Development and Implementation of Real-Time Web-Based Dashboards in a Multisite Transfusion Service

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Abstract

Background: In hospital transfusion services, visualization of blood product inventory in the form of web-based dashboards has the potential to improve the workflow and efficiency of blood product inventory management. While off-the-shelf "business intelligence" solutions by external vendors may offer the ability to display and analyze blood bank inventory data, laboratories may lack resources to readily access this technology. Using in-house talent, our transfusion service developed real-time, web-based dashboards to replace manual processes for managing both blood product inventory and cooler tracking at two large academic hospital blood banks. **Methods:** Dashboards were developed using Hypertext Markup Language, Cascading Style Sheets, and Hypertext Preprocessor scripting/programming languages. Data are extracted in real time from Sunquest (v7.3) Laboratory Information Systems Database (InterSystems Cache) and are refreshed every 2 min. Data are hosted internally by our institution's web servers and are accessed on a webpage via Microsoft Group Policy shortcuts. **Results:** Dashboards were designed and implemented to provide a fully customizable, dynamic, and secure method of displaying blood product inventory and blood product cooler status. Transfusion service staff utilized dashboard data to maintain adequate blood product supply, modify blood product replacement orders to prevent excess inventory, and transfer short-dated blood products between our facilities to minimize wastage. **Conclusions:** Dashboard technology can be readily implemented at hospital transfusion services with minimal capital expenditure. The implementation of real-time web-based dashboards for blood product inventory and cooler management at our centers facilitated on-demand blood product monitoring and replaced a tedious, manual process with a user-friendly and intuitive electronic tool.

Keywords: Blood bank, dashboard, data visualization, inventory management, laboratory information system

Introduction

Blood product inventory management is an essential component to the operation of any transfusion medicine service. The stochastic supply and demand of blood products makes it challenging for hospital blood banks to safeguard against blood product shortages while also minimizing wastage. Hospital blood banks routinely rely on the laboratory information system (LIS) to extract blood product inventory data in order to maintain appropriate levels of products. This commonly entails a query of the LIS database resulting in a printed report for review. With increasing advances in health-care data management, data visualization has become crucial for the sharing and processing of data. In the blood bank, visualization of blood product inventory in the form of web-based dashboards has the potential to improve the workflow and efficiency of blood product inventory management.

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Today, off-the-shelf "business intelligence" solutions by external vendors perform various functions including the display and reporting of clinical laboratory data in addition to presenting actionable information to involved stakeholders. However, these products are often expensive, inaccessible to most laboratories, and have varying capabilities for displaying blood bank-related information.[1] While commercial blood bank information systems in the United States have the capability for basic inventory management, they may not intrinsically have the ability to display real-time inventory

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information in a dashboard format. Either these services are not available or require the purchase of add-on applications, thereby incurring additional costs. As an additional disadvantage, these add-ons may also lack the capability for full customization.

Our hospital transfusion service desired to create real-time web-based dashboards to improve the workflow of blood product inventory management. Dashboards were also created to improve the monitoring of blood product containers used for the transport of blood products outside of the blood bank, including coolers for red blood cells (RBCs) and plasma and insulators for platelets and cryoprecipitate (henceforth collectively referred to as coolers). To meet these goals, we designed and implemented dashboards at our blood banks to reduce costs and to achieve full customization with the use of in-house talent and minimal overhead.

Technical Background

We have a multisite transfusion service supporting three academic hospitals with a total of 979 beds and transfusing approximately 28,000 RBCs, 17,000 platelets, and 11,000 plasma units annually between all three sites. All three hospitals (Hospitals A, B, and C) serve adult patients, while Hospital B also serves a large pediatric population. Patient populations supported in Hospitals A and B include those undergoing hematopoietic stem cell transplants, solid organ transplants, oncologic treatment, and routine and high-risk maternity treatment. Hospital C is a much smaller inpatient and outpatient medical and surgery center with 10 operating rooms and 90 beds focusing on comprehensive cancer care and women's health.

