

## ORIGINAL RESEARCH

# Red Blood Cell Transfusion: Impact of an Education Program and a Clinical Guideline on Transfusion Practice

Howard L. Corwin, MD<sup>1\*</sup>, John W. Theus, MD<sup>2</sup>, Christopher S. Cargile, MD<sup>3</sup>, Nicholas P. Lang, MD<sup>3</sup>

<sup>1</sup>Department of Medicine, College of Medicine, University of Arkansas for Medical Sciences, Little Rock, Arkansas; <sup>2</sup>Department of Pathology, College of Medicine, University of Arkansas for Medical Sciences, Little Rock, Arkansas; <sup>3</sup>Department of Hospital Administration, College of Medicine, University of Arkansas for Medical Sciences, Little Rock, Arkansas.

**BACKGROUND:** Red blood cell (RBC) transfusion guidelines have been developed by professional societies. These guidelines recommend a restrictive RBC transfusion practice for most clinical populations. Despite the consistency of guidelines and limited evidence for RBC transfusion efficacy, there is variability in RBC transfusion practice.

**METHODS:** A program was initiated in a tertiary medical center to align RBC transfusion practice with best-practice RBC transfusion guidelines. The program included an educational program, followed after 6 months by RBC transfusion decision support that included the approval of a best-practice RBC transfusion guideline by the hospital medical board and an RBC transfusion order form that included the guideline recommendations. RBC transfusion practice was followed over an 18-month period and compared with transfusion practice over the prior 18 months. The primary

outcome variables were adult inpatient RBC units transfused, RBC units per admission, and RBC units per 100 patient-days.

**RESULTS:** The mean RBC units transfused decreased with initiation of each component of the program: from  $923 \pm 68$  units to  $852 \pm 40$  ( $P = 0.025$ ) with education and further to  $690 \pm 52$  ( $P < 0.0001$ ) with the RBC transfusion decision support. Similarly, RBC transfusions per 100 patient-days fell from  $10.56 \pm 0.80$  to  $9.69 \pm 0.49$  ( $P = 0.02$ ) and to  $7.68 \pm 0.63$  ( $P = 0.0001$ ) during the 3 time periods.

**CONCLUSION:** An education program coupled with institutional adoption of a best-practice RBC transfusion guideline and RBC transfusion order set resulted in a reduction in total RBC units transfused. *Journal of Hospital Medicine* 2014;9:745–749. © 2014 Society of Hospital Medicine

Historically, red blood cell (RBC) transfusions have been viewed as safe and effective means of treating anemia and improving oxygen delivery to tissues. Beginning in the early 1980s, primarily driven by concerns related to the risks of transfusion-related infection, transfusion practice began to come under scrutiny.

Numerous studies over the past 2 decades have failed to demonstrate a benefit of RBC transfusion in many of the clinical situations in which RBC transfusions are routinely given, and many of these studies have in fact shown that RBC transfusion may lead to worse clinical outcomes in some patients.<sup>1,2</sup> The few available large, randomized clinical trials and prospective observational studies that have assessed the effectiveness of allogeneic RBC transfusion have demonstrated that a more restrictive approach to RBC transfusion results in at least equivalent patient outcomes as compared to a liberal approach, and may in fact reduce morbidity and mortality rates.<sup>1,2</sup>

Over the last decade, RBC transfusion best-practice guidelines have been developed by a number of

professional societies,<sup>3</sup> addressing RBC transfusion practice in specific patient populations including critical care as well as more general hospitalized populations. These guidelines are generally consistent, strongly recommending a restrictive RBC transfusion approach in most clinical populations. However, despite the general consistency of the guidelines and the lack of evidence for the efficacy of RBC transfusion, there still remains significant variability in clinical RBC transfusion practice.<sup>4,5</sup>

The difficulty in getting physicians to follow clinical guidelines in general has been well described.<sup>6</sup> Over the last 2 decades there have been reports of a variety of interventions directed toward improving RBC transfusion practice either in specific care units (eg, intensive care units [ICUs]) or institution wide.<sup>7–14</sup> These initiatives have had varying degrees of success and have employed strategies that have included clinical guidelines, education, audit/feedback, and most recently computer order entry and decision support. We report on the effectiveness of an institution-wide intervention to align RBC transfusion practice with best-practice clinical guidelines. Our approach included institutional endorsement of a RBC transfusion guideline coupled with an ongoing education program and RBC transfusion order set.

