Development of Risk Assessment Framework for Blood Bank Operations During Emerging Infectious Diseases like Covid-19

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Abstract

The most life-threatening infectious disease the world has been fighting is SARS–CoV–2. The outbreak of this virus has affected so many day–to–day activities of people and businesses. Almost all businesses in India have been impacted by the lockdown and restrictions on connectivity to cities and towns. Moreover, many operations of the business have faced adverse consequences, which have led to the closure of a few businesses. One of the industries that was affected during the COVID outbreak was the blood bank. This study aims to assess the level of risk in the blood bank operations during COVID–19. The enablers, criteria, and attributes that facilitate the risk in blood bank operations were identified and evaluated using the multi-grade fizzy technique. The results stated that low risk was observed in the blood bank operation during COVID-19 and also that stayed the same during the emergence of any other infectious diseases. The final risk index average is 4.49, which confirms that it is low risk. An important performance analysis was performed to identify the attributes that contribute to higher risk in blood bank operations.

Keywords
Blood bank operations, Emerging infectious diseases, Risk assessment, Covid-19 and importance Performance Analysis.

1. Introduction
The COVID-19 outbreak has drastically affected many countries and also many industries. The day-to-day activities of many industries have also been affected because of the changes in the supply chain. One of the industries that has been affected and is crucial to handling any health emergency is the blood bank services. Blood bank services are one of the essential services in health emergencies. Due to the COVID-19 outbreak and restrictions on transportation during the outbreak, blood bank services have been affected (Arcot et al., 2020). This infectious disease has imposed a higher risk on blood bank operations. Risk can be anything related to operational, clinical, or safety aspects of the services and also the people involved in delivering those services. This research aims to find out the factors that affected the risk level in blood bank services during the COVID-19 outbreak and also to find out which factors may have the same effect in the future in any such explosion of infectious diseases.

Risk assessment in the blood bank is so crucial because blood is an important component when it comes to saving lives. Handling blood carefully is essential. The SARS CoV–2 virus is one of the diseases that can be identified through blood testing. Hence, we discuss the potential challenges faced by blood banks that increase the risk level in blood bank operations, such as inventory balancing, smooth service operations, and blood bank safety.

The objective of this research is to answer the following three research questions:

- How can the risk level be assessed in blood bank operations during emerging infectious diseases like COVID-19?
- What are the enablers, criteria, and attributes that influence the level of risk in blood bank operations?
- What are the weaker and stronger attributes that contribute to the risk level in blood bank operations and how can they be addressed?

2. Literature Review

Research papers and articles were studied to identify the key aspects of risk in the blood bank operations during the pandemic and disastrous situations. A few of those are discussed below in brief.

Teo (2009) studied the effect of the influenza pandemic on blood bank operations. Though there has been no reported case of that virus being spread through blood transfusion, there has been a decrease in the number of donors. Donor selection criteria have become important to make sure that no infection is passed on through blood transfusion. The author studied various factors like supply shortages, donor and staff safety, clinical demand, and service operations. The author concluded that employee absenteeism is 35–50% during the pandemic due to the spread of the infection.

Zaheer (2012) scrutinized the research about blood management during disaster situations in Pakistan. Due to the fragmented blood transfusion system in Pakistan, there is a higher risk involved in blood management during disasters or emergencies. The various risk factors and challenges identified by the author are: no proper physical infrastructure; lack of information; no proper documentation; and there are no standardized procedures adopted. All these factors contribute to the higher risk in the blood bank operations and also in the supply chain of the services.

Caramello et al., (2019) assessed the preparedness of hospitals and blood transfusion centers. The authors identified 74 action items that are required for hospitals to be prepared for all disasters and emergencies. Those action items included vendor and supply chain issues, donor and staff safety, security, and transportation issues. The action items are ranked from 1 to 5 on the global level. The results stated that the global level of blood transfusion centers' preparedness was at a very low level; hence there is a higher risk associated with hospitals and blood banks carrying out blood transfusion services.

