JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 2, 2022, p. 1184 - 1227
https://publishoa.com
ISSN: 1309-345

A Systematic Review on Smart Blood Bank System: Taxonomy, Motivations, Challenges, Study Directions and Recommendations

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Abstract:

This work introduces a systematic review of state-of-the-art studies about enhancing the blood banks systems based on modern and smart technologies in line with the healthcare sector development, such as artificial intelligence, the Internet of things, blockchain, cloud computing, as well as machine learning, novel Multiple criteria decision-making (MCDM) method, and a fuzzy stochastic programming approach, all used to cover issues in the blood banks. Then, taxonomy has been built to group articles according to their motivations, objectives, and challenges. The search has been conducted in four major databases: IEEE Xplore, Science Direct, Springer, and PubMed. The final sets were included 54. Most articles (22 out of 54) about blood bank systems: computer and mobile-based blood bank systems(13), blood donor searching systems(5), and Internet of Things-based blood banks(4). Reviews (12 out of 54) have discussed the importance of smart technologies in blood donations. Studies (15 out of 54) have included various analyses about inventory issues with blood/platelet supply chain networks problems in disasters. Meanwhile, few articles (5) have presented devices to detect blood groups and measure viscosity in an easy, cost-effective way. This work also has provided an overview of the recent contributions in blood banks mechanisms from 2017 to 2021 facilitating the donation in difficult situations, monitoring blood inventory. Besides, has highlighted the weaknesses in medical care techniques in developing countries suffering from disasters, diseases, and wars. On the other hand, how some limitations in such applications need to take more seriously ex: security, and privacy, older people may face problems in operating, as well as internet and power connectivity which are the main worries. We anticipate that this systematic review can help other researchers grasp the available concepts and gaps so that they can subsequently add to this type of research.

Keywords: blood bank, blood donors, blood transfusion, Internet of Things, smart blood bank systems.

	Terminology, Term	abbreviation
1.	Internet of Things	IoT
2.	World Health Organization	WHO
3.	Blood Supply Chain Network	BSCN

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4.	Sciences, Technology, And Medicine	STM
5.	Medical Internet of Things	MIoT
6.	Machine Learning	ML
7.	Transfusion-Transmissible Infections	TTI
8.	Human Immunodeficiency Virus	HIV
9.	Hepatitis B Virus	HBV
10.	Hepatitis C Virus	HCV
11.	Information and Communication Technologies	ICTs
12.	Unstructured Supplementary Service Data	USSD
13.	Short Message Service	SMS
14.	Blood Donors Support System	BDSS
15.	Geographic Information System	GIS
16.	One-Time-Password	OTP
17.	Intelligent Blood Management System	IBMS
18.	Abo, D Blood Group	A, B, AB and O
19.	3D-Printed Capillary Circuit	3D-CC
20.	Red Blood Cell	RBC
21.	Blood Supply Chain	BSC
22.	Platelets	PLT_s
23.	Hemoglobin	Hb
24.	Stochastic Programming	SP
25.	Multi-Criteria Decision-Making	MCDM
26.	Personal Computer	PC
27.	Point of Care Tests	POCT
28.	Supply Chain Of Blood And Planning	DRBDP
29.	Special Collection Vehicles	SCVs
30.	Messaging Queue Telemetry Transport	(MQTT)
31.	Convalescent Plasma	CP
32.	Improved Bacteria Forging Algorithm	IBFA
33.	Application Program Interfaces	APIs
34.	User Interface	UI
35.	Temporary Emergency Shelters	TESs
36.	Patient Blood Management	PBM

1- Introduction

In recent years, the world has witnessed numerous events and disasters requiring blood transfusions, including diseases, particularly cancer and subsequent treatments for blood cancer (leukaemia) or (thalassemia), significant surgeries (heart surgery, organ transplants), childbirth complications, problems with newborns and premature babies, burns[1], wars, earthquakes and traffic accidents. Following traumatic events, blood transfusions have saved lives[2, 3], thus highlighting the essential role of blood banks in the medical field[4-10]. One crucial area is the

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blood bank, which facilitates blood donation, storage and transfusion[11]. This place collects and stores blood for future transfusions. It is located in medical laboratories[5, 12] to ensure the safety of donated blood and its products before usage[12, 13]. A blood bank's primary goal is to receive blood from various donors, check a blood type group's database and provide an appropriate quantity of blood to hospitals and medical centres during emergencies[2]. Some essential procedures must be implemented before a blood transfusion in a blood bank: assigning blood groups based on the ABO blood group system, dividing blood into four types (A, B, AB and O) and counting erythrocytes[14, 15]. A blood donation is a noble act that rescues lives[16]. As Dr. Margaret Chan, former director-general of the World Health Organisation (WHO), "Although we have many external differences, the same vital blood pumps through all our veins…Voluntary, unpaid blood donation is the act of giving life – the greatest gift any person can give or receive."/13 June 2016 News release – GENEVA . Blood is essential to human survival; even those who donate their blood may require blood at some point[6]. Nowadays, most blood donors are volunteers, and most of these donations occur in developed nations. Hospitals massively rely on them to help anonymous recipients without compensation[3, 17]. Under this circumstance, blood banks receive a large amount of blood from donors[13], which is an archetypal example of altruistic behaviour[3]. In providing blood, a blood bank must first assign the correct blood type requested because mismatched blood groups produce blood clumping or agglutination, which is highly harmful. Bank staff must also understand that blood only lasts 30-35 days[15]. Usually, they tend to supply old units first[18]. As a result, the health of the recipient may be put at risk[19]. As such, providing patients with old units is considered an inventory allocation issue[20]. Furthermore, blood supplies are low in developing nations; hence donors frequently give blood when family or friends require a transfusion[17]. Blood banks may not always have sufficient stocks of blood in each group[21]. In addition, numerous other issues are often caused by disasters, including devastation, loss of life, financial and transportation challenges, a scarcity of workforce and a lack of emergency facilities in affected areas. Human safety has become a primary concern and an essential public health factor because of the world's population and the growing number of patients[22]. Therefore, healthcare operations and disaster management are the two widely addressed research fields[23]. For instance, medical health or m-health has been developed to facilitate mobile healthcare communications and network technologies[24]. The improvement of healthcare systems primarily includes converting these systems into digital form to provide adequate information and technology, thus allowing doctors, nurses and other researchers to comprehend and identify various concerns related to patients efficiently[25]. Enhancing the healthcare system also helps decrease medical mistakes, improve legibility, keep costs down and increase quality by meeting timely information requests[26]. Furthermore, as the literature has suggested, new technologies can be essential in healthcare services, as they provide ubiquitous, individualised and high-quality services. For instance, keeping electronic health records involves observation, education, interaction and behaviour tracking[27]. Distributed systems, such as fog, cloud and IoT, have accelerated the evolution of healthcare systems while maintaining interoperability, dependability, accessibility and reply time[28]. These developments can lead to the realisation of a healthcare information system designed to handle, save and obtain medical data on demand[26]. Difficulties in locating a suitable blood group can cause numerous lives[4]. Hence, new blood donation systems are already becoming necessary, especially as the technological world is constantly evolving and people are seeking effective communication networks to establish

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efficient blood banks [29]. Moreover, mobile, web and computer applications used worldwide for donation processes have become efficient, thus demonstrating that using technology for this operation is beneficial[6]. Such observation is not surprising given that an impressive number of academics and developers work in technology and are concerned about health[4]. The main goal in this field is to automate the entire blood donation process in blood banks and acquire blood promptly[13, 30]. Furthermore, researchers aim to strengthen the relationship among hospitals, donors and centres to overcome shortfalls in each by using internet technology, especially Internet of Things (IoT) techniques that help to make work more flexible[29, 30]. Integrated databases must also be built to occupy decisions based on safe and correct data[13]. IoT is a new and rapidly growing concept that connects devices with one another [1]. In addition, cutting-edge technologies and applications to motivate and raise knowledge about blood donations are at the forefront of the desired outcomes of research in the field [29]. Thus, the current work aims to introduce a systematic review that presents state-of-the-art blood bank management systems, blood donation activities, inventory problems and blood supply chain networks (BSCNs) in disasters. The studies that will be discussed in this review tackled new approaches to modern and intelligent technologies, as well as examined some social and environmental determinations in different countries that affect the donor's behaviour. The present review extracts the highlights, systems and applications in these topics. Then, this review builds a taxonomy that classifies studies depending on their motivations, objectives and challenges, as presented in Figure1. The remainder of this paper is organised as follows. Section (2) discusses the methodology of this work. Then, Section (3) provides the results and statistical information of articles with taxonomy. Next, Section (4) discusses the motivation, challenges, direction of studies and recommendations. Finally, the conclusions are drawn in Section (5).

2- Method

The systematic review used inclusion criteria to narrow topics from general to specific issues. The keywords were used to identify relevant papers by logical order to cover problems regarding blood donations and IoT-based blood banks. One limitation of this study was the selection of English articles only (literature, research review, scientific papers and conference articles). In addition, the search was limited to articles published in the last five years (2017– 2021). The search databases were: IEEE Xplore, Science Direct, Springer and PubMed. The exhaustive search extracted 657 articles. Ultimately, the final set after filtering comprised 54 studies.

2.1. Information sources

The databases below were selected to cover technical literature and provide a balanced perspective of researchers' work in various domains. As a result, four digital databases provided the target articles. Firstly, IEEE Xplore offers a collection of studies on engineering and technology. Secondly, Science Direct is a database that allows access to journal articles in the sciences, technology and medicine (STM). Thirdly, MEDLINE database, which is accessible via the PubMed search engine, covers life sciences and biomedical journals. Fourthly, Springer is a global scientific leader in technical and medical publishing that also offers research services.

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2.2. Study selection

The first filter was applied by scanning the title and abstract and downloading articles containing the keywords ‘blood donors’ and ‘IoT’ in a blood bank management domain. After articles were extracted from the first filter, the second step dealt with multiple issues in blood banks (blood banks systems, devices, blood inventory management and reviews), which discussed solutions to improve the blood donation process. In this step, irrelevant articles were excluded. Then, the third filter focused on the technologies used in the blood bank system. The full text of each article was read.

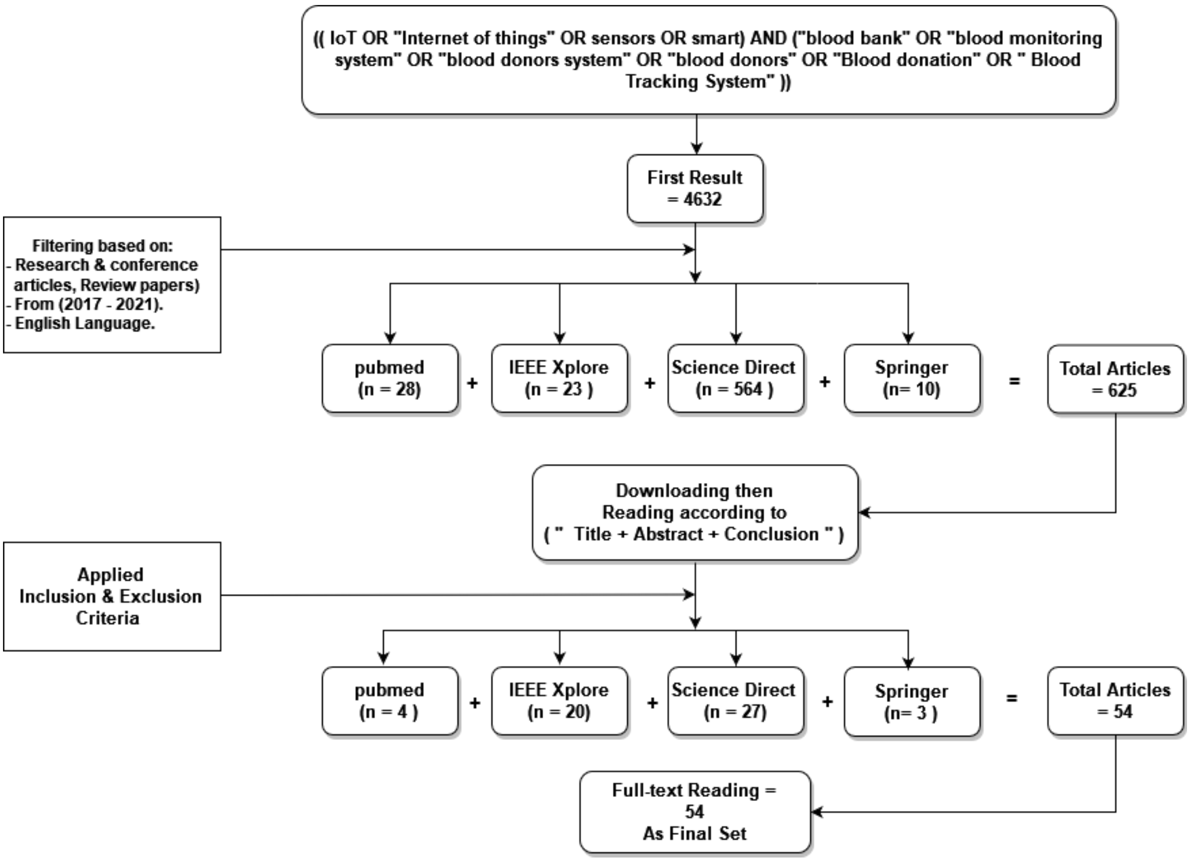

Figure 1: Flowchart of study selection, including the search query and inclusion criteria

2.3. Search

The search began in the first week of November 2021 via an advanced search in the databases of IEEE Xplore, Science Direct, Springer and PubMed. The query was IoT OR ‘Internet of Things’ OR sensors OR smart AND ‘blood bank’ OR ‘blood monitoring system’ OR ‘blood donor system’ OR ‘blood donors’ OR ‘blood donation’. A combination of keywords was used to cover most subjects related to computer science and information technology, including ‘smart’, ‘sensors’ or ‘monitoring systems’, which helped to obtain the associated topics, including IoT techniques, e.g. blood monitoring systems in blood banks and donor tracking applications. To eliminate books and

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reports, journals and conference articles were selected from each digital database. These articles are more suitable for the review, as they offered the most recent research on this topic. In addition, only English articles were selected, as shown in Figure1.

