

Patient Safety Intervention to Reduce Unnecessary Red Blood Cell Utilization

Scott Hasler, MD; Amanda Kleeman MS; Richard Abrams, MD; Jisu Kim, MD; Manya Gupta, MD; Mary Katherine Krause, MS; and Tricia J. Johnson, PhD

Red blood cell (RBC) transfusions are performed at a rate of approximately 13 million RBC units per year in the United States.^{1,2} Transfusions are commonly performed on surgical and trauma patients with blood loss, as well as patients with cancer who have decreased blood cell production.³ RBC transfusion practices vary widely, with significant differences existing among the hemoglobin threshold used to determine when transfusions are performed. As a result, the use of blood can deviate up to 4-fold among physicians performing the same procedure.

Transfusion strategies are generally categorized as liberal or restrictive, with a liberal strategy using a higher hemoglobin threshold and a restrictive strategy using a lower hemoglobin threshold before transfusing.⁵ There is mounting evidence that liberal transfusion strategies have led to worse health outcomes. A systematic review of 494 studies concluded that 59% of transfusions were inappropriate in all scenarios where a patient's hemoglobin level was 10 g/dL or above, and in 71% of scenarios where the patient's hemoglobin level was 8 to 9.9 g/dL.⁶ These results are supported in studies that have evaluated transfusion strategies in specific populations, including head injury, hip surgery, and upper gastrointestinal (GI) bleeding.⁷⁻¹⁰ In response to these data, the AABB (formerly the American Association of Blood Banks) constructed a clinical guideline in 2012 recommending a restrictive transfusion strategy for RBC utilization when hemoglobin levels fall below 8 g/dL for hospitalized, stable adults.⁵

In addition to the patient safety advantages of adhering to a restrictive transfusion strategy, there are important implications for hospital costs and clinical resource management. The cost of blood ranges between \$522 and \$1183 per unit when including storage, labor, and waste.¹¹ If a restrictive transfusion strategy was widely implemented, transfusions would be expected to decrease by an average

ABSTRACT

Objectives: To measure the impact of a local patient safety intervention and a national guideline to reduce unnecessary red blood cell (RBC) transfusions in the Department of Medicine of an academic medical center.

Study Design: This was a retrospective, pre-post study.

Methods: In May 2013, a clinical practice guideline, modeled after the 2012 AABB recommendations for RBC use, was implemented with the goal of decreasing unnecessary RBC transfusions. This was done using a previously developed model for change management in the Department of Medicine that included academic safety conferences, e-mail safety alerts, and feedback to providers on global blood product utilization. Data regarding the utilization of RBC products were obtained for the time before the AABB guideline, after the AABB guideline but before the local intervention, and after the local intervention (January 2011 through March 2014).

Results: Blood product use started to decline after the AABB guideline, but dropped much further after the focused, local interventions were implemented. The proportion of patients receiving a transfusion decreased from 12.6% prior to the AABB guideline to 8.8% after the intervention ($P < .001$). The percent of total blood use with a hemoglobin level above 8 g/dL decreased from 20.2% to 12.4%; the total units of RBCs transfused per 100 discharges also decreased from 33.4 to 21.7. The direct RBC costs per discharge dropped from \$61.60 to \$39.70.

Conclusions: Passive adoption of restrictive transfusion guidelines was shown to reduce blood product use on general medicine floors of an academic medical center, but the effect was greatly improved after a local, targeted intervention to improve patient safety was implemented.

Am J Manag Care. 2016;22(4):295-300

Take-Away Points

Although passive adoption of the AABB guideline that recommended a restrictive transfusion strategy for red blood cell (RBC) utilization moderately reduced blood product use, blood product use decreased significantly following a targeted patient safety intervention.

- The introduction of national guidelines targeted at reducing unnecessary utilization is often not sufficient to change physician behavior.
- The effectiveness of national guidelines to reduce unnecessary RBC utilization could be improved through targeted patient safety initiatives.
- A patient safety intervention that included a patient safety education conference and electronic alerts to supplement the education reduced unnecessary blood product use.

of 40%.⁵ Thus, widespread adherence to a restrictive transfusion guideline would be expected to result in a significant impact on hospital finances through both the direct cost savings and the indirect benefits of improved patient safety outcomes.

