Blood Bank Predictive Model

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Case summary and assumptions:

From the case we have below information about the **Model Blood Bank (MBB)**:

- Approximately 90% of total blood collection at MBB came through voluntary non-remunerated donations collected at blood donation camps.
- Approximately 70% to 80% of the whole blood collected, was broken into components.
- All units collected from donors at the blood donation camps were tested in the laboratory to determine whether they were safe for transfusion. The failed units(discarded) accounted for approximately 2% of the total blood collection.
- Composition of blood groups at the MBB by percentage:

Blood Type	O+	O-	A+	A-	B+	B-	AB+	AB-
Distribution	39.0%	1.0%	27.0%	0.5%	25.0%	0.4%	7.0%	0.1%

- For Red Blood Cells (RBC) and Plasma, the blood type is important, but Platelet is not specified by the blood types.

Q1-a- We assume that here we have the demand of red blood cells (RBC), by assuming that extra supply of each day is wasted, and the above information about the case, we can calculate the daily and monthly shortage and wastage. To do so, first we need to know how much of the blood would not fail in the process of disease testing and then using the percentage-making components and the blood type distribution to calculate the amount of total O+ RBC supply to compare it with the demand.

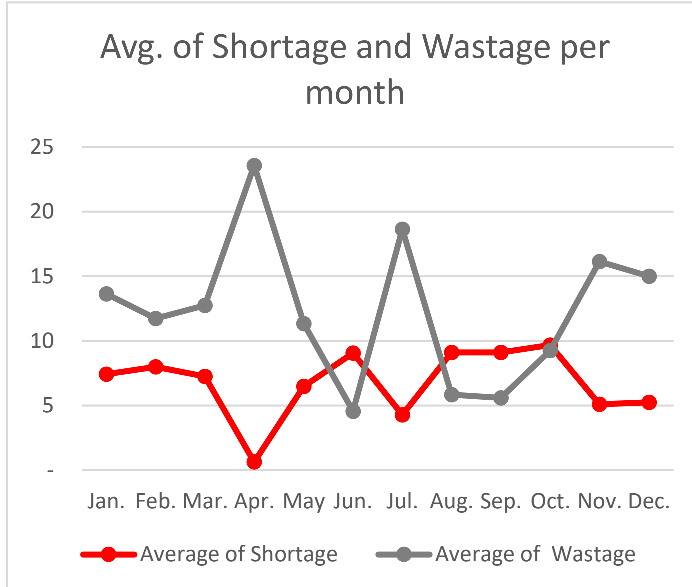
To calculate the amount of supplied blood that passes the health test, we use the case information. We knew that approximately 90% of the total supplied blood comes from the camp's donation. Moreover, we know that among camp donated blood, 2% could not pass the test. As a result, by assuming the same rate of failure for the extra 10% of the supplied blood from other methods, we could conclude that 2% of total supplied blood at the MBB could not use and discard.

Then by using case information, we know that at least 70% of the total collected blood at MBB will break into its components. We used lower bound to be safe about the shortage.

After that, based on the distribution of blood types we could calculate the number of red blood cells of blood type O+ which supplied each day. Here we assumed that the fraction of blood type in campus and other methods are the same and the table is valid for all collected blood.

By using the daily shortage and wastage column, we can calculate the average monthly shortage and average monthly wastage of each month. The results are as below:

Months	Average of Shortage	Average of Wastage
Jan.	7.4	13.6
Feb.	8.0	11.7
Mar.	7.3	12.7
Apr.	0.6	23.6
May	6.5	11.3
Jun.	9.1	4.6
Jul.	4.3	18.6
Aug.	9.1	5.8
Sep.	9.1	5.6
Oct.	9.7	9.3
Nov.	5.1	16.1
Dec.	5.3	15.0
Total	6.8	12.3