Wang et al. (2020) investigated the impact of COVID-19 on Chinese blood centers. The blood donor and supply information was collected from different centers and reviewed. A self-administered questionnaire was sent to the donor through text, and data was collected. The collected data was analyzed using SPSS. The results of the study showed that most of the donors were worried about getting infected while blood donation. The success rate for the donations dropped by 60%. Movement restrictions, failure to implement preventive measures such as mask use and temperature checks, and a lack of public awareness about the outbreak all increased the risk of blood bank operations.

Shah and Zang (2004) investigated the viral attacks on the blood supply during the emergence of infectious diseases. Even though the diseases are not spread through blood transfusion, there will be a lot of hurdles on the supply side because of the drastic reduction in the number of donors. Most of the time, there are only two scenarios possible in the blood transfusion sector; either an increase in demand or a reduction in supply. The authors of the study highlighted the issues faced by the blood bank during the crisis, which are quality of blood products, transportation of blood products, temperature maintenance during transportation, packaging errors, and ensuring the safety of the samples collected.

Arcot et al., (2020) studied various potential challenges faced by blood banks during the COVID–19 pandemic. The authors identified four main categories of the challenges faced by blood banks in the pandemic outbreak. The challenges identified are blood and component storage, consumables logistics and supply, donor and staff safety, and convalescent plasma.

Cai et al., (2020) observed various issues that impacted the blood transfusion due to COVID–19. The authors identified a huge impact on blood safety, recruitment of blood donors, and blood collection. The restriction on transportation and logistics services also affected the blood bank and transfusion services. Since there has been a reduction in the supply of blood, the inventory and the allocation have to be managed efficiently to satisfy the demand. Acquiring convalescent plasma was also a critical task because there were very few donors during the pandemic outbreak. A few other factors that influenced the blood bank and blood transfusion services during the pandemic are laboratory safety, communication between the departments and health institutions, virus transmission during blood transfusion, and health policies.

Ohto (2016) scrutinized the four important points to be noted by the blood banks to be prepared for calamity. Firstly, during such conditions, the delivery systems are affected primarily. Hence, the institutions should be prepared for the immediate replacement of local transportation services. Secondly, there should be clear communication systems to help the officers handle situations better. The last two points, including maintaining civil order and the decision-

making power of the authorities, will help the officials to handle the situation appropriately with all the support needed from the government.

Based on the above background study, our further research was carried out using multi-grade fuzzy logic to develop risk assessment framework for blood bank operations. An important performance analysis was used to identify the more risky and less risky attributes of the identified attributes.

3. Research Methodology

3.1 Multi-grade fuzzy

The multi-grade fuzzy was used to assess lean, agile, performance, safety practice level, and supply chain management effectiveness in the manufacturing and service industries (Vinodh and Aravindraj, 2015; Sridharan and Suresh, 2016; Ganesh and Suresh, 2016; Vinodh and Chintha, 2011; Vinodh, 2011; Vimal et al., 2015; Almutairi et al., 2019).

The study used multi-grade fuzzy logic to assess the level of risk in blood banks. The current study begins with a review of the literature on emerging infectious diseases such as COVID-19, blood bank operations during COVID-19 repeated epidemics, and multi-grade fuzzy assessment. A new conceptual model is framed to assess the blood bank risk index with three enablers, six criteria, and seventeen attributes shown in Table 1.

Table 1. Conceptual model of risk assessment in blood bank operations during emerging infectious diseases

Enablers	Criteria	Attributes
Logistics and supply (R1)	Consumable's supply (R11)	On-time consumable supplies to meet the needs of the crisis (R111)
		On-time delivery of reagents and chemicals (R112)
	Blood supply (R12)	Safe Supply of convalescent plasma to pharma companies and hospitals (R121)
		Transport of blood between centers and hospitals (R122)
Organizational commitment (R2)	Donor safety (R21)	Usage of unsterilized utensils (R211)
		Restriction of movement during lockdown (R212)
		Testing for infectious diseases (R213)
		Blood donation after vaccination (R214)
	Staff safety (R22)	Following safety protocols (R221)
		Exposure to infected patients/ donors (R222)
		Educate and train how to handle infected patients (R223)
Process risk (R3)	Blood donation (R31)	Incorrect venipuncture site (R311)
		Usage of outdated tools and devices (R312)
		Exposure to the virus (R313)
	Blood storage (R32)	Poor labeling (R321)
		Exchange of labels between two blood components (R322)
		Equipment malfunction (R323)

