Segregation of blood inventory: A key driver for optimum blood stock management in a resource-poor setting

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Abstract

Background: Blood inventory management entails maintaining a delicate balance between guaranteeing blood availability and minimizing wastage. The study was conducted to identify and analyze various factors of wastage which can provide insight to ideal inventory management, thus help in formulating policies and improve efficiency of blood transfusion services. **Materials and Methods:** The study was conducted in a tertiary care hospital. To determine various causes of wastage, a retrospective analysis was done over 6 months and preventive strategies adopted. Issuable stock index (ISI) and wastage as percentage of issue (WAPI) were used to compare the effect on blood inventory before and after adoption of strategies. The average number of times each ABO group and Rh type was crossmatched before final transfusion was calculated and compared for randomly selected units over the first 6 months of 2012 and 2013. **Results:** Outdating was found to be the largest cause, and decrease in discarding rate was observed after adoption of strategies. Mean ISI for different study periods was comparable. However, significant decrease ($P = 0.015$) was observed for WAPI and WAPI with respect to outdating. Significant decrease in average number of times a unit was crossmatched before final transfusion for all positive blood groups and O-negative blood group was observed over corresponding first 6 months of 2012 and 2013. **Conclusion:** Division of inventory into two parts, enlistment of soon to outdate blood components, and reduction of holding of blood units to minimum period for elective surgery patients are simple measures which can minimize wastage.

Key words: Blood inventory, outdating, strategy

Introduction

Blood inventory management entails maintaining a delicate balance between guaranteeing maximal availability of blood and at the same time minimizing wastage. Wastage can occur at many points across blood supply chain. Identification and analysis of various factors of wastage can provide insight to ideal inventory management, thus help in formulating policies

and improve efficiency of blood transfusion services. We present our experience with blood inventory management at our blood center over 1½ years.

Materials and Methods

The study was conducted in the Department of Transfusion Medicine of a tertiary care teaching hospital. A retrospective analysis was done over 6 months from January to June 2012 to analyze the various causes of wastage of blood units. All blood units discarded due to various reasons–exceeding

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their shelf life, undercollected units (<10% of the desired volume), late receive back units (units outside the cold chain for more than 30 min after issue from the blood bank), rupture or leakage during blood component preparation and discolored blood units. Transfusion transmitted infections reactive units were excluded from the study. Based on these results, corrective and preventive strategies [Table 1] were planned and adopted.

Two parameters, issuable stock index (ISI) and wastage as a percentage of issue (WAPI),[1] were used to compare the effect on blood inventory before and after adoption of these strategies.

ISI was an approximation of the number of days of unreserved stock of all blood groups held in the inventory.

$$ISI = \frac{\text{Number of unreserved red cell units of all groups}}{\text{Number of red cells issued in a month / number of days of the month}}$$

$$WAPI = \frac{\text{Number of units wasted}}{\text{Number of units issued}} \times 100$$

ISI and WAPI were compared for the first 6 corresponding months of 2012 and 2013, i.e., January to June 2012 and January to June 2013.

The average number of times each ABO group and Rh type was crossmatched, not transfused, and returned to available inventory before final transfusion was calculated and compared for randomly selected units over the first 6 months of 2012 and 2013. For randomization, over 6 months, each consecutive day of the week was selected for evaluation (all Mondays of January, all Tuesdays of February, all Wednesdays of March, all Thursdays of April, all Fridays of May, and all Saturdays of June). The first and the last unit of morning blood inventory of the corresponding day of each positive blood group while only first unit of morning blood inventory of the corresponding day of each negative group was selected. Thus, in all, 48 units of each positive group and 24 units of each negative group were randomly selected.

Statistical analysis

The statistical analysis was carried out using Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, version 17.0 for Windows). Mean and medians were calculated for all quantitative variables and standard deviation was calculated for measures of dispersion. Normality of quantitative data was checked by measures of Kolmogorov–Smirnov tests of normality. For normally distributed data (average of each type

blood collected), means of two groups were compared using Student's *t*-test. For skewed data WAPI, Mann–Whitney test was applied. Qualitative or categorical variables were described as frequencies and proportions. Proportions were compared using Chi-square or Fisher's exact test. All statistical analysis tests were being two-tailed and $P < 0.05$ was taken as statistically significant.

RESULTS

During 1½ year study period, a total of 20,517 units of blood were collected. Of 6352 units of blood collected over the first 6 months of the year 2012, 254 (4%) units were discarded. Of these 254 units discarded, outdating was found to be the largest cause [45.7%, $n = 116$; Table 2].

