al., 2021), lacking any prior planning regarding the optimal location for the camp or which blood bank to coordinate with for collecting blood units (Sadri et al., 2021). In certain instances, these camps may even be influenced by the vested interests of a few political leaders (Dutta et al., 2018), rendering any form of pre-computation or data analysis (Ghosh, Sadhu, & Sen, 2021) irrelevant. As a result, a significant number of blood units end up being wasted (Alexander & Adler, 2020) over time.

Another reason for wasting blood units is mismanagement (Sadri et al., 2021) in distributing blood units. Consequently, blood banks in need of blood units are facing shortages, while those with lower demand have an excess of blood units, resulting in a waste of human blood. In developing countries with limited medical infrastructure, these challenges have a more pronounced impact (Devi et al., 2012). The lack of sufficient healthcare resources and facilities exacerbates the effects of these issues on the population. Therefore, it is vital to emphasize the importance of raising awareness about blood donation while simultaneously highlighting the critical significance of effectively managing blood unit distribution and preservation. Both aspects are essential to meet healthcare demands and ensure a steady and safe blood supply for those in need. In the subsequent paragraphs, different mathematical concepts are presented that relate to distance calculation as blood needs to be moved between blood donation camp, blood banks, hospitals, etc.

The most common form of distance calculation is Euclidean geometry, and the formula is shown in Equation 1:

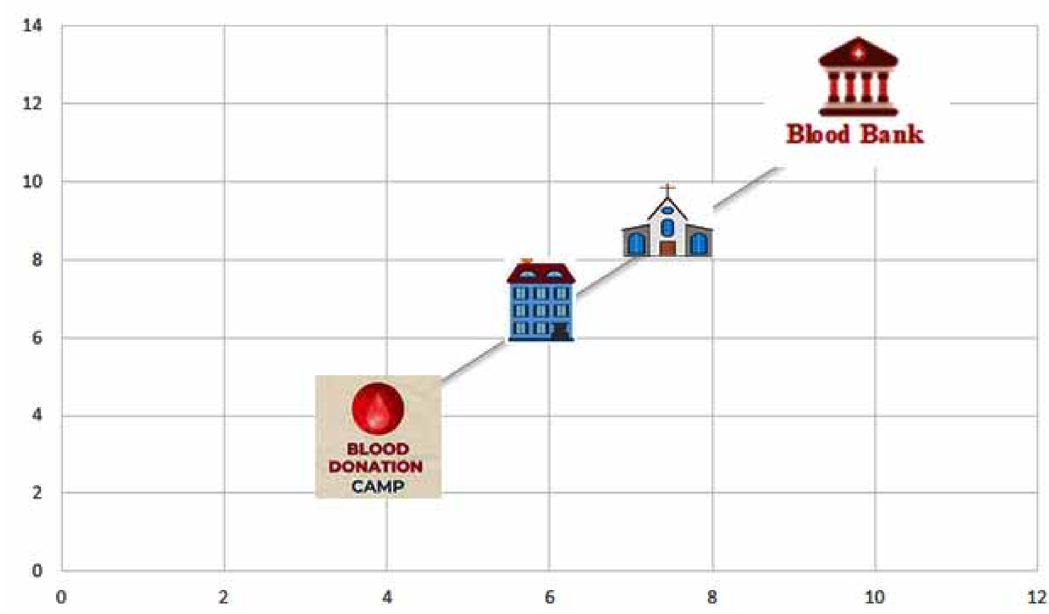
$$distance\left(A,B\right)=\sqrt{\left[\left(X_A-X_B\right)^2+\left(Y_A-Y_B\right)^2\right]} \quad (1)$$

Equation 1 functions accurately in the areas that have no obstacles, however in reality that is not possible due to the physical obstacles in the form of buildings, other constructions, water bodies and other constraints, such as one-way roads, private roads, etc. These barriers can hinder the direct route, making it challenging to determine an efficient and straightforward distance measurement between the two locations as shown in Figure 1.

Therefore, considering all different constraints in this domain, the lexicographic optimization (Arora, 2017; Zykina, 2004) technique is used to optimize dimensions one after another, starting from the most important dimension. Applying lexicographic optimization in this case mainly requires optimization of three dimensions:

1. Minimum distance traversal from blood donation camp to the blood bank.
2. Minimum distance transfer of the excess blood units from one blood bank to the other that need them the most.
3. And supplying new blood units to the blood banks having minimum available blood units with respect to the demand (Sadri et al., 2021).

