

ORIGINAL ARTICLE

A pragmatic approach to embedding patient blood management in a tertiary hospital

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On behalf of the Western Australian Patient Blood Management Program

BACKGROUND: We describe the implementation and impact of a patient blood management program (PBMP) in an Australian teaching hospital.

STUDY DESIGN AND METHODS: A PBMP was introduced at a single tertiary care hospital in 2009 as a pilot for the Western Australian Health Department statewide PBMP. The first 3 years of interventions aimed to make effective use of preoperative clinics, manage perioperative anemia, improve perioperative hemostasis, reduce blood sample volumes, and implement restrictive transfusion triggers and a single-unit transfusion policy.

RESULTS: Between 2008 and 2011, admissions to Fremantle Hospital and Health Services increased by 22%. Using 2008 as a reference year, the mean number of red blood cell (RBC) units per admission declined 26% by 2011. Use of fresh-frozen plasma and platelets showed 38 and 16% declines, respectively. Cryoprecipitate increased 7% over the 4-year period. For elective admissions between 2008 and 2011, the leading decline in RBC transfusion rate was seen in cardiothoracic surgery (27.5% to 12.8%). The proportion of single RBC unit use increased from 13% to 28% ($p < 0.001$), and the proportion of double units decreased from 48% to 37% ($p < 0.001$).

CONCLUSION: This is the first tertiary hospital in Australia to establish a multidisciplinary multimodal PBMP. Interventions across disciplines resulted in decreased use of RBC units especially in orthopedic and cardiothoracic surgery. Continuing education and feedback to specialties will maintain the program, improve patient outcomes, and decrease the transfusion rate.

ABBREVIATIONS: CABG = coronary artery bypass graft; CNC = clinical nurse consultant; FHHS = Fremantle Hospital and Health Service; G&A = group-and-antibody; ICU = intensive care unit; LOS = length of stay; MDS = myelodysplasia; PBM = patient blood management; PBMP(s) = patient blood management program(s); ROTEM = rotational thromboelastometry; THA = total hip arthroplasty; TKA = total knee arthroplasty; WA = Western Australia.

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TRANSFUSION **,***-**-**

The practice of blood transfusion, which was introduced for the management of trauma before the Second World War, has continued with little change over the past 65 years.¹ Various guidelines have been introduced to develop some coherency into the use of blood products but in many hospitals red blood cell (RBC) and other blood product use has been at the whim of the clinician.^{1,2}

In Australia, approximately 800,000 units of RBCs, 134,000 units of platelets (PLTs), 159,000 units of fresh-frozen plasma (FFP), and 78,000 units of cryoprecipitate are issued each year to correct anemia and coagulopathies and replace blood lost in acute hemorrhage at a cost of \$548 million.³ Over the past 10 years there has been a surge in literature suggesting that perioperative transfusion with RBCs is associated with increased mortality, morbidity, and mean intensive care unit (ICU) and hospital length of stay (LOS).⁴⁻⁸

Perioperative interventions, especially in orthopedic and cardiac surgery, reduce transfusion requirements

and are associated with improved health outcomes.^{9,10} The new Australian *Patient Blood Management Guidelines: Module 2 Perioperative* recommends that health care services establish multidisciplinary, multimodal perioperative patient blood management programs (PBMPs).^{7,11} The Australian Council on Health Care Standards has included patient blood management (PBM) in hospital accreditation policies.¹¹

Programs can be based on the three pillars of PBM (Fig. 1), which provide a framework for development including optimizing the RBC mass and coagulation status, minimizing blood loss and bleeding, and improving the patient's tolerance to anemia.^{8,12}

This article outlines the implementation and impact of a PBMP started in 2009 in a Western Australian (WA) tertiary care hospital.

The local environment

The WA Department of Health initiated a statewide PBMP in 2008 with the development of a business plan and