Before implementation of web-based dashboards at our transfusion service, blood product inventory management was a manual process involving the printing and review of lengthy reports generated from the LIS, Sunquest v7.3 (Sunquest, Tucson, AZ, USA). Clinical laboratory scientists and hospital laboratory technicians reviewed printed reports and/or occasionally counted physical units within refrigerators and incubators to monitor the general blood product inventory, status of blood products close to outdate/expiration, and units already allocated to specific patients. The entire process occurred multiple times over multiple shifts, requiring approximately 3 h of staff time each day (15 min to run reports, with reports run every 2 h). On busy days or busy shifts, reports were often not run every 2 h, resulting in less frequent updates, and therefore potential for short-dated units to expire on the shelf.

Blood product cooler tracking was also a manual process, involving the preparation of a pair of handwritten labels per cooler, to include documentation of patient name, medical record number, cooler location, and cooler expiration time as coolers are validated to maintain temperature for set amounts of time. While one label was issued with the cooler, the other label would be retained in the blood bank for tracking purposes. Staff time for cooler setup included 5 min to prepare labels and issue each cooler, totaling 2.5 h with an average of 30 coolers issued daily. On a daily basis, an additional 55 min was spent on manually tracking all coolers using the handwritten labels and completing inventory of returned coolers using LIS reports.

While several operational and logistical issues were recognized and addressed before implementation of these dashboards, some others were handled as part of the postimplementation learning curve. Early on in our process, we sought input from all stakeholders, including transfusion service staff and supervisors, laboratory IT programmers, and transfusion medicine physicians. Constructive suggestions from transfusion service staff, in particular, were critical in designing and implementing an easy to use dashboard that displayed accurate, real-time, and clinically relevant data, for efficiently managing blood product inventory and blood product cooler status. We developed standard operating procedures to define the display settings and action triggers, describe the optimal use of dashboard data, and maintain version control. Requirements for staff training and competency were added subsequently to orient new staff and achieve better standardization and uniformity of practice.

The dashboards were designed in collaboration with laboratory informatics and our transfusion service. Resources and competencies required for the development of the dashboards included a full-stack programmer capable of backend and frontend programming using the technologies described as follows. The dashboards run on an Apache web server which is part of a technology stack that utilizes Hypertext Preprocessor (PHP). There are numerous embedded functions that are provided within the PHP language to allow for data extrapolation from various databases. In the case of the dashboards, data are extracted in real time from the Sunquest (v7.3) Laboratory Information Systems Database (InterSystems Cache) via Open Database Connectivity and are refreshed every 2 min. Data are queried from Sunquest using Structured Query Language, the results of which are processed using PHP and rendered in a browser in the form of a dashboard, using Hypertext Markup Language for document definition and Cascading Style Sheets for display presentation. Data are hosted internally by our institution's web servers and are accessed on a webpage via Microsoft Group Policy shortcuts. Secure Sockets Layer (SSL) certificates were installed on the web server to secure data both at rest and when in transit to client workstations. Direct links to the dashboards are provided through the start menu on all staff workstations.

The time required for dashboard programming and validation was approximately 162.5 h. This included approximately 90 h of programmer time required for backend programming and frontend development of multiple dashboards for various clinical laboratory sections over the span of 2 years. For the blood product inventory and cooler dashboards specifically, an additional 5 h was spent in the design of dashboard layout and 60 h on writing all the queries over 2 weeks. The dashboards were tested and validated over 6 weeks by cross-referencing the data from a printed LIS report, which took approximately 15 min of technologist's time per weekday for a total of 7.5 h.

Maintenance of the dashboards requires minimal programming time. The addition of new unit product codes and threshold modifications are the most frequent types of modifications requested and take less than an hour to complete and validate. The amount of resources needed for dashboard redesign and/or addition of dashboards will vary depending on the complexity of what is requested.

The dashboard is a standalone system used only as an inventory tool, not for the selection/allocation of products. As such, it is not subject to Federal Drug Administration Blood Establishment Computer Systems, College of American Pathologists, or AABB requirements governing blood bank computer systems. The database does not interfere or impact the functioning, integrity, or security of the LIS.