Figure 1. Obstacles along the direct route between the blood donation camp and the blood bank



To manage the physical obstacles over the shortest distance path, taxicab geometry-based path distance (Ghosh et al., 2017; Ekici et al., 2012; Ghosh et al., 2018) is applicable in this case. It can compute distance between two points by taking modular difference of longitude and latitude as shown in Equation 2:

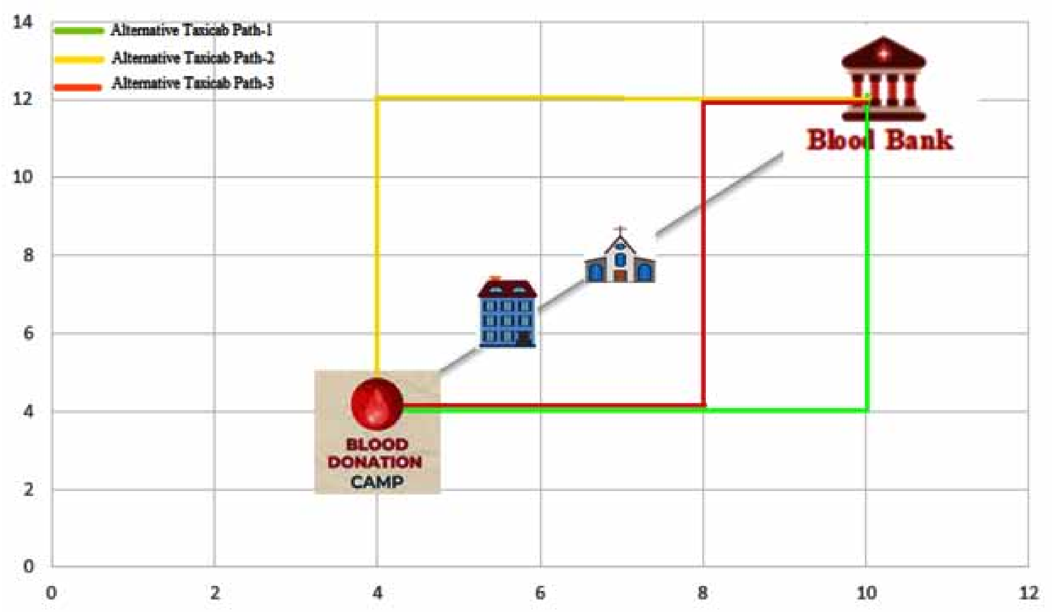
$$T\_distance(a,b) = \left|a_{latitude} - b_{latitude}\right| + \left|a_{longitude} - b_{longitude}\right| \quad (2)$$

Taxicab geometry-based formula satisfies all the axioms for a metric space (Ghosh et al., 2017), such as non-negativity, identity of indiscernible, symmetry, and the triangle inequality. Due to these features taxicab geometry can be applied in this type of problem effectively. Most importantly, if there are any physical obstacles upon taxicab path, the methodology can automatically find alternative taxicab paths. Most importantly, all the distances of these taxicab paths remain consistent, as illustrated in Figure 2. For example, in Figure 2, taxicab path-1 distance is |4 - 10| + |4 - 12| = 14 units. For any reason, if there is a requirement for selecting path-2 or path-3, the alternative taxicab path distance remains constant and that is always 14 units in this case.

Therefore, in this proposed methodology, to determine the shortest distance from the blood donation camp to the blood bank and between different blood banks, we have employed the taxicab path (Ghosh et al., 2017; Ekici et al., 2012; Ghosh et al., 2018) distance that suits the scenario best.

The paper's organization is outlined as follows: related study is in the Section 2 followed by the goal of this research in Section 3. The proposed methodology is presented in Section 4, followed by a detailed case study in Section 5. A comparative study is conducted in Section 6. Section 7 encapsulates the conclusions drawn from the study and suggests potential directions for future research endeavors.

