ResearchUnit #50

Collected in **February 2019**

One in a million: Modelling rare blood flow

What is this research about?

Blood type is determined by whether specific molecules (called antigens) are present or absent on the surface of red blood cells. There are over 300 red blood cell antigens and over 30 blood group systems, including the well-known ABO and Rh groups. Some combinations of antigens are far less common than others, making some blood types rarer than others. Blood is considered rare if the combination of antigens is only found in one person in 500, and is very rare if only found in one person in 1000.

It can be very difficult to find a suitable donor when a person with rare blood requires a transfusion. To help meet the needs of patients with rare blood types, Canada, like many countries, has established a rare blood program. This program identifies rare blood types through screening and extensive testing of a donor's blood to understand the exact make up of their red blood cell antigens. Canadian Blood Services keeps a registry of identified rare blood donors, encourages them to donate regularly and have their family members' blood types tested, and keeps frozen stocks of rare blood. The Canadian Blood Services' rare blood program manages 29 different rare blood types identified from 1800 rare blood donors and it stores approximately 800 units of frozen rare blood across the country.

When someone with a rare blood type donates, their donation is flagged. The red blood cell unit is initially held in liquid inventory in case there is a need for that specific type of blood. If the blood isn't requested by the midpoint of a unit's shelf life of 42 days, the units are sometimes frozen so they can be available if needed in the future. Two weeks before the end of shelf life, any rare blood unit that has not been frozen leaves the rare blood inventory and enters the regular inventory stream, so that it can be transfused to any compatible patient in need and doesn't go to waste.

IN BRIEF: Keeping modest amounts of frozen inventory of rare blood types, combined with increased donor screening, provides the greatest chance of ensuring that Canadian patients with rare blood have access to red blood cell transfusions when they need them.

It is challenging to know whether to freeze a rare blood unit or not. In this study, the researchers used analytical modelling and simulation to investigate how best to manage liquid versus frozen inventory of rare blood types to ensure optimal patient access to rare blood.

Canadian Blood Services
BLOOD PLASMA STEM CELLS ORGANS & TISSUES

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What did the researchers do?

The researchers asked how rare a blood type must be, before a frozen inventory is needed. To do this, they analyzed supply and demand for rare blood types. They identified the minimum donor screening rates needed to ensure a stable supply of rare blood types. A simulation model was then used to understand how having a frozen inventory impacts patient access to rare blood.

Using information about rare blood donors in Canada, the researchers ran a set of 29 simulated scenarios. Each scenario consisted of a rare blood type, its frequency within the Canadian population, the number of known donors (if any) as of November 2016, and the amount of frozen inventory (if any) on hand. They tested frozen inventory limits of 0, 2, 4, or 6 units each of blood types O+, O−, A+, and A−.

What did the researchers find?

Looking at the flows of rare blood into and out of frozen and liquid inventory, the researchers found that for 27 of the 29 rare blood types managed by Canadian Blood Services, the number of known donors with that type of blood is lower than the mathematically-calculated minimum number needed to ensure a stable flow. That means not enough donors with the rare blood type have been identified to ensure a stable inventory.

In general, the researchers found a greater delay in patient access to blood as the rareness of the blood type increased.

However, their results show that in some scenarios, patient delay is not affected by the rareness of the blood because enough rare donors had been identified through programs to test near relatives of rare donors for similar blood types. The study also found that to avoid patient delay in accessing blood with a frequency rarer than 1 in 3000, some amount of frozen inventory is necessary. This ensures that units are available when a request for that blood type is made. Having at least 2 units of frozen blood led to a significant decrease in patient delay. However, holding more than two units apiece of O+, O−, A+, and A− blood did not reduce delays in patient access.

How can you use this research?

Anyone can have a rare blood type, and patients who require rare blood transfusions and rare blood donors are essentially the same population. Maximizing patient access to rare blood types requires a careful balance of screening to identify rare donors, programs to register and retain rare donors, and the use of frozen inventory to smooth the inevitable mismatches between supply and demand. This study showed that while some level of frozen blood is needed to buffer fluctuations in supply and demand for rare blood, large inventories are unlikely to improve access. Instead, the results suggest that modest amounts of frozen

inventory, combined with increased donor screening, provides the greatest chance of ensuring that Canadian patients with rare blood have access to red blood cell transfusions when needed.

This study helped the Canadian Blood Services rare blood program determine the optimal minimum and maximum number of frozen units for each rare blood type to keep in storage. This helps the program to operate more efficiently, and could bring cost-savings, as maintaining stores of frozen blood is more expensive than fresh blood. Strikingly, this study predicts that the best way to ensure adequate supplies of rare blood is to test a much higher proportion of Canadian Blood Services donors for rare blood types. Canadian Blood Services is exploring new technologies such as next-generation sequencing, which would allow extended testing of many more donors to identify rare blood donors and ensure we can continue to meet the needs of patients with rare blood.

About the research team: Gwen Clarke is a Canadian Blood Services associate medical director and a clinical professor in the department of laboratory medicine and pathology at the University of Alberta. **John Blake,** is an associate professor in the department of industrial engineering at Dalhousie University and a research engineer at Canadian Blood Services.

This ResearchUnit is derived from the following publication(s):

[1] Blake JT, Clarke G: Modeling rare blood in Canada. Transfusion 2019; 59:582-592.doi: 10.1111/trf.15027

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ResearchUnit is a knowledge mobilization tool developed by Canadian Blood Services' Centre for Innovation. It is available online at blood.ca