2.4. Eligibility criteria

As a result of a pre-survey of the literature, some categories relied on researchers to classify their work. Following the first removal of duplicates, articles were eliminated depending on excluded criteria in both screening and filtering iterations if they did not meet the eligibility requirements. Examples of exclusion reasons included: (1) the article was not in English; (2) the article focused on technologies for healthcare use, such as Medical Internet of Things (MIoT); and (3) the article targeted multiple technologies used in blood banks, such as computer, web and mobile applications, some smart blood donation systems; blood donor searching systems and IoT-based blood banks. The inclusion and exclusion criteria are determined according the table(1) below.

Table 1: Inclusion & Exclusion Criteria

	Criteria for Inclusion	**Criteria for Exclusion**
1.	Only articles are written in English languages.	The article is written in another language.
2.	Full text is available online	Full text is not available online
3.	Available within the 4 selected databases	Not available within the 4 selected databases
4.	Only Research & conference articles, scientific papers.	Books and reports are excluded.
5.	Different technologies-based blood bank systems for blood donation process or finding donors (Computer, Web, Mobile, ..).	A New detecting and avoiding Mechanisms in Transfusion- Related disease Injury.
6.	IoT-based smart blood bank or tracking/ management system.	MIoT- based articles.
	Reviews that contain blood bank related topics.	Reviews & articles that proposed related to medical issues like therapies, and new technology for detecting and identifying certain diseases such as blood diseases.
7.	Research that was published between 2017 and 2021 only.	

2.5. Data collection process

Several full-text articles were read among an extensive collection of highlighted topics and new ideas on the surveyed works. A total of 54 articles were filtered from the four databases. Then, inclusion criteria were applied to these articles, as mentioned above in Figure1. Moreover, the articles were classified into a more clarified taxonomy. To make the next steps more manageable, a complete list of all included papers, along with their initial categorisation, was gathered from several sources and recorded in a single Excel file. This step was followed by the summarisation,

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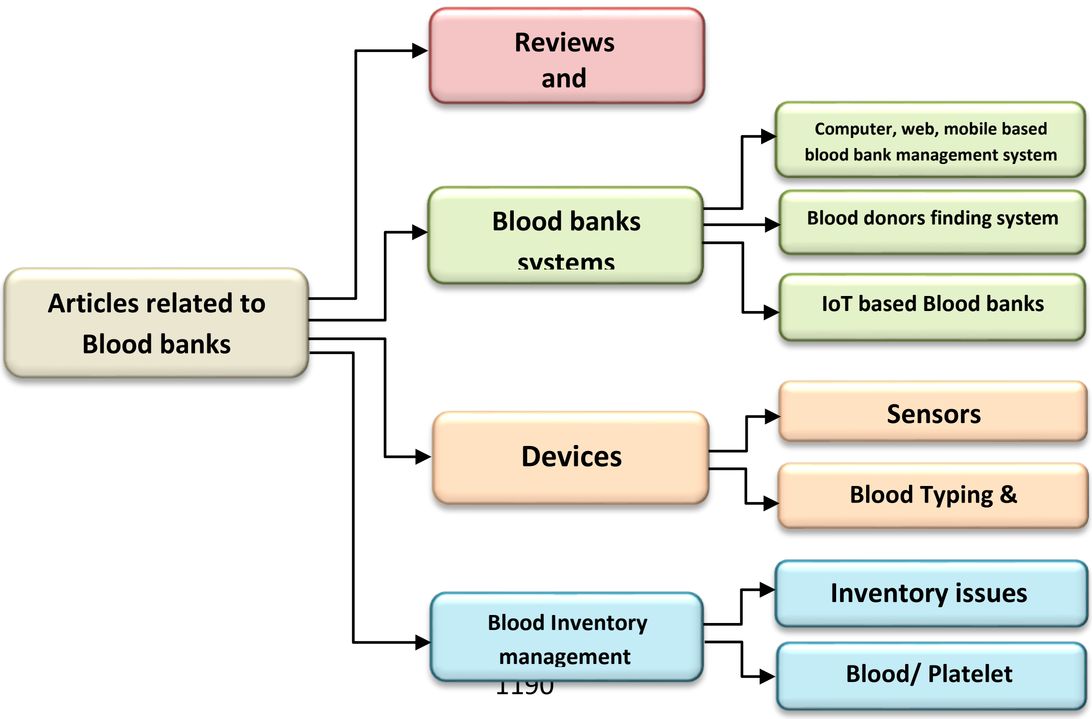
tabulation and description of the actual results. In addition, the extracted related information was saved in Excel and Word files. All data from the articles were kept in ordered columns, namely, summary, description information, categorisation tables, specialties, goals, review sources, years, target platforms, relevant database, various topics and issues related to the blood donation process and suitability of solutions regarding donors (e.g. systems, applications, IoT techniques, devices, etc..). Various figures and statistics were also collected as needed.

3- Articles with Taxonomy: Results and Statistics

The initial query, or the first result before any filters were applied (i.e. year of publication, type of research and language of research), resulted in 4632 papers: 2579 from the Science Direct database, 1936 from Springer, 79 from PubMed and 38 from IEEE Xplore. The filtering process began with articles published from 2017 to 2021. Then, the results were narrowed to 625 research papers, conference articles and reviews in English. These articles were adopted and grouped into four categories depending on articles objective. After downloading and scanning the titles and abstracts, inclusion criteria were applied (as shown in Table 1), and duplicates were removed. Next, 571 papers were further excluded after reading the full text of the review. Then, the final set consisted of 54 articles, all of which were related to blood bank management techniques, blood donation through different technologies and reviews with surveys. The taxonomy is presented in Figure2 to evaluate the significant lines of research concentrating on general subjects in blood bank management. This taxonomy demonstrated the thorough development of numerous studies and applications. The classification suggested different classes and subclasses. The first class consisted of review and survey articles on blood donation (12 out of 54 papers). Papers in the second class contained blood bank systems that demonstrated mobile, web and IoT-based applications and their usage in wide blood banks and blood donor identification (22 out of 54 papers). The third class comprised devices, such as sensors, that helped to monitor the blood temperature and measure blood viscosity (5 out of 54 papers). The final class included blood inventory management issues, as well as designs and improvements for blood supply chain networks (15 out of 54 papers), as shown in Figure3.



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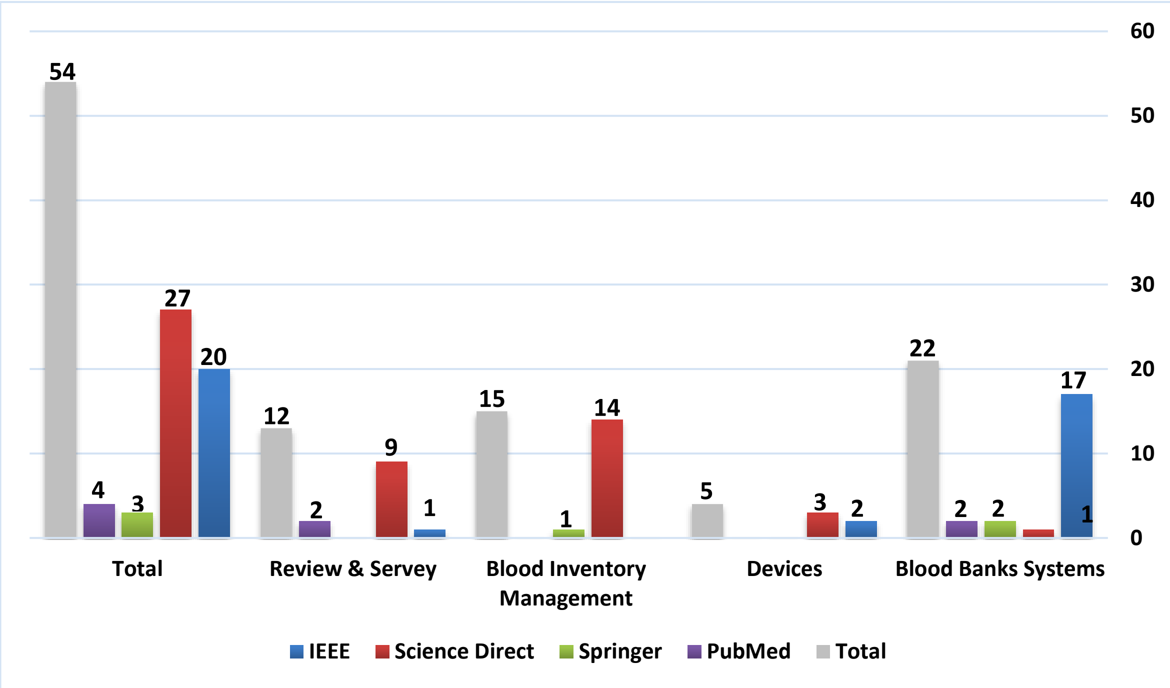

Figure 3: Articles According to the four Data Bases

3.1. Blood Banks Management

Blood is crucial in the preservation of human life. As a result, blood donation remains the most important way of transmitting blood from one person to another. Blood transfusion is necessary because of some surgeries, organ transplantation, accidents and patients undergoing cancer treatment[1, 12]. A blood bank is a bank or storage facility where blood is gathered, stored and used as required or needed[31]. Thus, the blood bank is an integral part of the blood supply chain network. Its main task is to deliver blood to hospitals to meet the growing demand[1]. Blood bank management has been discussed through different issues by reviewing the existing literature. Hence, this study classified 54 articles as reviews and surveys on blood banks systems, devices and inventory management.

3.1.1. Reviews and Surveys

We extracted interesting ideas from 22.22% (12 out of 54) of the reviews regarding different issues in blood bank systems and blood donor management. The first review provided an overview of recent studies that used information management and intelligent improvement methods based

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ISSN: 1309-345

on artificial intelligence programs and a blood supply chain network (SCN), which aimed to decrease blood waste and unnecessary importation. Some of these approaches forecast future donation attitudes. The researchers also reviewed several innovative blood donation systems using machine learning and data mining techniques to outline how to govern the donation operations[32]. Technologies, such as smartphone applications, were among the main factors that affected blood donation. Accordingly, in Riyadh, Saudi Arabia, a survey [16] analysed the characteristics and preferences of a blood donation smartphone application. Age was identified as a contributing factor that might reduce the utilisation of the application among donors. The study found that the design to satisfy the consumers' needs, such as privacy and secrecy. Then, donation centre staff focused on the application's educational elements, emphasising the necessity of giving statistics and sending messages and reminders to donors. The researchers defined various mobile applications by examining the features, the number of downloads, the disciplines that could use them and the availability of hospital workers. Recently, these applications have increased consistently with the growth of mobile health, a rapidly growing topic within e-health, which is defined as the use of mobile and wireless technologies to support health goals. Blood donation is a highly regulated activity that supplies blood to hospitals to fulfil demand and save lives, whether as indispensable components or as a therapeutic modality. As a result, numerous health professionals and medical experts have become used to using smartphone applications, which achieve sound effects in a variety of fields, including searching for blood donors, requesting blood and finding emergency blood donors. Some examples of these applications include Donor Find by (Morph.org, Uber, COUNTRY COVERAGE and others). As blood donation is an ethical activity, donation centres must be strategically located across the country to improve blood donations. Blood banks help collect blood from volunteer donors, and these samples are checked and tested before use to avoid infectious infections[3, 32, 33]. Screening potential blood donors before a donation is also crucial for blood safety. Expert evaluation has improved blood donors' adherence to donor selection criteria[34]. Moreover, researchers have studied and focused on transfusion transmitted infections (TTI) to help prevent donations from those infected with blood diseases, such as human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV), syphilis and malaria[35]. Furthermore, considering the conditions that donors can suffer, blood donations can be risky in some instances. Nevertheless, the researchers' task is to identify and reduce risks as much as possible through donor evaluation. As a result, they have introduced definitions of donor health and disease and the treatment of some common and less pathophysiological conditions. For instance, the Blood Centre of Oslo University Hospital, Norway's largest blood centre, provides certain medications for blood donors[36]. Hemoglobin (Hb) estimation is usually performed before a donation. This procedure involves extracting capillary blood via finger prick to diagnose anaemia; thus, this procedure is similar to all other traditional techniques that may cause discomfort and infection hazards. To prevent blood transfusion disorders, expert devised Hb testing prior to the donation; notably, this procedure has demonstrated adequate agreement with the usual method of estimating haemoglobin[18, 37]. An in-depth investigation has also been conducted to determine how people use social media for blood donation requests. In particular, the study focused on Twitter to explore the demands and behaviours of people who use social media to publicise blood requests. It analysed the submissions received from individual accounts in a variety of ways to gain multiple viewpoints and identify trends, e.g. statistics of most active accounts, the time it takes for information to spread and for requests to be fulfilled and the delays in the dissemination of information for applications used for submission[38]. Researchers are optimistic that apheresis (one of the essential parts of the blood) will remain one of the most potential elements that will aid future treatments. In addition, experts have focused on available clinical data outlining the function, results and applications of apheresis platforms and discussing systems that are likely to meet the demands of clinics and blood donation centres[39]. Meanwhile, another review offers a study on the impact of COVID-19 outbreaks on the blood community. The outbreaks have had the most critical consequences because the pandemic has resulted in a significant decrease in blood donors. Thus, a strong communication strategy must be established with voluntary blood donors to persuade them to donate and connect them with local blood businesses[19].