## METHODS

### Study Setting

The University of Arkansas for Medical Sciences (UAMS) is a tertiary care university teaching hospital

\*Address for correspondence and reprint requests: Howard L. Corwin, MD, UAMS Medical Center, 4301 West Markham Street, Little Rock, AR 72205; Telephone: 603-252-6829; Fax: 501-686-8365; E-mail: hcorwin@uams.edu

Additional Supporting Information may be found in the online version of this article.

Received: January 7, 2014; Revised: June 20, 2014; Accepted: June 28, 2014

2014 Society of Hospital Medicine DOI 10.1002/jhm.2237

Published online in Wiley Online Library (Wileyonlinelibrary.com).

**TABLE 1. RBC Transfusion Guideline and RBC Transfusion Order Form.**

RBC Transfusion Guideline	
PURPOSE: Unnecessary blood transfusions increase healthcare costs and expose patients to potential infectious and noninfectious risks. The purpose of this clinical practice guideline is to establish an evidence-based approach to the transfusion of RBCs in hospitalized patients at UAMS.	
GUIDELINE: In order to avoid the potential risks and increased costs associated with unnecessary blood transfusions, the medical staff of UAMS will adhere to a restrictive transfusion strategy in which:	
(I) RBC transfusion should be considered unnecessary for hospitalized, hemodynamically stable patients unless the hemoglobin concentration is <7–8 g/dL.	
(II) RBC transfusion is appropriate for patients who have evidence of acute hemorrhage or hemorrhagic shock.	
(III) RBC transfusion is appropriate for patients with acute MI or unstable myocardial ischemia if the hemoglobin concentration is $\leq 8$ g/dL.	
(IV) The use of the hemoglobin concentration alone as a trigger for RBC transfusion should be avoided. The decision to order an RBC transfusion should also consider a patient's intravascular volume status, evidence of shock, duration and extent of anemia, and cardiopulmonary physiologic parameters as well as other symptomatology.	
(V) In the absence of acute hemorrhage, an RBC transfusion should be ordered and administered as single units.	
(VI) It is the physician's responsibility to weigh the risks and benefits of an RBC transfusion for a particular patient based on their medical condition. As such, it is recognized that there will be situations in which an RBC transfusion is appropriate outside of the guidelines put forth in this document. In these instances, the physician should document in the medical record his/her rationale for the RBC transfusion.	
RBC Transfusion Order Form	
The following are RBC transfusion indications consistent with UAMS-approved guidelines (check 1):	
Acute hemorrhage or hemorrhagic shock	Yes
Hgb <7–8 g/dL	Yes
Acute MI, Hgb $\leq 8$ g/dL	Yes
Acute coronary syndrome Hgb $\leq 8$ g/dL	Yes
Other indications/attending physician	If the RBC transfusion is for an indication other than those listed above, please note the indication and attending physician in the space provided. Free text of other indications. In the absence of acute hemorrhage or a hemoglobin concentration <6.5 g/dL, it is recommended that RBCs be ordered as single units.

NOTE: Abbreviations: Hgb, hemoglobin; MI, myocardial infarction; RBC, red blood cell; UAMS, University of Arkansas for Medical Sciences.

with a total of 437 patient beds. UAMS is a level 1 trauma center and has 52 ICU beds. The study took place between July 2012 and December 2013. At the time of study initiation, there was no institutional RBC transfusion protocol or guideline.