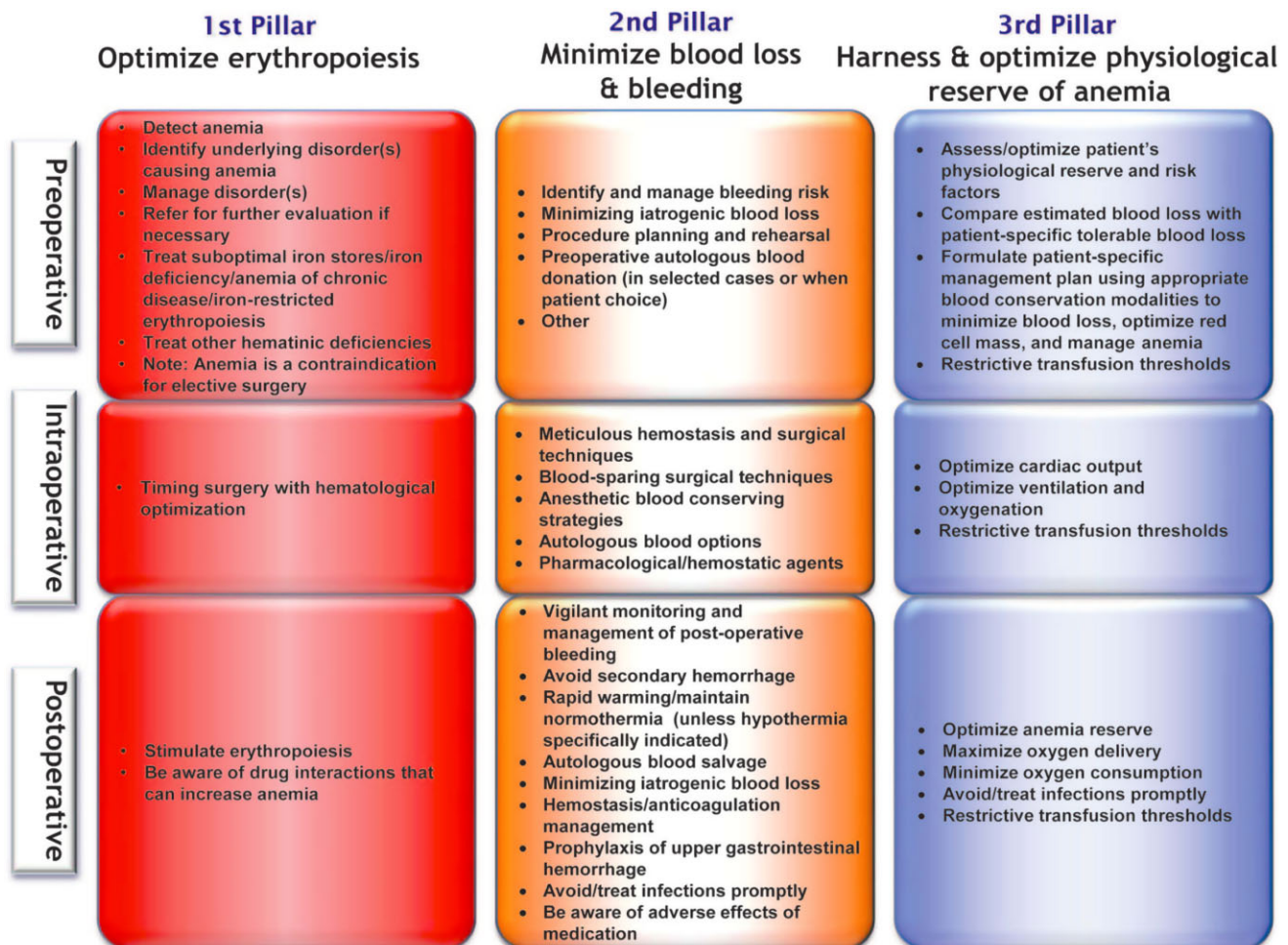


Fig. 1. The pillars of PBM. Reproduced with permission of the Western Australian Department of Health.

proposal for implementation.¹³ The 5-year program received executive support and funding from the WA State Health Executive Forum and the Health Department of WA and was endorsed by the Australian Red Cross Blood Service. The program aim was “delivering optimal patient outcomes through the effective conservation and management of the patient’s own blood.”¹⁴

The pilot hospital

Fremantle Hospital and Health Service (FHHS) is a 450-bed acute care teaching hospital with a full range of medical and surgical specialties including cardiothoracic, orthopedic, vascular, colorectal, and trauma surgery.

A blood conservation program previously established in 1990 in nearby Fremantle Kaleeya Private Hospital had influenced local practice regarding management of perioperative anemia.^{15,16} This left an existing “culture” and interest in blood conservation by the hematology and orthopedic departments at FHHS.

MATERIALS AND METHODS

Develop and sustain a collaborative PBMP

The aims in 2009 were to 1) develop and sustain a multidisciplinary PBMP, 2) educate clinical staff about anemia identification and management, 3) optimize hemoglobin (Hb) and iron stores for patients undergoing elective surgery, 4) reduce patient exposure to inappropriate RBC and blood product components, and 5) attempt to standardize transfusion practice.

With funding from the Health Department of WA two crucial appointments were made. The Director of Hematology was appointed as part-time PBM medical director and a full-time PBM clinical nurse consultant (CNC) was appointed to develop protocols and education packages and monitor compliance. The medical and nursing leadership jointly supervised the program and directed its development.

Governance of policies and audit was provided by a multidisciplinary PBM committee with representatives from relevant departments including hematology, anesthesia, transfusion medicine, pharmacy, surgery, the hospital executive, and the state PBMP and chaired by the director of hematology. While there was some overlap in membership and activity between this and the transfusion medicine committee, the role of each became defined. No additional funding was required for voluntary clinical staff attendance at the PBM committee.

Education of clinical staff

The hospital executive supported the program and presentations were made to all specialty departments and also to intern training programs and at medical and sur-

gical grand rounds. The aim was to increase awareness of the three pillars of PBM (Fig. 1).⁸ Clinical staff were actively encouraged through department education and data feedback meetings, and after transfusion requests, to investigate the cause of anemia in their patients and avoid “default” blood transfusions in asymptomatic patients based on Hb levels. All transfusion requests were reviewed by senior laboratory staff and, if not compliant (with hospital guidelines), referred to a member of the anemia team (PBM CNC, hematology registrars, and consultants) for further advice.

Optimize patient Hb and iron stores

Anemia clinic

A CNC-led anemia clinic was initiated to run in parallel with established hematology clinics. Patients referred to general hematology outpatients with recent laboratory tests including iron studies consistent with the diagnosis of iron deficiency were treated with intravenous (IV) iron in the day ward and followed up in the anemia clinic to assess response and cause. This clinic also managed elderly patients with transfusion-dependent myelodysplasia (MDS) who, with many medical, social, and quality-of-life issues, were inappropriate for general hematology clinics.

At the commencement of the PBMP, IV iron, available on the hospital formulary, was administered as iron polymaltose over 5 hours but this slow infusion time caused logistic problems and a backlog of patients requiring treatment. In 2010 the infusion rate was decreased to 70 minutes without any significant change in the incidence of side effects.¹ In 2011 ferric carboxymaltose became available on the hospital formulary with doses up to 1 g administered over 15 minutes allowing increased numbers of patients through the day ward.¹

Preoperative clinics

Preoperative clinics for orthopedic, cardiothoracic, and other elective surgeries were reviewed by a multidisciplinary team from the departments of anesthetics, hematology and transfusion medicine, pharmacy, and hospital administration to confirm the clinic role in assessing fitness for operation and identifying patients requiring management of anemia and other comorbidities. Previously patients came to surgery with untreated anemia and other comorbidities resulting in operation delays and increased likelihood of perioperative RBC transfusion despite evidence that anemia and transfusion are risk factors for adverse outcomes.⁶

Initially patients were triaged on the basis of a point-of-care (Hemocue, Hemocue AB, Angelholm, Sweden) capillary blood sample result performed by the PBM CNC. Patients who were anemic were investigated for iron,

vitamin B12, and folate deficiency and renal failure. If there was evidence of absolute or functional iron deficiency, patients would receive IV iron and/or be referred back to their general practitioner for management. In the second year of the program, after clinical assessment, patients had an expanded evaluation including complete blood count, coagulation, iron studies, serum B12 and folate levels, and renal and liver function to identify anemia and other comorbidities including suboptimal iron stores if at risk of significant operative blood loss. Abnormal results were reviewed by the PBM CNC and in consultation with the PBM medical director given appropriate therapy (e.g., with IV iron) and/or referred to a relevant specialty.

Postoperative anemia

Management of postoperative anemia involved education and feedback to clinical staff regarding restrictive transfusion thresholds and clinical assessment of the patients' need for transfusion. Patients were assessed the day after surgery and IV iron considered if there was blood loss or if anemic.⁷ This postoperative assessment has been associated with an increase in iron infusions and a reduction in RBC transfusion.

