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RBC Transfusion Practices in Two Surgical ICUs: a Mixed Methods Assessment of Barriers to Evidence-based Practice

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Abstract

BACKGROUND—Despite evidence supporting the restrictive red blood cell (RBC) transfusion thresholds and associated clinical practice guidelines, clinical practice has been slow to change in the ICU. Our aim was to identify barriers to conservative transfusion practice adherence.

STUDY DESIGN AND METHODS—A mixed methods study involving observation of prescriber (i.e. physicians, physician assistants, nurse practitioners) and bedside nurse daily bedside rounds, provider survey, and medical record abstraction was conducted in one cardiac surgical ICU (CSICU) and one surgical ICU (SICU) in an academic hospital in Baltimore, MD.

RESULTS—Of 52 patient encounters observed during bedside rounds, 38 (73%) involved patients without evidence of active bleeding or cardiac ischemia. Surveys were completed by 52 (93%) of the 56 providers participating in rounds. Prescribers in the CSICU and SICU (87% and 90%, respectively) indicated the ideal pre-transfusion hemoglobin (Hgb) to be 7g/dL in non-bleeding/non-ischemic patients compared to a minority of nurses (8% [p=0.002] and 42% [p=0.015], respectively). Prescribers and nurses in both ICUs overestimated the typical pre-transfusion Hgb in their units (CSICU: p<0.001, SICU: p=0.019). During rounds, providers infrequently explicitly discussed Hgb monitoring or transfusion thresholds (33%) despite most (60%) reporting significant variation in transfusion thresholds between individual prescribers.

CONCLUSIONS—Our study identified several provider and system barriers to evidence based transfusion practices including knowledge differences, overly optimistic estimates of current practice, and heterogeneous transfusion practice in each ICU. Further work is necessary to develop targeted interventions to improve evidence-based RBC transfusion practices.

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Keywords

blood transfusion; intensive care units; evidence-based medicine; critical care; quality assurance; healthcare; patient care team

INTRODUCTION

Anemia, bleeding, and other potential indications for allogenic red blood cell (RBC) transfusions are common among patients admitted to intensive care units (ICUs).^{1–3} Historically, pathophysiologic reasoning informed recommendations that a hemoglobin concentration (Hgb) greater than 10 g/dL should be maintained in this patient population.⁴ However, based on more than a decade of clinical research evidence,^{5–7} more recent clinical practice guidelines advocate for using restrictive transfusion thresholds in ICU patients (e.g. a hemoglobin threshold ≥ 7 g/dL in patients who are not actively bleeding or experiencing active cardiac ischemia).^{8–11}

Despite evidence supporting the restrictive transfusion threshold and associated clinical practice guidelines, RBC transfusion practice has been slow to change.^{12,13} Multiple factors may influence adherence to evidence-based practices, including patient characteristics, individual provider knowledge and experience, unit organization, and team communication.^{14–16} While a clear understanding of such factors is critical to improving adherence to best practices, there is limited understanding of these factors with regards to RBC transfusions.^{12,13,17} We conducted a mixed methods assessment of RBC transfusion practices and the factors influencing these practices through direct observations of teaching rounds, surveys of participating providers, and an audit of electronic medical record RBC transfusion data.

MATERIALS AND METHODS

Study Setting

The study was conducted in two ICUs (one 16-bed general surgical [SICU] and one 15-bed cardiothoracic surgical [CSICU]) at Johns Hopkins Hospital in Baltimore, MD. Both ICUs utilize a co-management physician staffing model in which both intensivist and surgical attending physicians are responsible for patient management decisions. In addition to attending physicians, the CSICU is staffed by 2 resident physicians, 1 physician assistant (PA), and 3 nurse practitioners (NPs) whereas the SICU has 3 fellows and 6 residents. Nurse staffing is similar with one nurse per two patients in both ICUs. Teaching rounds are conducted in both ICUs during which, clinicians discuss recent clinical events and make evaluation and treatment decisions for the day. This discussion includes the bedside nurse and prescribers (i.e. physicians, PAs, NPs) systematically reviewing the goals of care for patients not being transferred out of the unit that day (i.e. Daily Goals).¹⁸

RBC transfusion education is not standardized across units or disciplines. Residents and fellows are exposed to teaching on transfusion medicine as part of their clinical training; however, this teaching varies both within and between ICUs based on the attending physician providing the teaching as part of their medical education responsibilities. There is

no transfusion protocol in place in either ICU and RBC transfusions are not a specific component of the Daily Goals reviewed in either unit.

Direct Observations

Consecutive patient encounters during teaching rounds in each ICU were observed one day per week for three weeks by one of the investigators (DJM) in April 2010. Initiation of the study period was determined independent of patient case-mix or provider schedule to minimize selection bias. Providers were recruited prior to rounds by the investigator, who provided a standard study overview and obtained oral consent. Participants were informed that the intent of the study was to examine aspects of clinical decision making, but providers were blinded to the study's focus on RBC transfusion decisions.

