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Trends in Red Blood Cell Transfusion and 30-Day Mortality among Hospitalized Patients

Nareg H Roubinian, MD^{1,2,3}, Gabriel J Escobar, MD², Vincent Liu, MD², Bix E Swain, MS², Marla N Gardner, BS², Patricia Kipnis, PhD², Darrell J Triulzi, MD⁴, Jerome L Gottschall, MD⁵, Yan Wu, MD⁶, Jeffrey L Carson, MD⁷, Steven H Kleinman, MD⁸, Edward L Murphy, MD^{1,3}, and NHLBI Recipient Epidemiology and Donor Evaluation Study (REDS-III)

¹Blood Systems Research Institute San Francisco, California

²Kaiser Permanente Northern California Division of Research Oakland, California

³University of California, San Francisco San Francisco, California

⁴Institute For Transfusion Medicine Pittsburgh, Pennsylvania

⁵BloodCenter of Wisconsin Madison, WI

⁶Yale University New Haven, CT

⁷Rutgers Robert Wood Johnson Medical School New Brunswick, NJ

⁸University of British Columbia Victoria, BC, Canada

Abstract

Background—Blood conservation strategies have been shown to be effective in decreasing red blood cell (RBC) utilization in specific patient groups. However, few data exist describing the extent of RBC transfusion reduction or their impact on transfusion practice and mortality in a diverse inpatient population.

Methods—We conducted a retrospective cohort study using comprehensive electronic medical record data from 21 medical facilities in Kaiser Permanente Northern California (KPNC). We

Corresponding author: Nareg H. Roubinian, MD, MPHTM Blood Systems Research Institute 270 Masonic Avenue, San Francisco CA 94118 Nroubinian@bloodsystems.org Phone: 415-513-4463 Fax: 415-901-0733.

The NHLBI Recipient Epidemiology Donor Evaluation Study - III (REDS-III), domestic component, is the responsibility of the following persons:

Hubs: A.E. Mast and J.L. Gottschall, BloodCenter of Wisconsin (BCW), Milwaukee, WI

D.J. Triulzi and J.E. Kiss, The Institute For Transfusion Medicine (ITXM), Pittsburgh, PA

E.L. Murphy and E.W. Fiebig, University of California, San Francisco (UCSF), San Francisco, CA

E.L. Snyder, Yale University School of Medicine, New Haven, CT and R.G. Cable, American Red Cross Blood Services, Farmington CT

Data coordinating center: D. J. Brambilla and M. T. Sullivan, RTI International, Rockville, MD

Central laboratory: M.P. Busch and P.J. Norris, Blood Systems Research Institute, San Francisco, CA

Publication Committee Chairman: R. Y. Dodd, American Red Cross, Holland Laboratory, Rockville, MD

Steering Committee Chairman: S. H. Kleinman, University of British Columbia, Victoria, BC, Canada

National Heart, Lung, and Blood Institute, National Institutes of Health: S. A. Glynn and A.M. Cristman

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examined unadjusted and risk-adjusted RBC transfusion and 30-day mortality coincident with implementation of RBC conservation strategies.

Findings—The inpatient study cohort included 391,958 patients who experienced 685,753 hospitalizations. From 2009 to 2013, the incidence of RBC transfusion decreased from 14.0% to 10.8% of hospitalizations; this change coincided with a decline in pre-transfusion hemoglobin levels from 8.1 to 7.6 g/dL. Decreased RBC utilization affected broad groups of admission diagnoses and was most pronounced in patients with a nadir hemoglobin level between 8 and 9 g/dL (n=73,057; 50.8% to 19.3%). During the study period, the standard deviation of risk adjusted RBC transfusion incidence across hospitals decreased by 44% (p <0.001). 30-day mortality did not change significantly with declines in RBC utilization in patient groups previously studied in clinical trials nor in other subgroups.

Conclusions—Following the implementation of blood conservation strategies, RBC transfusion incidence and pre-transfusion hemoglobin levels decreased broadly across medical and surgical patients. Variation in RBC transfusion incidence across hospitals decreased from 2010 to 2013. Consistent with clinical trial data, more restrictive transfusion practice did not appear to impact 30-day mortality.