Although clinical guidelines are an important component of moving toward value-based care,¹² they have had a limited effect on changing physician behavior to date. Barriers to changing physician behavior include a lack of awareness about a guideline, lack of understanding about how a guideline applies to a physician's practice, lack of consensus about the importance or relevance of a guideline, and its conflict with a physician's current routine or training. Furthermore, adherence can be affected by "outcome expectancy," or the belief that following the guideline will not significantly impact patient outcomes, and is thus not worth implementing into practice. Finally, many physicians may lack the resources needed to follow guidelines.^{13,14} Educational interventions to increase the adoption of guidelines, such as large conferences, small-group interactive sessions, and academic "detailing" have also been met with mixed results.¹⁴⁻¹⁶

Although the effectiveness of education interventions is unclear, organizations that successfully adopt evidence-based practices often have a culture that supports continuous quality improvement. The purpose of this study was to evaluate the impact of the AABB guideline and a subsequent education intervention that was grounded in continuous quality improvement methodology on RBC use at an urban academic medical center.

METHODS**Intervention and Study Design**

In May 2013, the Department of Medicine at a large, urban academic medical center implemented an education intervention to integrate the AABB guidelines into practice. The intervention began with a patient

safety conference for all residents and hospitalists. The conference consisted of a literature review presented by educators and an analysis of local practice patterns, and ended with recommendations. Following the conference, safety e-mail alerts were sent from June to October 2013, to all physicians, reminding them to comply with AABB guidelines when ordering transfusions.

This was a retrospective pre-post study of all patients who received care from the general medicine units of the academic medical center from January 1, 2011, to March 31, 2014. To be included in the study sample, patients were required to have an attending physician within the center's Department of Medicine. Exclusions included patients who received a transfusion outside of a general medicine floor and patients with a principal diagnosis of neoplasm. During these 39 months, 23,368 patients were discharged from general medicine floors. Of these discharges, 1894 were diagnosed with neoplasms, 1151 had transfusions outside of a general medicine floor, 491 had incomplete patient demographic information, and 265 had a provider releasing the transfusion outside of the Department of Medicine; this left a final sample of 19,567 patients.

Clinical data were retrieved from the organization's electronic health record, and cost data were obtained from the organization's cost accounting system. Institutional review board approval was obtained prior to data collection. Data were separated into 3 time periods: "Pre-AABB Guideline" was defined as discharges occurring between January 1, 2011, and February 28, 2012; "Pre-Intervention" included discharges occurring between March 1, 2012, and May 31, 2013; and "Post-Intervention" consisted of discharges between June 1, 2013, and March 31, 2014.

The presence of an RBC transfusion, number of RBC transfusions performed with a hemoglobin level above 8 g/dL, average pre-transfusion hemoglobin concentration, units of RBCs transfused, RBC units transfused above 8 g/dL, and direct cost of RBCs were measured in all 3 groups. Total units of blood transfused and units transfused with hemoglobin >8 g/dL were expressed as units per 100 patient discharges. The direct cost of RBCs was reported in 2013 dollars and derived by multiplying the units per patient discharge by \$183, the average direct cost of an RBC unit at our institution in March 2014.

Additionally, sociodemographic characteristics, hospital length of stay (LOS), and diagnosis category were

collected. Diagnosis category was assigned using the Clinical Classification System for *International Classification of Diseases, 9th Revision, Clinical Modification*.¹⁷

Statistical Analysis

The first part of the analysis included all patients discharged from general medicine floors. A χ^2 test was used to test the association between time period and whether a patient received a transfusion. This association was also tested through a binary logistic regression model controlling for patient age, sex, race/ethnicity, diagnosis category, primary payer, and LOS.

The second part of the analysis was limited to patients who received transfusions. First, a χ^2 test was used to test the association between time period and whether a patient received a transfusion with hemoglobin >8 g/dL. A 1-way analysis of variance (ANOVA) was then used to test the association between time period and pre-transfusion hemoglobin concentration. Only the hemoglobin level prior to the patient's first transfusion was included. A 1-way ANOVA was used to test the association between time period and the total units of RBCs transfused per 100 patient discharges, the total units of RBCs transfused above 8 g/dL per 100 patient discharges, and the total direct cost of RBCs for the hospital stay. Data were analyzed via Microsoft Office Excel 2010 and SPSS Statistical Package Software, version 15.0 (IBM Analytics, Armonk, New York).

RESULTS

Of the 19,567 patients in the sample, 11.1% received at least 1 transfusion. Of these patients, 909 (41.7%) were transfused between January 2011 and February 2012 (Pre-AABB Guideline period), 816 (37.5%) were transfused between March 2012 and May 2013 (Pre-Intervention period), and 453 (20.8%) were transfused from June 2013 to March 2013 (Post-Intervention period).