Figure 2. Alternative taxicab paths



RELATED WORK

Distribution of blood units to the blood bank and hospital includes some computational aspects to ensure timely delivery of the blood to the patients, as well as after the collection of blood as those units need to be delivered to the blood bank quickly for preservation purpose. Over time, various techniques (Chaudhari et al., 2018; AlZu'bi et al., 2022; Sadri et al., 2021; Alexander & Adler, 2020) have been proposed to manage and distribute blood units. These works (Chaudhari et al., 2018; AlZu'bi et al., 2022; Sadri et al., 2021) optimized the blood donation process by preventing blood shortages and minimizing the wastage of blood units with regards to the expiration. Optimization equations (AlZu'bi et al., 2022; Dutta et al., 2018) have been developed further to enhance the blood donation process, aiming to minimize blood wastage and prevent shortages. An intelligent model is implemented as a sophisticated system to effectively describe and optimize the management of the C/T ratio (Alexander & Adler, 2020), which represents the ratio of blood collected from donors to the actual transfused units. Additionally, the model (Alexander & Adler, 2020) is designed to address the critical issue of wastage in whole blood units, aiming to minimize unnecessary discarding of blood while ensuring an adequate supply to patients as needed (Luo et al., 2021; Devi et al., 2012; Alexander & Adler, 2020). A framework (Maji et al., 2018) developed to integrate isolated web based sub systems of a blood management system proposed a data warehouse model to store historical blood donation data (Maji et al., 2018) centrally for analytical processing and decision making. This informed blood donation camping decision is based on the analytical reports from the DW (Ghosh, Sadhu, & Sen, 2021) for some area for a particular time and citizen demography. Furthermore, certain researchers have directed their focus towards managing the blood donation supply chain using Blockchain technology (Luo et al., 2021; Sadri et al., 2021; Lakshminarayanan et al., 2020). The system (Luo et al., 2021) employs Blockchain technology mainly for secure storage of essential information related to blood donation and Hash file details. Additionally, it utilizes the Interplanetary File System (IPFS) (Luo et al., 2021) to store identity images and signature files of verified blood donors. By integrating the K-Nearest Neighbors (KNN) algorithm, the system matches the nearest blood supply center with a specific blood type, facilitating prompt deployment during critical situations when hospitals are experiencing blood shortages.

At the same time, to minimize wastage of blood units, standard operating procedures (SOPs) (Alexander & Adler, 2020; Kumari & Wijayanayake, 2016) for blood transfusion are essential to ensure the safe and efficient handling of this vital resource. A forecasting model (Kumari & Wijayanayake, 2016) focuses on efficiently managing the daily supply of platelets through accurate prediction of the daily demand. It leverages three forecasting techniques, analyzing historical daily demand to estimate future demand with a 95% confidence level (Alexander & Adler, 2020). The model encompasses nine distinct implementations, utilizing three primary algorithms, all with the shared objective of minimizing platelet shortages. They (Alexander & Adler, 2020; Kumari & Wijayanayake, 2016) also proposed that regular audits should be conducted to enhance the processes of blood collection, treatment, delivery, and utilization, especially considering the scarcity of this valuable resource. However, none of the proposed methodologies have presented a comprehensive solution that addresses the full spectrum of organizing a scientifically sound blood donation camp while also effectively managing surplus blood units within the blood bank and minimizing the associated costs.

Therefore, the goal of this research involves consideration and balancing of multiple dimensions (Arora, 2017; Ghosh, Sen, & Cortesi, 2021; Maji et al., 2018), like maximizing blood collection, minimizing blood wastage, efficient resource utilization, optimal camp location, etc. starting with most important dimension. Hence, optimization by techniques lexicographic (Arora, 2017; Zykina, 2004) could be one of the desirable solutions in this case, as it involves addressing each dimension separately, starting from the most important dimension. Lexicographic optimization is capable of optimizing multiple criteria, even when they are inversely proportional (Zykina, 2004; Ghosh, Sen, & Cortesi, 2021) to each other. In this domain, implementing lexicographic optimization considers the optimization from three aspects: minimizing the distance from the blood donation camp to the blood bank, ensuring the supply of blood units to blood banks with the lowest available inventory (Sadri et al., 2021), and minimizing wastage of blood unites. In order to forecast (Ghosh, Sadhu, Mandal, Debnath, & Sen, 2021; Puri et al., 2022; Sharma et al., 2023) blood unit requirements, Long Short Term Memory (LSTM) forecasting could be one of the modern practice. LSTM (Kumar et al., 2018; Sirisha et al., 2022) forecasting offers notable advantages compared to traditional methods like ARIMA, SARIMA, and Prophet (Ghosh, Sadhu, Mandal, Debnath & Sen, 2021; Sirisha et al., 2022). It excels in capturing complex nonlinear relationships present in time series data and is adept at understanding long-term dependencies that span extended periods. Unlike traditional models that often require manual feature engineering, LSTM autonomously learns relevant features from data. It can handle irregularly spaced (Sirisha et al., 2022) time series data and effectively manage multiple variables, making it adaptable to diverse scenarios. Furthermore, the advantageous capability of LSTM (Kumar et al., 2018; Sirisha et al., 2022) to handle complex and irregular patterns proves invaluable for capturing subtle trends and seasonal variations. This attribute is of paramount importance in this research, particularly for managing the crisis of blood units, especially during the winter and festive seasons. It maintains accuracy over extended forecast horizons, which is a challenge for traditional models due to their inherent limitations.

