Model of a Fair Blood Allocation System in Transfusion Haematology

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Summary: A mathematical model that targets the problem of fair allocation of blood units collected for blood transfusion. We propose an approach for allocation and reservation of collected blood units that objectively renders account of the compatibility of donor / recipient blood types, the shortage or availability of options for recipients, weighted with the actual frequencies of the blood groups' distribution in a given human population.

Introduction

Transfusion hematology faces some major problems and challenges, among them:

- safety and compatibility of blood products
- managing blood shortages
- supply chain issues preventing transfusion reactions,
- addressing the risk of transfusion-transmitted infections

Donor/recipient compatibility per blood group

		Recipient							
		O-	O+	A-	A+	B-	B+	AB-	AB+
Donor	O-	🩸	🩸	🩸	🩸	🩸	🩸	🩸	🩸
	O+		🩸		🩸		🩸		🩸
	A-			🩸	🩸			🩸	🩸
	A+				🩸				🩸
	B-					🩸	🩸	🩸	🩸
	B+						🩸		🩸
	AB-							🩸	🩸
	AB+								🩸

Generic mathematical model

		Recipient							
		O-	O+	A-	A+	B-	B+	AB-	AB+
Donor	O-	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
	O+		0.250		0.250		0.250		0.250
	A-			0.250	0.250			0.250	0.250
	A+				0.500				0.500
	B-					0.250	0.250	0.250	0.250
	B+						0.500		0.500
	AB-							0.500	0.500
	AB+								1.000
Sum per column:		**0.125**	**0.375**	**0.375**	**1.125**	**0.375**	**1.125**	**1.125**	**3.375**

Iteration 1/3: Allocation of donatable blood per blood group into equal shares
for the compatible recipients (per row, red) and summation of the shares (per column, blue)

Generic mathematical model

		Recipient							
		O-	O+	A-	A+	B-	B+	AB-	AB+
Donor	O-	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
	O+		0.125		0.125		0.125		0.125
	A-								
	A+								
	B-								
	B+								
	AB-								
	AB+								
Sum per column:		0.125	0.375	0.375	1.125	0.375	1.125	1.125	3.375

Step 1/3: Allocation of donatable blood per blood group into equal shares for the compatible recipients (per row, red) and summation of the shares (per column, blue)

Outline the relative capacity

		Recipient								*Sum per row:*
		O-	**O+**	**A-**	**A+**	**B-**	**B+**	**AB-**	**AB+**	
Donor	**O-**	1.000	0.333	0.333	0.111	0.333	0.111	0.111	0.037	**2.369**
	O+		0.667		0.222		0.222		0.074	**1.185**
	A-			0.667	0.222			0.222	0.074	**1.185**
	A+				0.444				0.148	**0.592**
	B-					0.667	0.222	0.222	0.074	**1.185**
	B+						0.444		0.148	**0.592**
	AB-							0.444	0.148	**0.592**
	AB+								0.296	**0.296**

Iteration 2/3. Receivable shares of blood from donor/recipient compatible groups (Table 1: normalization per column, blue) and their summation (per row, green)

Fair allocation

		Recipient							
		0-	0+	A-	A+	B-	B+	AB-	AB+
Donor	0-	0.422	0.141	0.141	0.047	0.141	0.047	0.047	0.016
	0+		0.563		0.188		0.188		0.063
	A-			0.563	0.188			0.188	0.063
	A+				0.749				0.250
	B-					0.563	0.188	0.188	0.063
	B+						0.749		0.250
	AB-							0.749	0.250
	AB+								1.000
Sum per column:		**0.422**	**0.703**	**0.703**	**1.171**	**0.703**	**1.171**	**1.171**	**1.954**

Iteration 3/3. Fair allocation of shares of donatable blood per blood group
to recipients from compatible blood groups (Table 2: normalization per row, green)

A curious observation

We notice that the sums per column (yellow row) maintain the ratio of 1.666 (5/3) which is curiously close to the Golden Ratio ($\varphi \approx 1.618$), connecting the members of the Fibonacci sequence

Discussion of the results

		Recipient							
		0-	0+	A-	A+	B-	B+	AB-	AB+
Donor	0-	0.422	0.141	0.141	0.047	0.141	0.047	0.047	0.016
	0+		0.563		0.188		0.188		0.063
	A-			0.563	0.188			0.188	0.063
	A+				0.749				0.250
	B-					0.563	0.188	0.188	0.063
	B+						0.749		0.250
	AB-							0.749	0.250
	AB+								1.000
Sum per column:		**0.422**	**0.703**	**0.703**	**1.171**	**0.703**	**1.171**	**1.171**	**1.954**

Iteration 3/3. Fair allocation of shares of donatable blood per blood group to recipients from compatible blood groups (Table 2: normalization per row, green)

Thank you for your attention!

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