Results

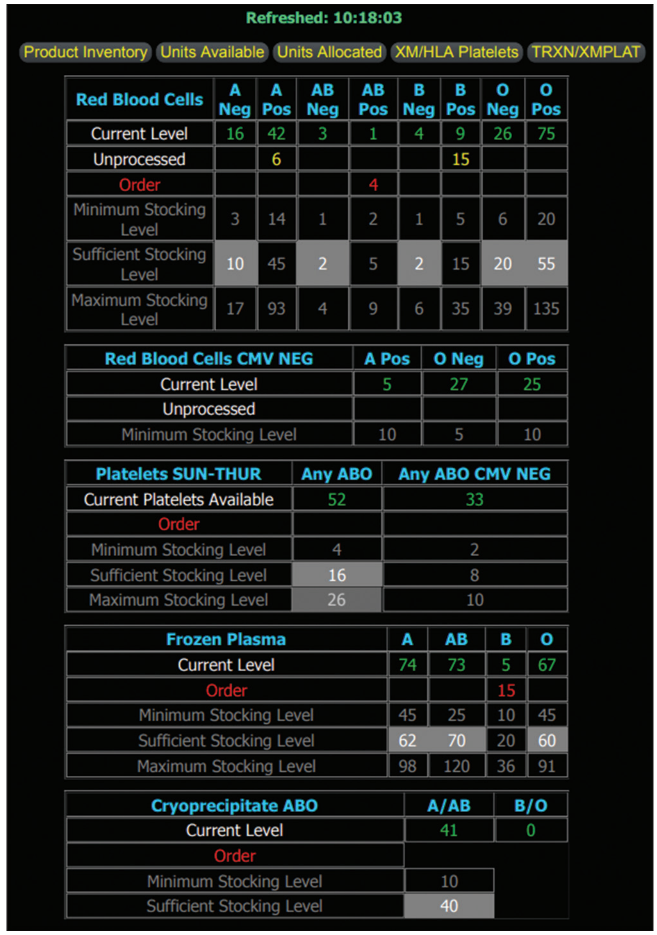
Blood product inventory dashboard

The dashboard display is completely customizable, affording flexibility for updating pages on-the-fly, as well as the capability of running them against a test environment. To monitor blood product inventory, multiple tabs were created on the blood product inventory dashboard to display various inventory information: Product Inventory, Units Available, and Units Allocated. Additional tabs were also created for the management of crossmatch/human leukocyte antigen compatible (HLA-compatible) platelets, transfusion reactions, and status of platelet crossmatch tests. Unique dashboards were implemented for hospitals A and B, as they served different patient populations. A dashboard was not implemented for hospital C due to very low transfusion volume.

Product inventory tab

The "Product Inventory" tab displays the following attributes for RBC units: ABO/Rh, CMV status, and "unprocessed" units awaiting ABO/Rh retype [Figure 1]. Serologic ABO retype and Rh-negative confirmation is a requirement by AABB standards before issuing RBC, whole blood, and granulocyte products.[2] At our hospitals, such units are entered into LIS with an "unprocessed" status, which is changed to "available" after serologic confirmation testing is completed and the unit becomes part of general inventory. As staff need time to complete confirmatory testing, the real-time, visual display of "unprocessed" units helps staff gauge RBC inventory and prioritize tasks, so that an adequate number of RBCs are available for issue during massive bleeding episodes. For platelets, the inventory is broken down by CMV status. For plasma and cryoprecipitate, only ABO type is displayed. CMV status is not relevant for plasma and cryoprecipitate as these products are acellular.

For hospital B, which also serves a large pediatric population, the dashboard provides additional RBC details to capture products important in the care of pediatric patients, including fresh (age <5 days), and divided units. Furthermore, for



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Product Inventory | Units Available | Units Allocated | XM/HLA Platelets | TRXN/XMPLAT

Red Blood Cells	A Neg	A Pos	AB Neg	AB Pos	B Neg	B Pos	O Neg	O Pos
Current Level	16	42	3	1	4	9	26	75
Unprocessed		6				15		
Order				4				
Minimum Stocking Level	3	14	1	2	1	5	6	20
Sufficient Stocking Level	10	45	2	5	2	15	20	55
Maximum Stocking Level	17	93	4	9	6	35	39	135