Analysis Part 1: All Patients Discharged From General Medicine Floors

Overall, the proportion of patients receiving a transfusion decreased over time, falling from 12.6% of patients in the Pre-AABB Guideline period to 8.8% of patients in the Post-Intervention period ($P < .001$) (Table 1). Patients in the Pre-AABB Guideline and Pre-Intervention periods were 1.62 and 1.34 times more likely, respectively, to receive a transfusion compared with patients in the Post-Intervention period ($P < .001$) (Table 2).

Analysis Part 2: All Patients Receiving Transfusions on General Medicine Floors

Table 3 describes the subset of patients who received at least 1 transfusion during the study period ($n = 2178$; 11.1%). The results of the 1-way ANOVA test indicated a decline in the total number of RBC units transfused per 100 patient discharges, which dropped from 33.4 ± 5.8 units per 100 patient discharges in the Pre-AABB Guideline period to 21.7 ± 6.7 units per 100 patient discharges in the Post-Intervention period ($P < .001$).

There was a decrease in the proportion of patients receiving a transfusion with hemoglobin >8 g/dL, which fell from 20.2% of patients Pre-AABB Guideline to 14.8% of patients Pre-Intervention to 12.4% Post-Intervention ($P < .001$). This decline translated to an overall decrease in average pre-transfusion hemoglobin concentrations across all 3 time periods, decreasing from 7.4 ± 1.0 Pre-AABB Guideline to 7.0 ± 1.4 Post-Intervention ($P < .001$). A decline in the units of blood transfused with hemoglobin >8 g/dL also dropped from 5.9 ± 3.1 to 2.4 ± 1.6 units per 100 patient discharges throughout the study period ($P = .004$) (Table 3).

A decline in RBC associated cost was also observed. The average RBC unit cost per discharge fell from $\$61.60 \pm \10.60 Pre-AABB Guideline to $\$52.60 \pm \7.70 Pre-Intervention, and finally to $\$39.70 \pm \12.3 Post-Intervention ($P < .001$) (Table 3). Calculating the RBC unit cost difference per patient discharge between the Pre-AABB Guideline and Post-Intervention periods ($\$21.90$) and multiplying by total discharges (19,567), we were able to estimate annual savings of $\$131,851.48$ in RBC acquisition costs.

DISCUSSION

The study aim was to determine whether an educational intervention to promote the AABB guideline was successful in decreasing unnecessary transfusions. The results suggest that the initial drop in transfusions between the Pre-AABB Guideline and Pre-Intervention periods may have been due to passive adoption of the AABB guidelines. However, the larger drop between the Pre- and Post-Intervention periods highlighted the effectiveness of an active intervention in further reducing the number of transfusions and suggests this targeted approach may hasten the adoption of clinical practice guidelines.

The decrease in transfusions among all patients is complemented by the analyses conducted on the subset of patients who received transfusions. The drop in the number of patients receiving a transfusion who had a

Table 1. Descriptive and Bivariate Results, All Internal Medicine Patients (N = 19,567)

Variable	Pre-AABB Guideline n = 7221	Pre-Intervention n = 7196	Post-Intervention n = 5150	P
Age, years: mean ± SD	58.6 ± 18.4	58.2 ± 18.6	58.6 ± 18.2	.445
Gender, n (%)				.115
Male	2990 (41.4)	3092 (43.0)	2208 (42.9)	
Female	4231 (58.6)	4104 (57.0)	2492 (57.1)	
Race, n (%)				<.001
Caucasian	2421 (33.5)	2557 (35.3)	1831 (35.6)	
African American	3875 (53.7)	3921 (54.5)	2827 (54.9)	
Other	925 (12.8)	718 (10.0)	492 (9.6)	
Payer, n (%)				<.001
Medicare	4230 (58.6)	3945 (54.8)	2743 (53.3)	
Medicaid	1471 (19.5)	1743 (22.6)	1245 (24.2)	
Commercial	1485 (20.6)	1599 (22.2)	1140 (22.1)	
Other	35 (0.5)	26 (0.4)	22 (0.4)	
Diagnosis, n (%)				<.001
Endocrine, nutritional, metabolic diseases, and immunity disorders	2341 (32.4)	2144 (29.8)	1529 (25.4)	
Circulatory system	1326 (18.4)	1437 (20.0)	914 (17.7)	
Digestive system	536 (7.3)	575 (8.0)	403 (7.8)	
Blood/blood-forming organs	584 (8.1%)	590 (8.2)	406 (7.9)	
Nervous system/sense organs	423 (5.9)	381 (5.3)	256 (5.0)	
Respiratory system	414 (5.7)	413 (5.7)	308 (6.0)	
Infectious/parasitic diseases	393 (5.4)	371 (5.2)	254 (4.9)	
Mental illness	328 (4.5)	379 (5.3)	276 (5.4)	
Other	886 (12.3)	906 (12.6)	804 (15.6)	
Length of stay, days: median (25th-75th quartiles)	2.5 (1.3-4.4)	2.6 (1.5-4.9)	2.6 (1.5-4.6)	<.001 ^a
Received transfusion, n (%)				<.001
Yes	909 (12.6)	816 (11.3)	453 (8.8)	
No	6312 (87.4)	6380 (88.7)	4697 (91.2)	

