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SUPPLY CHAIN

AUTHORS
Joanna Dobbin
Prof Richard Wilding
Sue Cotton

True Blood: challenges of the blood supply chain in England

Some supply chains really are a matter of life and death. This fascinating article investigates the vital flow of our blood supply chain.

The collection, processing, testing and delivery of blood to hospitals within England is facilitated by the National Health Service Blood and Transplant (NHSBT). In 2008, it collected 1.9 million units of whole blood from 1.4 million donors to be tested, processed and given to patients in 294 hospitals across England and North Wales. The blood supply chain – see Figure 1 – is a fascinating system, in which blood given on a purely voluntary basis is distributed to patients suffering from a variety of illnesses. The careful management of the supply chain is essential, and the balance of supply and demand is a matter of life and death. This article gives an overview of the blood supply chain, looking at the types and movement of blood components and information, relationships involved and the problems that are present in the system.

Donation

Since the late 1970s, most developed countries employ a volunteer-only basis for blood donation. Blood is either collected through mobile teams – approximately 90% of collections – who visit places such as universities and office blocks, or at static donor centres. NHSBT has a donor base of 1.4 million. A lot of emphasis is placed on making the experience of donation a pleasant one in order to retain donors. A large percentage of blood collected comes from repeat donors – that is, those who have donated blood in the past two years – while the rest is through first-time donors. This compares to other countries, for example, China, where over 90% of their blood comes from first-time donors. Once they have registered, donors are encouraged to donate two or three times a year through blood group-specific mail and telephone calls.

The donation process for whole blood lasts around 45 minutes. Donors arrive, are screened, donate their blood, which takes about five minutes, and then are asked to remain, and are offered refreshments, in order to ensure that no adverse effects occur. A single unit of whole blood – 470ml, just less than a pint – is taken from a donor during a session, along with three sample tubes that are later used for testing the blood.

The screening process involves answering a number of questions that focus on health, lifestyle choices and travel, which over the years have become increasingly stringent. All potential donors also have a health check given by a nurse, in which their haemoglobin level is checked to see if they have a sufficient amount of iron – which absorbs oxygen – in the blood to donate. This is done through a prick to the finger, allowing a drop of blood to fall into solution, where is either sinks, if it has sufficient iron, or remains at the surface, in which case the donor is deferred for further investigation.

The whole blood is sent for processing, where it is split into three main components: red blood cells (RBC), which carry oxygen in the body; platelets, which are essential for clot formation; and plasma, which is also used for clotting and to replace large volume loss. These can then be broken down into further specialist products – for example, neonatal products and blood that contains rare antibodies.

Processing and testing

Once whole blood is collected, it is delivered to a processing centre. There are currently 10 processing centres based around England. However, NHSBT is under going a consolidation process at the moment, moving to fewer larger processing centres, while the rest will remain as distribution centres, distributing blood to hospitals.

Platelets – short shelf life

There are two ways in which platelets can be collected: pooling of four units of buffy coats; or two to three units can be collected at once from a single donor through apheresis. NHSBT has a target for 80% collection through apheresis, as it reduces the exposure of the patient to various donors, reducing the risk of adverse reactions. The process of collection of apheresis platelets spins the whole blood through a centrifuge, removing the platelets, and returns the remaining blood to the donor. The process takes much longer than for whole blood (around 90 minutes), but the donor can give more regularly, once a month.

Platelets are a part in blood that help clotting to occur. A unit of platelets has a platelets count of above 240x109. Around 220,000 units are issued to hospitals by NHSBT annually. They must be stored between 20°C and 24°C on a special agitator rack, which keeps them moving and thus prevents them from clotting. Platelets have an extremely short shelf life of only five days. Their main use is in haematology/oncology and massive haemorrhage. Due to their short shelf life, platelets must be managed in a more responsive way than RBCs. Due to fewer collections at the weekend, stocks must be built up leading up to a Friday, to ensure that there is not a shortage over the weekend – this is even more of a challenge for bank holiday weekends – thus collection targets vary with each day of the week. Collection targets for platelets, in fact, also specify blood group targets. This can be done for platelets as opposed to whole blood, as 80% are collected through apheresis, which are kept appointments, and the relationship between the donor and NHSBT is a stronger one. The 80% apheresis target also allows for flexibility in demand, as any excess demand can be accommodated for through pooling extra platelets. Males, particularly those who are A+, are recommended to become platelets donors, in which case they can donate two to three units of platelets every month.

The blood supply chain

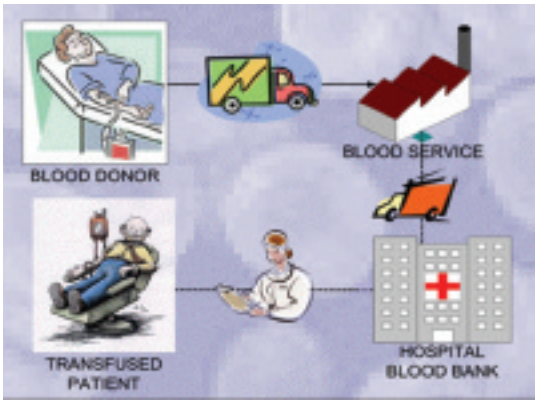

Figure 1

When whole blood arrives, it is checked into the centre electronically through the scanning of bar codes. The sample tubes are sent for testing, and the whole blood to processing. The blood is put through a centrifuge, which separates it into three components: RBC, a buffy coat and plasma.