Furthermore, all the previous methodologies (Dutta et al., 2018; Maji et al., 2018; Luo et al., 2021; Alexander & Adler, 2020) use shortest distance formula for determining the distance from the blood donation camp to the blood bank and between different blood banks. But in the current road conditions, considering the shortest distance, which relies on calculating distance on a fly, may not be the most appropriate approach due to the physical obstacles and traffic constraints. Therefore, to avoid physical obstacles upon the shortest distance path, the most suitable method for determining the distance from the blood donation camp to the blood bank and between different blood banks in this scenario is the taxicab path distance (Ghosh et al., 2017; Ekici et al., 2012; Ghosh et al., 2018).

GOAL OF THE RESEARCH

The main objective behind the implementation of this model is to mitigate the mortality rates arising from inadequate blood availability. Several computational aspects are associated with the blood collection and donation. The proposed methodology takes care of these issues and is listed below:

1. Organizing blood donation camps in strategically significant geographical locations.
2. Systematic distribution of blood units.
3. Minimizing the wastage of blood units.

In the proposed methodology, by considering the above issues, an enhanced healthcare solution is achieved that guarantees timely access to the essential blood resources for patients in need.

PROPOSED METHODOLOGY

The proposed methodology can be divided into two distinct parts. The initial part emphasizes the organization of blood donation and the systematic distribution of blood units to ensure they are prioritized for the blood bank with the greatest need. In the second part, this methodology centers around assessing surplus blood units in each blood bank and redistributing them to the blood bank with the highest demand or need.

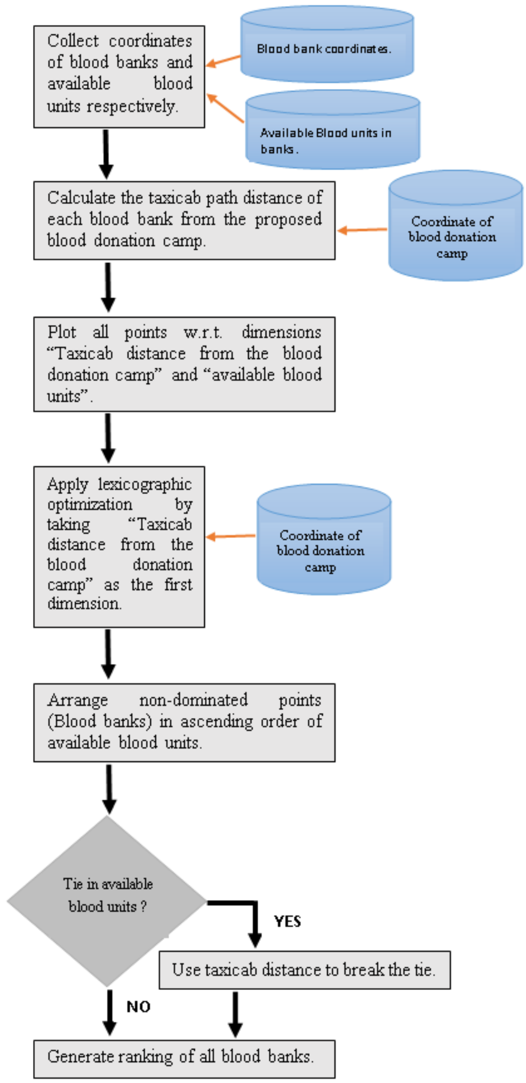
Scientific Organization of Blood Donation and the Systematic Distribution of Blood Units

Blood bank coordinates are easily accessible for many modern countries. Additionally, in all modern countries, there is a standard practice to regularly update the available blood units for each blood group in each blood bank through a central repository system. This is done to ensure the right to information and for administrative purposes (Sadri et al., 2021). Hence, the first phase starts with collecting all coordinates of blood banks in the region the blood donation camp is likely to be organized. In this proposed methodology, the timely deposit of blood units in the blood bank is most essential. To achieve this, the first dimension (considered the most important) to be optimized is the taxicab path distance from the blood donation camp to the blood banks. This approach allows for maximum utilization of taxicab distance based on the current road conditions, ensuring efficient and effective transportation of blood units to their respective destinations. Therefore, this approach excludes blood bank coordinates that fall within the specified range concerning the first dimension, which is the “taxicab distance from the blood donation camp to the blood banks.” Afterward, among the accessible points (blood banks), the dimension “Available blood units” is chosen as the next important dimension. Hence, based on the minimum available blood units, the proposed methodology assigns ranks to all blood banks. If two or more blood banks have the same units of blood, then the methodology ranks them according to the shortest taxicab distance. Figure 3 illustrates the comprehensive flow diagram of Phase-1 of the proposed methodology.