### Study Design

In June 2012, a program was initiated to align RBC transfusion practice at UAMS with best-practice RBC transfusion guidelines. This initiative consisted of several components: a series of educational programs, followed by hospital medical board approval of an intuitional RBC transfusion guideline, and initiation of an RBC transfusion order set of approved RBC transfusion guideline recommendations (Table 1).

The educational program included grand rounds presentations for all major clinical departments (internal medicine, surgery, obstetrics and gynecology, geriatrics, anesthesiology), presentations to high-volume transfusing services (hematology, vascular surgery, cardiac surgery), presentations to high-transfusion-volume nursing units (eg, medical and surgical ICUs, intermediate care unit, hematology), and scheduled and ad hoc resident educational programs. Educational sessions were repeated over the 18 months of the study and were presented by a clinical content expert.

A UAMS-specific transfusion guideline was developed based on published best-practice guidelines.<sup>15,16</sup> The UAMS medical board approved this guideline in November 2012 (Table 1). The guidelines were disseminated to the entire medical staff in December 2012

via email communication from the hospital's chief medical officer. Membership of the medical board included clinical leadership of the medical center (ie, department chairs) as well as ad hoc members from the hospital administrative leadership.

An RBC transfusion order form that included the guideline recommendations was implemented in the electronic medical record (Sunrise Enterprise 5.5; Eclipsys Corp., Atlanta, GA) in March 2013. There was no "hard stop" for an RBC transfusion order that was outside of the guideline recommendations; however, for documentation, the ordering physician was required to note the indication and the supervising attending physician for these out-of-guideline RBC transfusions. RBC transfusion orders are entered in an electronic medical record. There was no alert triggered by an RBC transfusion order outside of the RBC transfusion guideline.

### Outcomes

The number of RBC units transfused during the baseline period of January 2011 through June 2012 was compared with RBC units transfused July 2012 through December 2013. The latter period was further divided into the time period July 2012 through December 2012, during which the education program was initiated (education) as well as the time period January 2013 through December 2013 following the transfusion guideline approval and the initiation of the transfusion order set (decision support). All adult inpatient RBC units transfused, excluding RBC units transfused in the operating room and emergency room, were included in the analysis. RBC transfusions

**TABLE 2.** Patient Demographics

	Baseline	Education	Decision Support
Total patients	28,393	12,353	23,390
Age, mean, y*	48.2 ± 0.6	48 ± 0.1	48 ± 0.5
Gender, % female	56	57	58
Race, % non-Caucasian	63	61	61
Weighted DRG	1.60	1.59	1.59
MDC, %			
Nervous system	13	13	12
Circulatory system	11	12	11
Digestive system	10	10	10
Respiratory system	9	8	9
Musculoskeletal system	8	8	8
Kidney and urinary tract	8	8	8
Hepatobiliary system	5	5	5
Infectious and parasitic	5	5	6
Endocrine, metabolic	3	4	3
Blood, immunologic	3	2	2
Myeloproliferative	4	4	3
Multiple significant trauma	1	1	1
Other	20	20	22

NOTE: Abbreviations: DRG, diagnosis-related group; MDC, major diagnostic group.\*Mean monthly age of adult patients.

per month were normalized to RBC transfusions per 28 days. RBC transfusions were also calculated as RBC units per adult hospital admission and RBC units per 100 patient-days.

Hospital mortality is presented as mortality index (observed/predicted mortality). The mean weighted diagnosis-related group (DRG) was calculated using the monthly average of the Centers for Medicare and Medicaid Services (CMS)-derived relative weighted DRGs.