Red Blood Cells CMV NEG	A Pos	O Neg	O Pos
Current Level	5	27	25
Unprocessed			
Minimum Stocking Level	10	5	10

Platelets SUN-THUR	Any ABO	Any ABO CMV NEG
Current Platelets Available	52	33
Order		
Minimum Stocking Level	4	2
Sufficient Stocking Level	16	8
Maximum Stocking Level	26	10

Frozen Plasma	A	AB	B	O
Current Level	74	73	5	67
Order			15	
Minimum Stocking Level	45	25	10	45
Sufficient Stocking Level	62	70	20	60
Maximum Stocking Level	98	120	36	91

Cryoprecipitate ABO	A/AB	B/O
Current Level	41	0
Order		
Minimum Stocking Level	10	
Sufficient Stocking Level	40	

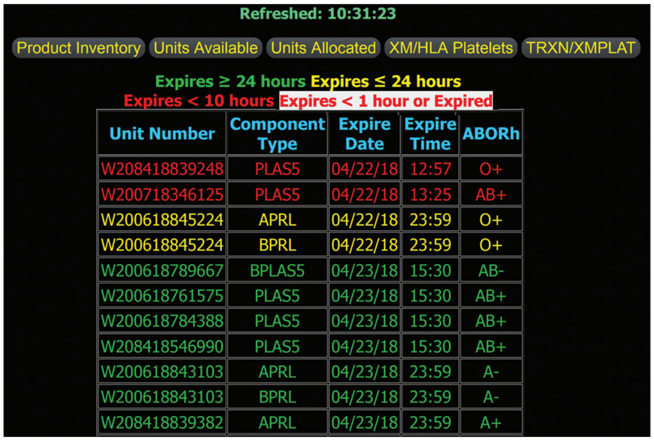
Figure 1: "Product Inventory" tab displays current, minimum, sufficient, and maximum stocking levels for various blood products

platelets, breakdown is by ABO, with total number of CMV-seronegative units also being specified.

Display of minimum, sufficient, and maximum stocking levels as defined by each site makes it easy for staff to compare data against the current inventory. Data are color coded to visually assist staff and direct their attention when action is needed. The dashboard automatically calculates and displays the difference between current and sufficient inventory ("order" row). Red font indicates the number of units needed to achieve a sufficient stocking level. A gray background indicates excess above the sufficient stocking level, and gray flashing indicates excess above the maximum stocking level. The dashboard also has logical rules to identify when blood product inventory level is less than minimum stocking level or exceeds the maximum stocking level. When such conditions are met, an E-mail is automatically generated to alert supervisors to consider intervention just in case staff are delayed in responding to the changes in inventory. These automated E-mails are easily customizable based on site and supervisor schedule.

Units available tab

The "Units Available" tab was created to aid in the monitoring of all platelets, thawed plasma, and washed RBCs [Figure 2].



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Product Inventory | Units Available | Units Allocated | XM/HLA Platelets | TRXN/XMPLAT

Expires ≥ 24 hours Expires ≤ 24 hours
Expires < 10 hours Expires < 1 hour or Expired

Unit Number	Component Type	Expire Date	Expire Time	ABORh
W208418839248	PLAS5	04/22/18	12:57	O+
W200718346125	PLAS5	04/22/18	13:25	AB+
W200618845224	APRL	04/22/18	23:59	O+
W200618845224	BPRL	04/22/18	23:59	O+
W200618789667	BPLAS5	04/23/18	15:30	AB-
W200618761575	PLAS5	04/23/18	15:30	AB+
W200618784388	PLAS5	04/23/18	15:30	AB+
W208418546990	PLAS5	04/23/18	15:30	AB+
W200618843103	APRL	04/23/18	23:59	A-
W200618843103	BPRL	04/23/18	23:59	A-
W208418839382	APRL	04/23/18	23:59	A+

Figure 2: "Units Available" tab was created to aid in the monitoring of products with short expiration dates, including platelets, thawed plasma, and washed red blood cells