3.1.2. Blood Bank Systems

A blood donor usually donates at regular intervals. Numerous methods are used to connect blood banks with donors and those in need of blood. However, very few people are capable of donating regularly. To ensure the continuation of blood recruiting efforts, blood banks should continually undertake several programs to raise public awareness and encourage persons interested in blood donation to register as volunteer donors. The most important aspect of the process is connecting a blood bank and a patient. To achieve such link, the blood bank must organise the blood donation process using new technology. Meanwhile, current blood bank management practices have faced challenges in achieving high-grade reliabilities. As a result, an automated system for managing blood bag storage requires the minimisation of harmful issues in emergencies, such as the lack of supply or unavailable blood, whereby the outfitting of blood is a vital factor in every crisis[1, 6, 40]. The representative ratio of this branch of research is 40.74% (22 out of 54). Among the articles (final set = 54) on the blood banks, researchers have proposed and developed several systems based on different technologies. These topics are classified into three groups depending on how to manage the blood donation process and how to find donors through various situations, as listed below.

3.1.2.1. Computer, Mobile and Web-based Bank Management System

The representative ratio of this branch of research is 59.09% (13 out of 22). Information and communication technologies (ICTs) are widely used (smartphones, smart TVs and tablets). The rapid expansion of m-health has been affected by the development of smartphones and tablets because of the need to make quick life-saving decisions in several events, such as road accidents, major surgeries, long-term treatments (chemo or blood treatment) and regular blood transfusions in special situations, such as patients with anaemia and thalassemia. Specifically, Android devices offer various health and medical applications that aid patients and caregivers in reducing effort and saving time. Applications can assist a blood donor or a person in need of blood in determining how, when and where the blood donation is complete, particularly mobile applications[5, 41, 42]. For the reasons above, numerous researchers and developers have contributed to enhancing the blood donation process by designing or developing systems, applications and prototypes depending on different technologies. They have used an Android system based on mobile applications with GPS technologies to improve the blood bank system, management and ability to find the nearest blood donors. For instance, in Algeria, the Zomraty application[4] saves thousands of lives by connecting volunteers to donate blood and individuals in need within 10 kilometres of the user in need of blood. Meanwhile, the prototype in[5] is a blood donor system based on a smartphone application that uses crowdsourcing to find donors within 5 kilometres. Furthermore, the project in[31] uses smartphones to store information on donors and local hospitals by tracking the position of the neighbouring blood banks or hospitals using cloud computing technologies. In addition, the research in[40] proposed an approach to shorten the donor and recipient time using an Android application with a GSM modem and a Raspberry PI to provide real-time results. Creating an Android mobile application framework[6] will make blood services more accessible to blood banks, blood donations and blood recipients. Meanwhile, another study[2] presented the correlation between the existing blood bank framework of the blood bank information system and an upgraded framework to increase effectiveness. Such improvement is dependent on the database, web services and mobile services that use data from the cloud. Meanwhile, other studies have focused on web applications to provide information on blood and organ donation that blood banks and patients need in emergencies. Hence, researchers have created a one-of-a-kind platform, a web application, through which registered users can enter the system's blood and organ management system[43]. In addition, the intelligent GIS-based organ and blood donation system increases efficiency in donation areas based on a web application built with HTML5, CSS3, JavaScript, PHP and AJAX[44]. The system described and executed in[15] has been proposed and implemented as a functional system for the blood bank service system to thrive even in the most remote areas. It is straightforward for both young and older adults, as it ensures that patients have immediate blood donors in any circumstance. Given that the system is a web application that uses Unstructured Supplementary Service Data (USSD) code, Short Message Service (SMS) and a free toll line, it is available for online and offline database searches. To reinforce the effective information management of blood banks and to find blood donors in emergencies, other researchers proposed to merge both web-based and Android-based applications[45]. A mobile application provides direct communication between the donor and the beneficiary by allowing them to send SMS notifications. Meanwhile, a web-based program can generate a database using a web interface and store the collected data in a centralised server[13].

To sustain and increase the number of blood donors, researchers also developed a blood donation promotion application and built a donor support system as part of a new framework focusing on a service design. The design is called the Blood Donors Support System (BDSS). In addition, a survey on awareness of blood donation promotion applications was undertaken[46].

3.1.2.2. Blood Donors Finding Systems

The representative ratio of this branch of research is 22.72% (5 out of 22). Throughout the mobile computing revolution, numerous features have been introduced to the medical industry, such as blood donation, through which the donation of whole blood or its specific components has helped save lives every day in various situations. However, despite the proliferation of blood donations, patients still struggle to find appropriate blood donors during emergencies or when the matching blood type is unavailable. Nevertheless, the advent of new applications has aided in finding donors with suitable blood types, especially during emergencies. For instance, one Android mobile application makes use of a trustworthy information system based on GIS and OTP (one-time-password)[17]. In addition, one study has proposed a system[42] that delivers available hospital and doctor information depending on the patient's nearby location using GPS on a smartphone. Moreover, an online application[47] has integrated a solution to improve the healthcare system by developing a customisable Android application; this application provides online doctors' appointments, emergency blood donor's information and 24/7 emergency services. Meanwhile, some researchers[48] presented an automated blood bank system that can direct blood donors to one location and accomplish all blood requests using an Android mobile app, a Raspberry PI and a GSM modem (to send SMS). In addition, BLOODR[21] is a web and reliable requester mobile application that meets the needs of users and provides an easy way to connect donors and patients directly. Thus, finding blood donors has become easier than ever, as these applications allow users to track available donors nearby.

3.1.2.3. IoT-based Blood Banks

The representative ratio of this branch of research is 18.18% (4 out of 22). The manual steps in the present blood bank administration system have caused difficulty in maintaining a high degree of precision and authenticity. Currently, in some nations, blood banks are operated manually, with medical workers handling blood bags directly. Meanwhile, some hospitals still use Excel spreadsheets on computers in emergencies and alert individuals through phone or SMS. This shortage of management makes the data susceptible to errors and human mistakes, which in turn puts patients' lives in danger. Hence, blood banks must find ways to have enough inventory of various blood groups, especially rare blood types (O-). In addition, having an alert system that promptly notifies hospitals and blood banks when a certain bank needs a specific blood type can help them form a strong network. In other words, an automated system that manages, monitors and stores blood is much needed. Intelligent Blood Management Systems and IoTs have a primary role in effectively solving these difficulties in the field. Researchers must help establish efficient and real-time blood management coordination inside a blood bank and maintain a blood supply chain network and a robust communication system among several blood banks[1, 29]. For instance, an intelligent blood management system (IBMS) takes a critical part in the preservation of the supply chain of blood using IoT devices. The system uses a novel and cost-effective concept of weight-detecting sensors, image processing and cloud connectivity. Moreover, mobile applications enable users to connect to the system quickly[1]. Another research [29] proposed establishing an intelligent blood network architecture for patients and hospitals using IoT technology by constructing a smartphone application that can be used as a connector between the hospital system and the donor. Meanwhile, the goal of another application[30] is to help blood banks, donors and patients by involving IoT to facilitate blood donation and supply through a better automated system. Moreover, the application can help detect the right donors using GPS coordinates. Management and blood donation governance have an important of smart city branches, especially within the previous years. Since the concept of 'smart city' was proposed, it has become a buzzword for developing technology and urban sustainability. Sensors and technologies in rapidly expanding smart cities generate citizen-centric big data, which can assist individuals in making better decisions about their communities. According to experts, extensive data analysis can improve outcomes while decreasing expenses. This validation is done through a case study on blood donation governance in China, a significant issue in smart cities, by using blood donation governance as an example to verify the proposed framework as a functional module in the My Nanjing App. This study emphasises the importance of citizen-centred big data in smart cities and improves the joint supplement across numerous fields[49].

3.1.3. Devices

The representative ratio of this branch of research is 9.25% (5 out of 54). The absence of a management automation system in blood banks may result in errors that endanger people's lives. The two main procedures for blood transfusion in critical life-saving treatments are determining the ABO blood group and counting erythrocytes. To maintain the quality of blood supplies in blood bank hospitals, the temperature range inside the transit blood box should range from 2 °C to 10 °C with a validity of 1 °C according to WHO guidelines. Therefore, researchers have published numerous publications on these topics, such as using a technique to assess the degradation of stored blood, which opens up an exciting potential for larger quality-control applications[11, 12, 14].

3.1.3.1. Sensors

The representative ratio of this branch of research is 60% (3 out of 5). Healthcare deals with daily human life. Thus, it has stringent requirements in its services. Blood bank and blood donation operations are among the critical areas of healthcare, and these areas are still the most important methods for blood transfusion. Typically, these operations require human assistance when data on blood donations are entered into a system or when the expiry dates of blood bags are visually evaluated. The lack of automation in this process can cause errors and risk lives; as a result, an L-resonator-based chipless RFID tag is provided for tracking and identifying purposes in blood banks[11]. Blood bags are used to store donated blood. These bags are collected and stored in a blood bank for future blood transfusions. Furthermore, the blood bank must ensure that the blood's quality does not degrade during transport from distribution centres to blood banks and from blood banks to blood transfusion sites. One study described the design and development of a transporting cooler, which controls the temperature in the blood bank to keep the temperature within the desired range, that is, between 2 °C and 8 °C, using a PID controller. The temperature sensor measures the temperature within the blood transport cooler and displays the data on the LCD screen, along with a fault notice via a buzzer whenever the temperature falls outside of the desired range, thus prompting a notification using light and sound[12]. The optical sensor chip has a good chance of achieving full automation, which can save time and avoid human mistakes in blood group typing. As such, researchers created a prototype of an LSPR optical biosensor that can perform blood group typing and a proof-of-principle analysis of erythrocyte counting[14].

3.1.3.2. Blood Typing and Viscosity Analysis

The representative ratio of this branch of research is 40% (2 out of 5). Among the studies in this group, one project aimed to develop a paper-based device that can visually identify ABO and RhD blood groups with 100% accuracy and integrate an optical answer sheet with Android smartphones to read and understand the results. ABO and RhD typing with paper-based devices

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ISSN: 1309-345

and smartphone interpretation may benefit home-based users, mobile blood donation facilities and fieldwork usage[50]. As blood viscosity is an essential rheological feature that can make a diagnosis and prognosis of haemorheological changes, it opens up exciting prospects for larger quality-control applications. Given that conventional viscometers often rely on expensive and specialised equipment for device operation and viscosity measurement, their applicability in resource-constrained environments is limited. Hence, researchers introduced a 3D-printed capillary circuit (3D-CC) technology that allows for a simple blood viscosity investigation using a hand-powered device by eye reading. They used the technology to quantify the degradation of stored blood based on these characteristics[51].

3.1.4. Blood Inventory Management

The representative ratio of this branch of research is 27.77% (15 out of 54). In recent years, a fresh data-driven method has sparked significant interest in a variety of fields, including e-commerce, engineering fault detection and predictive maintenance. Data-driven optimisation in computer science can generally produce robust solutions exceeding traditional optimisation algorithms[52]. Blood transfusion of whole blood or one of its components is safe, familiar and lifesaving. Another excellent aspect includes blood-storing techniques for managing perishable products, as human blood is among the common types of perishable products, such as fresh agri-products, dairy foods and medications. Given their nature, the age of products is critical[53]. The world population is increasing rapidly, which has caused a growing number of diseases, injuries and pollution, thus emphasising the need for healthcare considerations. Blood and its byproducts are essential commodities in every healthcare system because they have no replacements and each has a specific application. Additionally, blood-related costs account for a sizable portion of total healthcare expenditures[9]. The most critical challenge is that blood and its components are always needed in the medical field, as they have no alternatives. Although many people donate blood each year, the supply does not always meet the demand. Furthermore, platelets, one of the most critical components in leukaemia treatment, have a five-day shelf life because they cannot be industrialised and can only be extracted directly from whole blood. If platelet inventories are not successfully managed using age and disaster volume information, a lot of stock-outs or platelet waste may be produced. As a result, an accurate ordering policy is required to optimise the limited blood supplies [10, 52, 53]. The BSCN optimal architecture is an appropriate technique for improving the coordination of blood supply and demand. Blood supply costs include collection (45%), testing and processing (42%), storage and distribution (3%) and the rest of the overhead (11%), all of which contribute to the safety and quality of blood products. Time delay substantially influences the effectiveness of perishable products in this network[10]. For these reasons, the inventory system and blood supply network in blood banks are fundamental challenges. Thus, suitable strategies are needed to manage blood and its components to achieve the right donation process. Moreover, inventory policies and blood supply chain network techniques are enhanced and improved.