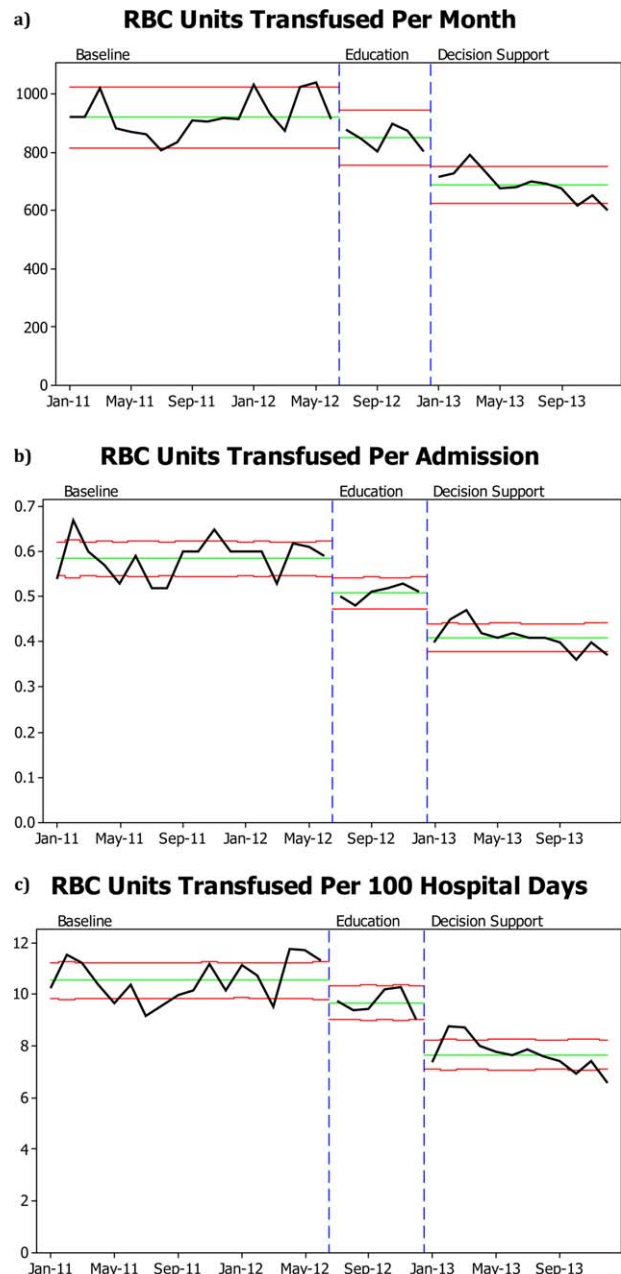
### Statistical Analysis

Data are presented as mean ± standard deviation. Comparisons were by Student *t* test or analysis of variance as appropriate. GraphPad InStat (GraphPad Software, Inc., La Jolla, CA) was used for statistical analysis, and Minitab (Minitab Inc., State College, PA) was used for control graphs.

## RESULTS

There were 28,393 adult admissions (excluding psychiatry) during the baseline period (January 2011–June 2012) and 35,743 (12,353 education, 23,390 decision support) adult admissions during the study period (July 2012–December 2013). The patient demographics for the 3 time periods were comparable (Table 2).

There was a significant decrease in the mean number of RBC units transfused as a result of the RBC transfusion program (Figure 1A). As compared to the baseline period, the mean number of RBC units transfused fell immediately during the 6 months following the initiation of the education program ( $923 \pm 68$  to  $852 \pm 40$ ,  $P = 0.02$ ), and further still during the subsequent 12 months following the approval of the RBC



**FIG. 1.** Red blood cell (RBC) transfusion. (A) Total RBC units transfused (mean, 95% confidence intervals). (B) Total RBC units transfused per admission (mean, 95% confidence intervals). (C) Total RBC units transfused per 100 patient-days (mean, 95% confidence intervals).

transfusion guideline by the UAMS medical board and initiation of the RBC transfusion order set (to  $690 \pm 52$ ,  $P < 0.0001$ ). These results do not reflect a change in the number of hospital admissions or length of stay; results are comparable if calculated based on RBC units transfused per patient admission or RBC units transfused per 100 patient-days (Figure 1B,C). Overall, there was a 29% reduction in mean RBC units transfused per hospital admission ( $0.58 \pm 0.04$ – $0.41 \pm 0.03$ ,  $P = 0.0001$ ) and a 27% reduction in mean RBC units transfused per 100 hospital-days ( $10.56 \pm 0.8$ – $7.68 \pm 0.63$ ,  $P = 0.0001$ ).