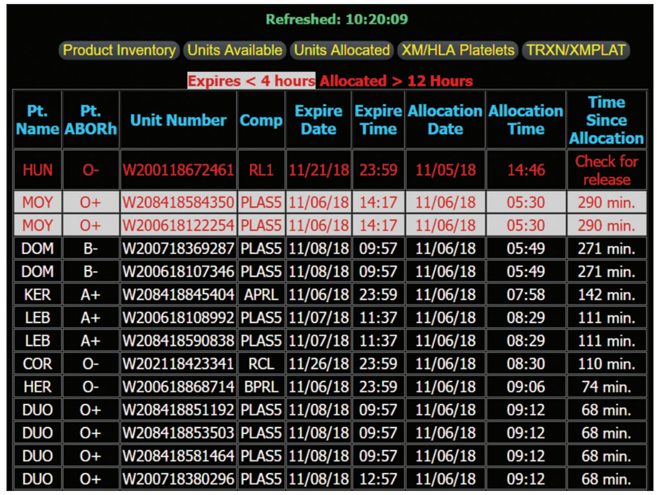
These units are particularly challenging to manage due to their short shelf-lives: 5-day expiration for platelets and thawed plasma and 24-h expiration for washed RBCs. This tab displays the blood product unit number, component type (based on component code defined by our transfusion service), expiration date/time, and ABO/Rh. Units are sorted by expiration time, with those outdating first displayed at the top of the list. Different colors display units expiring in >24, <24, and <10 h. A flashing display alerts staff to products expiring in <1 h, prompting them to minimize wastage using these products for filling active orders. Expired units continue to flash until their status is updated in the LIS and changed from "available" to "outdated."

Units allocated tab

The "Units Allocated" tab displays all O-negative RBCs, washed RBCs, platelets, plasma, and cryoprecipitate currently allocated to a specific patient [Figure 3]. The display includes the first three characters of the patient's last name, unit number, component type, expiration date/time, allocation date/time, and time since allocation. Hovering the cursor over the first three characters will display the patient's full name. Units are sorted by time from allocation, with units allocated for a longer period displayed at the top of the list. When units have been allocated for >12 h, they will be displayed in red, and time from allocation changes to "check for release," so staff can follow up and release to general inventory as appropriate. A flashing display alerts staff for units expiring in <4 h.

Additional tabs

To highlight special blood products, we added a "XM/HLA platelets" tab to the dashboard. This tab displays the blood product unit number, ABO type, status (available, allocated, or issued), and expiration date/time of crossmatch ("XM") and HLA-compatible platelets, as well as the name and medical record number of the assigned platelet refractory patient. If status of unit changes from "issued" to "issued final," the dashboard will not display the unit (LIS updates product status



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Product Inventory | Units Available | Units Allocated | XM/HLA Platelets | TRXN/XMPLAT

Expires < 4 hours Allocated > 12 Hours

Pt. Name	Pt. ABORh	Unit Number	Comp	Expire Date	Expire Time	Allocation Date	Allocation Time	Time Since Allocation
HUN	O-	W200118672461	RL1	11/21/18	23:59	11/05/18	14:46	Check for release
MOY	O+	W208418584350	PLAS5	11/06/18	14:17	11/06/18	05:30	290 min.
MOY	O+	W200618122254	PLAS5	11/06/18	14:17	11/06/18	05:30	290 min.
DOM	B-	W200718369287	PLAS5	11/08/18	09:57	11/06/18	05:49	271 min.
DOM	B-	W200618107346	PLAS5	11/08/18	09:57	11/06/18	05:49	271 min.
KER	A+	W208418845404	APRL	11/06/18	23:59	11/06/18	07:58	142 min.
LEB	A+	W200618108992	PLAS5	11/07/18	11:37	11/06/18	08:29	111 min.
LEB	A+	W208418590838	PLAS5	11/07/18	11:37	11/06/18	08:29	111 min.
COR	O-	W202118423341	RCL	11/26/18	23:59	11/06/18	08:30	110 min.
HER	O-	W200618868714	BPRL	11/06/18	23:59	11/06/18	09:06	74 min.
DUO	O+	W208418851192	PLAS5	11/08/18	09:57	11/06/18	09:12	68 min.
DUO	O+	W208418853503	PLAS5	11/08/18	09:57	11/06/18	09:12	68 min.
DUO	O+	W208418581464	PLAS5	11/08/18	09:57	11/06/18	09:12	68 min.
DUO	O+	W200718380296	PLAS5	11/08/18	12:57	11/06/18	09:12	68 min.