Observations from each patient encounter on rounds were documented utilizing a pilot tested standardized observation form. The form captured discussions related to the reporting of RBC transfusions in the ICU during the last 24 hours (e.g. pre-transfusion hemoglobin, transfusion indication), decision-making regarding transfusions on rounds (e.g. most recent hemoglobin, indication for transfusion), and planning related to transfusions (e.g. hemoglobin monitoring frequency, hemoglobin transfusion trigger). Additionally, the form facilitated documentation of other relevant data including the number of providers participating in each encounter, the primary surgical diagnosis (e.g. cardiac valve dysfunction, trauma), operative status (e.g. post-operative day), and active clinical diagnoses (e.g. respiratory failure requiring mechanical ventilation, infection, shock).

Provider Survey

The provider survey was distributed to all bedside nurses and prescribers who participated in the observed patient encounters. Survey development was guided by our conceptual framework for identifying barriers to evidence base practices.¹⁵ A draft survey was pilot tested through administration to 12 local providers (i.e. 6 ICU attending physicians, 2 physician trainees, and 4 ICU nurses). After completing the draft survey, providers offered feedback to ensure ease of use, face validity, and content validity.¹⁹

The final survey collected data on provider demographics, provider knowledge, perceived adherence to evidence based practice, influential factors, and potential strategies to improve restrictive RBC transfusion practices in the ICU. Provider demographics related to clinical discipline (i.e. physician, NP, PA, and nurse), years of ICU experience, and current clinical ICU time commitment. Providers indicated ideal and typical pre-transfusion hemoglobin concentrations for RBC units transfused in patients without active bleeding or cardiac ischemia to assess knowledge of restrictive RBC transfusion practices and perceived adherence, respectively.

Factors influencing RBC transfusion practice were assessed in the domains of provider (e.g. perceived importance of appropriately managing RBC transfusions), patient (e.g. applicability of evidence to their ICU patients), and system characteristics (e.g. inter-professional transfusion threshold variation, explicit communication of transfusion thresholds) using a 5-point Likert scale. The survey assessed expectations regarding potential strategies to improve evidence-based RBC transfusion practices (e.g. clinical

protocols). Respondents were also asked to note any additional factors that influence local RBC practices and to provide suggestions for improving evidence based transfusion practices.

Transfusion Measure Audit

Hemoglobin concentrations as well as RBC transfusion information were extracted from the electronic medical record system (Sunrise SCM, Allscripts, Chicago, IL) for all patients admitted to the study ICUs between July 2008 and June 2009. We excluded patients with evidence of cardiac ischemia (i.e. any elevated troponin on any ICU day) or active bleeding (i.e. ever receiving more than two RBC units on a single ICU day). For the remaining non-bleeding, non-ischemic patients, we extracted the pre-transfusion hemoglobin for all transfused RBC units.

Data Analysis

Direct observations of discussions regarding patients with active bleeding or cardiac ischemia were not included in the analysis. A sensitivity analysis restricting the analyzed encounters to the first observation for each patient was performed to evaluate for potential non-independence of observations within patients. Due to the limited number of providers surveyed, respondents were categorized as bedside nurses or prescribers (i.e. attending physicians, physician trainees, NPs, PAs) to preserve anonymity. For ease of interpretation, Likert scale items are evaluated dichotomously as agreement (i.e. strongly agree or agree) versus non-agreement (i.e. neutral, disagree, strongly disagree, don't know). Qualitative survey responses were assigned to relevant categories for descriptive analyses.²⁰

Descriptive statistics are reported using means and standard deviations (SD) for continuous variables and proportions for categorical variables. We used Student's t-test and Fisher's exact test to examine differences as appropriate with a two-sided p-value <0.05 considered statistically significant. Analyses were performed using STATA v10.1 (StataCorp, College Station, TX). The Institutional Review Board at the Johns Hopkins School of Medicine approved the study.

RESULTS

Fifty-two patient encounters were observed, with 56 individual providers participating (Figure 1). After excluding patients with active cardiac ischemia or bleeding, 38 encounters were analyzed representing 34 unique patients. One (2%) provider did not return the survey and 3 (5%) returned incomplete surveys that stated they were too new to the ICU to provide useful information. Thus, completed surveys were received from 52 providers (93% response rate).

Characteristics of Providers and Patients Observed on Rounds

For the 14 encounters observed during CSICU rounds, an average of three providers participated in each encounter (Table 1). In the SICU, an average of nine providers participated in the 24 encounters. The primary surgical diagnoses for CSICU patients were most frequently cardiac valve dysfunction requiring valve replacement (43%) or coronary

artery disease requiring a coronary artery bypass graft (29%), whereas gastrointestinal disease (37%) and trauma (21%) were most common in SICU patients.

The majority of patients in both ICUs were in their post-operative period (95%) with a mean of 11 days (SD=17) since their last operation. Observed patients frequently had respiratory failure (45%), active infection (39%), and shock (21%). Teams reviewed the patient's daily goals or confirmed transfer orders at the end of all but one encounter.