3.1.4.1. Inventory Issues

The representative ratio of this branch of research is 26.66% (4 out of 15). Traditional inventory management does not encompass the products' age, thus making it unsuitable for perishable inventory systems, which require new methodologies [53]. The research looks at the platelet scheduling problem using a new data-driven strategy, which compares models and data-driven approaches[52]. Others have also presented reinforcement concepts that define close ordering policies in the entire network supply chain via an inventory system of perishable items under random demand and deterministic lead times to reduce a retailer's total cost. These policies are improved using Q-learning and Sarsa algorithms to restock supplies based on stock amounts. The life time approach considers both inventory level and the age of the products[53]. Meanwhile, others have offered a mathematical framework for managing the inventory of RBC units, aside from reducing outdating and scarcity[20]. Some researchers have proposed a hybrid approach for detecting viscosity, which combines a camera phone and a microfluidic instrument. Therefore, the biophysical state of stored blood samples may be monitored by analysing changes in blood viscosity, which is another monitoring policy in the blood inventory system. Based on the experimental results, this technology holds promise as a viscometer with considerable advantages in terms of portability, ease of use and data management[54].

3.1.4.2. Network of Blood/Platelet Blood Supply

The representative ratio of this branch of research is 73.33% (11 out of 15). Healthcare spending is expected to climb at a 54 per cent annual rate by 2040. Furthermore, rising casualties, manufactured and natural calamities and other factors all contribute to a shift in blood demand. Therefore, managing the blood supply chain (BSC) has become a critical decision-making issue. One study proposed a multilateral viewpoint for BSC network infrastructure as a complex decision-making problem by combining quantitative and qualitative aspects into a revolutionary multi-objective mathematical model inspired by a real-life case study[9]. Given their unique characteristics, the design and planning of such networks in disaster aid are highly complex. Hence, one study formulated a novel architecture for a disaster relief BSC network with several tiers and products. It comprises four factors: blood donors' conduct and location of blood donation, an estimate of the number of people affected in each disaster, the volatility of input parameters and the residual capacity for satisfying the demand caused by the disruption in blood institutions[7]. Even though blood provides few sub products, such as platelets, plasma and red cells, new blood supply networks and blood components are being developed. The rapid pace of change has forced decision makers of supply networks to use more sophisticated and up-to-date models because traditional systems cannot satisfy their needs. The primary goal is to collect and produce sufficient blood to meet the demand in various scenarios[55]. As donors can only provide blood and platelets, reviewing donors' therapies is critical in the supply chain network. According to an actual study, researchers discussed four significant issues that have a direct impact on the amount of platelet donation, namely, different kinds of donors, number of booked and unbooked donors during and after working time, submission of social announcements and allocation of blood extraction technologies to hospitals. Given the relevance of persistent natural platelets, one group of researchers proposed a method for synchronising supply chain network layers with social advertisements and providing efficient consideration[56]. Integrating transitory product manufacturing, inventory and distribution in a supply-chain context is difficult for practitioners and scholars. In general, a standardised best design for perishable items in such a network cannot be developed. Hence, a comprehensive solution centred on process integration is required. The total cost includes price setting, variable transportation expenses, fixed transport costs, costs of inventory holding and ordering costs that must be kept to a minimum[57]. When a disconnect exists between distribution and inventory management, an efficient blood supply is usually required. However, if the blood supply is adequate and inefficient, the distribution strategy will harm the BSC's performance. To that end, one study aimed to create a BSCN for arranging blood product distribution in disaster-stricken areas. As blood varies from other relief commodities due to its unique qualities, the same work presented a two-stage stochastic programming (SP) approach to help in structuring the blood supply after disaster events; this approach can help in inventory decisions under hybrid uncertainty, thus decreasing shortages and wastage[8]. Today, we are suffering from an increase in natural and man-made diseases, such as the newfound virus called COVID-19, which has triggered a heavy recession. As a result, governments have intervened to restrict the general activities of people at the peak of the COVID-19 crisis. Given the concern about donors being exposed to the COVID-19 virus in medical facilities, the number of blood donors has significantly dropped. In such scenario, the main challenges of healthcare administrators are ensuring the safety of blood donors and employees and providing enough blood supply. Hence, one study presented an improved analytical approach for the management of blood supply networks during the COVID-19 outbreak through a mathematical formulation. This approach aids in making the right decision in blood collection from different areas, considering the particular circumstances of blood donations, such as unpredictable demand, different collection techniques, perishability and dangers of disruption in blood supply[58]. The growing demand for blood and the decrease in the number of donors is the source of wariness for blood centres. Hence, an effective management plan for blood transfusion services is necessary. Moreover, using fuzzy stochastic programming to deal with uncertainty is essential because providing an efficient platelet supply and blood are among the main concerns in critical situations[59]. One study looked at the blood supply system in the context of the COVID-19 outbreak. A four-tiered multi-objective supply chain was designed to deliver plasma from recovered patients to others to reduce transfer time and supply chain costs. The network includes collection locations, temporary and permanent facilities and hospitals. The amount of blood plasma required by patients is considered an unknown parameter and is analysed using a simulation approach [60]. The proposed concept uses integrated intelligence to identify the most convenient convalescent plasma (CP) that matches with COVID-19 priority patients. Furthermore, multi-criteria decision-making (MCDM) is one of the methods that have been evaluated and considered for use in the proposed framework based on its adoption capability[61].

3.2. Statistical Information

In the 54 articles, India takes the highest percentage among the articles on blood banks, as shown in Figure4. Several factors have been observed. Blood banks and blood donors have a large ratio in medical topics because of the huge number of diseases, victims of accidents, surgeries, lack of awareness about donations[13, 30] and lack of automated blood banks [1, 11, 13, 31]. The statistics clearly reveal a grave scenario in which blood deficiency is at 30 to 35 percent while demand for blood is growing by at least 5 percent each year[30, 40]. Meanwhile, Iran takes the second-highest percentage among the articles, as shown in Figure4. Researchers have identified a

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https://publishoa.com
ISSN: 1309-345

rise in the number of blood requests and an urgent necessity to provide an efficient design for blood delivery during disasters. Iran is prone to natural disasters, particularly earthquakes, which causes a large number of casualties; amidst this circumstance, suitable foresight and planning relief efforts are absent, this harming the network design blood supply. Hence, disaster management is one of the most vital tasks in medical health [7, 8]. Iran is also one of the rare countries where blood donation is done by volunteers, an act which may stem from Iranian culture and values. At the moment, only 22 out of 1,000 individuals donate blood[10]. To add to this shortage, the income and development of a country mainly affect the donation process. Compared with low-income nations, the average rate of blood donation in high-income nations is over nine times higher[9, 10]. Moreover, a blood transfusion will be affected by population aging, and the blood transfusion rate will grow significantly thereafter[9, 59]. In addition, the shortage of blood products, such as platelets, place patient lives at risk and increase the expenses in the supply chain[56]. Usually, any epidemic outbreak such as COVID-19 has adverse influences on the activities of the blood supply network. Thus, one grave risk is the decrease in blood donation before, during and after an outbreak[58]. On the other hand, researchers focused on developing coronavirus vaccines using blood and its products[59]. Furthermore, blood and its byproducts are vital for thalassemia victims of car accidents [60]. In other countries, the ratio varies depending on the importance and difficulty of the task of regulating the supply and demand of blood components in blood centres and hospitals (26), where blood is a perishable product[52, 53, 57] and the safety of blood transfusion must be ensured[14, 18, 20, 34]. The closure of donation centres due to blood donor lapse is also a contributing factor[27].

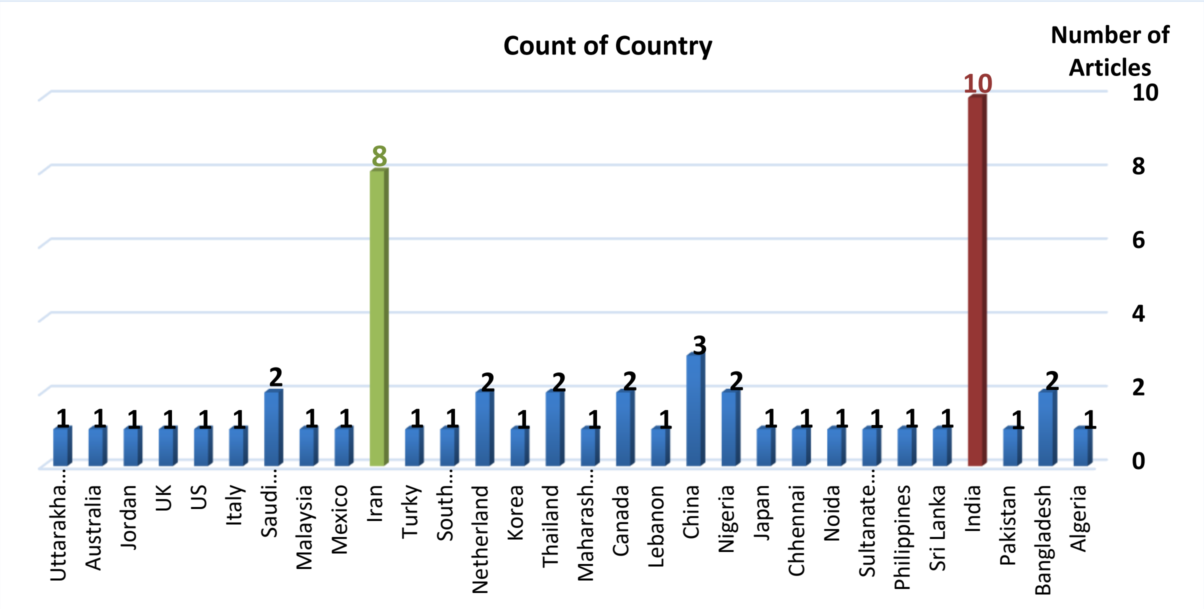

Figure 4: Total number of articles according to country

Figure5 shows how the blood banks topics are distributed among countries according to their types and year of publications.

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ISSN: 1309-345

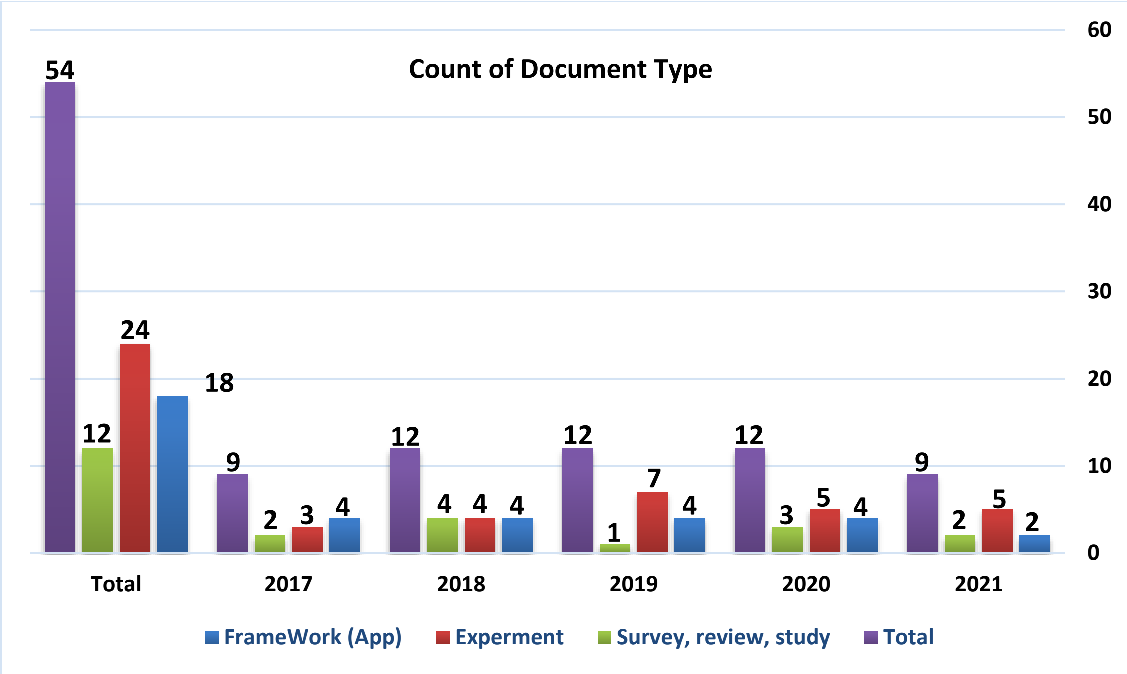

Figure 5: Number of articles according to their type and year of publication

Figure6 shows how articles are variated according to their types.