Figure 3: "Units Allocated" tab displays all O-negative red blood cells, washed red blood cells, platelets, plasma, and cryoprecipitate currently allocated to a specific patient

in early AM, every 24 h; units not returned are presumed transfused and electronically stamped "issued final").

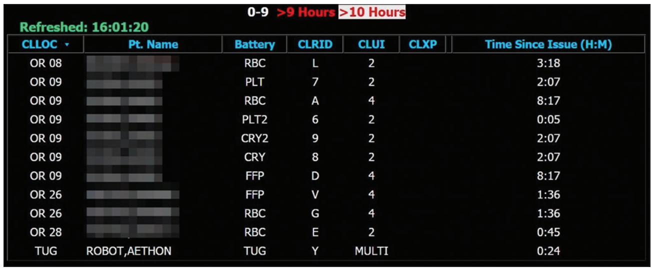
A "TRXN/XMPLAT" tab was added to display transfusion reactions that are pending laboratory workup, physician review and sign off, or billing in LIS. This tab also displays platelet crossmatch test results that are pending result entry in LIS.

Blood product cooler dashboard

To create the blood product cooler dashboard, a new LIS test battery was first created to assign coolers to specific patients. This information is extracted from the LIS and displayed in the form of the blood product cooler dashboard. Cooler dashboard displays location of the cooler (CLLOC), patient name, and cooler battery type (RBC, plasma, platelet, or TUG). The blood bank robot used for delivering products to patient care areas is designated as TUG. The dashboard also shows cooler identification (CLRID), number of products issued in the cooler (CLUI), and time since issue (H:M) [Figure 4]. Cooler display changes to red when 1 h is left until expiration, prompting staff to alert clinical teams to either return the cooler to the blood bank before products expire or obtain fresh coolers to allow for extended storage of products until the end of the procedure. A flashing display alerts staff to expired coolers. These are flagged and standard procedures followed to determine suitability of returned products. On rare occasions when a cooler contains one or more short-dated RBC or plasma units expiring earlier than the time period the cooler is validated for (10 h in our hospital), the expiration time of the shortest date unit is entered in the CLXP column. In such cases, CLXP time, rather than the H:M column, is used to accurately monitor that particular cooler.

User interface and security

A direct link to the dashboards is provided through the start menu on all workstations used by transfusion service staff and physicians and can also be bookmarked for ease of access. The dashboard display can be changed by manually toggling


0-9 >9 Hours >10 Hours

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CLLOC	Pt. Name	Battery	CLRID	CLUI	CLXP	Time Since Issue (H:M)
OR 08	[redacted]	RBC	L	2		3:18
OR 09	[redacted]	PLT	7	2		2:07
OR 09	[redacted]	RBC	A	4		8:17
OR 09	[redacted]	PLT2	6	2		0:05
OR 09	[redacted]	CRY2	9	2		2:07
OR 09	[redacted]	CRY	8	2		2:07
OR 09	[redacted]	FFP	D	4		8:17
OR 26	[redacted]	FFP	V	4		1:36
OR 26	[redacted]	RBC	G	4		1:36
OR 28	[redacted]	RBC	E	2		0:45
TUG	ROBOT,AETHON	TUG	Y	MULTI		0:24

Figure 4: Cooler dashboard

between the tabs. However, within our blood bank, four different monitors are used to display information relevant to the staff workstation that is adjacent to the monitor to minimize the need to toggle between displays. Based on the size of the monitor, one or two tabs are displayed individually or side by side. Certain tabs display protected health information and provide staff quick access to information that they would otherwise have to look up themselves directly through the LIS. This functionality significantly enhances their ability to efficiently manage their inventory-related tasks.