After adoption of inventory management strategies, there was a decrease in overall discarding rate (2.19%) and discarding due to outdating of units (23.2%). A significant decrease ($P \leq 0.0001$) in discarding rate and outdating of units

Table 1: Blood inventory management strategies

Segregating the blood inventory into two parts (1-15 and 16-35 days of collection)

  Crossmatching units of 16-35 days of collection for clinical conditions where blood is likely to be issued

  Crossmatching blood units of 1-15 days of collection for patients where it is less likely to be issued

  Crossmatching of fresh blood (<7 days of collection) wherever scientifically recommended (e.g., cardiac surgery, thalassemia, neonatal exchange)

Report of soon to outdate blood components should be generated

Reducing the holding period of blood units in blood bank from 72 to 48 h for all elective surgery patients where blood is not issued within 48 h

Strictly following first in, first out issue policy in the respective two groups of inventory

Table 2: Causes of discarding from January to June 2012

Cause	Explanation	Contribution to total wastage January to June 2012 (%) (n=254)	Contribution to total wastage January to June 2013 (%) (n=161)
Outdating	Units exceeding their shelf life	45.7 (n=116)	15.5 (n=25)
Late receive back (out of temperature control outside laboratory)	Blood units outside the cold chain for >30 min after issue from blood bank	12.2 (n=31)	19.9 (n=32)
Under collection	Volume of blood units <10% of the desired volume	10.6 (n=27)	18 (n=29)
Miscellaneous	Wastage not classified in the other categories such as leakage or rupture during processing	31.5 (n=80)	46.6 (n=25)

was observed when first 6 months of 2 consecutive years of the study period were compared [Table 3].

Mean ISI for the different study periods (4.08 for period of January 2012 to June 2013; 3.6 for January 2012 to June 2012; and 4.75 for January 2013 to June 2013) was comparable. A significant decrease ($P \leq 0.015$) was observed for WAPI and WAPI with respect to outdating [Figures 1 and 2].

Similar significant results for WAPI with respect to outdating ($P \leq 0.001$) were observed on comparison of corresponding first 6 months of 2012 and 2013 [Figure 3].

On randomization, a significant decrease in average number of times a unit was crossmatched before final transfusion for all positive blood groups and O RhD negative blood group was observed over the corresponding first 6 months of 2012 and 2013 [Table 4].

DISCUSSION

Proper management of stock is essential for the blood transfusion services to be able to provide clinical user with sufficient products. In ideal inventory management, wastage should be kept to minimum. In our set up, 90% of blood collection is through outdoor voluntary blood donation camps. These camps are organized by various nongovernment organizations and are usually held on public holidays or religious occasions. Moreover, the number of donations in a camp also varies. Therefore, maintaining a consistent inventory in such a situation becomes a major challenge. In addition, lack of functional hospital information system and awareness among the clinicians further aggravate the situation.

Wastage of blood can be because of many causes, some of which are out of the control of blood bank. On analysis of various causes of wastage, 45.7% was found to be wasted due to outdating of blood units in the blood bank. Simple corrective measures were implemented in the blood bank to reduce outdating. We were able to reduce the wastage due to outdating by around 50% (from 45.7% to 23.2%). Marked reduction (from 45.7% to 15.5%) in wastage due to outdating

**Table 3: Blood units collected and discarded for different study periods**

	Period I	Period II
	Before adopting inventory management strategies (January to June 2012)	After adopting inventory management strategies (January to June 2013)
Units collected	6352	6920
Units discarded	254	161
Discarding due to outdating	116	25

was observed on comparing corresponding first 6 months of 2012 and 2013. First 6 corresponding months of 2012 and 2013 were compared to decrease the possible bias arising from differences in holidays and religious occasions resulting in varied collection.
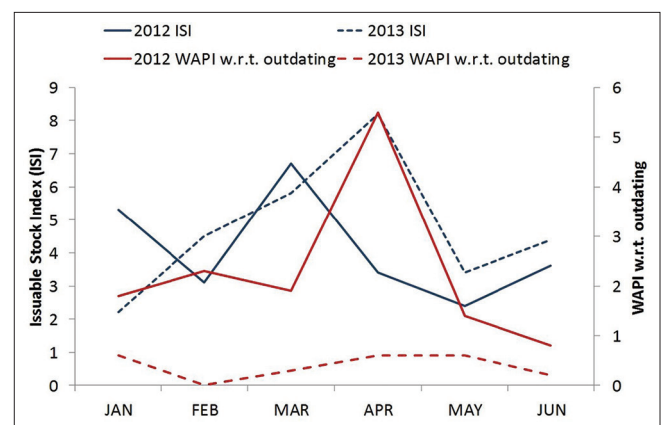
Segregation of blood inventory into two parts in the refrigerators (1–15 and 16–35 days of collection) and reducing
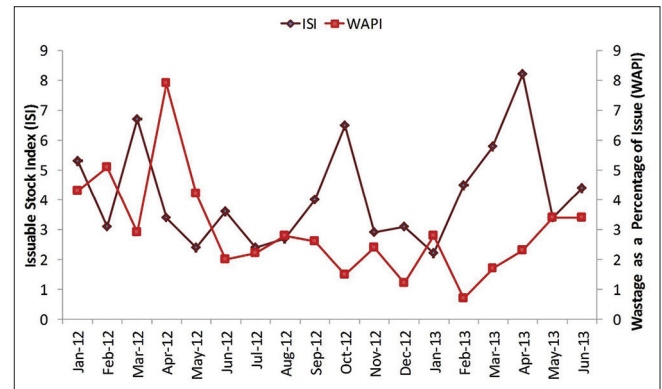
Figure 1: Issuable stock index and wastage as percentage of issue for the study period
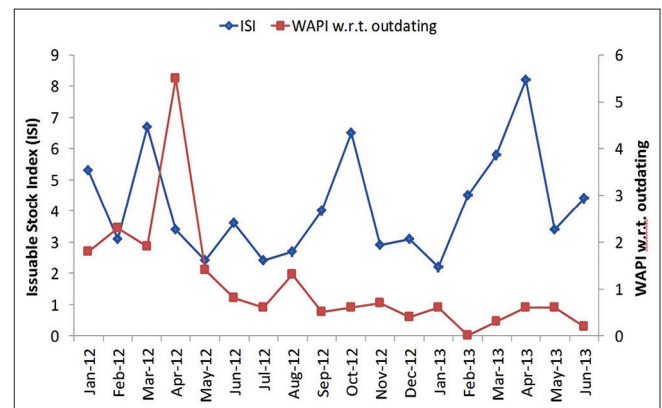
Figure 2: Issuable stock index and wastage as percentage of issue with respect to outdating for the study period

