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HEALTHCARE SYSTEMS OF INVENTORY CONTROL FOR BLOOD BANK STORAGE WITH RELIABILITY APPLICATIONS USING GENETIC ALGORITHM

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ABSTRACT. A deterministic Healthcare systems of Blood Bank Storage inventory control has been developed for the deterioration of items with increasing demand, Inbound, outbound logistics with ramp time demand and inflation effects on stocks using Reliability Applications and Multi-objective optimization problem genetic algorithm. The Healthcare systems of Blood Bank Storage has a fixed capacity of δ_W units using Reliability Applications and Multi-objective optimization problem genetic algorithm. Stock outs are allowed and partially deferred, and inventories are expected to deteriorate over time with a variable rate of deterioration using Reliability Applications and Multi-objective optimization problem genetic algorithm. The numerical example is also used to examine the behavior of the model using Reliability Applications and Multi-objective optimization problem genetic algorithm. The cost minimization technique is used to obtain the terms of total cost and other parameters using Reliability Applications and Multi-objective optimization problem genetic algorithm.

1. INTRODUCTION

Healthcare systems of Blood Bank Storage is an institution that collects, tests, processes and stores blood and its components for future use. The main task of

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Healthcare systems of Blood bank is to plan the collection of blood and respond to the demand for blood and its components from patients. The main objectives of Healthcare systems of Blood Bank Storage are: Make sure there is enough blood for patients requiring a blood transfusion. Make sure the waste of blood products is minimized. The main blood supply of typical Healthcare systems of Blood Bank Storage comes from blood drives carried out as part of blood donation campaigns and camps; donors who come to the bank and donate blood are other sources of supply. Many large Healthcare systems of Blood Bank Storage take their own blood from camps and donations from Healthcare systems of Blood bank Blood Bank Storage. Blood is collected and stored in plastic bags containing anticoagulant solutions. Blood collected by donations and stored in plastic bags is commonly called whole blood (WB). Healthcare systems of Blood bank can also break down the blood collected in the camps. A single empty bag is used to store whole blood (WB), while a triple empty bag is used to collect blood that must be separated into components (depending on the number of components required).A triple blood bag is a system consisting of a main bag of blood collection and several satellite bags connected to it to collect the components. To separate various components, a triple / quad blood bag is centrifuged at high speed in a centrifuge. Due to the centrifugation, the various components separate according to their density in several layers in the main bag. The lightest component, plasma, precipitates in the upper layer, followed by platelets in the middle and red blood cells (the heavier ones) underneath. These components can be emptied from the main bag into their respective satellite bags once the separation of the layers is complete. Since white blood cells can cause many complications in the patient's body, some advanced blood bags are equipped with leukocyte reduction filters. These filters eliminate most leukocytes that would otherwise be fractionated with erythrocytes. Individual blood bags with a capacity of 250 ml and 300 ml as well as quadruple pockets with a capacity of 400 ml and 450 ml are very popular in Healthcare systems of Blood bank Blood Bank Storage. The main benefit of separating whole blood into components is that only the necessary components can be delivered to the patient in need.

Pandey, et. al. (2019) An Analysis Marble Industry Inventory Optimization Based on Genetic Algorithms and Particle swarm optimization. Malik, et. al. (2019) Security Mechanism implemented in Gateway Service Providers. Yadav and Swami (2019) A Volume Flexible Two-Warehouse Model with Fluctuating

Demand and Holding Cost under Inflation. Yadav, et. al. (2019) Supply Chain of Chemical Industry For Warehouse With Distribution Centres Using Artificial Bee Colony Algorithm. Yadav, et. al. (2020) Electronic components supply chain management of Electronic Industrial development for warehouse and its impact on the environment using Particle Swarm Optimization Algorithm. Yadav, et. al. (2020) Reliability Consideration costing method for LIFO Inventory model with chemical industry warehouse. Yadav, et. al. (2020) proposed National Blood Bank Centre Supply Chain Management For Blockchain Application Using Genetic Algorithm. Yadav, et. al. (2020) a give Medicine Manufacturing Industries supply chain management for Blockchain application using artificial neural networks. Yadav, et. al. (2020) proposed Red Wine Industry of Supply Chain Management for Distribution Center Using Neural Networks. Yadav, et. al. (2020) a give Rose Wine industry of Supply Chain Management for Storage using Genetic Algorithm. Ahlawat, et. al.. (2020) a give White Wine Industry of Supply Chain Management for Warehouse using Neural Networks. Chauhan and Yadav (2020) proposed An Inventory Model for Deteriorating Items with Two-Warehouse & Stock Dependent Demand using Genetic algorithm. Chauhan and Yadav (2020) a give Inventory System of Automobile for Stock Dependent Demand & Inflation with Two-Distribution Center Using Genetic Algorithm. Yadav, et. al. (2020) a give Reliability Consideration costing method for LIFO Inventory model with chemical industry warehouse. Yadav, et. al. (2020) a give Electronic components supply chain management of Electronic Industrial development for warehouse and its impact on the environment using Particle Swarm Optimization Algorithm International Journal Procurement Management.