Surplus Blood Unit Management

To manage surplus blood units in each blood bank efficiently, it is essential to predict the excess units that might be at risk of expiring in a short period. After a time gap of seven days, this proposed methodology involves running the LSTM (Long Short-Term Memory) forecasting model at each blood bank to predict the blood unit requirements for the following seven days. Upon identifying surplus blood units that are likely not to be utilized within the next seven days through forecasting, the proposed methodology involves redistributing them among the blood banks that require them the most. The proposed methodology employs the same distribution technique and distribution van used in Phase-1 for the redistribution of surplus blood units among

Figure 3. Flow-diagram of Phase 1 of the proposed methodology



the blood banks. If any deficiency in the blood units is predicted within the upcoming seven days, the proposed methodology will raise a demand request to the system. Figure 4 illustrates the overall flow diagram of Phase-2 in the proposed methodology.

CASE STUDY

In this section, the proposed methodology implemented on an actual dataset (Data, 2023) sourced from "kaggle.com," a well-known subsidiary organization of Google LLC that offers reliable and authentic data. These are available at https://www.kaggle.com/datasets/sachinprabhu007/ blood-bank-directory-india. The dataset contains information from blood banks of India (Data, 2023).

In this proposed methodology, our initial focus is on identifying a specific region where a blood donation camp can be organized. Therefore, we extract a dataset (Data, 2023) based on the column "District." For this case study, we have selected "Kolkata" district, a province in India, as our primary

Algorithm 1. Phase 1

/* The algorithm takes the coordinates of blood banks within a specific region and the coordinates of the proposed blood donation camp as input. The ultimate output of this algorithm is the ranking of blood banks with respect to proposed blood donation camp. */

Step 1: Start

Step 2: Calculate the taxicab path distance of each blood bank from the proposed blood donation camp and store it in a 2D matrix format having columns taxicab distance and available blood units.

Call method computeTaxicabDistance_AvailableBloodUnit (coordinateBloodBanks[ ][ ], coordinateCamp)

Step 3: Plot all points (blood banks) with respect to the dimensions "taxicab distance" and "available blood units."

Step 4: Discard dominated points by lexicographic optimization with respect to the first dimension "taxicab distance."

Call method filterPoints(taxicabDist_Availability[ ][ ])

Step 5: Sort available points (blood banks) in ascending order with respect to the dimension "available blood units."

Step 6: If (Tie in available blood units)

then

Use taxicab distance from blood donation camp to the blood bank to break the tie.

end if

Step 7: Generate the ordered list of blood banks.

Step 8: Stop

Method computeTaxicabDistance_AvailableBloodUnit (coordinateBloodBanks[ ][ ], coordinateCamp)

/* This method takes coordinate of blood banks in a longitude and latitude format as an input and returns the taxicab path distance from the proposed blood donation camp and availability of blood units of each blood banks. */

Step 1: Start

Step 2: Loop for i=1 to numberOfBloodBanks

do

taxicabDist_Availability[i][1] = $|camp_{latitude} - bloodBank\_i_{latitude}| + |camp_{Longitude} - bloodBank\_i_{Longitude}|$

taxicabDist_Availability[i][2]=Available Blood Unit of i^{th} blood bank.

end loop

Step 3: return taxicabDist_Availability[ ][ ]

Step 4: Stop

Method filterPoints(taxicabDist_Availability[ ][ ])

/* This method takes taxicab distance of blood banks from proposed blood donation camp and available blood units in each blood bank as an input and retain only blood banks those are within the permissible taxicab distance from the blood donation camp. */

Step 1: Start

Step 2: td=input(permissible distance)

Step 3: Loop for i=1 to taxicabDist_Availability.Length - 1

do

If (taxicabDist_Availability[i][1] > td

then

Discard i^{th} blood bank from taxicabDist_Availability[ ][ ]