Observed reporting of recent transfusions, transfusion decision-making, and plans for monitoring

The most recent hemoglobin was commonly reported in both the CSICU and SICU (86% and 71%, respectively; Table 1). No reporting of RBC transfusion, or lack thereof, was observed in most CSICU and SICU encounters (79% and 75%, respectively). In the majority of CSICU and SICU encounters, no explicit discussion regarding the need for transfusion occurred (86% and 100%, respectively).

No explicit discussion of hemoglobin monitoring intervals or transfusion threshold was observed in 93% of CSICU encounters and 50% of SICU encounters. Providers stated plans for hemoglobin monitoring but did not discuss a transfusion threshold in 1 CSICU and 11 SICU patients (7% and 46%, respectively). During the remaining SICU encounter, providers explicitly stated that they would not monitor the hemoglobin until the patient was re-assessed clinically. A sensitivity analysis including only the first encounters for each patient (n=34) yielded similar results in RBC specific communication relative to the primary analysis.

Characteristics of Survey Respondents

Table 2 presents the characteristics of the 52 providers responding to the survey. Of the surveys returned by CSICU providers, 8 were completed by prescribers and 12 were completed by bedside nurses. In the SICU, prescribers and bedside nurses provided 13 and 19 surveys, respectively. The majority of respondents in both ICUs reported less than 2 years of experience both in the study-site ICUs and any ICU. Most bedside nurses worked in the study ICU for more than 40 weeks in the past year while most prescribers worked 20 weeks or less in the study ICU during the past year.

Pre-transfusion Hemoglobin Concentrations: Provider Knowledge, Self-assessed Adherence, and Actual Performance

Differences in the ideal, estimated, and actual pre-transfusion hemoglobin thresholds for ICU patients without active bleeding or cardiac ischemia were observed in both study ICUs (Table 3). The majority of CSICU and SICU prescribers indicated that the ideal pre-transfusion hemoglobin threshold was <7 g/dL (87% and 90%, respectively). Relative to the prescribers in their ICUs, CSICU and SICU bedside nurses identified significantly higher ideal hemoglobin thresholds with only 8% of CSICU bedside nurses and 42% of SICU bedside nurses indicating an ideal pre-transfusion hemoglobin threshold of ≥ 7 g/dL ($p=0.002$ and $p=0.015$, respectively).

When considering the typical pre-transfusion hemoglobin for patients without active bleeding or cardiac ischemia in their ICU, most prescribers and bedside nurses similarly estimated a threshold of 7.1–8.0 g/dL in both the CSICU and SICU ($p=0.11$ and $p=0.309$, respectively). Based upon the electronic medical records for the CSICU and SICU, the actual mean (SD) pre-transfusion hemoglobin for patients without active bleeding or cardiac ischemia was 8.5 (1.1) and 7.9 (0.9). The pre-transfusion hemoglobin was rarely <7 g/dL (CSICU: 8% and SICU: 16%), and frequently >8 g/dL (CSICU: 55% and SICU: 39%). Both CSICU and SICU providers significantly underestimated the average pre-transfusion hemoglobin for patients in their unit ($p<0.001$ and $p=0.019$, respectively).

Factors Influencing Local RBC Transfusion Practices

Although almost all providers considered appropriately managing RBC to be an important component of ICU care, awareness of the evidence for restrictive RBC transfusion strategies differed between provider types (Table 4). Notably, 90% of prescribers indicated awareness of evidence to avoid RBC transfusions in non-bleeding, non-ischemic patients with Hgb >7 g/dL while only 65% of bedside nurses reported knowledge of this evidence ($p=0.05$). Similarly, agreement with the evidence for restrictive transfusion practices was also more frequently reported by prescribers (95%) than bedside nurses (68%, $p=0.034$).

When considering patient factors related to RBC transfusion practices, 50% of CSICU providers and 18% of SICU providers indicated feeling that their non-bleeding, non-ischemic patients were too sick to avoid RBC transfusions if their hemoglobin was >7 g/dL ($p=0.03$). More than 80% of providers agreed or strongly agreed that they would be more likely to transfuse patients with active bleeding or cardiac ischemia.

Several important system factors related to RBC transfusion decisions were identified. First, most prescribers (86%) perceived that some patients in their ICUs received unnecessary transfusions while 42% of bedside nurses agreed with this statement ($p=0.002$). Second, significant variation in transfusion thresholds between clinicians was perceived by more ICU prescribers (81%) than bedside nurses (45%, $p=0.012$). Third, no prescribers and few bedside nurses (29%) felt that explicit transfusion thresholds were clearly communicated for their patients ($p=0.007$).

Providers in both study ICUs reported additional factors perceived to influence local practice (Table 5). All 16 respondents discussing clinician factors reported that surgical attending physicians (or the surgical team) influenced RBC transfusion practices within their ICU, while critical care physicians and nurses were referenced less frequently. Of the 18 respondents commenting on patient factors that influenced transfusion decisions, general clinical status (33%), type of recent operation (33%), end-organ perfusion (17%), and type of upcoming operation (17%) were most frequently discussed.