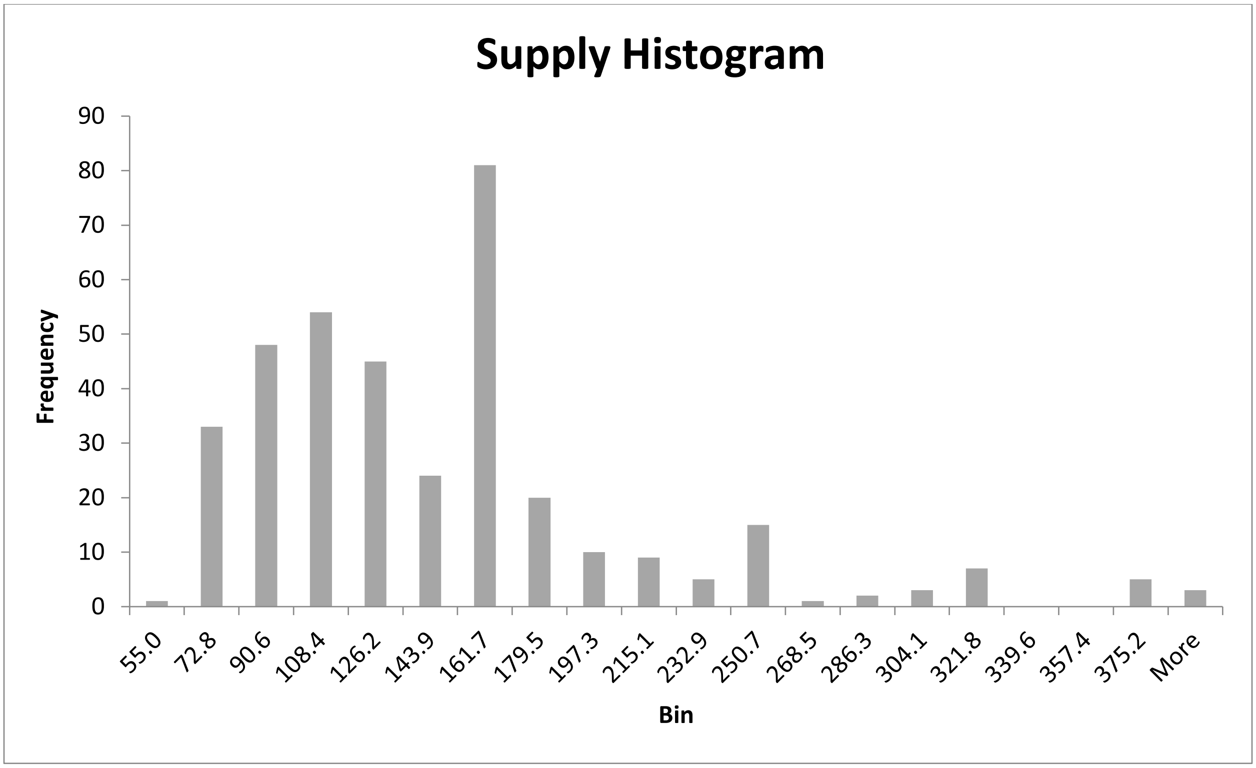
Note: The shortage is very pessimistic, and the wastage is very optimistic. Since units of blood should be an integer, we use round down formula for supply which affected the amount of shortage and wastage in oppose way. To be safe about the shortage, we use round down however using the LP-relaxation method could change the results.