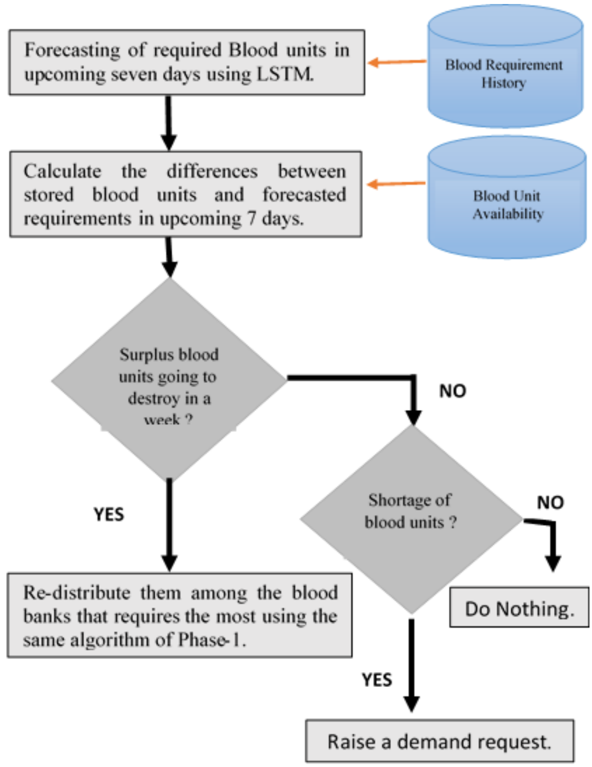
end if

end loop

Step 4: return updated taxicabDist_Availability[ ][ ]

Step 5: Stop

Figure 4. Flow-diagram of Phase 2 of the proposed methodology



area for this case study. Within the Kolkata area, there is a renowned blood donation organization called "Association of Voluntary Blood Donors, West Bengal," with the following coordinates: 22.555132 (latitude) and 88.379776 (longitude). The proposed methodology involves calculating the taxicab distance from this blood donation camp to all the blood banks (points) located in Kolkata district. Subsequently, these distances are plotted against the dimensions "Taxicab distance from blood donation camp" and "Available blood units," as depicted in Figure 5.

By applying the proposed algorithm's "filterPoints" function in Phase-1, we have identified a set of points corresponding to blood banks that adhere to the permissible taxicab distance criterion, illustrated in Figure 6. (It's important to note that a permissible distance of 40 kilometers was utilized for this purpose.)

Therefore, in this specific example, there are only eleven points (representing blood banks) that meet the criteria for collecting blood units from the designated blood donation camp, as shown in Figure 6.

Upon completing Steps 5 and 6 of Phase-1 within the proposed methodology, the eligible points (blood banks) are systematically arranged through a sorting process. Subsequently, a comprehensive ranking of these points (blood banks) is established, with a primary focus on evaluating the available blood units dimension. The result of this ranking procedure is visually shown in Figure 7.

For the next stage, we require data concerning the supply of blood units and the flow of patients at each specific blood bank. Unfortunately, this information is not readily available on any online data platforms. So, we synthesized data with the help of the annual report (Report, 2023) of the blood banks published by the Department of Ministry of Health and Family Welfare, Government of India. The report is available at the following link: http://nbtc.naco.gov.in/assets/resources/reports/commonResource_1517229005.pdf. Pages 42 to 48 of the report encompass the compilation of the

Algorithm 2. Phase 2

/* This algorithm takes the requirement history of blood units from each blood bank and the record of stored blood units as inputs. Its primary objective is to identify whether there will be a surplus or shortage of blood units in the upcoming seven days at each blood bank in the system. Once identified, the algorithm's secondary goal is to distribute surplus blood units to the blood banks with the highest requirements. */

Step 1: Start

Step 2: Collect blood requirement history for each blood bank.

Step 3: Loop for i= 1 to NumberOfBloodBank

```
        required = Forecast using LSTM(i^th blood bank)
        gap = stored blood units - required
        If gap < threshold
        then
                raiseDemandRequest(i^th blood bank, gap)
        Else If gap > threshold
        then
                re-distribute blood units using the same algorithm of Phase-1
        Else
                do-nothing
        End If
```