Potential Strategies to Improve Practice

Attitudes towards potential approaches to improve adherence to evidence based transfusion practices were fairly consistent in both ICUs (Table 4). Most CSICU and SICU providers agreed that clinical protocols generally helped clinicians treat patients (80% and 69%, respectively). Approximately half of CSICU (40%) and SICU (50%) providers felt that a

clinical protocol avoiding RBC transfusions in non-bleeding, non-ischemic patients with a hemoglobin >7 whereas a few felt this could be harmful (CSICU [15%] and SICU [6%]).

Of the 15 respondents providing additional suggestions for improving local practice, 67% suggested establishing a local transfusion protocol or other standardized practice (Table 5). Providers also advocated for improved provider education (20%) and increased provider communication regarding RBC decision-making (27%). Similar response patterns were observed between the two study units.

DISCUSSION

This mixed methods study used a combination of direct observations, provider surveys, and medical record abstraction to examine provider and system factors underlying RBC transfusion practices in two surgical ICUs. The study yielded several important findings related to the translation of RBC transfusion evidence into routine clinical practice.

First, we found that the actual pre-transfusion hemoglobin concentrations in both study ICUs are commonly higher than that supported by the evidence. The mean actual pre-transfusion hemoglobin values observed in our study (SICU= 7.9 g/dL and CSICU=8.5 g/dL) is similar to other observational studies both in the US^{2,12,17} and abroad.^{1,21–24} Nevertheless, evidence-based clinical guidelines suggest a lower target pre-transfusion hemoglobin concentration.^{7–11}

Second, we observed that ICU clinicians reported an overly optimistic estimate of the actual transfusion practices in their ICU. This builds on existing literature that providers overestimate adherence to other ICU best practices.^{25–29} For example, in a national sample of German ICUs, Brunkhorst and colleagues reported that although the majority of ICU directors reported adherence to 7 sepsis best practices, most patients in their ICUs did not receive these therapies.²⁵ Such poor calibration between perceptions and actual practices highlights the importance of complementing surveys of perceived adherence self-assessment with objective assessments of actual clinical behaviors. Additionally, this finding supports the rationale for including effective provider feedback mechanisms to improve adherence to evidence based practices.^{30,31}

Third, we found significant differences in knowledge regarding the ideal pre-transfusion hemoglobin for non-bleeding, non-ischemic ICU patients. The vast majority of prescribers in our study correctly identified the evidence-based threshold of less than or equal to 7 g/dL while bedside nurses reported significantly higher ideal hemoglobin thresholds. The high level of prescriber knowledge is consistent with other studies that many Canadian ICU physicians were aware of the evidence supporting the use of restrictive transfusion thresholds.³² Lower level of bedside nurse knowledge regarding transfusion thresholds is also consistent with studies examining knowledge differences related to other ICU evidence based practices.^{33,34} This disparity may influence provider adherence to evidence-based transfusion practices and highlights the need for additional nursing education as part of improvement efforts.

Finally, our study identified that although providers recognized transfusions as an important aspect of ICU care, transfusion thresholds were infrequently discussed on rounds and significant variation in transfusion thresholds existed between providers. Ambiguity regarding the expectations for the typical management (e.g. hemoglobin threshold of 7g/dL for transfusions) and which specific patients should be excluded from this typical management (e.g. active hemorrhage or cardiac ischemia) has been found to be a common factor hindering adherence with evidence based best practices.³⁵ Standardizing processes of care related to transfusions (i.e. hemoglobin monitoring frequency and transfusion thresholds) within ICUs and using standardized communication tools (i.e. Daily Goals) may facilitate communication between providers and improve adherence to evidence based transfusion practices.¹⁸

Strengths of this study include using a mixed-methods approach with complementary assessments of barriers to evidence-based transfusion practices and actual transfusion practices.^{15,36} By surveying the individuals participating in rounds, we were able to identify individual factors potentially contributing to the team's behaviors related to RBC transfusion decisions. Use of direct observation or survey techniques alone may have hindered our ability to establish such links between individual perceptions and team behaviors. Furthermore, this mixed-methods approach enabled the comparison between perceptions and actual transfusion practices.

We recognize several limitations of this study. First, teams may have altered their discussions related to RBC transfusions based upon the presence of an observer during rounds (i.e. the Hawthorne effect). We attempted to minimize this limitation by speaking generally about clinical decision making in the informed consent, and administering the survey after teaching rounds. If our observations did influence decision-making, we expect that teams would have explicitly discussed RBC transfusions and monitoring plans more frequently, and thus, overestimate typical practices.

Second, our study population was limited to providers participating in the observed patient encounters. Thus, critical care attending physicians represent a relatively small percent of the survey respondents and no surgical attending physicians, who are also responsible for co-managing patients in the study ICUs, were surveyed as they did not participate in any of the observed encounters. Nevertheless, the absence of this information does not detract from important insights into the team behaviors and underlying individual factors related to RBC transfusions. Future efforts will need to further assess attending critical care physician and surgeon perspectives as well as involve them in efforts to standardize transfusion practices.