RBC transfusion reduction was observed in both the medical and surgical ICUs (Figure 2B) as well as

the general patient wards (Figure 2A). The trends noted above were similar in the medical ICU and general patient wards; however, in the surgical ICU, the RBC transfusion rate fell on initiation of the education program and remained stable at this lower rate for the subsequent 18 months, with no further decrease following RBC transfusion guideline approval and initiation of the RBC order set.

There was no significant difference in hospital mortality observed pre- versus post-RBC transfusion program (mortality index  $0.89 \pm 0.05$  vs  $0.84 \pm 0.04$ ,  $P = 0.13$ ).

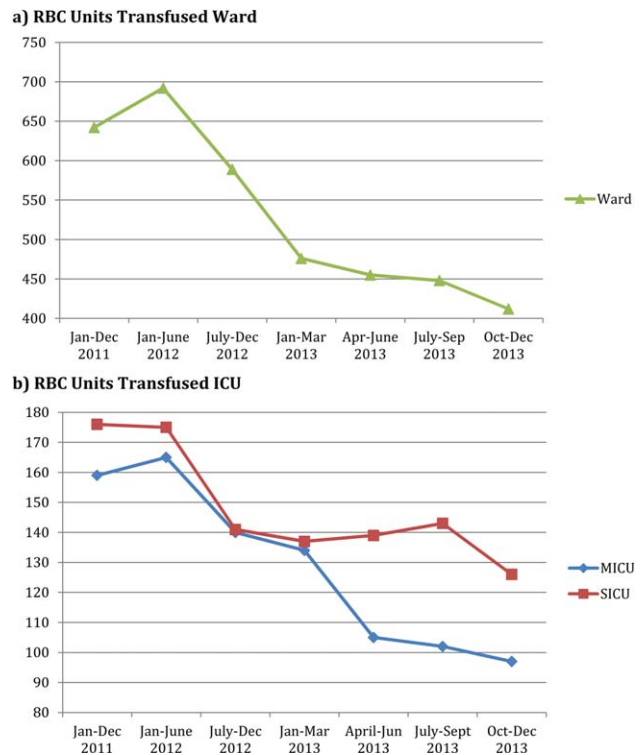
## DISCUSSION

We were able to demonstrate a 25% reduction in total RBC units transfused with an ongoing education program coupled with an institutional adoption of an RBC transfusion guideline that was incorporated into an RBC transfusion order set. Our program was novel in that the RBC transfusion guideline was approved by the hospital medical board as an institutional practice guideline. Importantly, the RBC transfusion reduction has been maintained over a 18-month period. The program was instituted in stages: educational program, followed by guideline approval by the hospital medical board, and the initiation of an RBC transfusion order set. At each stage we observed an additive increase in RBC transfusion reduction, with the largest reduction following guideline approval and initiation of the order set.

The pattern of RBC transfusion reduction was observed in all areas of the hospital with the exception of the surgical ICU, where transfusion practice remained stable after the initial decrease in RBC transfusions following initiation of the education program. That RBC transfusion practice on the general surgical wards mirrored practice in other areas of the hospital suggests that the difference seen in the surgical ICU reflects factors unique to that specific area rather than the general approach of surgeons to RBC transfusion.

Despite the substantial data now available regarding RBC transfusion risks and the proliferation of RBC transfusion practice guidelines, wide variation in clinical practice still exists.<sup>4,5</sup> The delay for evidence from clinical studies to be incorporated into clinical practice can be considerable. Balas and Boren<sup>17</sup> have estimated that it may take over 15 years from publication of a landmark study for the results to reach a 50% utilization rate in clinical practice. The barriers to guideline adherence have been described, including lack of familiarity, lack of agreement, and external factors.<sup>6</sup> Overcoming these barriers involve approaches toward knowledge, attitudes, and behavior.