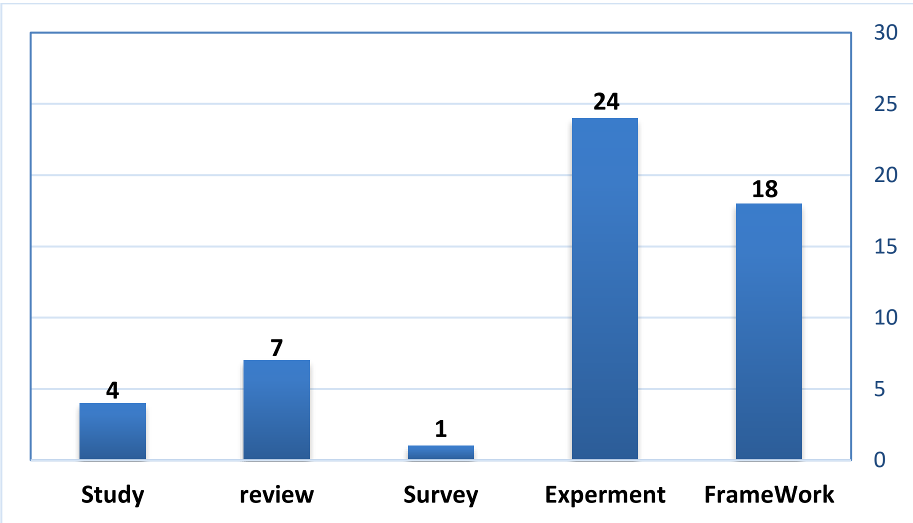

Figure 6: Number of articles according to their type

4. Discussion

The review aims to build a taxonomy to provide an overview of the recent contributions to the research on blood bank mechanisms and blood donation techniques from 2017 to 2021. The studies come especially from developing countries suffering from weak medical care techniques and

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ISSN: 1309-345

facilities. The goal of this review is to focus on how the different techniques, such as those related to IoT, are helping to improve the functions of blood banks in the donation process by integrating automated systems based on computers, web and mobile technologies. The spread of mobile systems, especially the Android system, has been used to aid in finding the nearest donors or hospitals. Moreover, IoT-based intelligent systems have been used to achieve a balance in the supply of blood between the main and subsidiary centres depending on the required blood type[1, 2, 4-6, 13, 15, 17, 21, 29-31, 40-49]. New devices can also help in managing storage temperature to facilitate the preservation of healthy blood, blood viscosity and ABO/RhD testing[11, 12, 14, 50, 51]. Meanwhile, a number of new surveys and reviews discuss the ways through which blood saves lives, the importance of transfusion, the safety measures before donating blood and the impact of social media and some technologies in blood donations and donors[3, 16, 18, 19, 32-39]. Moreover, the proposed taxonomy of the related literature shown in Figure2 has been helpful in explaining and classifying the goals of the studies discussed in this review.

4.1.Motivation

This section is grouped into lists on the basis of the motivating factors of the studies, surveys and real case studies. These factors are important in understanding the perspectives of authors. Motivation has summarized in Figure7.

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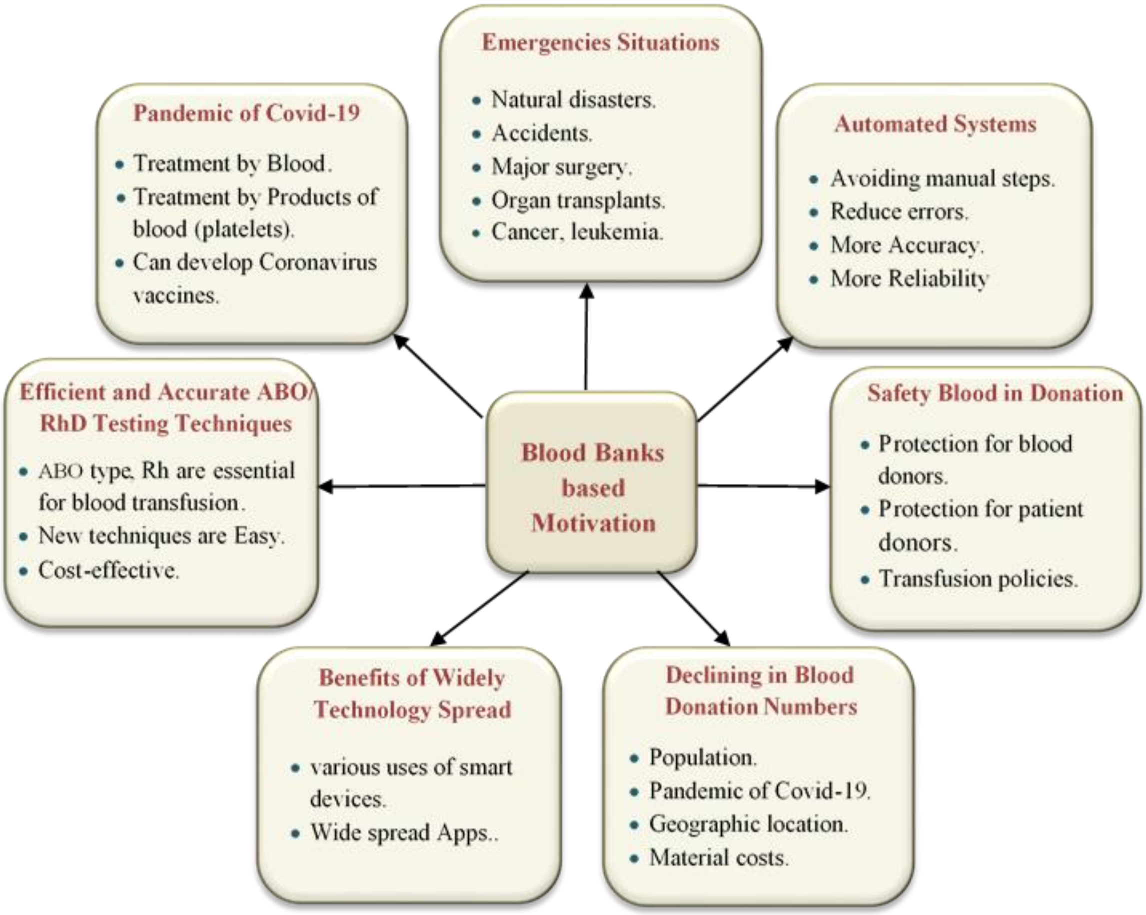

Figure 7: Blood Banks based Motivation

4.1.1 Related to Emergency Situations

The availability of blood during an emergency is crucial for all living things. Currently, patients have difficulty reaching hospitals on time, thus resulting in the loss of many lives. Moreover, in the absence of available first aid response, people rarely find blood donors in time in these critical times. Although several medical mobile/web applications exist, most of them are not authorised to facilitate donations. Given this circumstance, requests from long distances will not be usable. In addition, when a patient enters the type of blood he or she requires, the patient may not be able to receive the correct blood type promptly. Emergency situations that require blood transfusions include natural disasters, accidents, burns, major surgery for a serious injury, surgery on the heart and organ, bleeding, childbirth, newborn complications, cancer treatment and blood transfusion in multiple clinical cases. Hence, doctors should check the availability of blood first at the hospital or blood bank for a patient who needs blood. In an emergency, blood has distinctive features, such as wastage, multiple components, different blood type groups, blood appropriateness based on the ABO-Rh (D) consistency and priority norms, variety of ages of blood units and unpredictability in blood demand and supply[1-10, 12, 14, 17, 29, 30, 32, 40, 41, 48, 55].

4.1.2. Related to Demand for Automated Systems

Currently, the management of blood banks has numerous manual steps, thus making the task strenuous and complex and diminishing their capacity to maintain reliability and accuracy at a high level[1]. Such management is ineffective because of the deficiencies in donation information, medical information of donors, amount of required blood and specific blood types. These issues directly affect blood banks, especially those in rural areas[31]. Errors in paperwork cause numerous mistakes as well. Another worrying aspect is that the lack of an intelligent system may decrease voluntary donations[45]. Another reason is that many blood banks based on traditional systems do not allow immediate interactions between the donor and the recipient[13]. Meanwhile, several operations, such as entering blood donation data into the system or checking the expiration date of blood bags, require human help. However, accidents occur when medical personnel improperly identify blood bags or when they are not accurately verified. As a result, technology-based systems can be useful in such situations[11]. Hence, blood management and storage must be automated to monitor whether the blood supply is insufficient or inaccessible[1]. Moreover, several reasons, such as rising complexity, global rivalry, economics and social limitations, demonstrate the necessity for management information systems[2]. Blood bank software can assist in lowering the obstacles between those who are in need of blood and the actual suppliers[40]. The lack of a technique for transferring information between blood donation centres and donors leads to a breakdown in communication, thus causing difficulties among people who need blood transfusion and those who frequently donate blood or are interested in donating. This direct link becomes necessary to avoid a long waiting time for the availability of blood. Furthermore, a lack of communication has grave consequences, as it may primarily affect organ donation and result in longer wait times for patients. Therefore, smart applications, particularly mobile phone-based applications, are increasingly regarded as crucial communication tools to reduce gaps and save lives[6, 16, 44, 48]. Even if electronic online blood donation centres use certain frameworks, the real downside of such frameworks is that they fail to offer immediate contact between beneficiaries and donors. Besides, they are tedious, require more labour and are expensive. Another issue to consider is that a successful organ transplant system in the local healthcare field is still in its infancy, with flaws that must be addressed. Thus, blood bank managers use information from the available system to address these challenges[2, 43]. Blood banks in some special hospitals now lack an advanced and integrated infrastructure. As such, experts must implement a new online service for blood banks in hospitals to improve existing ones[43]. Various software packages that run only on desktop computers are commonly used to administer the primary hospital tasks; however, this feature may not always allow for quick and practical usage among healthcare staff. Merging software with mobile health applications can solve this problem[33].

4.1.3. Related to the Importance of Safety Blood in Donation

Blood services aim to offer patients with safe blood products. They should also provide high-level protection for volunteers. These services can safeguard donors and enhance public health by implementing the standards required to ensure the safe delivery of blood products. The guidelines contain the most significant physiological parameters for blood donor protection[36, 46]. Transfusion protocols differ among physicians and cardiac centres in various countries. To avoid hazards in blood transfusion and to assure its safety, proper policies should be considered before making a final decision[18]. Without blood type identification and compatibility testing, blood

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transfusion may result in post-transfusion haemolytic reactions, such as shock, renal failure and death. As a result, two critical matters must be addressed: ABO blood group detection and quantitative erythrocyte counts[14]. The determination of the Hb ratio is an important initial test that is regularly conducted prior to blood donation to avoid the receipt of blood from affected anaemic donors[37]. Moreover, certain infections, such as Hepatitis B and C, could be transmitted[35]. Another important point is that human blood and its components are perishable; as such, their age is crucial. For example, platelets can only be used efficiently for five days. Therefore, any delay in its use largely impacts the performance of these products. Furthermore, temperature variations of blood bags outside of the appropriate range will induce blood degradation. The inefficient handling of stocks can result in a lot of stock-outs or wastage. Thus, the main aim is to create a comprehensive optimum strategy in a supply chain network for perishable products as well as a dependable temperature control system[12, 53, 57]. Usually, the donated blood or its components are stored in a blood bag to be used later[12, 20]. Donated blood units are treated (split into platelets, plasma and red blood cells), screened for numerous infectious illnesses and stored until required by hospitals[20].

4.1.4. Related to Declining in Blood Donation Numbers

WHO reported that the blood donation rates are rising in high-income countries while falling in countries with low income[16]. Some researchers have focused on the decline of blood donors to explore the reasons behind this decrease and to propose solutions that may help. These proposals are presented below in Table(2) based on the reviewed scientific articles.

Table 2: The reasons of Declining in Blood Donation Numbers

	easons	Country	Proposed Solution	Paper Published Year	References
1.	The problem of increasing Population.	India[1], Iran[2]	Proposed System uses Android App with Raspberry PI[1], A fuzzy stochastic programming approach[2].	2018, 2020	[40], [59]
2.	A shortage of information concerning donation because of the traditional systems.	Nigeria[1], Mexico[2]	(Web and mobile)-based blood bank system[1]. Designing a blood network, evaluating the paradigm demeanor of classic systems using stochastic programming[2].	2019, 2021	[45], [55]

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3.	The drop is started in the late teens and continued until donors were in their thirties.	Japan	Enhancement of a system to assist blood donation activity.	2017	[46]
4.	Awareness is lacking because of people's preoccupation with their daily responsibilities, which prevents focusing on blood drives.	India	Iot-Enabled Intelligent Blood Bank Systems	2019	[30]
5.	Pandemic of Covid-19.	Iran(2)[1, 2], Uttara hand	To deal with risks the technique of flexibility programming hybrid stochastic probabilistic is provided [1]. To fudge the uncertainty, a strong, fuzzy, stochastic programming (RFSP) method is designed [2]. An efficient communication plan with donors, as well as networking with neighboring blood institutions, is required to motivate them.	2020, 2021, 2020	[58] [8] [19]
6.	- The physical location of donation clinics has a significant impact on blood donor conduct. - The number of portable donation stations. - Material costs.	Netherlands	Investigating the causes for altruistic contribution, as well as donors' prosocial behavior.	2020	[3]
7.	People who donate blood to patients are not properly cared for (lack of medical history	Chennai	Develop blood donation services by the android mobile app and GIS.	2017	[17]

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	update), which may pose a threat.				