Third, our assessment of transfusion practices was restricted to 2 surgical ICUs at an academic medical center which may limit the generalizability to non-surgical ICUs or non-teaching hospitals. The internal consistency of the findings observed across our study units as well as the comparability with observations in other related areas suggests that these barriers may be more generally relevant.^{25,33} Despite these limitations, the mixed methods utilized in this project as well as the initial results provide an important basis for further efforts to assess the factors affecting the translation of RBC transfusion evidence into practice.

Conclusions

This mixed methods study identified important provider and system barriers to evidence-based RBC transfusion practices. Specific barriers include overly optimistic perceptions of actual transfusion practices, knowledge deficits, significant variations between prescribers, and limited explicit communication. Identifying specific barriers to evidence-based transfusion practice within specific units can help organizations select targeted interventions to overcome these barriers including provider and unit-level audit and feedback systems, professional education efforts for specific disciplines, local consensus processes and electronic medical record system design changes to foster more standard practices, and standardized communication tools to facilitate explicit communication. Future research is necessary to validate these findings across additional settings and to evaluate the effects of targeted interventions to improve RBC transfusion practices.

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REFERENCES

1. Vincent JL, Baron JF, Reinhart K, et al. Anemia and blood transfusion in critically ill patients. *JAMA*. 2002; 288:1499–1507. [PubMed: 12243637]
2. Corwin HL, Gettinger A, Pearl RG, et al. The CRIT Study: Anemia and blood transfusion in the critically ill—current clinical practice in the United States. *Critical Care Medicine*. 2004; 32:39–52. [PubMed: 14707558]
3. Thomas J, Jensen L, Nahirniak S, Gibney RT. Anemia and blood transfusion practices in the critically ill: a prospective cohort review. *Heart & lung : the journal of critical care*. 2010; 39:217–225. [PubMed: 20457342]
4. Allen JB, Allen FB. The minimum acceptable level of hemoglobin. *International Anesthesiology Clinics*. 1982; 20:1–22. [PubMed: 6757141]
5. Hébert PC, Wells G, Blajchman MA, et al. A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. Transfusion Requirements in Critical Care Investigators, Canadian Critical Care Trials Group. *N Engl J Med*. 1999; 340:409–417. [PubMed: 9971864]
6. Marik PE, Corwin HL. Efficacy of red blood cell transfusion in the critically ill: a systematic review of the literature. *Crit Care Med*. 2008; 36:2667–2674. [PubMed: 18679112]
7. Hajjar LA, Vincent JL, Galas FR, et al. Transfusion requirements after cardiac surgery: the TRACS randomized controlled trial. *JAMA*. 2010; 304:1559–1567. [PubMed: 20940381]
8. Ferraris VA, Ferraris SP, et al. Society of Thoracic Surgeons Blood Conservation Guideline Task F. Perioperative blood transfusion and blood conservation in cardiac surgery: the Society of Thoracic Surgeons and The Society of Cardiovascular Anesthesiologists clinical practice guideline. *Ann Thorac Surg*. 2007; 83:S27–S86. [PubMed: 17462454]
9. Dellinger RP, Levy MM, Carlet JM, et al. Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock: 2008. *Crit Care Med*. 2008; 36:296–327. [PubMed: 18158437]
10. Napolitano LM, Kurek S, Luchette FA, et al. Clinical practice guideline: red blood cell transfusion in adult trauma and critical care. *Crit Care Med*. 2009; 37:3124–3157. [PubMed: 19773646]