Step 4: Stop

Figure 5. Available blood units vs. taxicab distance

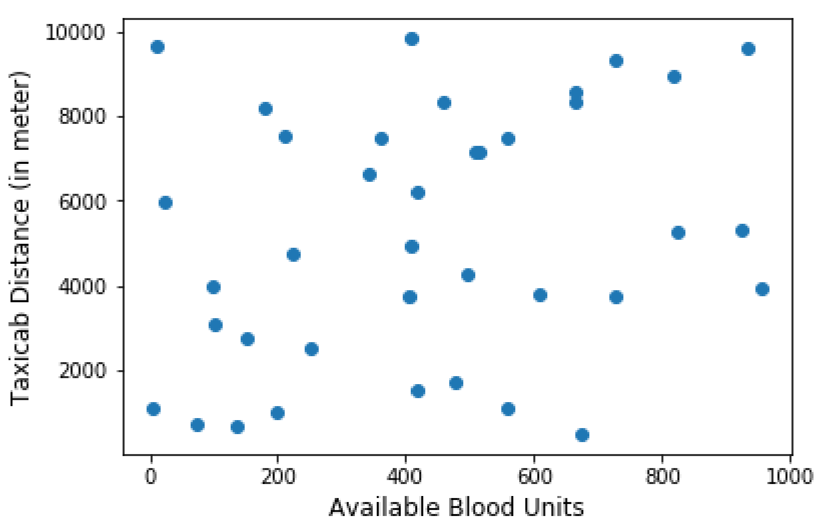


Figure 6. After filtration of points (blood banks) w.r.t. permissible taxicab distance

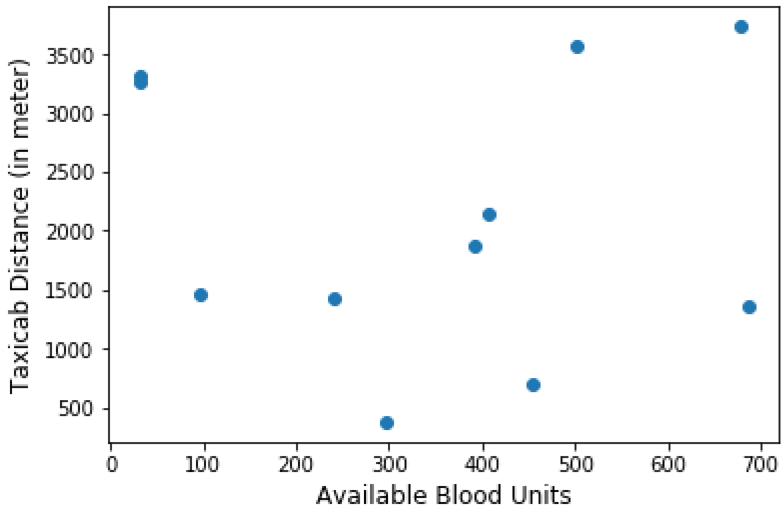


Figure 7. Ranking of blood banks

	Sr No	Blood Bank Name	District	Latitude	Longitude
0	2781	Life Care Medical Complex Private Limited Bloo...	KOLKATA	22.549891	88.370811
1	2766	Bhoruka Research Centre for Haematology and Bl...	KOLKATA	22.555075	88.357116
2	2778	Lions District 322B1 Blood Bank	KOLKATA	22.567572	88.351051
3	2768	Mission of Mercy Hospital and Research Centre ...	KOLKATA	22.548112	88.360060
4	2775	Indian Association of Blood Cancer and Allied ...	KOLKATA	22.571820	88.392401
5	2779	Calcutta Medical College Hospital Blood Bank	KOLKATA	22.573681	88.360779
6	2769	Apollo Gleneagles Hospital Limited Blood Bank	KOLKATA	22.574843	88.401517
7	2780	Marwari Relief Society Blood Bank	KOLKATA	22.582859	88.357493
8	2776	Institute of Blood Transfusion Medicine and Im...	KOLKATA	22.585192	88.375102
9	2782	N.R.S. Medical College and Hospital Blood Bank	KOLKATA	22.561845	88.370626
10	2797	Tata Medical Centre Trust Blood Bank	KOLKATA	22.577236	88.479461

overall blood collection figures for each blood bank in a year. The annual collection of the blood units of the selected eleven blood banks are shown in Table 1.

We have distributed this data on a weekly basis and apply the proposed algorithm of Phase-2. The final forecasted results of shortage/surplus blood units are shown in Figure 8.

A negative value in the column “shortage” of Figure 8 represents surplus blood units and NaN represents no shortage of blood units. Therefore, according to Figure 8, the following blood banks need to re-distribute their excess blood units using the same algorithm of Phase-1: “The Haemophilia Society Calcutta Chapter Blood Bank,” “Chittaranjan National Cancer Institute Blood Bank,” “Health Point – A Multispeciality Hospital Blood Bank,” “Cord Life Sciences India Private Limited Blood