Minimize blood loss and bleeding

Surgical education

A number of surgical hemostasis education initiatives were undertaken to reduce surgical blood loss in line with pillar two of the three pillars of PBM (Fig. 1).⁸ In May 2010 a preceptorship was arranged with a cardiothoracic surgeon experienced in "bloodless" cardiac surgery.¹⁷ The visit included workshops, demonstrational surgery, and symposia. In August 2010 and November 2011 courses in surgical hemostasis were held at The Clinical Training and Education Centre (CTEC) of the University of Western Australia with attendance from neurosurgeons, cardiothoracic, urologic, general, orthopedic, and trauma surgeons from FHHS and other WA hospitals.¹⁸ The 1-day workshops included sessions on the perioperative multidisciplinary multimodal approach to PBM and the theory and practice of surgical hemostasis.

Intraoperative hemostasis management

Surgical techniques used to reduce perioperative blood loss included hypothermia avoidance, cell salvage, and acute normovolemic hemodilution.⁷ A rotational thromboelastometry (ROTEM)¹⁹ analyzer (Tem International GmbH, Munich, Germany), enabling rapid analysis of whole blood samples became available in 2010. Sited in the coagulation laboratory, this provided real-time graphical results of hemostasis to the anesthetist in the operating theater thereby allowing targeting of coagulation abnor-

malities with the appropriate coagulation product. Samples were submitted to the coagulation laboratory for ROTEM analysis for the investigation of perioperative bleeding in all surgical specialties and in management of massive blood transfusion.

Other methods to minimize bleeding included routine use of pre- and postoperative tranexamic acid in orthopedic and cardiac surgery, cardiac output monitoring, and lower-volume bypass circuits including microplegia.⁷ Propofol-based total IV anesthesia was utilized and has been associated with reduced blood loss in a variety of operative settings due to its effects on hemodynamics and uterine tone.⁷

Reduce patient blood sampling

Computerized prescriber order entry for blood products

In 2011 an alert was set up for electronic ordering of group-and-antibody (G&A) screens. The alert reminded clinicians if the latest laboratory Hb value was outside the 2001 National Health and Medical Research Council transfusion guidelines²⁰ and advised if there was already a valid G&A sample for their patient.

Frequent blood sampling may contribute to anemia; therefore, blood collection tubes with smaller draw (reduced sample size) were implemented. This reduced the sample volume by approximately one-half in biochemistry tubes and one-third in hematology and cross-matching tubes for transfusion.^{21,22}

Small draw tubes volumes for complete blood count (2 mL, potassium EDTA) and for biochemistry (2.5 mL, lithium heparin) (Greiner Bio-One International AG, Kremsmuenster, Austria) were used in ICU, the emergency department (ED), and the hematology and oncology wards. Small draw tubes for blood grouping and antibody screen (6 mL) and coagulation testing (2.7 mL citrate; BD, Becton, Dickinson and Company, Franklin Lakes, NJ) were implemented throughout the hospital. Existing laboratory analyzers were used for standard and small draw tubes. In the ICU blood waste from central line sampling was reduced by the use of a closed in-line flushing device (Safeset, ICU Medical Aust Pty Ltd, Baulkham Hills, NSW, Australia).

Bedside electronic patient identification labeling in the ED

Blood sample mislabeling and patient identification errors in G&A screens occurred in all departments but 50% from the ED. When patient identification was missing or unclear, blood samples were discarded and repeat sampling was required. Despite continuing education and feedback no sustained reduction in this error rate occurred over 4 years. A trial of bedside electronic patient identification and sample labeling along with dedicated

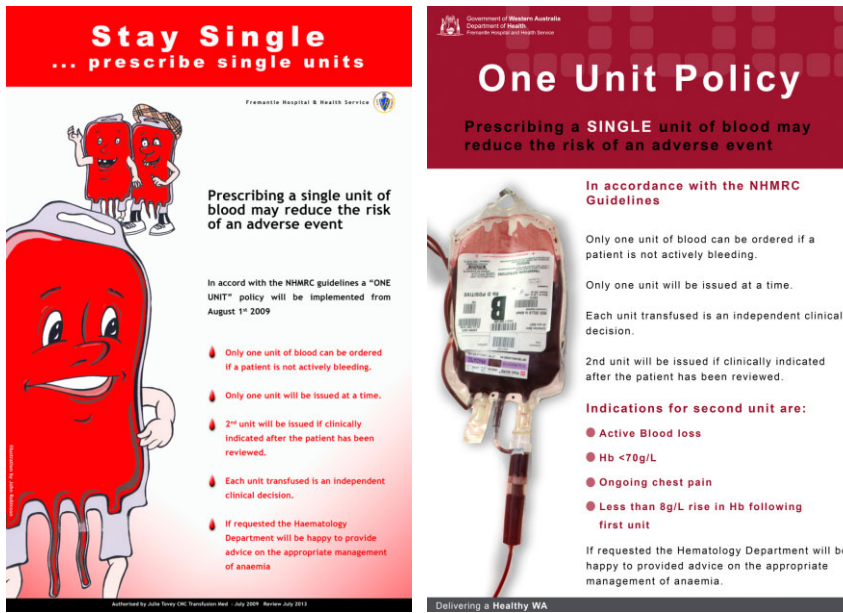


Fig. 2. Single-unit posters used by Fremantle Hospital.

phlebotomists for ED is underway to reduce this error rate and improve patient safety while reducing costs associated with sample wastage and blood loss due to repeat sampling.

Reduce patient exposure to transfusion of blood components

Patient informed consent for transfusion

A full information and consent form outlining the risks and benefits of transfusion requiring signatures from patient and consenting clinician has been designed and approved by FHHS executive and is to be used from early 2013. It is anticipated that this will reduce inappropriate transfusions through doctor and patient education and engagement.

"Single-unit" transfusion policy

Early in the program a single unit transfusion ordering policy was initiated for hemodynamically stable nonbleeding patients. Introduction of this restrictive transfusion practice was accompanied by education regarding adverse outcomes relating to liberal transfusion policies.²³⁻²⁵

Department heads were notified that the use of 2-unit transfusions for nonbleeding patients was not best practice and contrary to national guidelines.⁷ Allowing 1 unit of RBCs only to be administered to hemodynamically stable nonbleeding patients with symptomatic anemia, and requesting that the patient be reviewed for resolution of symptoms, subsequent transfusions may be avoided.²⁵

Single-unit posters using the slogans "Stay single, prescribe single units" and "Prescribe less, then reassess"

were distributed (Fig. 2). Transfusing a second unit was permitted where a patient was actively bleeding, with a Hb level of less than 70 g/L or an Hb increase of less than 8 g/L, or there was evidence of active cardiac ischemia, according to the national guidelines.⁷ The senior scientist in transfusion medicine provided the "gate keeper" function for inappropriate requests with the support of the PBM CNC. Hematology registrars and consultants provided additional management advice.