Stringent programming measures were adopted to securely display sensitive patient information. Our dashboards monitor connections between workstations, and web pages are secured via SSL encryption, ensuring that data flowing between any given workstation and the server are encrypted. The servers at our data center are also encrypted, so that data are encrypted both at rest and in transit. Future security considerations could include advanced logging requirements to lock down pages to certain users or machines and capturing login information to identify users and details of data accessed.

Cost analysis

The transition from manual processes to dashboard inventory management resulted in a saving of 180 min of staff time per day. Implementation of the cooler dashboard decreased staff's time managing coolers by 76 min/day, as follows: setup and return of the coolers decreased from 5 to 4 min per cooler, saving an average of 30 min each day. Specifically, cooler setup required less staff time, although documenting return of coolers within LIS required more time compared to the predashboard manual processes. In addition, the total time required for completing inventory of returned coolers and monitoring coolers using handwritten labels decreased from 55 to 9 min/day. In total, staff time to manage coolers decreased from 205 to 129 min/day.

A total of 162.5 h was required for the implementation and validation of the dashboards. Postimplementation, we estimate that 256 min (180 min for the product inventory dashboards +76 min for the cooler dashboard) of staff time is saved per day. Salaries for early-level IT programmer/analyst and blood bank licensed technologist are nearly equivalent at our center. The break-even point for the new dashboard tool compared to the previous manual process is reached at approximately 38 days. While the total actual cost for designing and implementing a dashboard will vary according to wages at different locations, we used a rate of $55/h to arrive at an estimate of $8937.50. Using the same rate for a blood bank licensed technologist, we estimate a savings of $235/day or $7040/month, after the break-even point.

Discussion

Real-time web-based dashboards to monitor blood product inventory can be of considerable benefit to hospital transfusion services. At our hospitals, web-based dashboards allow for self-sufficient blood product inventory management and improved efficiency of transfusion service staff. For example, color-coded or flashing dashboard alerts help staff to quickly and easily identify products that are low in inventory and therefore replenish inventory as needed in a timely manner. Such visual alerts also allow users to easily identify excess inventory, thereby providing an opportunity to make adjustments such as decreasing or canceling a standing order for specific products. Our dashboard also contains logic to send E-mail alerts to defined users in situations when blood products are critically low or in excess of the maximum stocking level.

Staff use dashboard to readily identify products close to expiration. Short-dated units, especially platelets and plasma, are transferred to the larger facility, as they are more likely to be transfused before outdate. Web-based dashboards have been described by others as useful tools to reduce blood product outdate. The RBC dashboard described by Sharpe *et al.* resulted in a significant reduction in RBC unit outdate rates from 2.03% to 1.24%, with an outdate odds ratio of 0.625 (95% confidence interval: 0.497–0.786; $P < 0.0001$) postdashboard implementation.[3] A platelet dashboard implemented by the same group also resulted in a 9.4% reduction (from 24.5% to 15.1%) in the mean monthly platelet outdate rate.[4] Our center's outdate rates for RBC and platelets were already very low (<1%–2%) for several years before implementing dashboard, thanks to aggressive inventory management by transfusion service staff. We were unable to accurately quantify decreased plasma product outdates that may have resulted from dashboard implementation, as data analysis was confounded by other operation-related changes (e.g., move to 5-day plasma) that were implemented around the same time at both major sites.

We have also found the dashboard to be useful to track other special blood products. At our institution, we recently added psoralen-treated platelets to inventory. Psoralen-treated platelets are platelets that have been treated with pathogen reduction technology for the purpose of reducing the risk of transfusion-transmitted infection from platelet transfusion. Transitioning the entire platelet inventory to this product is a daunting task and takes several months to accomplish. During the "ramp-up" period, we received a limited number of psoralen-treated platelets. These were assigned to high-risk patients based on an algorithm. Managing dual inventory was therefore challenging to staff. As product codes differ, the

"Units Available" tab could easily distinguish conventional platelets from psoralen-treated platelets, making it easy for staff to follow the algorithm based on inventory.