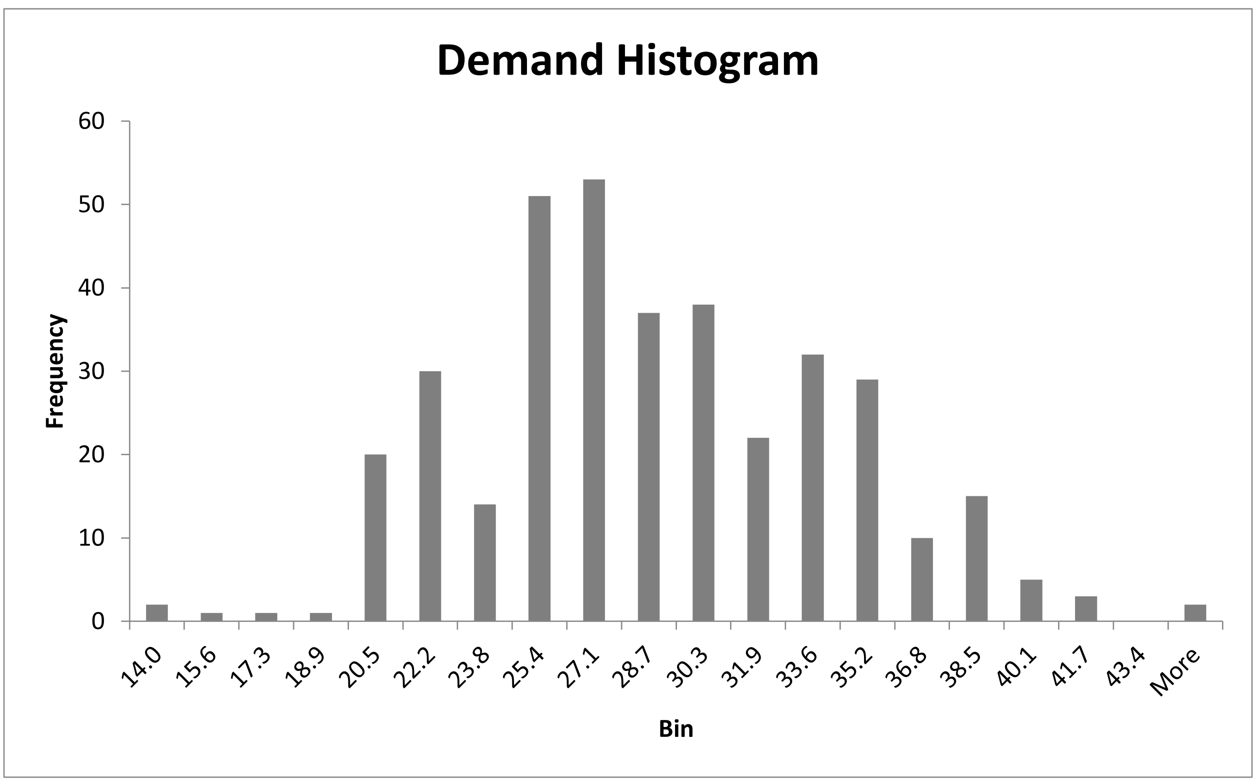
Q1-b- To conclude that there is a significate difference between the average wastage of O+ red blood cells in January and March, we need the below hypothesis:

- ✓ H_0: Average wastage of O+ RBC in January and March is the same
- ✓ H_1: There is a difference between the average wastage of O+ RBC in January and March

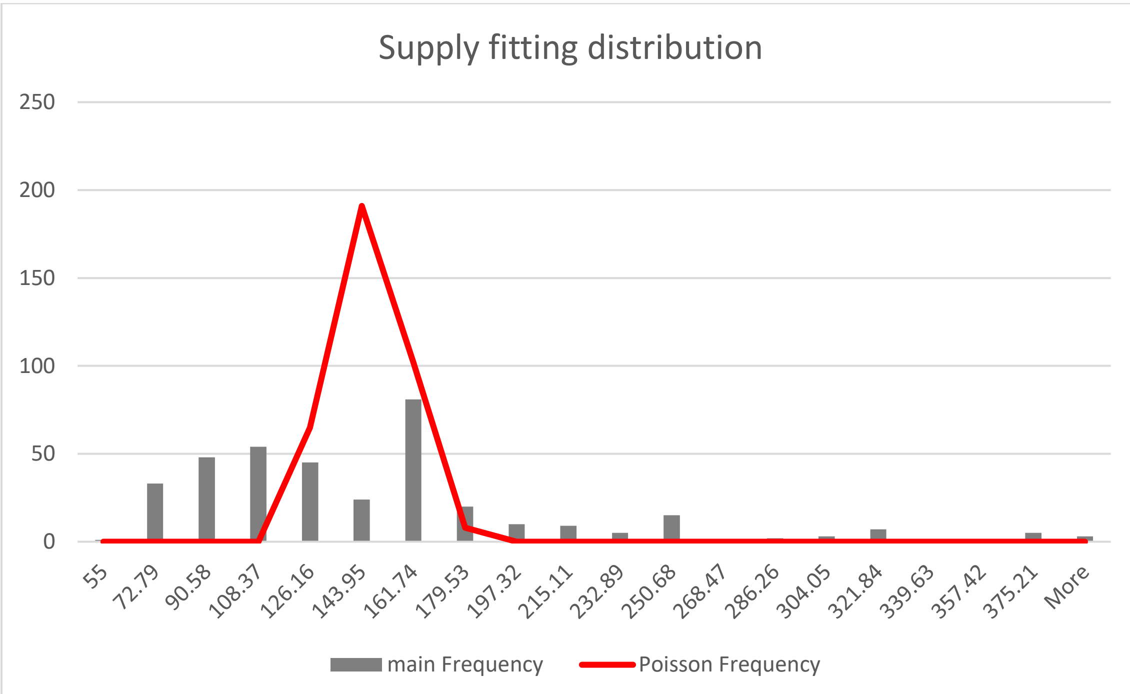
We assume that the variance in different months of the year is the same and use 95% confidence(α=0.05). As a result, by using the T-Test for these two samples' mean with equal variances from the analysis tool we could have two tail p-value=0.85 which is more than alpha=0.05. Thus, we retain the null hypothesis with 95% confidence and conclude that there is no significate difference between the average wastage of O+ RBC in January and March.