Anemic patients presenting to the ED

As a result of a retrospective audit of RBC transfusions it was noted that anemic patients were being referred to the ED by their general practitioner for blood transfusion and discharged without further assessment. Follow-up of the initial investigations taken in the

ED revealed that some of these patients were iron deficient. These patients were flagged as requiring rapid iron studies with results from the biochemistry laboratory made available within 30 minutes. If clinically appropriate, treatment with IV iron was administered thus avoiding RBC transfusion.

Methods for analyzing the impact of the PBMP

Data collection

Data from the WA PBM data system,² a repository linking inpatient admissions from the patient administration system for FHHS with blood transfusion events and laboratory results from the WA laboratory information system, was analyzed retrospectively over the 4-year period January 1, 2008, to December 30, 2011.

Approval for the data collection and evaluation was obtained through the Fremantle Hospital Human Research and Ethics Committee. All information was collected and stored anonymously on a password-protected system.

Single-unit admissions were defined as admissions where only 1 RBC unit was transfused. Pretransfusion Hb was calculated as the latest Hb recorded on the database before the transfusion date and time.

Data analysis

Poisson regression analysis was used to evaluate the trend in rate of blood units per admission over time and to calculate the rate ratios and test their significance. The proportion trend test was used to detect the change in transfusion rates over time. The test calculated a chi-square statistic for the trend (regression) of proportion or

rate over time. Therefore, all the p values within the tables and graphs represent the statistical significance for the test to assess whether the trend in proportion has changed significantly over the 4-year period (2008-2011).

RESULTS

Investigation of the WA PBM data system allowed a comprehensive assessment of blood product use before and after initiation of a PBMP in 2009. The majority of transfusions were administered to the older population with 70% of blood transfusions administered to adults over the age of 60 years in 2008, increasing to 74% in 2011. The over 80 years age group represented 20% usage, increasing to 25% over the same time (Table 1).

Between 2008 and 2011, the number of acute and elective admissions to FHHS increased by 22% (Fig. 3). Using 2008 as reference year, the mean RBC units per admission had declined 26% by 2011. Table 2 shows the decreasing trend in usage rates over the 4-year study period with RBC rates decreasing from 0.112 units per admission (95% confidence interval [CI], 0.109-0.114) in 2008 to 0.083 units per admission (95% CI, 0.081-0.085) in 2011. The differences in RBC usage rates were significant ($p < 0.001$). Compared to 2008 (the referent year), the RBC rate ratios for 2009, 2010, and 2011 were, respectively, 0.93 (95% CI, 0.90-0.97), 0.85 (95% CI, 0.83-0.87), and 0.74 (95% CI, 0.72-0.77). All the rate ratios were significant ($p < 0.001$; Table 2). Usage rate ratios for FFP showed a significant decline with a reduction of 38% but an increase in cryoprecipitate use of 7%. PLT use was stable (Table 2).

For elective admissions between 2008 and 2011, the leading decline in RBC transfusion rate was in cardiothoracic surgery from 27.5% to 12.8% (Table 1, Fig. 4) with transfusion rates in coronary artery bypass graft (CABG) surgery (including nonisolated CABG and combined CABG and valve procedures) decreasing from 51% to 27% ($p < 0.001$; Table 3).

In elective orthopedic surgery the overall transfusion rate decreased from 3.6% in 2008 to 2.7% in 2011 (Table 1) with primary total knee arthroplasty (TKA) decreasing from 9% to 3% ($p = 0.043$; Table 3). Over the corresponding period, the mean hospital LOS for primary TKA decreased from 5.9 to 4.8 days.

Blood transfusion rates for primary and revision total hip arthroplasty (THA) remained stable at 18 and 53% but the transfusion rate in revision TKA decreased from 30% to 16% (Table 3); however, trend analysis showed no significant difference. In the second half of 2011 transfusion rates in primary THA further declined to 12% and in primary TKA 1.6% and revision TKA 4.2%.

The mean number of RBC units per transfused admission decreased in all categories of orthopedic surgery (except revision TKA) and in CABG (Table 3).

TABLE 1. Transfusion rate by age group and specialty for elective admissions to Fremantle Hospital, 2008-2011*

Patients	2008				2009				2010				2011			
	N	Mean RBC	% RBC use	TX rate	N	Mean RBC	% RBC use	TX rate	N	Mean RBC	% RBC use	TX rate	N	Mean RBC	% RBC use	TX rate
Age groups—all admissions																
0-40	13,283	0.043	8.92	1.20	15,357	0.041	9.74	1.20	16,836	0.034	8.97	0.90	17,903	0.020	6.28	0.80
41-60	16,268	0.084	21.30	2.10	17,475	0.073	19.96	2.10	17,796	0.059	16.55	1.70	18,318	0.060	18.80	1.90
61-80	21,527	0.147	49.20	4.20	21,720	0.142	48.16	4.40	24,186	0.139	52.81	4.40	25,328	0.115	50.10	4.10
80+	6,249	0.212	20.59	7.50	6,852	0.208	22.14	7.70	7,238	0.190	21.67	7.50	8,371	0.172	24.82	6.80
Total	57,327	0.112	3.27	3.27	61,404	0.105	3.32	3.32	66,056	0.096	3.32	3.13	69,920	0.083	3.00	3.00
Specialty—elective admissions																
Cardiothoracic surgery	295	1.058	14.70	27.50	279	0.559	7.00	20.80	275	0.498	6.20	17.10	266	0.263	3.30	12.80
Gastroenterology	3,778	0.008	1.50	0.30	4,176	0.006	1.10	0.20	4,369	0.018	3.60	0.60	3,980	0.019	3.70	0.70
General surgery	1,853	0.155	13.50	3.30	1,806	0.109	8.90	3.30	1,468	0.165	10.90	3.90	1,276	0.190	11.60	4.40
Gerontology	777	0.058	2.10	2.60	732	0.067	2.20	2.70	609	0.064	1.80	3.00	753	0.048	1.70	1.70
Hematology	1,997	0.333	31.30	13.20	2,000	0.516	46.60	18.60	2,086	0.452	42.40	18.60	2,238	0.489	52.40	21.40
Nephrology	11,519	0.010	5.60	0.40	11,991	0.012	6.60	0.60	13,190	0.007	4.30	0.30	14,135	0.004	3.00	0.20
Oncology	2,836	0.045	6.10	2.30	2,958	0.027	3.60	1.70	3,047	0.034	4.70	1.90	2,888	0.032	4.40	1.90
Orthopedics	2,669	0.093	11.70	3.60	2,065	0.097	9.10	3.20	1,894	0.103	8.80	4.70	2,343	0.053	5.90	2.70
Urology	1,947	0.010	0.90	0.40	2,447	0.031	3.40	1.10	2,178	0.033	3.20	1.20	2,474	0.030	3.60	1.00
Vascular surgery	471	0.155	3.40	4.20	491	0.077	1.70	3.30	421	0.278	5.30	6.70	406	0.121	2.30	4.20