11. Dellinger RP, Levy MM, Rhodes A, et al. Surviving Sepsis Campaign: International Guidelines for Management of Severe Sepsis and Septic Shock: 2012. *Crit Care Med.* 2013; 41:580–637. [PubMed: 23353941]
12. Murphy DJ, Howard D, Muriithi A, et al. Red blood cell transfusion practices in acute lung injury: what do patient factors contribute? *Crit Care Med.* 2009; 37:1935–1940. [PubMed: 19384204]
13. Pham JC, Catlett CL, Berenholtz SM, Haut ER. Change in use of allogeneic red blood cell transfusions among surgical patients. *J Am Coll Surg.* 2008; 207:352–359. [PubMed: 18722940]
14. Cabana MD, Rand CS, Powe NR, et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. *JAMA.* 1999; 282:1458–1465. [PubMed: 10535437]
15. Gurses AP, Murphy DJ, Martinez EA, Berenholtz SM, Pronovost PJ. A practical tool to identify and eliminate barriers to compliance with evidence-based guidelines. *Jt Comm J Qual Patient Saf.* 2009; 35:526–532. [PubMed: 19886092]
16. Gurses AP, Marsteller JA, Ozok AA, Xiao Y, Owens S, Pronovost PJ. Using an interdisciplinary approach to identify factors that affect clinicians' compliance with evidence-based guidelines. *Crit Care Med.* 2010; 38:S282–S291. [PubMed: 20647785]
17. Netzer G, Liu X, Harris AD, et al. Transfusion practice in the intensive care unit: a 10-year analysis. *Transfusion.* 2010; 50:2125–2134. [PubMed: 20553436]
18. Pronovost P, Berenholtz S, Dorman T, Lipsett PA, Simmonds T, Haraden C. Improving communication in the ICU using daily goals. *J Crit Care.* 2003; 18:71. [PubMed: 12800116]
19. Aday, LA.; Cornelius, LJ. Designing and conducting health surveys : a comprehensive guide. 3rd ed.. San Francisco: Jossey-Bass; 2006.
20. Tashakkori, A.; Teddlie, C., editors. Handbook of Mixed Methods in Social and Behavioral Research. Sage Publications; 2003.
21. Rao MP, Boralessa H, Morgan C, et al. Blood component use in critically ill patients. *Anaesthesia.* 2002; 57:530–534. [PubMed: 12010265]
22. Chohan SS, McArdle F, McClelland DB, Mackenzie SJ, Walsh TS. Red cell transfusion practice following the transfusion requirements in critical care (TRICC) study: prospective observational cohort study in a large UK intensive care unit. *Vox Sang.* 2003; 84:211–218. [PubMed: 12670370]
23. Walsh TS, Garrioch M, Maciver C, et al. Red cell requirements for intensive care units adhering to evidence-based transfusion guidelines. *Transfusion.* 2004; 44:1405–1411. [PubMed: 15383011]
24. French CJ, Bellomo R, Finfer SR, Lipman J, Chapman M, Boyce NW. Appropriateness of red blood cell transfusion in Australasian intensive care practice. *Med J Aust.* 2002; 177:548–551. [PubMed: 12429003]
25. Brunkhorst FM, Engel C, Ragaller M, et al. Practice and perception--a nationwide survey of therapy habits in sepsis. *Crit Care Med.* 2008; 36:2719–2725. [PubMed: 18766100]
26. Akhtar SR, Weaver J, Pierson DJ, Rubenfeld GD. Practice variation in respiratory therapy documentation during mechanical ventilation. *Chest.* 2003; 124:2275. [PubMed: 14665511]
27. Pittet D, Simon A, Hugonnet S, Pessoa-Silva CL, Sauvan V, Perneger TV. Hand hygiene among physicians: performance, beliefs, and perceptions. *Ann Intern Med.* 2004; 141:1–8. [PubMed: 15238364]
28. Panu D, Lee DC. Beta-blocker use in the emergency department in patients with acute myocardial infarction undergoing primary angioplasty. *J Emerg Med.* 2003; 24:379–382. [PubMed: 12745038]
29. Henry K, Campbell S, Maki M. A comparison of observed and self-reported compliance with universal precautions among emergency department personnel at a Minnesota public teaching hospital: implications for assessing infection control programs. *Ann Emerg Med.* 1992; 21:940–946. [PubMed: 1497161]
30. Wolthuis EK, Korevaar JC, Spronk P, et al. Feedback and education improve physician compliance in use of lung-protective mechanical ventilation. *Intensive Care Med.* 2005; 31:540–546. [PubMed: 15731892]
31. Zaydfudim V, Dossett LA, Starmer JM, et al. Implementation of a real-time compliance dashboard to help reduce SICU ventilator-associated pneumonia with the ventilator bundle. *Arch Surg.* 2009; 144:656–662. [PubMed: 19620546]

32. Hébert PC, Fergusson DA, Stather D, et al. Revisiting transfusion practices in critically ill patients. *Critical Care Medicine*. 2005; 33:7–12. [PubMed: 15644642]
33. Dennison CR, Mendez-Tellez PA, Wang W, Pronovost PJ, Needham DM. Barriers to low tidal volume ventilation in acute respiratory distress syndrome: survey development, validation, and results. *Crit Care Med*. 2007; 35:2747–2754. [PubMed: 17901838]
34. Hayes SM, Murray S, Dupuis M, Dawes M, Hawes IA, Barkun AN. Barriers to the implementation of practice guidelines in managing patients with nonvariceal upper gastrointestinal bleeding: A qualitative approach. *Canadian journal of gastroenterology = Journal canadien de gastroenterologie*. 2010; 24:289–296. [PubMed: 20485702]
35. Gurses AP, Seidl KL, Vaidya V, et al. Systems ambiguity and guideline compliance: a qualitative study of how intensive care units follow evidence-based guidelines to reduce healthcare-associated infections. *Quality & safety in health care*. 2008; 17:351–359. [PubMed: 18842974]
36. Cochrane LJ, Olson CA, Murray S, Dupuis M, Tooman T, Hayes S. Gaps between knowing and doing: understanding and assessing the barriers to optimal health care. *J Contin Educ Health Prof*. 2007; 27:94–102. [PubMed: 17576625]

Figure 1. Study flow

* Although most providers contributed to multiple patient encounters, they were only invited to complete the survey once.