INTRODUCTION

Several large randomized controlled trials in specific groups of inpatients have found that a restrictive RBC transfusion strategy results in similar or improved patient outcomes compared to a more liberal strategy.^{1–4} These and other studies, along with efforts to control medical expenditures, have led to the development of initiatives that promote transfusion practice with a goal of minimizing non-indicated use.^{5–8}

“Patient blood management” strategies are designed to optimize erythropoiesis, minimize blood loss, and manage anemia.^{9–11} The World Health Organization recognizes them as a means to “promote the availability of transfusion alternatives,” and in the United States, The Joint Commission published measures for hospitals to evaluate their processes regarding blood utilization.^{12,13} Promotion of these quality measures has increased the awareness that blood transfusion can be benchmarked on a local and national level.^{13–15}

In this report, we detail RBC utilization within Kaiser Permanente Northern California (KPNC), a large integrated healthcare delivery system. Our objective was to characterize RBC transfusion practice among a diverse population of hospitalized patients during a period in which initiatives to decrease utilization were adopted. Several studies have shown blood conservation programs to be effective in reducing blood utilization and healthcare costs in cardiac and orthopedic surgery.^{16–18} Recent studies have evaluated the impact of these programs on transfusion practice, and we recently reported no correlation between decreased RBC use and mortality across an entire hospital population.^{19–21} In this report, we examined trends in RBC utilization and mortality in patients previously studied in clinical trials as well as other subgroups.

MATERIALS AND METHODS

Kaiser Permanente Northern California (KPNC) serves a total population of 3.5 million members. All KPNC hospitals and clinics employ common information systems based on the same unique medical record numbers. The KPNC and University of California, San Francisco (UCSF) Institutional Review Boards approved this study.

KPNC Transfusion Initiatives

In 2010, KPNC initiated multiple clinician educational sessions regarding blood transfusion guidelines across its facilities. These didactic presentations incorporated clinical trial data and transfusion practice guidelines as they became available over the study period. Concurrently, multidisciplinary blood conservation programs for specific clinical departments (e.g., orthopedic surgery) were developed in a non-uniform fashion across the 21 KPNC facilities. These efforts, while not constituting a formal, system-wide quality initiative, nonetheless permitted greater synchronization of clinical practice with transfusion practice guidelines. Management strategies focused on the identification and treatment of suboptimal iron stores pre-procedure, and starting in 2011, the increased use of cell salvage techniques and hemostatic agents (e.g., tranexamic acid) and blood-sparing techniques (e.g., radial artery cannulation for percutaneous coronary interventions). These initiatives were supported by ongoing hospital- and system-level quality improvement projects to improve blood product utilization by encouraging the adoption of transfusion guidelines with peer-review of transfusion events. Uniform transfusion guidelines (see Appendix Figure 1) were endorsed by groups representing all the medical specialties and facilities in July 2011. Finally, in May 2012, an electronic clinical decision support system was integrated into the transfusion order sets to support clinicians in following guidelines-based transfusion practice. These electronic orders (see Appendix Figure 2) incorporated the consensus indications for transfusion as well as most recent relevant laboratory values, such as hemoglobin and hematocrit levels, for clinician review.

Patient cohort and characteristics

To study the impact of this initiative on RBC transfusion incidence, we quantified the use of blood products in both inpatient and outpatient settings within KPNC between January 2008 and August 2013. Starting with data on blood product dispensing from the KPNC transfusion service, we verified the accuracy of transfusion administration in hospitalized patients by auditing clinical documentation and flowsheet records from 600 randomly selected patient charts with and without transfusion records (see Appendix Methods 1). We then linked the record of blood transfusions with an inpatient cohort comprised of all non-obstetric patients age ≥ 18 years admitted to KPNC hospitals between January 1, 2009 and August 31, 2013. We then linked these inpatient episodes with other KPNC databases using methods described in prior studies.^{22–23}