There have been a number of approaches to changing RBC transfusion practice over the last 2 decades.<sup>7-14</sup> These interventions have all achieved varying degrees of success. Most have involved some



**FIG. 2.** Total red blood cell (RBC) units transfused in patient-care units. (A) RBC units transfused in the ward. (B) RBC units transfused in the intensive care unit (ICU). Abbreviations: MICU, medical intensive care unit; SICU, surgical intensive care unit.

combination of education, practice guideline, and audit/feedback. More recently, technology has allowed computer-assisted order entry and feedback. Good-nough et al.,<sup>7</sup> employing real-time clinical decision support and best-practice alerts, were able to achieve sustained adherence to clinical guidelines and a 24% reduction in RBC units transfused. Other recent reports have shown improvement in RBC transfusion practices comparable to what we observed with programs including audit/feedback and educational efforts.<sup>13,14</sup>

Our approach to RBC transfusion practice was relatively simple, involving education followed by institutional adoption of a best-practice guideline and simple RBC transfusion order form. We were able to begin to change RBC transfusion practice with the initiation of an education program; however, there was a more marked and persistent decrease in RBC transfusions following the adoption of the institution's RBC transfusion guideline and RBC transfusion order set. Although education alone is often ineffective in causing sustained change in behavior, a key aspect of our program was the approval of the RBC transfusion guideline by the hospital medical board. The approval by the hospital medical board, made up in part by the clinical leadership, was instrumental in changing the transfusion culture, or beliefs, in the institution. The consistency of practice seen within the time periods both before and after our intervention suggest a given set of beliefs driving RBC transfusion in each time

period. Further supporting this view is the consistency of RBC transfusion practice change throughout the institution, and the fact that patient volumes and severity of illness were comparable pre- and postintervention. It is difficult to know which elements of the program were most important. It is likely that optimal transfusion practices promoted by the education program were reinforced by the guideline, which were further reinforced by the order set.

Given the known risks of RBC transfusion and the data supporting a restrictive approach to RBC transfusion practice, improved patient safety by aligning RBC transfusion with best-practice guidelines was the primary goal of our RBC transfusion program.<sup>1,2</sup> Although we were not able to look at specific complications such as infection rate, there was no change in overall hospital mortality. The total RBC units transfused at our institution fell by almost 30%. We estimate that in the 18 months following initiation of our program we “saved” approximately 3200 RBC units as compared with the number of RBC units that would have been transfused based on the transfusion rate prior to the initiation of our educational program. This preserves a scarce resource, RBCs, as well as reduces cost. The cost of an RBC transfusion involves both the direct cost of the RBC unit as well as the cost of activities surrounding an RBC transfusion. Shander et al.,<sup>18</sup> using an activities-based costing model, have estimated the direct and indirect cost of an RBC transfusion as between \$522 and \$1183 (mean \$761). Over the last 18 months we have achieved a direct savings of \$704,000 for purchase of RBC units and, using the low estimate based on the activities-based costing model, a total savings of at least \$1.7 million.

This study is limited by the fact that it reflects a single-institution experience. Although we cannot exclude other factors contributing to the decrease in RBC transfusion, the pattern of response suggests that the RBC transfusion program was largely responsible for the results observed. Further, patient volumes at our institution have remained constant, as have surgical volumes. RBC transfusions are reduced comparably whether analyzed as total units transfused, units transfused per admission, or units transfused per 100 patient-days. The complexity of care also limits our ability to draw any conclusions regarding the impact of RBC transfusion reduction on patient outcome. We also do not know how consistent RBC transfusion practice prior to our program was with our guideline; however, the significant decline in RBC units transfused following our intervention suggests that there

was a discrepancy in RBC transfusion practice preintervention.