* % RBC use = proportion of RBC units used by specialty or age group of total RBCs used by hospital; mean RBC = number of RBC units administered per admission; N = number of hospital admissions; TX rate = proportion of admissions receiving RBC transfusion.

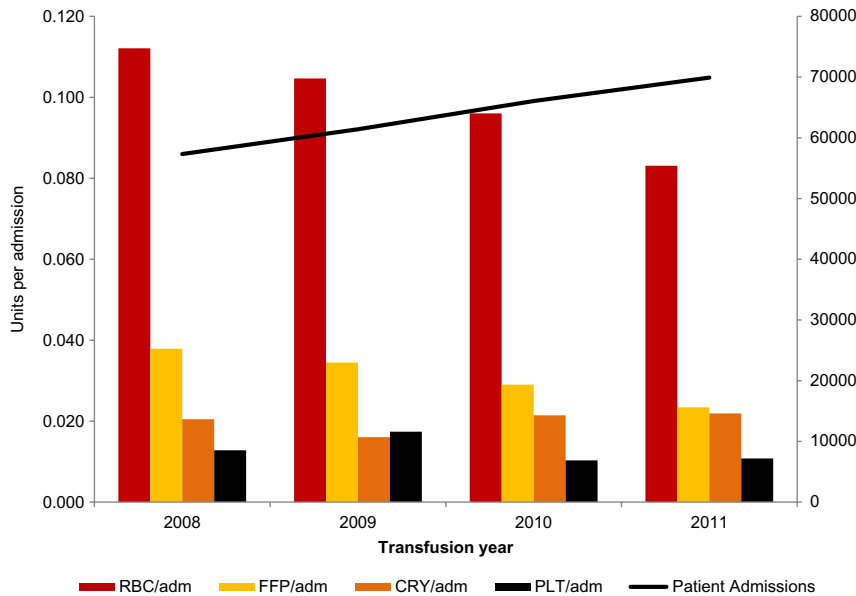


Fig. 3. Blood product use per admission (all admissions) 2008 to 2011. $p_{\text{trend}} < 0.001$ for RBC usage per admission 2008 to 2011. Patient admissions 2008 to 2011 increased 22%.

TABLE 2. Trend rate ratios by year for fresh blood products				
Year	Units per admission	Rate ratio	p value*	95% CI
RBCs				
2008	0.112	Referent year		
2009	0.105	0.933	<0.001	0.902-0.967
2010	0.096	0.857	<0.001	0.827-0.887
2011	0.083	0.741	<0.001	0.715-0.768
FFP				
2008	0.038	Referent year		
2009	0.034	0.911	0.002	0.857-0.966
2010	0.029	0.757	<0.001	0.720-0.814
2011	0.023	0.617	<0.001	0.579-0.658
Cryoprecipitate				
2008	0.020	Referent year		
2009	0.016	0.783	<0.001	0.720-0.853
2010	0.021	1.048	0.23	0.970-1.132
2011	0.022	1.071	0.078	0.992-1.155
PLTs				
2008	0.013	Referent year		
2009	0.017	1.36	<0.001	1.238-1.494
2010	0.010	0.806	<0.001	0.726-0.895
2011	0.011	0.842	<0.001	0.761-0.932

* p_{trend} values indicate whether the transfusion rates have significantly changed over the 4-year period. p values less than 0.05 are significant.

Among the nonsurgical specialties hematology and gastroenterology showed sustained increases in transfusion rates.

In hematology patients the transfusion rate increased from 13.2% to 21.4% (Table 1) over 2008 to 2011 as a result of increasing patient numbers with marrow failure syndromes such as MDS requiring hematologic support. Over this period the number of admissions with MDS increased 62% (from 104 patients in 2008 to 168 patients in

2011) with those requiring transfusion increasing by 65% (85 to 139). To date there has been no attempt at introducing the single-unit transfusion policy in these patients. The increase in transfusion rate in gastroenterology from 0.3% to 0.7% reflected the increasing numbers of hematemesis and melena admissions and a local protocol requiring an Hb of 100 g/L before endoscopy.

In a 3-month trial period December 1, 2010, to February 28, 2011, a total of 154 (8.5%) of the total 1803 computerized prescriber order entry orders were terminated by transfusion medicine. A total of 121 (79%) of these requests had a valid G&A order and the remaining 33 (21%) were not compliant with guidelines and were therefore canceled. In a follow-up period December 1, 2011, to February 29, 2012, of the 1947 orders via computerized prescriber order entry, 802 (41%) were canceled because of the new alert system, 621 (77%) because of the G&A alert and 181 (23%) because of Hb alert. These computer alerts reduced inappropriate blood sample collection and extra laboratory processing. This reduction was significant ($p < 0.001$).

Small draw tubes for blood sampling were used in critical care areas including ICU, hematology, and ED. In the ICU over a 12-month period it was estimated that approximately 100 L of blood was saved from patient sampling using small draw tubes.

Assessment of the impact of the single-unit policy revealed that the proportion of single units used per hospital admission increased from 13% in 2008 to 28% in 2011 ($p_{\text{trend}} < 0.001$; Fig. 5). The proportion of 2-unit use decreased from 48% in 2008 to 37% in 2011 ($p_{\text{trend}} < 0.001$), and 3 or more units use from 39% to 34% ($p_{\text{trend}} = 0.004$). All changes achieved significance.