^aThe Bonferroni post hoc test indicates that there is significance between all 3 time periods at the significance level of *P* < .001.

pre-transfusion hemoglobin concentration greater than 8 g/dL suggests that physicians were more cognizant of the recommended hemoglobin threshold. The decrease in the average pre-transfusion hemoglobin levels across all 3 time periods also supports this conclusion.

This study demonstrated that a restrictive transfusion strategy will translate into significant cost savings. Our estimate of just over \$131,000 in savings per year was for units that use less than 10% of our institution’s total RBC products and excluded the significant indirect expense of RBCs, including storage, transportation, and waste. Most importantly, there are likely substantial downstream decreases in hospital-acquired complications, mortality, and length of stay from adopting a restrictive transfusion strategy.

The success of this educational intervention provides insight into how hospitals can facilitate the adoption of evidence-based guidelines. Although edu-

Table 2. Results of the Binary Logistic Regression Analysis for Transfusion^a

Intercept	OR (95% CI)	P
Period		
Pre-AABB Guideline	1.62 (1.43-1.83)	<.001
Pre-Intervention	1.34 (1.19-1.53)	<.001
Post-Intervention	ref	
Area under the curve	0.72	

OR, odds ratio; ref, reference.

^aThis model controls for age, sex, race, payer, length of stay, and diagnosis category.

■ **Table 3.** Descriptive and Bivariate Results, Internal Medicine Patients Receiving Transfusions (N = 2178)

Variable	Pre-AABB Guideline n = 909	Pre-Intervention n = 816	Post-Intervention n = 453	P
Age, years: mean ± SD	61.8 ± 18.5	60.0 ± 18.9	60.1 ± 18.9	.100
Gender, n (%)				.454
Male	394 (43.3)	378 (46.3)	205 (45.3)	
Female	515 (56.7)	438 (53.7)	248 (54.7)	
Race, n (%)				.402
Caucasian	251 (27.6)	232 (28.4)	129 (28.5)	
African American	557 (61.3)	499 (61.2)	289 (63.8)	
Other	101 (11.1)	85 (10.4)	35 (7.7)	
Payer, n (%)				.014
Medicare	625 (68.8)	531 (65.1)	265 (58.5)	
Medicaid	162 (17.8)	173 (39.4)	104 (23.7)	
Commercial	117 (12.9)	109 (12.4)	81 (17.9)	
Other	5 (0.6)	3 (0.4)	3 (0.7)	
Diagnosis, n (%)				.449
Endocrine, nutritional, metabolic diseases, and immunity disorders	273 (30.0)	227 (27.8)	131 (28.9)	
Circulatory system	113 (12.4)	119 (14.6)	57 (12.6)	
Digestive system	59 (6.5)	47 (5.8)	33 (7.3)	
Blood/blood-forming organs	232 (25.5)	219 (26.8)	124 (27.4)	
Nervous system/sense organs	11 (1.2)	21 (2.6)	10 (2.2)	
Respiratory system	30 (3.3)	21 (2.6)	11 (2.4)	
Infectious/parasitic diseases	80 (8.8)	71 (8.7)	28 (6.2)	
Mental illness	26 (2.9)	24 (2.9)	9 (2.0)	
Other	85 (9.4)	67 (8.2)	50 (11.0)	
Length of stay, days: median (25th-75th quartiles)	4.3 (2.2, 9.3)	5.1 (2.5, 9.4)	5.2 (2.6, 11.2)	.019 ^a
Patient received transfusion with hemoglobin >8 g/dL, n (%)				<.001
Yes	189 (20.2)	124 (14.8)	58 (12.4)	
No	747 (79.8)	713 (85.2)	411 (87.6)	
Pre-transfusion hemoglobin concentration (g/dL), mean ± SD	7.4 ± 1.0	7.3 ± 1.0	7.0 ± 1.4	<.001 ^b
Units of RBCs transfused per 100 patient discharges, mean ± SD	33.4 ± 5.8	28.7 ± 4.2	21.7 ± 6.7	<.001 ^c
Units of blood transfused Above 8 g/dL per 100 patient discharges, mean ± SD	5.9 ± 3.1	3.7 ± 2.2	2.4 ± 1.6	.004 ^d
Direct cost of RBCs per patient discharges (\$), mean ± SD ^e	61.6 ± 10.6	52.6.0 ± 7.7	39.7 ± 12.3	<.001 ^e