Table 1. Annual collection of blood units

Name of the Blood Bank	Annual Collection (Units)
Life Care Medical Complex Private Limited Blood Bank	77559
KPC Medical College and Hospital	2115
N.R.S. Medical College and Hospital Blood Bank	23864
Marwari Relief Society Blood Bank	6101
The Haemophilia Society Calcutta Chapter Blood Bank	2814
Chittaranjan National Cancer Institute Blood Bank	3153
Calcutta Medical College Hospital Blood Bank	28281
Health Point - A Multispeciality Hospital Blood Bank	18699
Cord Life Sciences India Private Limited Blood Bank	11681
Bhoruka Research Centre for Haematology and Blood Transfusion	12517
Blood Bank Ramkrishna Mission Seva Prathisthan	3296

Figure 8. Forecasted results of shortage/surplus blood units

	Sr No	Blood Bank Name	Taxicab Distance (in meter)	Blood Units	Shortage
0	2781	Life Care Medical Complex Private Limited Bloo...	3270	31	1461.0
1	2791	KPC Medical College and Hospital	3316	32	9.0
2	2782	N.R.S. Medical College and Hospital Blood Bank	1456	97	362.0
3	2780	Marwari Relief Society Blood Bank	1424	241	NaN
4	2790	The Haemophilia Society Calcutta Chapter Blood...	376	296	-242.0
5	2773	Chittaranjan National Cancer Institute Blood Bank	1877	392	-331.0
6	2779	Calcutta Medical College Hospital Blood Bank	2148	407	137.0
7	2792	Health Point - A Multispeciality Hospital Bloo...	696	454	-94.0
8	2795	Cord Life Sciences India Private Limited Blood...	3579	501	-276.0
9	2766	Bhoruka Research Centre for Haematology and Bl...	3739	678	-437.0
10	2785	Blood Bank Ramkrishna Mission Seva Prathisthan	1358	687	-624.0

Bank," "Bhoruka Research Centre for Haematology and Blood Transfusion," and "Blood Bank Ramkrishna Mission Seva Prathisthan."

COMPARATIVE STUDY

In this section, a comparative study is presented to demonstrate and compare the relevant features related to blood donation organization and blood unit management. Five pertinent features are identified for this purpose. None of the existing work covers more than three features; however, the proposed work encompasses all the five features, as specified. A comparative study as provided in Table 2 demonstrates the novelty of this research work.

Table 2. Comparative study

Methodologies	Blood Donation Management?	Consider the Presence of Physical Obstacles During Blood Unit Transfer?	Blood Unit Wastage Management?	Consider the Presence of Physical Obstacles During Blood Unit Re-Transfer?	Minimize the Cost Both for Blood Donation and Wastage Management?
Luo, Gehao & Yiming, 2021	✓	×	×	×	×
Dutta, Maji, Ghosh & Sen, 2018	✓	×	×	×	×
Lakshminarayanan, Kumar & Dhanya, 2020	✓	×	×	×	×
Sadri, Shahzad & Zhang, 2021	✓	×	×	×	×
Alexander & Adler, 2020	×	×	✓	×	×
Ghosh, Goto, Ghosh, Sen, 2023	✓	✓	×	×	×
AlZu'bi, Aqel & Lafi, 2022	✓	×	✓	×	✓
Proposed Methodology	✓	✓	✓	✓	✓

CONCLUSION AND FUTURE WORK

This paper introduces an innovative approach for effectively arranging blood donation camps within appropriate geographic areas. It employs lexicographic analysis-based optimization to enhance criteria, beginning with the most crucial dimension. Initially, it optimizes the permissible distance between the blood donation camp and the blood bank, and subsequently focuses on supplying blood units to the blood banks with the lowest available blood units. In the next phase, using a forecasted model, this proposed methodology shows how to re-distribute surplus blood units of one blood bank to the other blood banks. Thus, utilizing this innovative model, organizers of blood donation camps can gain a distinct understanding of viable locations for conducting these camps. Simultaneously, they can possess a prioritized list of blood banks to engage with for the purpose of collecting blood units. On the other hand, through the re-distribution of surplus blood units, this novel model offers a means of minimizing the wastage of blood units. It uses the existing distribution chain for this re-distribution, eliminating the need for additional costs to be incurred for the re-distribution of excess blood units that would otherwise be at risk of expiring within a brief timeframe.

To calculate the distance from the blood donation camp to the blood bank and from one blood bank to other blood banks, the proposed methodology employs a taxicab geometry-based distance computation. As a result, it can identify alternate routes in cases where obstacles exist along the shortest distance path. Most importantly, it should be noted that all alternative path lengths are exactly same.

Furthermore, this research has the potential for expansion by incorporating additional parameters, such as identifying the optimal season for conducting blood donation camps to maximize their impact. Additionally, exploring strategies to minimize the costs associated with collecting each unit of blood presents another intriguing avenue for future research.

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