Mandatory tests are performed on the blood for blood group, microbiology screening and quality monitoring. Once testing is completed, the results are sent electronically to processing, so that the relevant units of blood can be labelled with their blood group ready for issue to hospitals. NHSBT has an ideal stock level of 40,000–50,000 units of RBCs, which equates to a national stock of approximately seven days. Each centre has a first-in, first-out (FIFO) inventory policy, so the stock level directly affects the remaining shelf life of the RBCs when they are issued to hospitals. There is a service level agreement with hospitals for blood not to be issued to hospitals with less than 12 days to expiry, which has led to wastage of blood by NHSBT in the past when stocks have been very high. A small percentage of blood remains within NHSBT to be used for research.

Transfusion

Hospitals hold their own supply of stock of RBCs and fresh frozen plasma (FFP), and a few of the larger hospitals also hold stock for platelets. It is estimated that within the supply chain around 50% of stock of RBCs is in NHSBT and 50% is held within hospitals. Hospitals receive a number of routine deliveries a week, depending on their size, with the largest receiving several each day. These deliveries are included in the price of the products and the same for all hospitals, regardless of location.

The cost of the products is related directly to NHSBT's costs for processing and transport. A unit of RBCs is about £140, platelets about £220, and plasma about £100. If a hospital plans carefully, then these routine deliveries should provide a sufficient supply of blood. In case of an emergency, a hospital can request an ad hoc delivery, which will be sent out immediately for a charge of approximately £50. If best use is made of the routine deliveries, then, except for emergencies, hospitals should not need to use ad hoc deliveries. However, due to the relatively low cost of an ad hoc delivery, some hospitals use it as a regular delivery service.

Once blood arrives at a hospital, it is checked into the main laboratory fridge. Once a clinician requests a unit of blood for a patient, the blood must first be cross-matched with a sample of the patient's blood to ensure that it is compatible. The compatible blood is then reserved for the patient for a period of 24–72 hours. If the hospital is large, the blood will be moved to a satellite fridge closer to the patient during this time. A significant development within hospitals is the 'electronic issue' fridges, which enable a much quicker, electronic testing to see if blood is compatible, freeing up stock that was previously tied to a single patient for 24–72 hours.

In general, each hospital – or hospital trust, usually one or two hospitals – operate as an independent organisation. However, a number of smaller hospitals

Red blood cells – medium shelf life

RBCs are fast-moving products for NHSBT, and hence managed in a lean way that focuses on efficiency. They are split into the eight main blood groups – see Table 1. A unit of RBCs consists of 270ml, and around 1.8 million units of RBCs are issued annually to hospitals. Within hospitals, they are used in haematology/oncology, general medicine, cardiothoracic surgery, casualty and orthopaedics. They have a shelf life of 35 days, and must be stored between 2°C and 6°C. The longest time that they can be out of a temperature-controlled area is 30 minutes. Collection targets for RBCs are set weekly to try to keep the national stock level between the desired levels. Targets are not blood group specific, although collection levels of each group do coincide approximately with population figures. However, marketing campaigns do treat different blood groups differently. If there is a shortage in a specific group – usually O- and B-, due to the percentage demand for both being slightly higher than their natural abundance in the population – registered donors are sent more urgent communications inviting them to donate. Contrarily, group AB is not desirable for RBC – whole blood – donation, as an AB patient can receive any blood group, but A's can only be given to other ABs, resulting in high stock levels. To try and encourage hospitals to take AB stock, they are not charged for wastage.

Percentages of the population in England that have each type of blood group

Blood type	% of population
O+	37
O-	7
A+	35
A-	7
B+	8
B-	2
AB+	3
AB-	1

Table 1

Blood is either collected through mobile teams – approximately 90% of collections – who visit places such as universities and office blocks, or at static donor centres. Pictured is the Bristol area 'blood mobile'.

operate a stock sharing system with a larger hospital, in which a larger hospital will take a unit of blood if a smaller hospital is not going to use it in order to decrease the likelihood of time expiry. RBC wastage as a percentage of issue within hospitals currently averages between 2% and 4%.

Transparency and trust

NHSBT manages the supply chain from donation up until the point where the blood is delivered to the hospitals. After that, each hospital is individually responsible for the fate of the blood. This creates the issue of limited visibility down the supply chain, and as hospitals do not share data with each other, there is no horizontal visibility at the end of the supply chain either. The only back communication from hospitals is through the Blood Stocks Management Scheme (BSMS), which run a data management system called VANESA, into which hospitals can enter their wastage data by group and product. The entering of this information is, however, voluntary, and only 208 of the 294 hospitals that NHSBT serve currently enter data regularly.