Table 1

Observed patient encounter characteristics and RBC specific communication

	CSICU (n=14)	SICU (n=24)
Provider Characteristics		
Providers participating per patient encounter, mean (SD)	3 (1)	9 (<1)
Attending intensivist	1 (0)	1 (0)
Fellow	1 (1)	2 (1)
Resident	1 (1)	6 (<1)
Physician assistant / nurse practitioner	1 (1)	-
Bedside nurse	1 (<1)	1 (<1)
Patient Characteristics		
Primary surgical diagnosis, n (%)		
Cardiac valve dysfunction (e.g. s/p valve replacement)	6 (43)	
Coronary artery disease (e.g. s/p CABG)	4 (29)	
Other cardiac (e.g. congestive heart failure s/p LVAD insertion)	1 (7)	
Other non-cardiac thoracic (e.g. COPD s/p lung volume reduction)	3 (21)	1 (4)
Gastrointestinal (e.g. small bowel resection)		9 (37)
Trauma		5 (21)
Other non-thoracic disease (e.g. PVD s/p aorto-iliac bypass)		9 (37)
Post-operative status, n (%)	14 (100)	22 (92)
Days post op, mean (SD)	12 (18)	10 (17)
Active clinical diagnoses, n (%)		
Respiratory failure requiring mechanical ventilation	4 (29)	13 (54)
Infection	5 (36)	10 (42)
Hypotension requiring vasopressors	3 (21)	5 (21)
Renal failure requiring dialysis	3 (21)	2 (8)
Coagulopathy	3 (21)	2 (8)
Thrombocytopenia	3 (21)	2 (8)
RBC Specific Communication		
Reporting of latest HgB, n (%)	12 (86)	17 (71)
Reported RBC transfusions in ICU during last 24 hours, n (%)		
Reported RBC transfusion	1 (7)	2 (8)
Reported no RBC transfusions	2 (14)	3 (13)
No report	11 (79)	18 (75)
RBC transfusion decision-making, n (%)		
Discussion with decision to transfuse	1 (7)	0 (-)
Discussion with decision to not transfuse	1 (7)	0 (-)
No discussion regarding RBC transfusion	12 (86)	24 (100)
Planning for hemoglobin monitoring, n (%)		
Plan to monitor HgB without explicit threshold	1 (7)	11 (46)
Plan to not monitor HgB until clinical reassessment	0 (-)	1 (7)
No discussion of monitoring plan	13 (93)	12 (50)

s/p, status post; CABG, coronary artery bypass graft, LVAD, left ventricular assist device; PVD, peripheral vascular disease; RBC, red blood cell; HgB, hemoglobin

Table 2

Survey Respondent Characteristics by study ICU and provider type, n (%)

	CSICU		SICU	
	Prescriber* (n=8)	Nurse (n=12)	Prescriber* (n=13)	Nurse (n=19)
Prescriber discipline				
Physician	5 (63)		13 (100)	
Nurse practitioner / physician assistant	3 (37)		--	
Physician training status				
Attending	3 (37)		2 (15)	
Resident or fellow	2 (25)		11 (85)	
Physician specialty				
Anesthesiology	3 (37)		7 (54)	
Surgery	2 (25)		6 (46)	
Experience in any ICU, n (%)				
Currently in training	2 (25)		11 (85)	
0–2 years	3 (37)	6 (50)		11 (58)
3–5 years	2 (25)	5 (42)		1 (5)
6–10 years		1 (8)	1 (8)	1 (5)
>10 years	1 (13)		1 (8)	6 (31)
Experience in study ICU, n (%)				
Currently in training	2 (25)		11 (85)	
0–2 years	4 (50)	9 (75)		11 (58)
3–5 years	2 (25)	3 (25)		2 (11)
6–10 years			2 (15)	2 (11)
>10 years				4 (21)
Annual effort in study ICU, n (%)				
Currently in training	2 (25)		11 (85)	
0–10 weeks	2 (25)	1 (8)	1 (8)	1 (5)
11–20 weeks	2 (25)	2 (17)	1 (8)	1 (5)
21–30 weeks		1 (8)		
31–40 weeks		3 (25)		1 (5)
>40 weeks	2 (25)	5 (42)		16 (84)

ICU, intensive care unit, CSICU, cardiac surgical ICU; SICU; surgical ICU

* Prescriber includes nurse practitioners, physician assistants, and physicians

Table 3

Ideal, estimated, and actual pre-transfusion hemoglobin in ICU patients without active bleeding or cardiac ischemia by study ICU and provider type, n (%)^{*}

Pre-transfusion Hgb, g/dL:	CSICU						SICU			
	Prescriber ^{**} (n=8)			Nurse (n=12)			Prescriber ^{**} (n=13)		Nurse (n=19)	
	Ideal [†]	Estimate [‡]	Actual [‡]	Ideal [†]	Estimate [‡]	Actual [‡]	Ideal [†]	Estimate [‡]	Ideal [†]	Actual [‡]
7.0	7 (87)	3 (37)	1 (8)	1 (8)	1 (8)	28 (8)	12 (90)	3 (23)	8 (42)	13 (16)
7.1-8.0	1 (13)	5 (63)	6 (50)	11 (92)	1 (9)	127 (36)	1 (9)	8 (61)	9 (47)	35 (44)
8.1-9.0			5 (42)			105 (30)		2 (15)	1 (5)	25 (32)
9.1-10.0						54 (15)				5 (6)
>10.0						34 (10)				1 (1)

ICU, intensive care unit, CSICU, cardiac surgical ICU; SICU, surgical ICU; Hgb, hemoglobin

^{*} Providers indicated ideal and estimated concentrations in survey for patients who are not actively bleeding or having active cardiac ischemia. Actual values are the number of RBC units transfused for each pre-hemoglobin concentration category in patients admitted to a study ICU from July 2008 to June 2009 and had never received more than 2 RBC units per ICU day or any elevated serum troponin during ICU admission.