2. Assumptions and Notations

In addition, the following notations are used throughout this paper:

$\Pi_{BBS}(t)$ = *The inventory level inBlood bank Storageat any time t.*
The demand rate $D(t)$ *at time t*, $D(t)=(\alpha_0-1)e^{-(\beta_0-1)t},(\alpha_0-1)>0,(\beta_0-1)>0$
δ_W = *The capacity of theBlood bank Storage.*

δ_Q = *The ordering quantity per cycle.*
T =Planning horizon.
$(\pi_0 - 1)$ = *Inflation rate.*
(θ_{IBL}) = *Inbound logistics costper unit per unit time*
(ν_{OBL}) = *Outbound logistics costper unit per unit time*
δ_{BBHC} = *The holding cost per unit per unit time in Blood bank Storage.*
δ_{BBDC} = *The deterioration cost per unit.*
δ_{BBSC} = *The shortage cost per unit per unit time.*
δ_{BBLSC} = *The opportunity cost due to lost sales.*
$(\mu_6 - 1)$ = *The replenishment cost per order.*
TCSCS = *Total cost Blood bank Storage.*

3. Formulation and Solution of The Model

$$\frac{d\prod_{BBS}(t)}{dt} = -(\beta-1)(t)\prod_{BBS}(t), \quad 0 \le t < t,$$

$$\frac{d\prod_{BBS}(t)}{dt} + (\beta-1)(t)\prod_{BBS}(t) = -(\alpha_0-1)\,e^{-(\beta_0-1)t_1}, \quad t_1 \le t \le t_2,$$

$$\frac{d\prod_{BBS}(t)}{dt} = -(\alpha_0-1)\,e^{-(\beta_0-1)t_1}e^{-(\eta_0-1)t}, \quad t_2 \le t \le T,$$

$$\prod_{BBS}(0) = \delta_W \quad \text{and} \quad \prod_{BBS}(t_2) = 0.$$

The solutions of equations (1), (2) and (3) are given by:

$$\prod_{BBS}(t) = \delta_W e^{-(\beta-1)t^2/2} \quad 0 \le t < t_1$$

$$\prod_{BBS}(t) = (\alpha_0-1)\,e^{-(\beta_0-1)t_1}\left\{(t_2-t) + (\beta-1)\frac{(t_2^3-t^3)}{6}\right\}e^{-(\beta-1)t^2/2} \quad t_1 \le t \le t_2$$

$$\prod_{BBS}(t) = \frac{(\alpha_0-1)}{(\eta_0-1)}e^{-(\beta_0-1)t_1}\left\{e^{-(\eta_0-1)t} - e^{-(\eta_0-1)t_2}\right\} \quad t_2 \le t \le T$$

Due to continuity of $\prod_{BBS}(t)$ at point $t = t_1$, it follows from equations (5) and (6), one has:

$$\delta_\pi e^{-(\beta-1)t_1^2/2} = (\alpha_0 - 1)\, e^{-(\beta_0-1)t} \left\{ (t_2 - t_1) + (\beta - 1)\frac{\left(t_2^3 - t_1^3\right)}{6} \right\} e^{-(\beta-1)t_1^2/2}$$

$$\delta_W = (\alpha_0 - 1)\, e^{-(\beta_0-1)t_1} \left\{ (t_2 - t_1) + (\beta - 1)\frac{\left(t_2^3 - t_1^3\right)}{6} \right\}$$

The total average cost consists of following elements:

(i) Healthcare systems of Blood Bank Storage cost of ordering units
$OC = (\mu_0 - 1)$

(ii) Healthcare systems of Blood Bank Storage cost of Holding units

$$HC = \delta_{BBHC} \left[\int_0^{t_1} \prod_{BBS}(t) e^{-(\pi_0-1)t} dt + \int_{t_1}^{t_2} \prod_{BBS}(t) e^{-(\pi_0-1)(t_1+t)} dt \right]$$

(iii) Healthcare systems of Blood Bank Storage Cost of deteriorated units

$$DC = \delta_{BBDC} \left[\int_0^{t_1} (\beta - 1)t \prod_{BBS}(t) e^{-(\pi_0-1)t} dt + \int_{t_1}^{t_2} (\beta - 1)t \prod_{BBS}(t) e^{-(\pi_0-1)(t+t_1)} dt \right]$$