Reduced visibility means that NHSBT has no, or limited, knowledge of wastage, mismatching – that is, if a unit of blood other than the patient's blood type is transfused – or why units are transfused. This can lead to feedback loops – for example, higher stocks – and a higher average age of issue, which can raise wastage. This would appear to NHSBT as an increase in issues, which might be read as an increase in demand. A 'fate of donation' project is currently being developed in order to give NHSBT point of sale data, and a greater insight into the reasons for transfusion.

One of the major challenges across the blood supply chain is one of collaboration. Despite all belonging to the wider NHS, NHSBT and each hospital functions independently with regard to working practices and financial budgets. Even within a hospital, segmentation occurs, with pressure coming from many directions.

It is important for a focus to develop, so that all areas of the supply chain can work together, and events, such as the BSMS open meeting, bring people from various hospitals and NHSBT together to highlight and discuss any issues. Initiatives such as the BSMS data transparency, which allows hospitals to compare wastage figures with their peers, help to develop and maintain relationships and traceability across the supply chain.

Time

The shelf life of a unit of RBCs is 35 days and of platelets is five days; FFP can last a year. Due to the short shelf life of these products, speed through the supply chain is an essential issue: 75% of wastage of RBCs, and over 95% for platelets, is due to time expiry. The processing time for a unit of RBCs is around two days, depending on the location of the hospital and the processing centre. However, this does not include the activation time to mobilise donors, which is harder to map. Radio and television ads are used in times of shortages, and the messages given to donors are altered to encourage speedier donation. However people are unpredictable, so predictability in procurement is very hard to maintain.

The process of collecting platelets through apheresis means that minimal processing needs to be performed on the components once they have been collected. Testing must still be performed, but the platelets themselves need only be split into individual units, taking a minimal time to process into a ready-to-use component. Despite the difference in process, apheresis platelets are moved through the supply chain the same as whole blood is, meaning that they are already on the second day of a give-day shelf life when they are ready to be issued to hospitals. The short shelf life of platelets means that hospitals often receive them with one day or no days to expiry, which makes the holding of stock difficult and can have an impact on patient care.

This problem is exacerbated by the low cost of ad hoc deliveries compared with wastage. One of the

major challenges within the blood supply chain is that wastage for platelets is high, and currently sits at around 9% within NHSBT, costing around £4 million a year, with a further £2 million occurring within hospitals. This wastage is over 95% time related, either expiring with NHSBT, before it can be sent to a hospital, or it being surgically or medically ordered for a patient by a hospital as a precaution, and the unit is not being used and expiring before it can be given to another patient.

Conclusion

Three of the major challenges within the blood supply chain are: collaboration between the various stakeholders, time and wastage; and demand outstripping supply due to a falling donor base.

A lot of the issues surrounding the blood supply chain are related to the disjointedness of different areas. Relations between NHSBT and hospitals are sometimes challenging, and individual areas often look at the own gain, rather than the system as a whole. Regulatory requirements provide a lot of pressure, and stricter guidelines for donation have an impact on the donor base, meaning that continuous improvement to the efficiency of the supply chain to ensure minimal wastage is essential.

Acknowledgement

This work has been done as part of a Knowledge Transfer Partnership (KTP) between the Blood Stocks Management Scheme (NHS) and Cranfield School of Management Centre for Logistics and Supply Chain Management, focusing on demand planning and waste reduction within the blood supply chain.

Further details on KTP, web site: www.ktponline.org.uk

Fresh frozen plasma (FFP) – long shelf life

Around 360,000 units of fresh frozen plasma (FFP) are issued to hospitals every year. FFP is widely used in cases of major haemorrhage, and is used to replace factors lost through bleeding that are essential for clotting. It is stored at -30°C, and has a frozen shelf life of two years. It takes around 30 minutes to thaw, and once thawed it must be used within 24 hours.

About the authors

Joanna Dobbin is a Knowledge Transfer Partnership Associate working with the Blood Stocks Management Scheme and Cranfield School of Management. Email: **joanna.dobbin@nhsbt.nhs.uk**

Professor Richard Wilding is Professor of Supply Chain Risk Management at the Centre for Logistics and Supply Chain Management at Cranfield School of Management, UK. He is currently supporting the Blood Stocks Management Scheme through the Knowledge Transfer Partnership. Email: **www.richardwilding.info**

Sue Cotton is manager of the Blood Stocks Management Scheme. Email: **sue.cotton@nhsbt.nhs.uk**

Further information, web site: **www.bloodstocks.co.uk**

Further reading

Two papers were presented at the recent Logistics Research Network Conference in Cardiff:

DOBBIN, J, WILDING, R and COTTON, S, 'The application of time-based analysis of the platelets supply chain', *Proceedings of the 14th Annual Logistics Research Network Conference, 9th–11th September 2009*, CILT(UK), 2009

DOBBIN, J, WILDING, R and COTTON, S, 'An exploration of blood and blood component demand drivers in England', *Proceedings of the 14th Annual Logistics Research Network Conference, 9th–11th September 2009*, CILT(UK), 2009

Further information

This paper was first delivered as a presentation at this year's LRN Conference. See report on page 41 for more details.

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U-boat across the Mersey

How Mersey Ferries won the battle for survival – see page 20