4.1.5. Related to Benefits of Wide Technology Spread

As the number of medical applications has been increasing consistently, doctors and healthcare professionals have become accustomed to using smartphones. These applications are becoming effective in a variety of businesses, as they are quick and simple to use. Recent literature evaluations have assessed the numerous advantages of smartphones and tablet devices in multiple contexts, such as smoking cessation, weight loss, alcohol reduction, lifestyle improvement, treatment, monitoring, diagnostic support, medical care and clinical settings[33]. The Android mobile phone is considered one of the most widely used electronic devices, and its automated applications have received colossal popularity in making human life more convenient. Google Play Store offers numerous applications, and thousands of advanced applications are transferred every day via the Internet. Furthermore, numerous instruments are used to identify the location of city hospitals, health centres and health clinics and how much accurate and consistent information is provided in each health professional and medical centre[42, 47]. Smartphones can help eliminate human mistakes; they can be used to read and translate data to recognise ABO and RhD using paper-based devices, which may provide further advantages for home-based users to locate mobile blood donation sites[50]. A hybrid model composed of a smartphone and a microfluidic device can provide a portable laboratory capable of performing a variety of detecting and analysing operations in the healthcare field. In addition, the model can be used to test the fluid viscosity of small samples swiftly. Its widespread availability ensures a convenient and cost-effective technology[54]. In addition, social media affects a variety of facets of human life, particularly in developing countries with outdated healthcare systems and methods[38]. With the rapid rise in the use of social networking sites worldwide, blood donation demands have also risen, as seen in numerous posts on Facebook and Twitter asking for donors[21]. Moreover, sensors and technologies within quickly increasing smart cities generate citizen-centred massive data; these advancements are of great value, as they can support decision making in urban governance[49].

4.1.6. Related to Demanding for Efficient and Accurate ABO/RhD Testing Techniques

The ABO blood type system is essential for blood-matching transfusions and organ transplants. Misfit in ABO can result in death. Rh determination is a crucial procedure as well. Hence, newly invented techniques have been developed to ensure proper processes. For instance, the typing slide method is commonly used for mobile blood donation and field applications[50]. In addition, erythrocyte counting is crucial in blood transfusion, particularly in life-saving treatments. Recently, an optical biosensor has been widely used for robust quantitative essays because of its simplicity, cost effectiveness and high diagnostic capability[14]. Blood viscosity is a vital feature for diagnosing blood rheological changes. However, standard viscometers require expensive and complicated equipment to operate, and viscosity testing limits their utility in resource-limited cases[51]. Numerous microfluidic devices have been proposed to measure the fluid viscosity of

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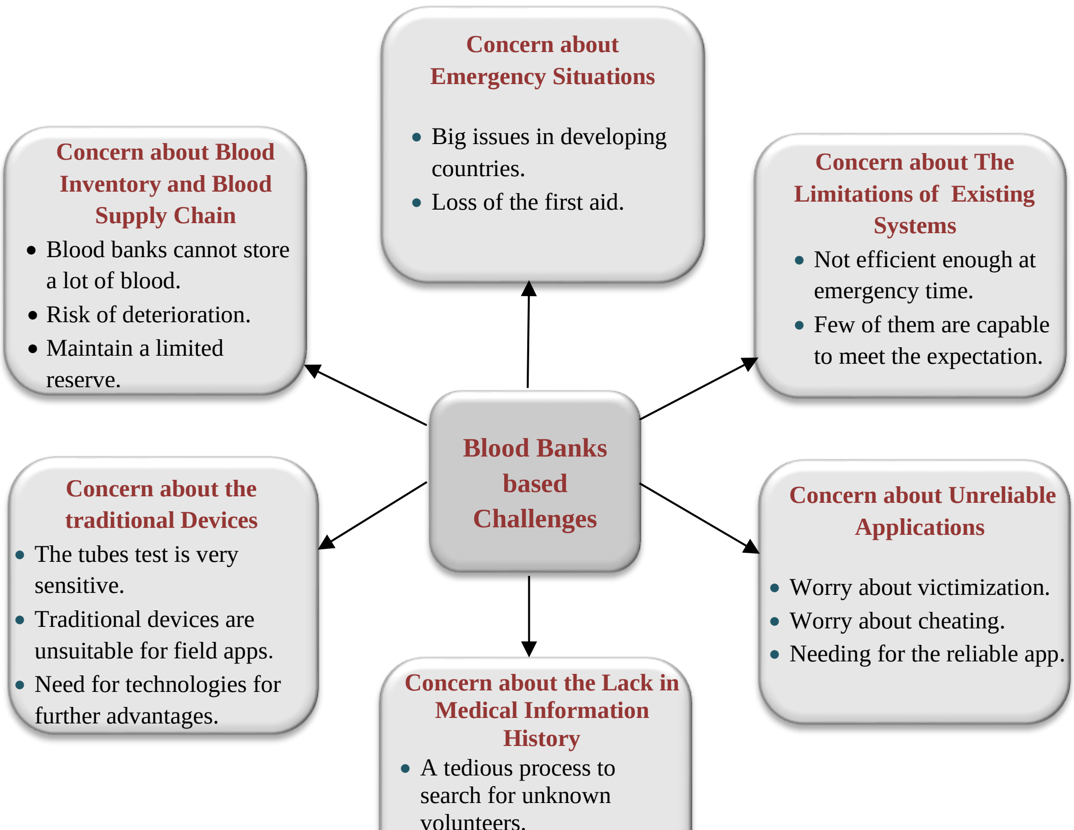
small samples quickly; one method includes a smartphone and a microfluidic device work together to form a hybrid system, which is a practical and suitable cost-saving solution[54].

4.1.7. Related to Treatment by Blood: COVID-19

One of the riskiest medical aspects is disease diagnosis. Upon diagnosis, each patient follows a treatment plan. Numerous diseases require humanitarian assistance, such as blood supplies, in addition to medical therapy. As a result, patients, such as those suffering from thalassemia, require blood or its components[60]. In addition, blood platelets are the most expensive component of whole blood, with a lifespan of only five to seven days. Platelet transfusion is a critical component in the treatment of leukaemia, chemotherapy, bone marrow transplant and the treatment of peripheral vascular disease and coronary artery disease[52, 56, 59]. Researchers have also discovered that blood and its components can aid in the development of coronavirus vaccinations[59]. When a person with COVID-19 has recuperated, they most likely have a substantial level of antibodies in their blood. Researchers have taken plasma from those who have survived and injected it into others suffering from serious diseases. These antibodies boost patients' immune system to detect and destroy the virus. Notably, this strategy has been used several times on patients[60, 61].

4.2. Challenges

This section presents the difficulties identified from the finalised articles. Subsections and details on these problems are presented in Figure8.



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4.2.1. Concern about Emergency Situations

The lack of a first-aid plan during an emergency inhibits easy access to accident data, which has been a large problem in several countries, including Pakistan[41]. This insufficiency also creates a weak point in obtaining blood for some cancer patients who need blood transfusions daily[48]. The COVID-19 outbreak's most significant impact on the blood donating community has been the reduction in the number of donors because of the international recommendations for social distancing, which is the only effective way to prevent the spread of this disease. All volunteer blood donation camps have been placed on hold to avoid massive crowds upon the guidance of the government[19]. Infection by blood transfusion is one of the most severe problems in sub-Saharan Africa. Hence, blood screening is the first step in ensuring safety. Although effective, timely distribution networks are vital, most developing countries have yet to construct a mature blood distribution network[15].

4.2.2. Concern about the Limitations of Existing Systems

Getting a blood donor is a difficult task in practically every country. The conventional blood bank administration system comprises paperwork, which is inefficient in emergencies. Several systems have been in place to connect blood banks with donors. However, only a handful of them can meet the demand. Despite advances in medical technology, the technique for selecting suitable donors remains unchanged. Some blood donor locator applications are available. However, more dependable applications that satisfy users' needs must be developed. Unavailable blood donors' database is one of the difficulties that health institutions and blood centres face. Another problem is that blood bank records have been kept manually for decades, using a paper filing system that is sluggish for data acquisition and processing. Moreover, Excel documents have led to ineffective communication with donors in emergencies, and advertising methods to motivate citizens to donate blood are unavailable[21, 29, 31, 40, 44, 45]. Human errors may occur in a classic blood bank management system due to the lack of automation, absence of a centralised database, integrated information and updated rules. The data are susceptible to these inaccuracies, thus putting human lives in peril. Despite hospitals or banks having their systems, coordination among these institutions are lacking. This scenario negatively affects the organisational management of volunteer blood donation camps. Blood bags and rare blood types in unregulated blood banks are vulnerable to loss;

moreover, blood banks may lack proper information and have difficulty finding blood groups. As a result, patients constantly experience pressure when looking for and obtaining blood[1, 4]. Although a variety of online blood donation centres are available, none of these centres provide rapid interaction. This issue is a fundamental disadvantage of specific current systems, as these problems can be time consuming, labour intensive and costly[2]. Blood bank systems lack the necessary tools to manage the blood obtained from camps. Despite the availability of cell phones, a patient in need cannot find matching blood or platelets at a critical time[13]. Numerous Android applications in practically every field are available. However, they either need a subscription fee or are only available in certain regions[47]. With contemporary apheresis technology, computer improvements have made it feasible to acquire more real-time information to improve the process and protect the system from probable adverse outcomes[39]. Although these frameworks offer significant advancements in data-driven decision making in several situations, they do not connect contextually relevant concerns to suitable data-analysis methods[49]. Hence, one study explored and evaluated strategies to increase donor compliance in donation settings and find evidence for the usefulness of digital interviews in enhancing risk factor recognition[34]. Unfortunately, given that patient blood management approaches are not implemented globally, intraoperative physicians and other personnel still need to be taught and trained to maximise these management possibilities[18]. Technology allocation in hospitals is expensive[56]. In some countries, the essential hospital activities are managed by different software suites that run on desktop PCs, which may not always allow for quick and effective usage by health workers[33]. One side of social media that has received little attention is the analysis of its usage and efficacy, particularly in underdeveloped nations; notably, social media has potential in such countries to facilitate patient-centric healthcare[38].

4.2.3. Concern about Unreliable Applications

Numerous Internet applications are available. However, mobile health users may not benefit from such applications. Existing systems do not give medical information about medical centres in real-time; instead, users must search online, this consuming a significant amount of time[42]. In addition, the strategy of asking for blood donation from the public through SMS may cause the public to perceive the message as untrustworthy[29]. Moreover, data integrity, updating and uniformity in information are the most common problems that systems face. In addition, searching records manually is difficult for employees[13]. Current procedures may also result in shady practices because of the shortages and necessity for blood and organs. Therefore, authorities have set measures against organ trade and selling in the black market[43].

4.2.4. Concern about the Lack of Medical Information History

Finding unknown volunteer donors is an arduous process. These conditions can confuse the sick and their relatives[5], and the lack of a platform to facilitate the scheduling of donation appointments can cause issues. Despite the stocks in hospital blood banks and blood donation sites, the quantity of blood in storage remains inadequate. This situation suggests that patients must still explore several banks and have difficulty obtaining enough blood for their immediate needs.

Furthermore, numerous studies have investigated people's views regarding donation conduct. Non-donors have provided numerous reasons for not contributing blood, including poor awareness, fear of infection, limited time, lack of request, or medical unfitness[16]. Another challenge that donors may face is the lack of medical information on doctors, donors, medical history problems. Booking a doctor's appointment is a large issue because of the mistakes junior medical staff or the doctor may commit, such as cancelled appointments without prior notification; in addition, patients may not have access to doctors' contact information, and they may even be unfamiliar with the available doctors[47]. Hence, blood donors receive insufficient care. If the donor has an illness or has a medical issue and comes forward to donate, his or her condition may pose a threat to the recipient. As a result, the donor's health records should be assessed. The lack of this type of information in present systems may be detrimental to patients receiving blood[17].

4.2.5. Concern about Traditional Devices

The tube test is more sensitive than the slide method, which is laborious and inconvenient for field applications. A low quantity of antigen causes a weak reaction and therefore cannot be detected. Thus, ABO and RhD typing with paper-based devices using a smartphone for interpretation may provide further advantages for home-based users, mobile blood donation sites and field applications[50]. Furthermore, classical viscometers often depend on expensive and specialised equipment; rotational viscometers also use enormous samples because of repetitive tests and ineffective and time-consuming processes[51, 54]. Traditional procedures often necessitate a lengthy performance time, competent laboratory personnel and specialised instruments. Paper- and thread-based diagnosis techniques can recognise blood groups that are cheap and practical but have limited reliability and accuracy. In addition, erythrocyte counting still requires a system capable of suitable, quick and efficient processes[14]. All procedures require finger pricking, which causes donors pain and is highly inconvenient. As a result, non-invasive point of care tests (POCT) are required in blood banks to eliminate discomfort and infection hazards[37].