4. Case Study

4.1 Case blood bank

The case blood bank is rendering its services for the past 20 years, successfully located in India. The rating has been collected from employees working in the case blood bank at different levels. The data has been collected through in-person interviews, and the collected data is assessed using the multi-grade fuzzy tool. An importance-performance analysis has been done to identify the weaker and stronger attributes contributing to the risk level in the blood bank operations during infectious diseases like COVID-19.

The risk index of blood bank operations is represented as *I*. It is the product of the overall assessment level of ratings based on each driver (*R*) and the overall weights (*W*) given by the experts. The equation for the risk index is

$A = W \times R$ (Anil and Suresh, 2020; Suresh et al., 2020; Menon and Suresh, 2020)

The assessment has been divided into ten grades since the entire risk index involves fuzzy determination. A = {10, 9, 8, 7, 6, 5, 4, 3, 2, 1}. 9-10 represents 'Extremely High Risk', 8–9 represents 'Very High Risk', 7–8 represents 'High Risk', 6–7 represents 'Risk', 5–6 represents 'Moderate Risk', 4–5 represents 'Low Risk', 3–4 represents 'Very low Risk', 2–3 represents 'Very very low Risk', 1–2 represents 'No Risk', and less than 1 represents 'Risk-free operations'. For the attribute's ratings, we used a questionnaire with a 10-point Likert scale that represents extremely high risk (10 points) to risk-free operations (1 point). The weightage has been collected from five experts from various blood banks using a 10-point Likert scale that represents extremely high importance (10 points) to extremely low importance (1-point). The risk ratings are collected from the case blood bank's experts and are captured in Table 2.

Table 2. Weights and risk ratings from experts

Ri	Rij	Rijk	R1	R2	R3	R4	R5	*Wijk*	*Wij*	*W*
R1	R11	R111	2	1	2	1	1	0.6086	0.3392	0.3
		R112	2	3	2	3	2	0.3913		
	R12	R121	4	4	5	4	4	0.6176	0.6607	
		R122	2	1	1	2	1	0.3823		
R2	R21	R211	1	1	1	1	1	0.1203	0.4761	0.475
		R212	7	6	6	7	8	0.1203		
		R213	7	9	8	7	7	0.4166		
		R214	6	4	7	5	8	0.3425		
	R22	R221	8	8	9	9	10	0.3358	0.5238	
		R222	9	10	9	10	10	0.3664		
		R223	5	4	4	3	4	0.2977		
R3	R31	R311	1	1	1	1	1	0.2222	0.5106	0.225
		R312	1	1	2	2	1	0.0793		
		R313	2	2	2	1	1	0.6984		
	R32	R321	2	1	1	2	1	0.3461	0.4893	
		R322	4	3	2	2	3	0.4615		
		R323	1	2	1	1	2	0.1923		

Primary assessment calculation

The primary calculation done for the "Consumable's supply (R11)" is given below.
Weights concerning to "Consumable's supply" criterion is W_{11}= [0.6086, 0.3913]

Assessment for the practice of the "Consumable's supply" criterion is given below as

$$R_{11} = \begin{bmatrix} 2 & 1 & 2 & 1 & 1 \\ 2 & 3 & 2 & 3 & 2 \end{bmatrix}$$

Index concerning of "Consumable's supply" criterion is given by

$I_{11} = W_{11} \times R_{11}$

I_{11} = [2, 1.782, 2, 1.782, 1.391]

Using the above principle, the indexes for the following risk assessment criteria are obtained and presented below.I_{12} = [3.235, 2.852, 3.470, 3.235, 2.852]