The proportion of RBC transfusions occurring where pretransfusion Hb was more than 100 g/L decreased from 16% in 2008 to 12% in 2011 ($p_{\text{trend}} < 0.001$; Fig. 6). Also, the proportion of RBC transfusions occurring where pretransfusion Hb was less than 70 g/L increased from 14% in 2008 to 19% in 2011 ($p_{\text{trend}} < 0.001$). Transfusions occurring where pretransfusion Hb was between 70 and 100 g/L were similar across the years. The data do not exclude actively bleeding patients or where point-of-care devices

may have been used for Hb measurement and the results not recorded on the laboratory information systems.

DISCUSSION

In May 2011 the World Health Assembly adopted Resolution WHA63.12 recommending PBM and its three-pillar approach to all its member states.²⁶ The new Australian *Patient Blood Management Guidelines: Module 2 Perioperative* contains 22 evidence-based recommendations and 20 practice points supporting this standard of

care. The associated literature review confirmed that RBC transfusion is associated in a dose-dependent manner with increased morbidity and mortality and ICU and hospital LOS and that PBMPs reduce RBC utilization. The first recommendation is that “health-care services should establish a multidisciplinary, multimodal perioperative PBMP which should include preoperative optimisation of red cell mass and coagulation status; minimisation of perioperative blood loss, including meticulous attention to surgical haemostasis; and tolerance of post-operative anaemia.”⁷

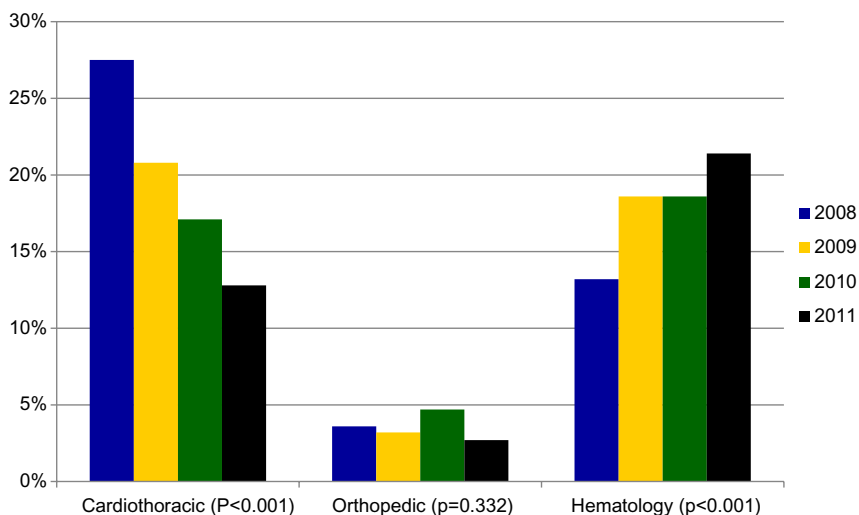


Fig. 4. Fremantle Hospital transfusion rate by key specialties for elective admissions 2008 to 2011. p values indicate whether the trend in proportion has changed significantly over the 4-year period 2008 to 2011. p values less than 0.05 are significant.

Internationally there is a great variation in blood product usage. The 2009 national blood collection and utilization survey report provided information for the United States for 2008. The whole blood and RBC collection rate per thousand population was 85.8, and 14,855,000 units of RBCs were transfused at a transfusion rate of 48.8 units per 1000 population.²⁷ Data published for 2008 indicated that the transfusion rate was lower in the European Union (41/1000), with lowest rates of 34 and 36 per 1000 population in the Netherlands and United Kingdom and high rates in Germany and Denmark at 57 and 60 per 1000 population, respectively.²⁸ In Denmark this had fallen from a high of 71.9 per 1000 annually in the years 2000 to 2002.²⁹

TABLE 3. Transfusion rate for key elective procedures at Fremantle Hospital 2008-2011*

Procedure	Year	Number of procedures	Transfusion rate (%)	Mean RBC units/adm	Mean RBC units/TX adm
Primary total hip replacement ($p_{\text{trend}} = 0.822$)	2008	195	19	0.46	2.41
	2009	148	22	0.51	2.34
	2010	184	21	0.45	2.10
	2011	194	18	0.4	2.20
Primary total knee replacement ($p_{\text{trend}} = 0.0432$)	2008	217	9	0.19	2.05
	2009	185	9	0.17	2.00
	2010	184	10	0.17	1.68
	2011	214	3	0.06	1.71
Revision total hip replacement ($p_{\text{trend}} = 0.716$)	2008	39	54	2.13	3.95
	2009	34	65	2.74	4.23
	2010	45	53	1.78	3.33
	2011	45	53	1.31	2.46
Revision total knee replacement ($p_{\text{trend}} = 0.164$)	2008	33	30	0.64	2.10
	2009	24	29	0.92	3.14
	2010	24	33	0.79	2.38
	2011	44	16	0.34	2.14
CABG ($p_{\text{trend}} < 0.001$)	2008	125	51	1.87	3.66
	2009	130	39	1.06	2.76
	2010	133	38	1.13	2.94
	2011	126	27	0.67	2.50

* Trend p values indicate whether the transfusion rates have significantly changed over the 4-year period. p values less than 0.05 are significant.

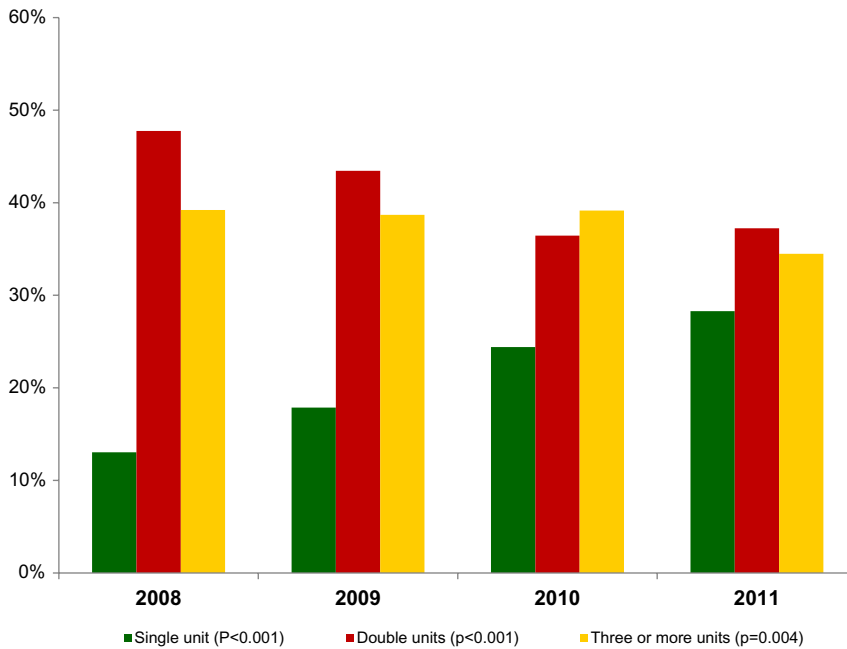


Fig. 5. Proportion of single- and multiple-unit RBCs administered during each admission to Fremantle Hospital 2008 to 2011. p values indicate whether the trend in proportion has changed significantly over the 4-year period 2008 to 2011. p values less than 0.05 are significant.