RBC indicates red blood cell.

^aSignificance was found between the Pre-AABB Guideline and Pre-Intervention periods ($P < .001$) and the Pre-AABB Guideline and Post-Intervention periods ($P < .001$), but no significance was found between the Pre-Intervention and Post-Intervention periods ($P = 1.000$).

^bSignificance was found between the Pre-AABB Guideline and Pre-Intervention periods ($P < .001$), the Pre-Intervention and Post-Intervention periods ($P < .001$), and the Pre-AABB Guideline and Post-Intervention periods ($P = .002$).

^cSignificance was found between the Pre-AABB Guideline and Post-Intervention periods ($P < .001$) and the Pre-Intervention and Post-Intervention periods ($P = .010$), but no significance was found between the Pre-AABB Guideline and Pre-Intervention periods ($P = .088$).

^dSignificance was found between the Pre-AABB Guideline and Post-Intervention periods ($P = .004$), but no significance was found between the Pre-AABB Guideline and Pre-Intervention periods ($P = .062$) and the Pre-Intervention and Post-Intervention periods ($P = .598$).

^eSignificance was found between the Pre-AABB Guideline and Pre-Intervention periods ($P < .001$), the Pre-Intervention and Post-Intervention periods ($P < .001$), and Pre-AABB Guideline and Post-Intervention periods ($P = .002$).

cational conferences, seminars, and reminders have shown mixed results in changing physician practice, such interventions can be successful when embraced

by leadership, implemented in a suitable safety culture, and when they seek maximum physician engagement.^{12,18} Our local intervention was aided by a strong

commitment to quality improvement and high-value care, as well as buy-in from leadership.

Limitations

There are several limitations in this study. This intervention was studied within 1 department, and the intervention's applicability to other medical centers or departments must be considered. This study was conducted at a teaching hospital with resident physicians, and it is plausible that its trainees are more likely to adopt guidelines because they are early in their career. Furthermore, although the statistical analysis suggests that the education intervention was responsible for the greater drop in transfusion rates, it is difficult to separate its impact from the global awareness of AABB guidelines in the medical community. Finally, it is important to note that the transfusion rate also decreased among patients with hemoglobin levels below 8 g/dL—an unexpected effect considering the education intervention should have only reduced the transfusion rate among patients with hemoglobin levels above 8 g/dL. This may have been due to physicians following a stricter guideline for some GI bleed patients, where evidence shows an even lower hemoglobin threshold of 7 g/dL to be more appropriate.^{7,10}

CONCLUSIONS

This analysis provides insight into the effectiveness of interventions used to guide physician behavior toward evidence-based practices. The results indicate that there was a significant decrease in transfusion rates, patients receiving transfusions above a hemoglobin level of 8 g/dL, total units of RBCs transfused, and the cost of RBC transfusions across all 3 time periods. Following evidence-based guidelines can be a crucial step in the transformation toward value-based care and reducing waste in the healthcare system. This study validated a fundamental approach to guideline adoption with the goal of improving patient safety, but also demonstrated the potential for cost-savings associated with the achievement of safer care.

Author Affiliations: Department of Internal Medicine (SH, RA, JK, MG) and Department of Health Systems Management (AK, MKK, TJ), Rush University Medical Center, Chicago, IL.

Source of Funding: None.

Author Disclosures: The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (TJ, RA, SH, MKK, AK, JK, MG); acquisition of data (TJ, RA, AK); analysis and interpretation of data (TJ, SH, RA, AK, JK); drafting of the manuscript (TJ, SH, RA, AK, MG); critical revision of the manuscript for important intellectual content (TJ, RA, SH, MKK, AK, MG); statistical analysis (TJ, AK); administrative, technical, or logistic support (TJ, SH, RA); and supervision (SH, MKK, JK).