(iv) Healthcare systems of Blood Bank Storage cost of Shortage units

$$SC = \delta_{BBSC} \left[\int_{t_2}^{T} - \prod_{BBS}(t) e^{-(\pi_0-1)(t_2+t)} dt \right]$$

(v) Healthcare systems of Blood Bank Storage cost of Opportunity cost due to lost sales units

$$OPC = \delta_{\mathrm{BBLSC}} \int_{t_2}^{T} \left[(\alpha_0 - 1) \left(1 - e^{-(\eta_0-1)t}\right) e^{-(\beta_0-1)y_1} e^{-(\tau_0-1)(v_2+\sigma} \right] dt$$

Therefore, the total Healthcare systems of Blood Bank Storage cost of per unit time of our model is obtained as follows:

$TCBBS\,(t_2, T) = \frac{1}{T}[$ Ordering Cost + Inbound logistics cost
+ Outbound logistics cost + Holding cost in Healthcare systems
of Blood Bank Storage + Deterioration cost + Shortage cost
+ Opportunity cost]

4. Formulation of The Model

By using Reliability Applications and Boolean algebra, the condition of efficiency of the successful operations of this Blood Bank Storage in terms of logic matrix is expressed as under:

$$\begin{vmatrix} C_1 & C_2 & C_3 & C_5 & C_6 & C_7 & C_3 & C_{10} \\ C_1 & C_4 & C_3 & C_5 & C_6 & C_9 & C_8 & C_{10} \end{vmatrix}. \tag{4.1}$$

4.1. **SOLUTION OF THE MODEL.** By using Reliability Applications and laws of algebra of logics, equation (4.1) may be written as:

$$\begin{aligned} \mathrm{F}\left(\mathrm{C}_1, \mathrm{C}_2, \mathrm{C}_3, \ldots, \mathrm{C}_{10}\right) = & \begin{vmatrix} C_1 & C_3 & C_5 & C & C_8 & C_{10} \end{vmatrix} \\ & \wedge F\begin{vmatrix} C_2 & C_4 & C_7 & C_9 \end{vmatrix} \end{aligned} \tag{4.2}$$

Here,

$$\mathrm{F}\left(\mathrm{C}_1, \mathrm{C}_2, \mathrm{C}_3, \ldots, \mathrm{C}_{10}\right) = \begin{vmatrix} C_2 & C_7 \\ C_4 & C_9 \end{vmatrix} = \begin{vmatrix} P_1 \\ P_2 \end{vmatrix} \tag{4.3}$$

$$P_1 = |C_2 \quad C_7| \tag{4.4}$$

$$P_2 = |C_4 \quad C_9| \tag{4.5}$$

$$P_1' = \begin{vmatrix} C_2' & \\ C_2 & C_2' \end{vmatrix} \qquad P_2' = \begin{vmatrix} C_4' & \\ C_4 & C_9' \end{vmatrix} \tag{4.6}$$

$$= \left(C_2' + C_2 C_7'\right)\left(C_4' + C_4 C_9'\right). \tag{4.7}$$

Using Reliability Applications and orthogonalization algorithm, equation (4.3) may be written as:

$$\mathrm{F}\left(\mathrm{C}_1, \mathrm{C}_2, \ldots, \mathrm{C}_{10}\right) = \begin{vmatrix} P_1 & \\ P_1' & P_2 \\ P_1' & P_2' \end{vmatrix} \tag{4.8}$$

$$\begin{aligned} & P_1 = |C_2 \quad C_7|, P_1' P_2 = \begin{vmatrix} C_2 & \\ C_2 & C_7 \end{vmatrix} \wedge |C_4 C_9| \\ & = \left(C_2' + C_2 C_7'\right)\left(C_4 C_9\right) \\ & = C_2' C_4 C_9 + C_2 C_4 C_7' C_9 \end{aligned} \tag{4.9}$$

$$P_1P_2' = \begin{vmatrix} C_2' & \\ C_2 & C_7' \end{vmatrix} \wedge \begin{vmatrix} C_4' & \\ C_4 & C_9' \end{vmatrix} \tag{4.10}$$

$$= C_2'C_4' + C_2'C_4C_9' + C_2C_7'C_4' + C_2C_7'C_4C_9'.$$

Using Reliability Applications and all these values in equation (4.8) one can obtain:

$$\begin{vmatrix} C_2 & C_7 & & \\ C_2' & C_4 & C_9 & \\ C_2 & C_4 & C_7' & C_9 \\ C_2' & C_4' & & \\ C_2' & C_4 & C_9' & \\ C_2 & C_4' & C_7' & \\ C_2 & C_4 & C_7' & C_9' \end{vmatrix}. \tag{4.11}$$