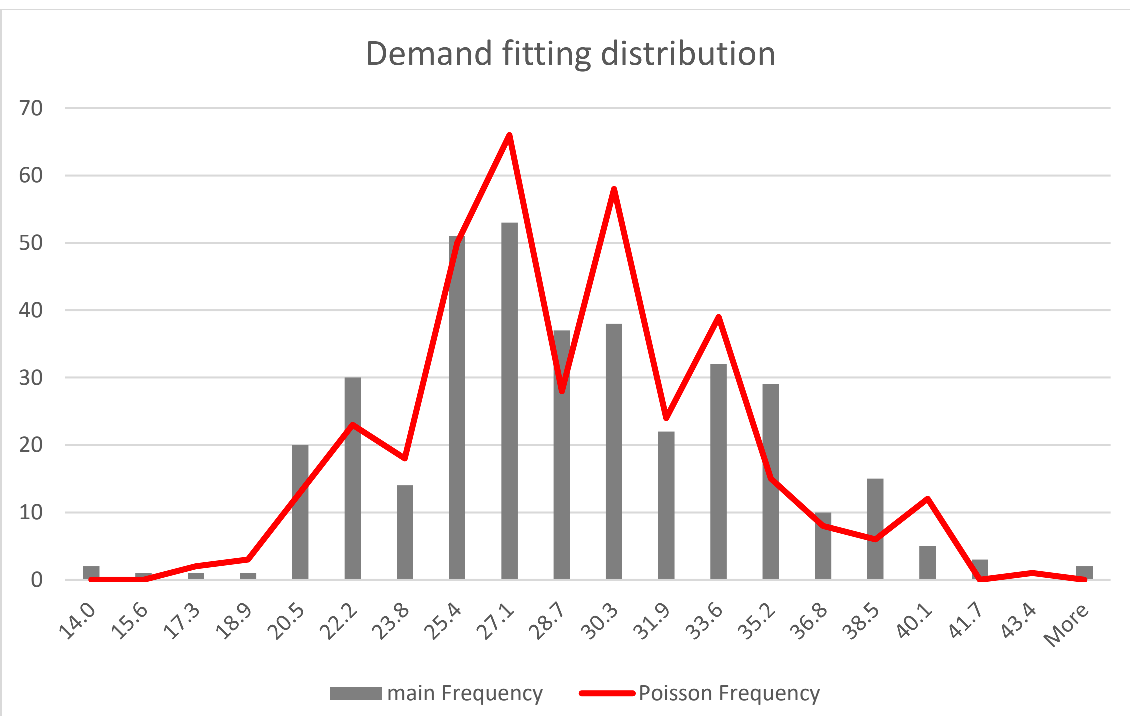
Q2-a- To graph a histogram for supply first we need to divide healthy blood and consider the fraction of blood that breaks into components. Here we don't need to consider blood type since platelet has no type. Then by using the analysis tool in excel, we could graph a histogram for supply and a histogram for demand as follow.