^{**} Prescriber includes nurse practitioners, physician assistants, and physicians

[†] p<0.05 for comparisons of ideal pre-transfusion hemoglobin between provider types

[‡] p<0.05 for comparisons between provider estimated and actual pre-transfusion hemoglobin

Table 4

Agreement with factors related to RBC transfusion practices and strategies to improve by provider type and ICU, n (%)

	Provider Type		ICU	
	Prescriber* (n=21)	Nurse (n=31)	CSICU (n=20)	SICU (n=32)
Provider factors				
Appropriate RBC transfusion management is important in ICU patient care.	19 (90)	31 (100)	18 (90)	32 (100)
Regarding your ICU patients with a HgB >7g/dL who are not actively bleeding or having active cardiac ischemia,				
There is evidence to avoid RBC transfusions in these patients.	19 (90) [†]	20 (65) [†]	13 (65)	26 (81)
I agree with the evidence to avoid RBC transfusions in these patients.	20 (95) [†]	21 (68) [†]	17 (85)	24 (75)
Patient factors				
Regarding your ICU patients with a HgB >7g/dL who are not actively bleeding or having active cardiac ischemia,				
My patients like this are usually too sick to avoid RBC transfusions.	6 (29)	10 (32)	10 (50)	6 (18) [†]
I am more likely to transfuse RBCs in my ICU patients with:				
Active bleeding with hemodynamic instability	21 (100)	31 (100)	20 (100)	32 (100)
Active bleeding (no hemodynamic instability)	19 (90)	25 (81)	18 (90)	26 (81)
Active cardiac ischemia	19 (90)	26 (84)	17 (85)	28 (87)
Stable coronary artery disease (e.g. prior MI)	9 (43)	10 (32)	5 (25)	14 (4)
Septic shock- initial resuscitation	6 (29)	16 (52)	12 (60)	10 (31)
Septic shock- post resuscitation management	4 (19)	13 (42)	8 (40)	9 (28)
Acute Respiratory Distress Syndrome (ARDS)	1 (5)	7 (23)	1 (5)	7 (22)
System factors				
Some patients in this ICU receive unnecessary RBC transfusions.	18 (86) [†]	13 (42) [†]	10 (50)	21 (66)
RBC transfusion thresholds vary significantly between clinicians in this ICU.	17 (81) [†]	14 (45) [†]	11 (55)	20 (63)
I am comfortable discussing transfusion decisions with all ICU team members.	16 (76)	27 (87)	14 (70)	29 (91)
Each patient in this ICU has an explicitly stated RBC transfusion threshold.	0 (0) [†]	9 (29) [†]	5 (25)	4 (13)
Potential strategies to improve				
Clinical protocols, in general, help clinicians treat patients.	15 (71)	23 (74)	16 (80)	22 (69)
A clinical protocol avoiding RBC transfusions in patients with a HgB >7g/dL who are not actively bleeding or having active cardiac ischemia would be...				
helpful for my patients.	10 (48)	14 (45)	8 (40)	16 (50)
harmful for my patients.	2 (9)	3 (10)	3 (15)	2 (6)

RBC, red blood cell; ICU, intensive care unit; CSICU, cardiac surgical ICU; SICU, surgical ICU; HgB, hemoglobin; ARDS, acute respiratory distress syndrome

* Prescriber includes nurse practitioners, physician assistants, and physicians

[†] p<0.05

Table 5

Categories of survey responses regarding provider and patient factors that influence local RBC practice and suggestions for improvement

	<u>CSICU</u>	<u>SICU</u>
Providers influencing local practice, respondents discussing, n	8	8
Surgeons, n (%)	8 (100)	8 (100)
Critical care physicians, n (%)	3 (37)	3 (37)
Critical care nurse, n (%)	-	1 (13)
Patient factors influencing local practice, respondents discussing, n	7	11
General clinical status, n (%)	3 (43)	3 (27)
Type of recent operation, n (%)	4 (57)	2 (18)
Type of upcoming operation, n (%)	1 (14)	2 (18)
End-organ perfusion, n (%)	1 (14)	2 (18)
Religion, n (%)	1 (14)	1 (9)
Oxygenation, n (%)	-	1 (9)
Hemoglobin trend, n (%)	-	1 (9)
Suggestions for improving local practice, respondents discussing, n	7	8
Establish local protocol or standard practice, n (%)	5 (71)	5 (63)
Increase provider communication regarding RBC, n (%)	2 (29)	2 (25)
Educate providers, n (%)	1 (14)	2 (25)

RBC, red blood cell; ICU, intensive care unit; CSICU, cardiac surgical ICU; SICU, surgical ICU

* Percents within categories may exceed 100% since clinicians may have provided more than one factor or suggestion for improvement.