In our experience, the primary benefit of blood product dashboard implementation has been a profound improvement in workflow and staff efficiency. For instance, our dashboard has eliminated the burden of manually querying LIS for inventory and allocation data, reviewing lengthy LIS printouts, and periodically performing physical reconciliation of inventory by checking and counting blood products stored in freezers, refrigerators, and incubators. Before dashboard implementation, these tasks would take at least 3 h of staff time (1 h per shift). Inventory management tasks are now accomplished by simply referring to the dashboard, requiring minimal physical effort by staff.

Our dashboard also tracks blood product coolers, easing workflow for monitoring cooler outdate and notification of clinical teams. Our dashboard digitized the previous manual process of handwriting blood product cooler labels and using them to track cooler location and expiration. Although our dashboard displays the initial location of the cooler, it does not currently have the ability to track real-time location. On rare occasions, coolers may travel with an actively bleeding patient to a new location (for example, from the ICU to operating room). Radio-frequency identification (RFID) systems in transfusion medicine have been described as a solution for the control, monitoring, and tracking of blood products throughout the hospital setting. Tagging of coolers with RFID allows a transfusion service to collect real-time location data, but initial costs, security, and privacy are major barriers to implementation.[5,6] Future enhancements to our dashboard could include the adoption of RFID to maintain greater control over coolers in the hospital.

Challenges to web-based dashboards include the potential requirement to rewrite software programs and repeat validation with upgrades to the LIS made by vendor. Regardless of major system upgrades, the transfusion service must also have in place a process for periodic validation to ensure integrity and accuracy of dashboard data. We have noted latency in the uptakes of data due to high server traffic, which results in short periods of "stale" data. At this time, the only data available regarding delays in refreshing are based on user feedback, although utilizing color changes or flashing to the refresh time could be implemented to signify long delays between refreshes. In the future, we will look into maximum interval between refreshes and frequency of lengthy refreshes as a quality performance indicator. Additional challenges include scheduled or unexpected LIS downtime periods, which necessitate staff to remain trained in manual blood product inventory management and manual blood product cooler tracking for periods when dashboards are not available. Finally, the need to be cognizant of PHI-related IT security risk assessment and mitigation measures increases the level of IT involvement needed for the implementation and ongoing support of technology-based tools. Despite these challenges, web-based dashboards have provided significant benefit to our transfusion medicine service. Full customization of the dashboards has proven especially useful, requiring minimal IT involvement when thresholds are modified or new product codes added.

The benefit of web-based dashboards can extend beyond that of inventory and cooler management, as dashboards have the potential to play a key role in patient blood management programs. Patient blood management is a term applied to the evidence-based and multidisciplinary approach to optimizing the care of patients who may require blood product transfusion. Dashboards can be utilized to display historical data on blood product orders for patients and/or blood inventory numbers over any specified time periods, broken down by time of day and day of week. Retrospective review of such data can be used by the transfusion service to gather information on hospital-wide transfusion practices and assist with optimum blood inventory and patient blood management. An additional component of patient blood management is the prospective review of orders before blood products are prepared for issue. Dashboards can be designed to capture the indication for transfusion and display patient's relevant laboratory data and use logic to flag new orders for additional review and prospective monitoring for transfusion appropriateness.[4]

In blood product inventory management, statistical modeling and computer simulation have also been developed to predict blood product demand to guide ordering strategy and minimize wastage. "Big-data" modeling from data retrieved from the LIS and hospital information system can potentially predict future blood product usage,[7] while computer simulations of various inventory policies can inform a transfusion service of potential variables that could be addressed to reduce shortages and minimize wastage.[8] While hospital transfusion services currently act upon predefined minimal inventory values as a trigger to order blood products, data from statistical models could be incorporated into the dashboard to help optimize ordering strategies.

Conclusions

We developed fully customizable web-based dashboards for blood product inventory management and tracking of blood product coolers at two large facilities in our system, using in-house talent and minimal capital expenditure. Dynamic, web-based inventory dashboards can be designed and implemented by most mid-size and large hospital-based transfusion services, without resorting to costly commercial business intelligence or inventory management applications. Dashboards improve workflow, make inventory management more efficient, and deliver a good return on investment for transfusion services.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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