Secondary assessment calculation

The calculation concerning to enabler of "Logistics and supply (R1)" is given below as
Weights concerning to "Logistics and supply" enabler given as W_1 = [0.339, 0.660]

Assessment of "Logistics and supply" enabler is given as below

$$I_1 = \begin{bmatrix} 2.000 & 1.782 & 2.000 & 1.782 & 1.391 \\ 3.235 & 2.852 & 3.470 & 3.235 & 2.852 \end{bmatrix}$$

Index concerning of "Logistics and supply" enabler is given by $I_1 = W_1 \times R_1$

I_1 = [2.816, 2.489, 2.971, 2.742, 2.357]

Using the above principle, the indexes for the following risk assessment criteria are obtained and presented below. I_2 = [6.740, 6.790, 7.065, 6.633, 7.512]

I_3= [2.203, 1.902, 1.623, 1.435, 1.545]

Tertiary assessment calculation

The risk assessment value of case blood bank operations has been calculated as followsComplete weight W = [0.3, 0.475, 0.225]

Complete assessment vector R = $\begin{bmatrix} 2.816 & 2.489 & 2.971 & 2.742 & 2.357 \\ 6.740 & 6.790 & 7.065 & 6.633 & 7.512 \\ 2.203 & 1.902 & 1.623 & 1.435 & 1.545 \end{bmatrix}$

Risk index of blood bank operations $I = W \times R$

I = [4.542, 4.400, 4.612, 4.296, 4.623]

The final risk index is the average of I = 4.49 ∈ (4 to 5). ∴ 'Low Risk'

4.2 Importance performance analysis

In the manufacturing and service industries, IPA is widely used to classify attributes based on their importance and performance. (Chacko et al., 2021; Vaishnavi and Suresh, 2021; Sreedharshini et al., 2021). The x-axis in IPA represents the risk rating of the attributes, while the y-axis represents their importance (Subramanian and Suresh,2022). The mean of the x-axis is 3.69 and the mean of the y-axis is 4.52 as a perpendicular line in the given below Table 3.

Table 3. IPA analysis for risk assessment of case blood bank operations during emerging infectious diseases

Importance →																						
	10	**Quadrant -I**														**Quadrant -II**				R222
	9.5																			
	9			R313												R213		R221		
	8.5																			
	8							R223												
	7.5											R214								
	7																			
	6.5																			
	6																			
	5.5																			
	5																			
	4.5								R121											
	4																			
	3.5																			
	3	R211, R311	R111, R122											R212						
	2.5					R322														
	2		R321		R112															
	1.5																			
	1		R312, R323	**Quadrant -IV**												**Quadrant -III**				
		1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
		Risk Rating →																		

Quadrant I (Keep up the good work): The attributes in the quadrant should be maintained in the same way, and the attributes are "Exposure to the virus".

Quadrant II (concentrate here): Case-blood bank managers must pay close attention to the attributes in the quadrant to reduce the risk level of their operations. The attributes are "Testing for infectious diseases,blood donation after vaccination, following safety protocol, exposure to infected patients/ donors, educate and training how to handle infected patients".

Quadrant III (Possible overkill): The attributes in this quadrant are low importance but high-risk rating (Thomas and Suresh, 2022). The risk level of these attributes should be minimized. The attributes are "Safe supply of convalescent plasma to pharma companies and hospitals, restriction of movement during lockdown".

Quadrant IV (Low priority): The attributes in this quadrant are low importance and low risk rating (Suresh and Gopakumar, 2021). The attributes are "on-time consumable supplies to meet the needs in the crisis, on-time delivery of reagents and chemicals, transport of blood between centers and to hospitals, usage of unsterilized utensils, incorrect venipuncture site, usage of outdated tools and devices, poor labelling, exchange of labels between two blood components, equipment malfunction".

5. Results and discussion

The suggestions for the improvement of riskier attributes are given in Table 4.