Address correspondence to: Tricia Johnson, PhD, Department of Health Systems Management, Rush University Medical Center, 1700 W Van Buren St, Chicago, IL 60612. E-mail: tricia_j_johnson@rush.edu.

REFERENCES

- Whitaker BI, Hinkins S. The 2011 national blood collection and utilization survey. HHS website. <http://www.hhs.gov/ash/bloodsafety/2011-nbcus.pdf>. Published 2011. Accessed April 4, 2016.
- Marik PE, Corwin HL. Efficacy of red blood cell transfusion in the critically ill: A systematic review of the literature. *Crit Care Med*. 2008;36(9):2667-2674. doi: 10.1097/CCM.0b013e3181844677.
- Khorana AA, Francis CW, Blumberg N, Culakova E, Refaai MA, Lyman GH. Blood transfusions, thrombosis, and mortality in hospitalized patients with cancer. *Arch Intern Med*. 2008;168(21):2377-2381. doi: 10.1001/archinte.168.21.2377.
- Frank SM, Savage WJ, Rothschild JA, et al. Variability in blood and blood component utilization as assessed by an anesthesia information management system. *Anesthesiology*. 2012;117(1):99-106. doi: 10.1097/ALN.0b013e318255e550.
- Carson JL, Grossman BJ, Kleinman S, et al; Clinical Transfusion Medicine Committee of the AABB. Red blood cell transfusion: a clinical practice guideline from the AABB*. *Ann Intern Med*. 2012;157(1):49-58. doi: 10.7326/0003-4819-157-1-201206190-00429.
- Shander A, Fink A, Javidroozi M, et al; International Consensus Conference on Transfusion Outcomes Group. Appropriateness of allogeneic red blood cell transfusion: the international consensus conference on transfusion outcomes. *Transfus Med Rev*. 2011;25(3):232-246.e53. doi: 10.1016/j.tmr.2011.02.001.
- Al-Jaghbeer M, Yende S. Blood transfusion for upper gastrointestinal bleeding: is less more again? *Crit Care*. 2013;17(5):325. doi: 10.1186/cc13020.
- Carson JL, Terrin ML, Noveck H, et al; FOCUS Investigators. Liberal or restrictive transfusion in high-risk patients after hip surgery. *N Engl J Med*. 2011;365(26):2453-2462. doi: 10.1056/NEJMoa1012452.
- McIntyre LA, Fergusson DA, Hutchison JS, et al. Effect of a liberal versus restrictive transfusion strategy on mortality in patients with moderate to severe head injury. *Neurocrit Care*. 2006;5(1):4-9.
- Frazer K, Kirley K, Stevermer J. Consider this strategy for upper GI bleeds. *J Fam Pract*. 2013;62(9):E6-E8.
- Shander A, Hofmann A, Ozawa S, Theusinger OM, Gombotz H, Spahn DR. Activity-based costs of blood transfusions in surgical patients at four hospitals. *Transfusion*. 2010;50(4):753-765. doi: 10.1111/j.1537-2995.2009.02518.x.
- Kenefick H, Lee J, Fleishman V. Improving physician adherence to clinical practice guidelines barriers and strategies for change. New England Healthcare Institute website. http://www.nehi.net/writable/publication_files/file/cpg_report_final.pdf. Published February 2008. Accessed April 4, 2016.
- Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet*. 2003;362(9391):1225-1230.
- Cabana MD, Rand CS, Powe NR, et al. Why don't physicians follow clinical practice guidelines? a framework for improvement. *JAMA*. 1999;282(15):1458-1465.
- Davis D, O'Brien MA, Freemantle N, Wolf FM, Mazmanian P, Taylor-Vaisey A. Impact of formal continuing medical education: do conferences, workshops, rounds, and other traditional continuing education activities change physician behavior or health care outcomes? *JAMA*. 1999;282(9):867-874.
- Giguère A, Légaré F, Grimshaw J, et al. Printed educational materials: effects on professional practice and healthcare outcomes. *Cochrane Database Syst Rev*. 2012;10:CD004398. doi: 10.1002/14651858.CD004398.pub3.
- Clinical Classifications Software (CCS) for ICD-9-CM. Agency for Healthcare Research and Quality website. www.hcup-us.ahrq.gov/toolsoftware/ccs/ccs.jsp. Published April 2016. Accessed April 4, 2016.
- King R, Michelman M, Curran V, Bean J, Rowden P, Lindsey J. Patient-centered approach to ensuring appropriateness of care through blood management. *South Med J*. 2013;106(6):362-368. doi: 10.1097/SMJ.0b013e318296d9fa. ■