Using Reliability Applications and this result in equation (4.2) we have:

$$\mathrm{F}\left(\mathrm{C}_1, \mathrm{C}_3, \ldots, \mathrm{C}_{10}\right) = \begin{vmatrix} C_1 & C_2 & C_3 & C_5 & C_6 & C_7 & C_8 & C_{10} & & \\ C_1 & C_2' & C_3 & C_4 & C_5 & C_6 & C_8 & C_9 & C_{10} & \\ C_1 & C_2 & C_3 & C_4 & C_5 & C_6 & C_7' & C_8 & C_9 & C_{10} \\ C_1 & C_2' & C_3 & C_4' & C_5 & C_6 & C_8 & C_{10} & & \\ C_1 & C_2' & C_3 & C_4 & C_5 & C_6 & C_8 & C_9' & C_{10} & \\ C_1 & C_2 & C_3 & C_4 & C_5 & C_6' & C_7' & C_8 & C_{10} & \\ C_1 & C_2 & C_3 & C_4 & C_3 & C_6 & C_7' & C_8 & C_9' & C_{10} \end{vmatrix} \tag{4.12}$$

Since R.H.S. of equation (4.11) is the disjunction there for the Reliability of considered Blood Bank Storage is given by:

$$R_S = P_r\left(f\left(R_1, R_2, R_3, \ldots, R_{10}\right) = 1\right).$$

5. Numerical Illustration

To illustrate the model numerically the following parameter values are considered:

$(\alpha_0) = 275$ units, $(\mu_0) =$ Rs. 450 per order, $(\pi_0) = 0.90$ unit, $\delta_{BBHC} =$ Rs. 70.5 per unit per year, $(\beta_0) = 11.2$ unit, $(\beta) = 11.102$ unit , $\delta_{BBSC} =$ Rs. 74.5 per unit per year, $t_1 = 1.0$ year, $\delta_{BBLSC} =$ Rs. 90.0 per unit, $(\eta_0) =$ 11.10 unit, $\mathrm{T} = 1$ year.

Then for the minimization of total average cost and with help of software. the optimal policy can be obtained such as: $t_2 = 14.922103$ year, $S = 72.186012$ units and $TCBBS =$ Rs. 956.22115 per year.

VEGA: real coded, population=140, generations=142, crossover probability=13.0, mutation probability=10.5

6. Sensitivity Analysis

TABLE 1. Demand Parameter α_0

(α_0)	T	$TCBBS$
58	81.8594	248.001
50.2	81.7589	247.987

TABLE 2. Demand Parameter β_0

(β_0)	T	$TCBBS$
0.625	32.6578	380.534
0.6256	32.5783	379.354

TABLE 3. Healthcare systems of Blood Bank Storage capacity δ_W

δ_W	T	$TCBBS$
30	95.5783	197.354
35	94.5555	196.236

TABLE 4. Backlogging parameter η_0

(η_0)	T	$TCBBS$
0.55	30.859	996.001
0.54	30.758	995.987

TABLE 5. Selling price δ_{BBLSC}

δ_{BBLSC}	T	$TCBBS$
24.5	52.6578	478.534
25.9	51.7589	475.987

TABLE 6. Deterioration parameter β

(β)	T	$TCBBS$
0.72	70.8594	306.001
0.724	70.7589	305.987

Conclusion

A single item Healthcare system of Blood Bank Storage inventory control with constant replenishment rate, exponential demand rate, infinite time horizon, with exponential partial backordered rate, linearly increasing holding cost in

TABLE 7. Some sample set of data used in the implementation Reliability Applications and Boolean algebra

S.N	OC	ILC	OLC	HC	DC	SC	OC
1	400	90	85	33	30	60	30
2	99	94	86	38	34	64	34
3	440	-89	-36	38	-69	-59	-69
4	94	-85	-30	33	-68	-59	-68
5	404	-84	-68	38	-63	69	-63
6	400	94	84	32	-64	68	-64
7	90	94	89	34	30	69	30
8	445	98	86	35	34	65	34

TABLE 8. Genetic algorithm (GA) model optimal solution

WW	% change in GA			
OPT	BEST	MAX	AVG	STD
6151.16	7210.16	8210.12	4308.18	5308.10
6151.27	7211.27	8211.23	4310.26	5310.22
6151.28	7211.28	8211.23	4311.25	5311.22
6151.29	7212.29	8212.23	4315.28	5315.23
6151.59	7212.59	8212.53	4316.57	5316.56

Healthcare systems of Blood Bank Storage inventory control and with the objective of maximizing the present worth of the total system profit, was developed in this paper. The total profit function is developed using Reliability Applications and five general costs: order cost, purchasing cost, holding cost, opportunity cost and shortage cost with sales Revenue. Order cost is fixed per replenishment and holding cost is linearly increasing with time. The cost of a backorder includes a fixed cost and a cost which is proportional to the length of time the backorder exists.

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