Table 4. Suggestions for riskier attributes

Riskier attributes	Suggestions for improvement
Testing for infectious diseases	Advanced technology to quickly test for the diseases.
Blood donation after vaccination	A proper awareness campaign among the people about all information about infectious diseases, vaccination details, and safety measures.
Following safety protocol	A well–equipped facility for the staff to follow all the safety procedures.
Exposure to infected patients/ donors	Following the safety protocols and proper testing before the donation
Educate and train how to handle infected patients	Proper and regular training sessions have to be conducted in the facility to train the staff on procedures and new technology.

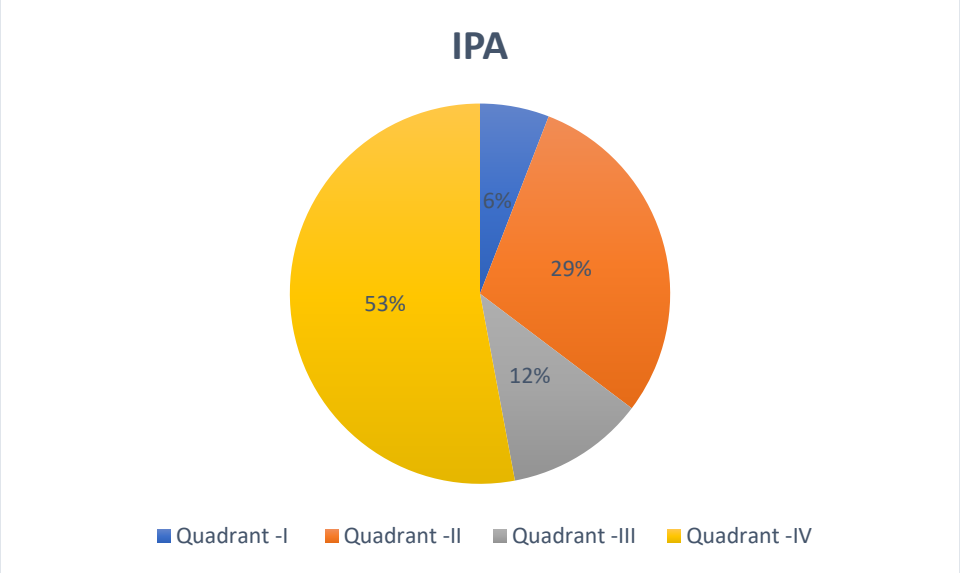

Figure 1. The percentage of number of factors in each quadrant.

Figure 1 represents the percentage of number of factors in each quadrant. Case-blood bank managers must pay close attention to the attributes in the quadrant II to reduce the risk level of their operations.

6. Practical implication

The risk level in the blood banks has been assessed with 17 attributes, 6 criteria, and 3 enablers using the multi-grade fizzy approach. The weaker and stronger attributes have been identified using importance performance analysis. The IPA will help us identify which attributes are contributing to more risk and which attributes are at an appropriate level to maintain the risk level in the organizations. This risk level analysis of the attributes will help the organizations to assess their current risk level and identify which attributes are contributing to the risk so that they can take measures to control them and bring them to the baseline. This analysis can be applied to any infectious outbreak and not only to the COVID–19 era. With the help of these 17 attributes, most of the risk levels in the blood banks can be measured and controlled.

7. Conclusion

The purpose of this study was to identify the factors influencing the risk level of blood bank operations during emerging infectious diseases such as COVID–19. The 17 attributes, 6 criteria, and 3 enablers were identified, and they are ranked on a scale of 1–10. The data was collected through personal interviews, and the data was analyzed using multi-grade fuzzy. Furthermore, an IPA was carried out to find out the riskier and less risky attributes. Through IPA, the riskier attributes were found to be testing for infectious diseases, blood donation after vaccination, following safety protocols, exposure to infected patients, and educating and training on how to handle infected patients. The possible suggestions have been provided to reduce risk rate. These results will help all the hospitals, blood banks, and any other institutions involved in blood transfusion services to be prepared for outbreak of infectious diseases like Covid-19 and will help to handle such situations wisely with available information.

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