Supply Histogram
Frequency
90
80
70
60
50
40
30
20
10
0
55.0
72.8
90.6
108.4
126.2
143.9
161.7
179.5
197.3
215.1
232.9
250.7
268.5
286.3
304.1
321.8
339.6
357.4
375.2
More
Bin


Demand Histogram
Frequency
60
50
40
30
20
10
0
14.0
15.6
17.3
18.9
20.5
22.2
23.8
25.4
27.1
28.7
30.3
31.9
33.6
35.2
36.8
38.5
40.1
41.7
43.4
More
Bin

Q2-b- In Poisson distribution λ=μ, so if we want to fit a distribution to this data, we need to generate a Poisson distribution with the lambda= mean of the observed data and check it. To do so we use the excel analyses tool to generate random data from the Poisson distribution with desire lambda. The lambda should be equal to the mean of observed data. Here we generate 366 random numbers. Then, by using the same bin for the histogram analysis tool, the expected frequency would be found. Then, we are plotting these two graphs based on available amounts.





Visually by checking these two graphs, we could say that the Poisson distribution is not a good fit for the supply distribution, but it could be a good fit into the demand curve.

To check this assumption about the demand mathematically, we could use “CHISQ.TEST” and using a 95% confidence level. We apply a Chi-square test in µ±2S interval and using hypothesis assumptions as follow:

- ✓ H_0: Poisson distribution is a good fit for demand distribution
- ✓ H_1: Poisson distribution is not a good fit for demand distribution

By using this test, we would have p-value= 0.003 which is less than alpha=0.05 and we reject null hypothesis with 95% confidence and conclude that Poisson distribution is not a good fit for demand. However, it visually seems a good fit.

Q3-a- In this question, we want to find a general form of the model based on its assumptions in order to check and compare different results (total cost) of different inputs values as a failed percentage, separation percentage and target inventory. To do so, we need to use a general format of the model and use colours to show input cells and output amounts in the excel sheet.

First, we need to find the demand based on the assumptions.

- **supply of platelets**: $total\ collectd\ blood\ units\ at\ each\ camp * (1 - failed\ percentage) * (percentage\ of\ separation\ into\ components)$
- **Failed blood units’ percentage**: in the process of quality testing of the blood units, some of them are failed.
- **Separation into components percentage**: a narrow percentage of blood units can be separated into platelets

Input cells address have been used to have a general format and being able to change inputs and compare the outputs.

Then, based on the cost assumptions and the inventory target, we create two columns for “Daily shortage cost” and “Daily over Inventory” costs.

  - **Over inventory cost: 1** per blood unit
  - **Shortage cost: 5** per blood unit
  - **Cost of over inventory** = the cost for keeping any blood units beyond the inventory capacity

For the next step, we create an output cell for the total cost as:

- ✓ **Total cost** = total cost of shortage + total cost of over inventory

By using the targeted amounts of each input in the input cells, we would have 18 possible outputs (which are available in sheet Q3-a). The results show that the minimum total cost is minimum between these 18 situations in case 17 based on the following input amounts.

Case17

Failed percentage:	60%
Separation percentage:	40%
Target Inventory:	500
Total shortage cost:	355
Total over inventory cost:	92,702
Total cost:	93,057

Q3-b- This time we change our assumption and assume blood products are perishable which means that the supply amount should be used on the same day and after that it is wasted. Also, we set out input amounts as follow:

Failed percentage:	60%
Separation percentage:	60%
Target Inventory:	100

Based on these assumptions we made three columns as “Daily Shortage”, “ Daily Wastage” and “Daily inventory/Shortage”

By using the same assumptions about costs, we could have the below outputs:

Over inventory cost:	1	per blood unit
Shortage cost:	5	per blood unit
Total shortage cost:	1945	
Total over inventory cost:	40	
Total cost:	1985	
Average Shortage:	1.1	
Average Wastage:	21.0	

Q3-c- This time we assume “the platelets expire after 2 days”. This means that if the oversupplied amount in each day doesn’t use for the next day’s shortage, it would be the wastage. Thus, by using “first of day inventory”, “On day shortage” and “last inventory”, we find “Daily shortage” and “Daily Wastage”. Also, by assuming the below assumptions, the output would be as below:

Over inventory cost:	1	per blood unit	Total shortage cost:	750
Shortage cost:	5	per blood unit	Total over inventory cost:	40
Failed percentage:	60%		Total cost:	790
Separation percentage:	60%		Average Shortage:	0.41
Target Inventory:	100		Average Wastage:	20.33