4.2.6. Concern about Blood Inventory and Blood Supply Chain

When a patient's blood group does not match that of his or her relatives or friends, they have to go to a blood bank to find a donor or blood. Blood banks preserve blood for approximately 42 days; hence, blood banks cannot hold a large quantity of blood and instead maintain a limited stock[5]. One of the reasons for this short shelf life is that the blood bags' temperature crosses the acceptable threshold. As a result, the bags' shipping repository should feature a cooling system and a dependable temperature control system. Sometimes, the inability to move blood between blood banks results in units expiring in storage[11, 12]. The key obstacles in a supply chain for perishable products are shelf life, temperature control, a significant number of various products, stochastic customer demand and vast quantities of products handled; cost effectiveness is also necessary in dealing with products/goods with a short shelf life[53, 57]. Four complex elements influence the blood inventory allotment (lack, outdating, blood type matching and randomness in RBC equipping and request). The design of an emergency relief supply chain of blood and planning (DRBDP) is highly complex due to the need to repair the network's unique features. On the one hand, the short

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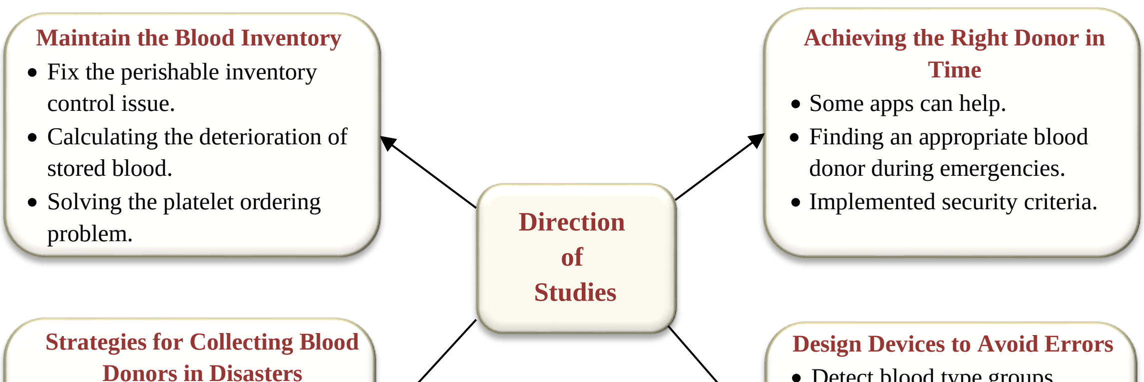
lifespan of blood and its products and the costly effects of blood scarcity and waste add to the difficulty in dealing with blood supply[7][21]. An adequate blood supply requirement becomes even more pressing when the coordination is poor between distribution management and stock management[58]. Another challenge in the BSCN design is deciding whether the location of facilities is strategic, which relies on a set of criteria. Maintaining stability while dealing with an uncertain environment during the design and planning of this network is a big challenge as well[10]. Although past research has used natural, common strategies to prevent disruption in the blood supply system, numerous real-world disturbances are impossible to forecast[59]. Nevertheless, timely and active networks to distribute blood are essential, but most emerging countries have yet to construct an enhanced network infrastructure[36]. The limitation of blood supplies is a significant issue in medical services[16]. Some main characteristics, such as the product's limited life cycle, vitality, high processing costs, collection matters and transmission to hospitals, are essential to design a stable blood supply chain. Moreover, specific vans should move between transfusion sites to collect all the blood. These special collection vehicles are referred to as (SCVs) [55]. An imprecise setting policy in highly stochastic surroundings is the fundamental cause of shortage and expired blood issues. Thus, managing the supply and demand is a critical responsibility for blood centres[52]. Among the most difficult issues that healthcare administrators encounter during pestilences are ensuring the health of donors, managing blood inventory, distributing supplies and making decisions regarding the logistics of blood facilities; these issues emerged during the spread of COVID-19, when the safety of workers and blood donors had to be guaranteed and a sufficient blood supply must be secured. Moreover, blood transferring technologies in hospitals deal with fluctuating requests, and the short lifespan of platelets is a significant aspect [57, 59, 61]. On the other hand, to save the most affected COVID-19 patients, plasma (CP) transfusion can fortify patients' immune systems by transferring these antibodies to them[61]. The donation can never be totally risk free, but such risks must be detected and limited as much as possible through meticulous donor assessment[36]. A reduction in the number of blood donors has been identified as a problem in Japan in recent years. Consequently, Japan has enacted a legislation to ensure a consistent supply of safe blood products and to implement the required procedures to enhance the blood product's safety, verify the legality of human blood for use and protect donors[46]. Likewise, to avoid the spread of TTI diseases, the Indian government has made checking donated blood compulsory over the years[32]. Nonetheless, other factors may influence donation, such as the distance between donor areas and centres, negative staff performance and so on; these factors may also have a detrimental impact on blood donation[10]. Finally, the closure of donation locations has affected blood donations[3].

4.3. Direction of Studies

In This section presents how researchers have directed their works which shown in Figure 9.



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4.3.1. Achieving the Right Donor in Time

Patients always suffer from finding an appropriate blood donor during emergencies. Hence, some applications focus on locating blood donors, gathering data from surrounding hospitals and providing them in less time. These applications help in quicker decision making and provide an easy way for patients to receive help in critical situations. They have various features, such as data security, user friendliness and enhanced ambulance system. Another application has a scheduling system that allows users to book appointments with doctors of various specialisations in multiple locations, thus providing users with a solution for their unexpected health difficulties through 24/7 emergency medical consultancy [41, 42, 47]. Meanwhile, some researchers focused their efforts on the creation of applications that simplify services among medical centres, donors and recipients[6, 45], such as mobile applications based on Android, Raspberry PI, GSM Modem and GPS to minimise the time between the donor and the beneficiary in emergency scenarios[40, 48]. The principal purpose of some blood bank systems is to automate the entire blood donation process, with an emphasis on finding donors during emergencies and creating a direct connection with patients via a web interface mobile app and SMS[13]. Similarly, one smart online tool for blood and organ donation helps to reduce death rates related to organ donations in the healthcare industry[43]. Other platforms can expand even in the most remote places, as they use a USSD code, SMS and a toll-free line, thus providing availability for online and offline databases and making the tool simple to use[15]. Some researchers implemented security criteria in their applications, such as requiring new users to register in the system before they can access it[31]. Meanwhile, another study proposed a trustworthy information system based on GIS and OTP in Android phones to establish blood donation services and store donor records[17]. IoT devices help blood bank administrators and donors by enhancing blood donation automation and supply for the needy. Donors can use GPS coordinates to define the location. In addition, an intelligent management system with a mobile application aims to provide effective coordination of blood banks. Thus system can alter the operations of storing blood bags using a suitable IoT technique that guarantees label accuracy for differentiating each blood type, developing framework smart blood network IoT-based and intelligent application for blood banks, MOH hospitals and donors[1, 29-31]. The significance of citizen-centred big data is that they move data-to-decision research in smart cities from theory to practice and improve mutual supplementation across various disciplines[49].

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Table (3) shows some of the techniques, software and tools that researchers have used to design programs and applications for blood banks to facilitate the entire blood donation process.

Table 3: Automated blood banks based on the different technologies

	The Proposed System/ App	**Needing for Registration?**	**The Communication way with Donors**	**References**
1.	Android Mobile App	Yes	Can contact directly by phone no.	[4]
2.	Android Mobile App using Crowdsourcing + GPS	No	Contact by phone number or email	[5]
3.	Android Mobile App + GPS	Yes	1-App notifications, SMS, and a blood group in the What's UP App. 2- List of emergency departments, together with their contact information, hotline numbers, and addresses.	[41]
4.	Android Mobile App + GPS	No	This App is for searching/ collecting Donors	[42]
5.	web application + Block chain technology	Yes	Publishing the requests on social sites or through (SMS).	[43]
6.	Android App	No	Through App This App is for searching/ collecting Donors	[47]
7.	Android App + IoT + Weight Detecting Sensors + 1- Camera. 2-Color Code. 3-Micro Controlle . 4-Cloud . 5 -An expiry label 6- IoT devices would use	No	Through App	[1]

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	Messaging Queue Telemetry Transport (MQTT)			
8.	Android Mobile App + GPS	Yes	- Through App - In need, automatically transmit the notification to the blood bank's emergency system.	[30]
9.	Web-based and Android-based Application	Yes	Send a notification by the app to registered blood donors	[45]
10.	web application + USSD/SMS/Toll Free Line (Offline)	-	USSD/SMS	[15]
11.	Android Mobile App + GPS	Yes	Through App	[31]
12.	Android Mobile Application + Raspberry PI + GSM Modem + GPS	Yes	By address or contact number.	[40]
13.	Android Mobile Application + Raspberry PI + GSM Modem + GPS	Yes	Direct communication through SMS	[48]
14.	Android Mobile Application	Yes	Social Media Platform	[6]
15.	Smart Phone App + Web Site	Yes	Through App By emails	[29]
16.	web based application + Mobile App	Yes	Bulk message technique (SMS)	[13]

17.	Android Mobile App	Yes	Through App and Phone Number	[2]
18.	System + Android Mobile App + GPS	Yes	By Phone Number	[17]
19.	Develop an Application + GPS	-	-	[46]
20.	Web App	Yes	Receive notification from App after registering in it	[21]

4.3.2. Design Devices to Avoid Errors

To avoid the impact of human errors, such as incorrectly labelled blood bags or unmatched blood types[11], ABO and RhD blood types may be visually detected with 100 percent accuracy using paper-based technology[50]. Technology can ease the blood viscosity analysis process, blood group typing and erythrocyte counting[14, 51]. Researchers can also design, develop and build a temperature-controlled blood bank transport cooler to keep blood characteristics stable during transit[12]. Table (4) presents some new devices to facilitate blood transport.

Table 4: The new proposed devices and Sensors in blood banks

	The proposed (device or Sensor)	The Purpose	References
1.	Making a paper-based gadget to identify the type and interpret the results using Android devices.	Detect blood type groups to limit the impact and amount of human errors.	[50]
2.	Producing a temperature-controlled blood bank transportation cooler . PID controller: to regulate the temperature of the blood bank cooler LCD screen: to show the results. Fault notification through Buzzer. Buzzer: warning of problems.	Make temperatures consistent.	[12]
3.	An L-resonator-based chip less RFID tag, using Wi-Fi routers	Tracking & identification purposes to avoid errors.	[11]

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4.	3D-printed capillary circuit (3D-CC).	For viscosity measurements.	[51]
5.	Designing an LSPR optical biosensor prototype.	ABO blood group typing determination, erythrocyte counting.	[14]

4.3.3. Strategies for Collecting Blood Donors in Disasters

Researchers are interested in providing a feasible plan for blood distribution and allocation in the aftermath of a disaster. Hence, most of their effort has focused on optimising a BSCN [8]. Table(5) presents necessary points to be considered in designing and developing a blood/platelet network. It also lists the main goals and methods to enhance the blood donation process.

Table 5: Strategies for Collecting Blood donors in Disasters

Methods or approach have used	**Challenges and factors which are an influence on BSCN design**	**Designing Goals**
• A New Multi-Product Multi-Objective Mathematical Formulation[7]. • Machine learning, novel MCDM methods[61]. • An efficient communication approach with volunteers to motivate them to donate be beneficial[19]. • Multi-Attribute Group Decision Making (MAGDM approach)[9]. • A Hybrid Stochastic Possibilistic Flexible Programming Approach[58]. • Stochastic Programming, Multi-Objective Meta-Heuristic Alg, Taguchi Alg[55]. • A Fuzzy Stochastic Programming Approach[56, 59].	1. Donor motivation 2. Optimizing. geolocation and ability decisions. 3. Regulating the network's reliability & robustness under merger risk[10] 4. Estimating the no. of infected people 5. The available response capacity. 6. Count the usefulness of blood collection facilities for donors[7]. 7. Quantitative factors that lower product freshness and network price[9]. 8. The uncertainty in request, perishability, different collecting techniques & disruption risk[58].	• Building a blood network that addresses both costs and blood decomposition while also considering sustainability issues[55]. • The construction of a platelet network to decrease the expense of disruptions[56, 59]. • It aids in the delivery of plasma from cured COVID-19 persons to patients in need[60] • The rescue framework provides transfusion to the most sick individuals[61].

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• Bi-objective model using: ε-constraint method, Strength Pareto Evolutionary Alg.II (SPEA-II), Nondominated Sorting Genetic Alg.II (NSGA-II), Multi-Objective Grey Wolf Optimizer (MOGWO), Multi Objective Invasive Weed Optimization alg. (MOIWO) approaches[60]		

4.3.4. Maintain the Blood Inventory

One of the most critical considerations of blood banks is blood inventory management. As blood is perishable and time sensitive, it is not readily available upon request[53]. Table(6) highlights the mechanisms and techniques provided by researchers to help develop inventory management within blood banks.