Figure 3: Issuable stock index and wastage as percentage of issue with respect to outdating during the corresponding first 6 months of 2012 and 2013

Table 4: Average number of times unit crossmatched before final transfusion

Period	O RhD positive (*n*=48)	O RhD negative (*n*=24)	A RhD positive (*n*=48)	A RhD negative (*n*=24)	B RhD positive (*n*=48)	B RhD negative (*n*=24)	AB RhD positive (*n*=48)	AB RhD negative (*n*=24)
January to June 2012	3.67	3.08	3.46	2.92	3.31	2.88	3.56	2.04
January to June 2013	2.50	2.13	2.69	2.42	2.29	2.17	2.29	2.04
P*	0.003	0.026	0.047	0.263	0.008	0.123	<0.001	1.000

*Using Chi-square test

the holding time from 72 h to 48 h where C:T ratio is more than 2 were seen as the most important disciplines in reducing wastage. Other studies have also observed a decrease in wastage by reducing the holding time.[1,2] Strict adherence to the policy of crossmatching units of 16–35 days of collection for clinical conditions where blood is likely to be issued and 1–15 days of collection for patients where it is less likely to be issued contributed to decrease the rate of outdating of units. First in, first out policy (FIFO) or oldest unit, first out policy is known tools in reducing wastage.[3] In our study, FIFO with the oldest units in front of the shelves was followed in two respective groups of inventory. Decreasing the crossmatch holding period means that red cell units spend more time in the stock rather than being kept reserved for patients. These blood units are therefore available for crossmatching during their shelf life.

A strong correlation exists between ISI and WAPI. More the ISI more will be the WAPI. If blood stock levels are high, more are the red cell units with reduced shelf life available for crossmatch/issue. This is because blood units do not have sufficient time to circulate through reserved/unreserved stock loop and eventually expire due to outdating.[4] The literature reports that hospital blood transfusion laboratories may reduce wastage by keeping ISI to a minimum.[1] On the contrary, in our study, we were able to reduce WAPI despite similar ISI. The same was true for WAPI with respect to outdating. Dividing the blood inventory into two halves and decreasing the crossmatch holding time from 72 h to 48 h where C:T ratio was more than 2 might have contributed to decreased WAPI.

Randomization was also done to know the impact of corrective measures on average number of times, a unit was crossmatched, not transfused, and returned to main stocks. A significant decrease was observed consistently for all the positive blood groups blood group in first 6 months of 2013 when compared to corresponding months of 2012. Among negative blood groups, significant decrease was observed only for O RhD negative blood group which could be because of more utilization in emergency situations.

Literature on inventory management within the blood supply chain is rather limited, and there have been two major periods of activity: 1970s and then 2000s.[5] In 1973, Jennings was the first to identify the 3 key measures of blood supply chain performance: shortage, outdating/wastage, and cost of information and transportation.[6] Subsequently, a few authors have proposed different mathematical models to develop policies for ideal inventory management.[7-9] We also propose a model of segregation of the blood inventory into two parts (1–15 and 16–35 days of collection) which helped in reducing wastage of blood units.

Conclusion

The blood supply chain as a system is very complex and dynamic. Our experience suggests that simple inventory measures enlisted in Table 1 can minimize wastage of blood units. Hence, each blood bank should analyze their causes of wastage and should formulate their own remedial measures.

Conflicts of interest
There are no conflicts of interest.

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