In conclusion, an education program coupled with institutional adoption of a best-practice RBC transfusion guideline and a RBC transfusion order set resulted in consistent reduction in RBC units transfused. The improvement in RBC transfusion practice was additive with implementation of each intervention. RBC transfusion practice was changed in all areas of the hospital and resulted in less exposure of patients to RBC transfusion risks, preserved a scarce resource, and was a direct cost savings.

## References

1. Carson JL, Carless PA, Hebert PC. Transfusion thresholds and other strategies for guiding allogeneic red blood cell transfusion. *Cochrane Database Syst Rev*. 2012;4:CD002042.
2. Marik PE, Corwin HL. Efficacy of RBC transfusion in the critically ill: a systematic review of the literature. *Crit Care Med*. 2008;36:2667–2674.
3. Shander A, Gross I, Hill S, Javidroozi M, Sledge S. A new perspective on best transfusion practice. *Blood Transfus*. 2013;11:193–202.
4. Bennett-Guerrero E, Zhao Y, O'Brien SM, et al. Variation in use of blood transfusion in coronary artery bypass graft surgery. *JAMA*. 2010;304:1568–1575.
5. Murphy DJ, Needham DM, Netzer G, et al. RBC transfusion practices among critically ill patients: has evidence changed practice? *Crit Care Med*. 2013;41:2344–2353.
6. Cabana MD, Rand CS, Powe NR, et al. Why don't physicians follow clinical practice guidelines? *JAMA*. 1999;282:1458–1465.
7. Goodnough LT, Shieh L, Hadhazy E, Cheng N, Khari P, Maggio P. Improved blood utilization using real-time clinical decision support. *Transfusion*. 2014;54:1358–1365.
8. Adams ES, Longhurst CA, Pageler N, Widen E, Franzon D, Cornfield DN. Computerized physician order entry with decision support decreases blood transfusion in children. *Pediatrics*. 2011;127:e1112–e1119.
9. Tinmouth A, MacDougall L, Fergusson D, et al. Reducing the amount of blood transfused. *Arch Intern Med*. 2005;165:845–852.
10. Rothschild JM, McGurk S, Honour M, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. *Transfusion*. 2007;47:228–239.
11. Brandt MM, Rubinfeld I, Jordan J, Trivedi D, Horst HM. Transfusion insurgency: practice change through education and evidence-based recommendations. *Am J Surg*. 2009;197:279–283.
12. Rana R, Afessa B, Keegan MT, et al. Evidence-based red cell transfusion in the critically ill: quality improvement using computerized physician order entry. *Crit Care Med*. 2006;34:1892–1897.
13. Perez ERF, Winters J, Gajic O. The addition of decision support into computerize physician order entry reduces red blood cell transfusion resource utilization in the intensive care unit. *Am J Hematol*. 2007;82:631–633.
14. Marques MB, Polhill SR, Waldrum MR, et al. How we closed the gap between red blood cell utilization and whole blood collections in our institution. *Transfusion*. 2012;52:1857–1867.
15. Napolitano L, Kurek S, Luchette FA, et al. American College of Critical Care and Eastern Association of Trauma. Clinical practice guideline: red blood cell transfusion practice in adult trauma and critical care. *Crit Care Med*. 2009;37:3124–3157.
16. Carson JL, Grossman BJ, Kleinman S, et al. Red blood cell transfusion: a clinical practice guideline of the AABB. *Ann Intern Med*. 2012;157:49–58.
17. Balas EA, Boren SA. Managing clinical knowledge for health care improvement. In: Bommel J, McCray AT, eds. *Yearbook of Medical Informatics 2000: Patient-Centered Systems*. Stuttgart, Germany: Schattauer Verlagsgesellschaft; 2000:65–70.
18. Shander A, Hofman A, Ozawa S, et al. Activity-based costs of blood transfusions in surgical patients at four hospitals. *Transfusion*. 2010;50:753–764.