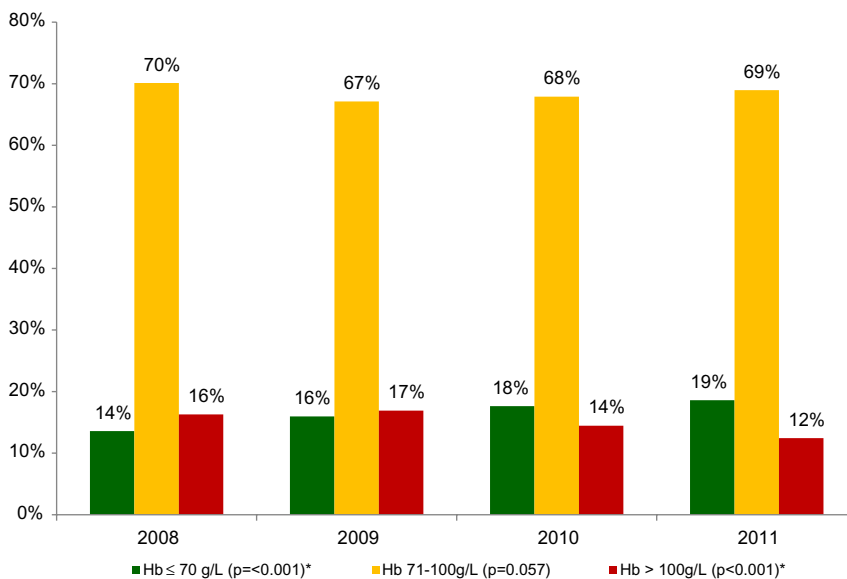


Fig. 6. Proportion of blood transfusions by pretransfusion Hb categories (all admissions Fremantle Hospital 2008-2011). p values represent the significance for the test to check whether the trend in proportion has changed over the 4-year period (2008-2011). p values less than 0.05 are significant.

The WA PBMP started in an environment where there was already a conservative approach to RBC transfusion. In 2009 the RBC issuance rate in WA was 30 per 1000 population. This compared with the Australian national issuance rate of 36 per 1000.³ These rates were the lowest in the

developed world. Data from the Australian Red Cross Blood Service show that the RBC issuance rate for WA decreased by 3% over each of the fiscal years (2009/2010 and 2010/2011) compared with an increase in RBC issuance nationally of 0.3 and 0.6% over the same periods.¹

Since the implementation of a hospital-wide PBMP at FHHS in 2009 there has been a downward trend ($p < 0.001$) in RBC use. Patient activity increased by 22% over the 4-year study period and the mean RBC units per admission decreased by 26%. The multi-disciplinary approach to PBM with an awareness of the program across the whole hospital contributed to this reduced blood product use. Particular strategies for reduction in mean RBC use can be attributed to laboratory “gatekeeping” and general awareness among clinicians regarding the adverse events associated with allogeneic blood transfusions. The decline in FFP use was in part due to the use of ROTEM allowing targeting of the coagulopathy and the increased focus on the use of fibrinogen or cryoprecipitate in the perioperative setting and in the management of massive bleeding. Also protocols for the reversal of anticoagulation with vitamin K antagonists were changed to prothrombin complex concentrates only thus avoiding FFP.

The “single-unit” policy, utilized in nonbleeding patients with symptomatic anemia, resulted in a significant increase in the prescription of single RBC units and a decrease in the use of two or more RBC units. The increase in single-unit RBC use is consistent with retrospective studies in tertiary care hospitals showing no adverse outcomes in these patients. Over the range of Hb thresholds from 70 to 90 g/L it was demonstrated that the transfusion of a single RBC unit would raise the Hb concentration sufficiently for most patients, thereby avoiding the need for a second unit.²³

For patients who might have received a 2-unit transfusion in the past and instead received a single unit, the dose-dependent risk associated with allogeneic blood transfusions is reduced and a unit of RBC “saved.” Adherence to the single-unit RBC transfusion policy

has not been easy and continuing education is required for medical and nursing staff.

Transfusion medicine staff who act as “gatekeeper” and monitor policy adherence need hematologist support especially outside normal weekday work hours.

Preoperative anemia and iron deficiency increase the perioperative transfusion risk.^{7,9} Effective preoperative clinics empowered to diagnose and manage anemia, absolute and functional iron deficiency, and other comorbidities, especially in orthopedic and cardiothoracic surgery before operation, have contributed to the reduction in perioperative RBC transfusion.

Our results for the second half of 2011 show that transfusion rates in key orthopedic procedures have shown an accelerating decline in primary THA and primary and revision TKA as a result of the PBMP. In orthopedic procedures, surgical technique, anesthetic practices, and use of tranexamic acid along with an effective preoperative assessment to optimize Hb level contributed to the low transfusion rate.³⁰

The reduced average LOS for primary TKA in our patients (5.9 to 4.8 days) is consistent with other studies evaluating the impact of PBM in orthopedic surgery.^{9,31} Kotze and colleagues⁹ described a systematic approach to optimizing patients’ RBC mass and limiting Hb loss perioperatively, which was associated with lower allogeneic RBC transfusion rates, shorter LOS (6 days vs. 5 days in THA and 6 days vs. 4 days in TKA), and a reduction in reattendance after elective arthroplasty.