Table 6: Blood inventory management maintain techniques

	Mechanisms or Techniques	The Objective of the proposed Techniques	References
1.	The reinforcement learning methods.	Fix the perishable inventory control issue with erratic client demand.	[53]
2.	Algorithm for Bacteria Forging Improvement (IBFA).	For perishable products, an effective decision-making tool has been devised.	[57]
3.	A mathematical framework for RBC inventory management.	Reducing out-of-datedness and lacking.	[20]
4.	Expanded applications for quality control.	Calculating the deterioration of stored blood.	[51]
5.	A hybrid method + smartphone camera+ device.	Keep track of changes in blood samples due to storage or rancidity.	[54]
6.	A new data-driven approach + difference analyzing	Solving the platelet ordering problem	[52]

4.4. Recommendations

The most important recommendations from the systematic review are also discussed, as are the obstacles that users, developers and researchers may confront and how these challenges can be overcome. Recommendations have summarized in Figure10.

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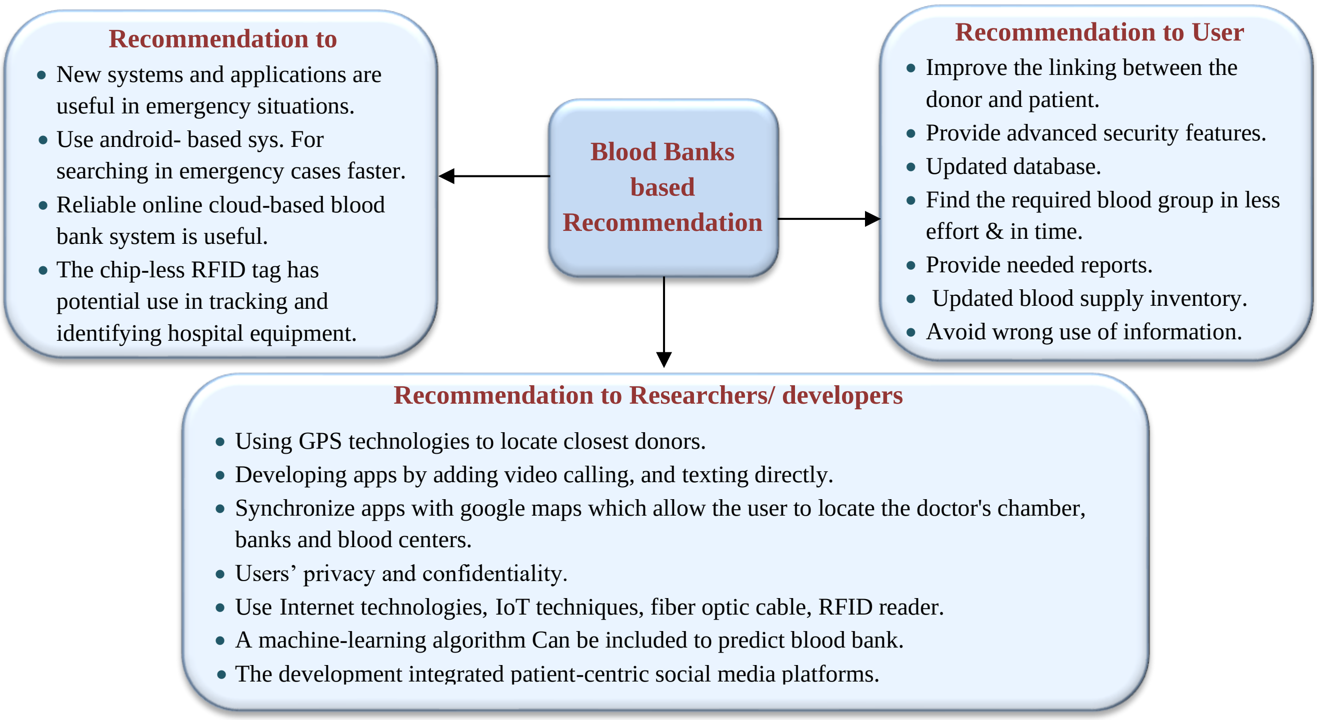

Figure 10: Blood Banks based Recommendation

4.4.1. Recommendations to User

Fig10: Blood Banks based Recommendations

The Life Share, web application delivers a one-of-a-kind platform for the efficient management of donated blood and organs, superior security capabilities and ability to share information with any blood bank by connecting users to hospitals and related databases[43]. Another Android applications facilitate blood services, find the nearest donor in time, update database, provide reports, update blood supply inventory, notify when the blood quantity is low and increase donors' willingness to donate[6]. The use of such applications can help avoid misinformation[17]. Meanwhile, another application can reliably book online consultations[42]. In addition, the blood bank application for Raspberry PI aims to increase communication between donors and patients, as well as any source of nearby volunteer blood donors[40, 48]. Furthermore, adopting IoT technologies can help strengthen connections between the patient and donor, thus allowing to search for the necessary blood types or blood byproducts from the nearest blood bank with less effort[30].

4.4.2. Recommendations to Researchers/Developers

This review will give rise to further research or ideas that are still absent in developing nations, such as suggesting applications or innovations that assist people in various situations, especially in emergencies[41]. Some valuable recommendations to improve current systems include locating the closest donors using GPS technology to help develop any health-related matters. For instance, one model integrates direct communication between the donor and the patient through video calling

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and texting[4, 5]. In addition, applications can be synchronised with online maps, which allows the user to locate the doctor's site[47]. Meanwhile, Google and Outlook calendars can be synchronised with user appointments for convenient use[21], and emerging technologies can be developed by adding more features[13]. To improve usability, these applications can be integrated with various social network application software interfaces (APIs) that allow users to log in and sign up, support applications in multiple languages and optimise the user interface (UI). Some new functionalities can also be integrated to improve the management of blood bank services even further. A smartphone application for offline and online services, such as one with a bar-code tag, should provide opportunities to educate users about blood safety to maintain the health of blood banks. Integrating local languages (audio and text) will also be required, particularly in provincial areas[15]. Moreover, when creating and building a blood donation app, the following factors must be considered: privacy and confidentiality, increased donation knowledge and unification among blood facilities[16]. A blood bank centre must have an integrated network to interact with other hospitals. Furthermore, donors need Internet access to use applications. Thus, the provider must offer a fibre core to connect the centre and the branch. A fibre optic connection must also be used between all devices to achieve breakneck speed, and an RFID reader must be installed[29]. Further advancements, such as the use of IoT, to monitor the entire network, can be made in conjunction with machine learning improvement[55]. In addition, a dynamic regulating strategy may provide new insights to assist real-world decision makers and improve the blood supply chain[52]. A machine-learning method may forecast which blood banks demand more of a specific blood type than others based on nearby populations[1]. Other MADM approaches (e.g. fuzzy AHP or fuzzy Topsis) can be used to assess the essential aspects involved. Collection, routing and creation modalities and their advantages and disadvantages should also be analysed. Furthermore, mathematical formulations can be helpful in the blood donation field, as it can determine the shelf life of different blood products. These developments are an exciting addition to this discipline, as they can assess the efficiency of obtaining blood donors to reduce possible shortages[9]. Hence, future studies can focus on further enhancements, such as MDP-based approximation[20]. In addition, researchers can develop an acceptable solution method, heuristics or meta-heuristics to assess disasters and address large-scale problems in designing a solid and adaptable blood supply chain network[10, 56]. The new approaches for predicting risk can be further developed to include new groups without jeopardising transfusion safety[36]. Moreover, supply chain accomplishment can be enhanced by managing donations and optimising the daily demand for blood bags more thoroughly to reduce wastage and shortfalls. Using novel decision-making tools, experts can reduce the cost of blood donation, estimate donor conduct and predict demand for blood[32]. Such methods should regard the non-stationary and unpredictable nature of consumer demand to measure the impact of new approaches on supply quality and challenges in the inventory management of perishable supplies [53]. To supplement innovations, each region can also designate temporary emergency shelters (TESs). Disruptions in banks and blood facilities and the unpredictability in the age of available blood should be taken into consideration as well. As such, blood delivery time and management are key aspects in the development of new approaches[8]. The pulse-oximetry approach for haemoglobin screening in blood donors is a non-invasive procedure; nevertheless, it requires several modifications before it can be used[37]. As technology advances, more case studies will be necessary to validate the performance of the suggested frameworks[49]. A successful health service must incorporate a wide range of participants through sharing data technology, which is

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Internet-based and can be used to construct patient-centric social media platforms. This service can help identify potentially valuable applications, detect areas that need automated processes and reduce delays[38]. Other future research directions include incorporating incentive mechanisms for blood donation and various technologies to decompose whole blood into transportable blood components[7]. Controlled studies in different geographical contexts should also be performed to determine the efficacy of the evaluated interventions to enhance blood donor loyalty [34]. Finally, one of the significant future concerns that some academics are working on is how to get people to recognise the presence of such application mechanisms[7].

4.4.3. Recommendations to Medical Health Institutions

To avoid health complications and deaths, the proposed android-based systems must be available to all people, as these systems can help search for blood supply in emergency cases faster[45]. For instance, to combat the COVID-19 virus, one proposed framework uses novel MCDM methods and ML to improve infected patients' immunity. This framework can be used with any new generation of coronaviruses. In addition, for newly infected patients, proposed systems can use IoT to address problems more easily. Moreover, a telemedicine environment can save the lives of a vast number of people. It also ensures the security and privacy of user data[61]. Hence, the health sector will benefit from the newest technology and software services, thus promoting the quality of healthcare and revolutionising conventional approaches[2]. The suggested cloud-based blood bank system benefits both the applicant and the donor, as it enhances the communication between both parties to deliver the necessary item on time[31]. In blood banks, chipless RFID tags are used to detect and monitor medical instruments, such as blood bags and blood type smart labels for donors and patients[11]. Maintaining the blood bank temperature at a steady level is also a priority[12]. In addition, an Android application with a web platform must be installed in numerous blood service locations[6]. Blood banks recommend strategically situating donation locations across the country to enhance the donation process and diminish donation barriers[3]. Furthermore, portable equipment, which includes smartphone application that can interpret data, can be helpful for blood group detection in field applications and hospitals[50]. The input flow to hospitals should be more than the number of requests, and the age of each product (e.g. platelets should also be noted[59]. Environmental, social and economic selectors should all be considered simultaneously. Local advertising, such as television advertisements, social networks and city banners can motivate people to donate blood[60]. The selection and development of hospital management software should be regularly checked as well [33]. Furthermore, applying an improved bacteria-foraging algorithm for the supply network improves the inventory procedures for perishable items; under this scenario, transfer costs are reduced, thus lowering the total price[57]. The new capabilities of technologies, such as the analysis of blood viscosity by hand-powered devices, would facilitate the work in clinical and industrial applications. Additionally, using smartphones has significant advantages in mobility, easy handling and data administration[51, 54]. Meanwhile, an optical biosensor chip is intended for use in urgent and resource-constrained scenarios, with outstanding quick diagnostics, security and mobile healthcare[14]. Meanwhile, apheresis will continue to be one of the most effective therapeutic methods in the future, and has potential for further development [39]. The selection to transfuse blood should be based on criteria and algorithms tailored to the unique circumstances of each

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patient. Approaches must be devised specifically for cardiac surgery patients. The patient blood management (PBM) approach also helps with anaemia therapy and the improvement of patient outcomes[18]. To avoid a shortage of blood and its byproducts, especially during epidemic outbreaks, an effective plan for blood collection management and monitoring the supply and demand must be implemented. A robust communication strategy with volunteer blood donors must be developed to urge them to donate; in addition, a network that links local blood organisations with one another will go a long way towards managing the blood supply during the COVID-19 pandemic[19, 58]. A donor-clinic model can also be provided as a public health intervention at the blood bank level, as it is beneficial in referral, counselling and donor care [35]. Furthermore, applications should be installed into hospital servers to help observe how people react. Decentralised servers should also store all pertinent data and provide entry methods to their patient data set[44].

5. Limitations

This study faces several limitations. For instance, we could not obtain some up-to-date related online articles. In addition, may have overlooked relevant studies that help look at newest applications which have systems integrate with different technologies especially IoT, some advanced sensors and secure information tracking in blood bank systems, such as the Block chain Ethereum platform, which can help improve each stage of the blood supply chain system. Notably, this area of study may assist in effectively increasing the number of cognitive results[62, 63]. Also, in Iraq we don’t have access to Web of Science database (WoS) to doing more search.

6. Conclusions

The proposed systems involve factors that help achieve blood bank targets, such as applications based on mobile or web, GPS technology and integrated IoT techniques to implement an intelligent blood management system. All of these factors can help to reduce the time between the donor and the patient while also ensuring that the victim receives the appropriate blood group type, which is critical in an emergency. A unique platform must also be provided for blood and organ donation management with advanced security features. Such platform can help keep records of users’ history, online doctors’ appointments, 24/7 emergency services, blood donors information and ambulance services. In addition, experts must build a database that can collect all information regarding the blood bank’s site, available blood groups and donor data and subsequently verify and update information. These technologies can help avoid existing issues in traditional banks, such as misinformation and misuse of details. In addition, receiving adequate help is more effective than calling other emergency hailing services with suitable alternatives, creating technologies that keep blood temperature within a reasonable level, detecting ABO types and measuring viscosity. Hence, a new framework must be introduced to sustain and raise the number of blood donors by concentrating on the performance design and developing an application that promotes blood donation and a donor support system.

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Volume 13, No. 2, 2022, p. 1184 - 1227
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ISSN: 1309-345

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