In a review of hip and knee surgery Spahn³¹ showed that in four prospective cohort studies anemia on admission and postoperative anemia were both associated with a significantly increased LOS. In three of the studies mean LOS for anemic patients compared with nonanemic patients was 18 days versus 11 days ($p < 0.001$), 13 days versus 8 days ($p < 0.001$), and 16 days versus 8 days ($p < 0.01$). He concluded that anemia in the orthopedic perioperative setting was frequent and associated with increased allogeneic transfusion rates and adverse clinical outcomes, contributing to increased LOS.

In cardiothoracic surgery our transfusion rate decreased by approximately 50% (27.5%-12.8%) over 2008 to 2011 principally due to preoperative optimization of Hb and improvements in perioperative hemostasis as a result of surgical hemostasis training and techniques and use of ROTEM by cardiothoracic anesthesiologists. Large studies from the United States and the United Kingdom have shown that reduced transfusion rates in cardiac surgery have been associated with reduced average LOS due to lower morbidity and mortality resulting from lower infection rates and other complications.^{10,32}

New technology utilizing ROTEM for point-of-care testing of hemostasis in the operating theater, or the rapid provision of meaningful intraoperative results transmitted in real time to the operating theater from the

coagulation laboratory, are changing management of coagulopathy.^{19,33} A snapshot of blood product use in the 6 months before and after implementation of ROTEM showed the use of perioperative cryoprecipitate increased 88% and FFP decreased 9% (written correspondence WA PBM data system administrator). This is overall FFP usage for resuscitation and coagulation reversal excluding use for plasmapheresis.

The ROTEM real-time plots from the coagulation laboratory to operating theater have improved the immediate management of coagulopathy, targeting the abnormality with specific therapy under guidance of hematologists rather than administering a cocktail of all blood products as default therapy. Over the 4-year period 2008 to 2011 our use of cryoprecipitate increased 7% and FFP decreased 38%.

In contrast, in Europe, use of ROTEM is generally a point-of-care activity in the operating theater under the control of and carried out by the anesthesiologist and/or technical staff³⁴ allowing immediate decision making by the anesthesiologist regarding appropriate blood product use for specific abnormalities in coagulation.

To date the FHHS PBMP has not specifically focused on hematology patients, although the single-unit rule has been encouraged in patients undergoing intensive chemotherapy and stem cell transplants but not rigorously applied. Many patients with irreversible marrow failure syndromes, for example, MDS, require regular transfusions to remain symptom free and maintain a good quality of life. This has resulted in an increase in the transfusion rate in hematology from 13.2% to 21.4% from 2008 to 2011.

However, there is evidence in patients undergoing intensive chemotherapy and stem cell transplants for hematologic malignancy that restrictive transfusion programs do not increase morbidity or mortality. A Swiss study demonstrated that a change from a double- to single-unit RBC transfusion policy is safe and associated with a 25% reduction in RBC transfusion requirements. There was no evidence of more severe bleeding or more PLT transfusions required during the single-unit period and the overall survival was similar in both single- and double-unit cohorts.²⁵ With the high proportion of donated RBCs and PLTs currently administered to hematology-oncology patients¹ the role of restricted transfusion support in intensive chemotherapy and stem cell transplantation requires further study.

As a result of PBM interventions there has been a positive shift in transfusion trigger. The proportion of transfusions in patients with a Hb level of less than 70 g/L has significantly increased over the study period, whereas the proportion of transfusions in patients with a Hb level of more than 100 g/L has significantly decreased (Fig. 6). Transfusion medicine laboratory staff did report difficulty refusing transfusion requests from medical officers, which were not compliant with guidelines and were often

passive providers “after hours” when they were without immediate access to blood component transfusion decision support from senior staff. Empowering after-hours staff with the 1-unit policy guidelines (Fig. 2) and providing telephone support by senior staff, including “on call” hematologists, improved compliance.

Further education for medical and nursing staff on tolerance of anemia may be needed to address why 12% of RBC transfusions in 2011 were administered to patients with a Hb level of more than 100 g/L.

However, this study analysis does not exclude patients who were actively bleeding. Hb levels guiding transfusion in the operating theater may be derived from point-of-care testing and these values, at present, do not enter the electronic data system. Thus, for patients in the operating theater the preoperative Hb value in the electronic data system may not be a true measure of the patient’s pretransfusion Hb.

This high-threshold Hb for transfusion might also reflect the traditional belief that older patients with cardiovascular risk require a higher transfusion threshold. The recent FOCUS study³⁵ did not support this and showed that a restrictive transfusion threshold is safe in elderly high-risk patients undergoing hip fracture surgery. Adoption of a restrictive transfusion threshold in older patients may contribute further to RBC reduction in this patient population that is putting an increasing demand on health services.³⁵

Our data, showing an increasing use of RBC transfusion in the elderly, confirm the concerns that in developed countries with an aging population and a shrinking donor pool, demand for transfusion is set to exceed supply and changes in medical practice are required to prevent this impacting on patient care.^{6,35}

PBM requires a team approach that can be promoted by hematologists and transfusion medicine specialists; however, clinician “ownership” is essential especially in the specialties of anesthetics, surgery, and intensive care where an understanding of PBM principles is necessary to maintain the program. The implementation of a hospital-wide PBMP is dependent on a combination of education and adherence to new protocols relating to the management of anemia and blood conservation activities.

Peer review is a powerful tool for changing practice.³⁶ Comparing data on transfusion rates between hospitals in surgical specialties such as orthopedics and cardiothoracic surgery enables clinicians to benchmark their practice. Presentations to the orthopedic department comparing transfusion rates at the three teaching hospitals in WA evoked a positive response at FHHS with a decrease in transfusion rates for primary and revision TKA (Table 3).

Ultimately the only sure way of achieving long-lasting change in patient management is to embed teaching into

medical student curricula and postgraduate programs especially in the specialties of anesthetics, surgery, and hematology-oncology. These curriculum changes are currently being evaluated in university medical schools in WA.¹⁸ Publications reflecting practice change to PBM have mainly concerned individual specialties such as orthopedic and cardiothoracic surgery and critical care rather than hospital-wide programs.^{5,9,10}

FHHS is the first hospital in Australia to implement a comprehensive PBMP as recommended in the new National Patient Blood Management Guidelines.⁷ Implementation of a multidisciplinary PBMP rapidly resulted in significant changes in perioperative care across surgical disciplines with lower RBC, FFP, and PLT transfusion rates, targeted use of cryoprecipitate and likely improved outcomes by reducing patient exposure to allogeneic blood transfusion.

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None.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest relevant to the manuscript submitted to **TRANSFUSION**.

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