To categorize patient admitting diagnoses and comorbidities we grouped International Classification of Diseases, 9th Revision (ICD-9) diagnosis codes by using Health Care Utilization Project (HCUP) (www.ahrq.gov/data/hcup) single-level and multi-level Clinical Classifications Software (CCS) categories. We evaluated hospitalizations for common

admission conditions on the basis of their association with medical or surgical bleeding (Gastrointestinal Bleeding & Orthopedic Surgery), anemia of chronic disease (Malignancy & Infection), as well as the potential benefit of improving oxygen delivery with RBC transfusion (Medical Cardiovascular) (Appendix Methods 2). We also evaluated hospitalizations in subsets of patients with admission diagnoses previously studied in clinical trials of RBC transfusion (cardiac surgery, hip fracture with cardiovascular risk factors, upper gastrointestinal bleeding and ICU admissions) as well as patients with anemia (hemoglobin levels < 10 g/dL) and a history of coronary artery disease (Appendix Methods 3).

We quantified comorbid disease burden with a previously described risk score, the COPS2 (Comorbidity Points Score, version 2), which is based upon patients' medical diagnoses within the 12 months preceding hospitalization.²³ We quantified severity of illness at admission with the LAPS2 (Laboratory Acute Physiology Score, version 2), which is based on laboratory test results, vital signs, and neurologic status within 72 hours prior to hospital entry.²³

We classified patients as having emergency or elective admission based on whether they were admitted through the emergency department. We also classified hospitalizations as primarily medical or surgical admission based on the presence of specific diagnosis-related group (DRG)-based procedural codes for surgery during hospitalization. We defined 'hospital entry' as admission to a non-emergency room inpatient location including the general medical-surgical wards, transitional/intermediate care unit (TCU), the intensive care unit (ICU), or operating room and surgical recovery area (OR).

To evaluate the association between hemoglobin thresholds and transfusion incidences, we defined 'pre-admission hemoglobin' as the patient's lowest hemoglobin value within 72 hours prior to hospital entry; if no values were available within 72 hours, we defined it as the lowest hemoglobin value within the preceding 30 days. The pre-transfusion hemoglobin was defined as the most proximate hemoglobin level within 36 hours of RBC transfusion. We also defined the 'nadir hospital hemoglobin' as the lowest hemoglobin level from the time of hospital entry to discharge. This variable was used to compare strata of anemic patients who did and did not receive a RBC transfusion. We categorized hemoglobin values into these ranges: < 7 g/dL, 7-7.9 g/dL, 8-8.9 g/dL, 9-9.9 g/dL, and 10 g/dL.

Statistical Analysis

Categorical variables were summarized as frequencies and percentages and continuous variables as medians and interquartile ranges (IQR). We used the chi-square and linear regression tests to compare annual frequencies and trends.

To evaluate whether changes in transfusion incidences over time were attributable to changes in inpatient case-mix, we utilized a transfusion risk-adjustment model to predict the likelihood of RBC transfusion during any hospitalization. We first divided the inpatient episodes for 2009 into equally sized derivation and validation samples. In the derivation sample, we performed multivariable logistic regression with the dependent variable being the receipt of any RBC transfusion during hospitalization. Predictor variables included age,

sex, comorbidity burden (COPS2), emergency or elective presentation, medical or surgical admission, admission diagnosis (HCUP code), pre-admission hemoglobin, nadir hemoglobin, severity of illness (LAPS2), prior inpatient RBC transfusion within the past year, prior hospitalization within the past six months, initial location following hospital admission, and hospital.

We computed summary statistics to assess model performance in the derivation and validation samples. The predictive model of RBC transfusion had a pseudo- R^2 (Nagelkerke's) of 0.57 and a C-statistic of 0.90, in the development sample ($n=62,122$). The validation sample, using the remaining cases from 2009, included 62,541 admissions and had a pseudo- R^2 (Nagelkerke's) of 0.57 and a C-statistic of 0.89, indicating excellent performance. In order to examine variability in transfusion practice over time, we calculated a risk-standardized transfusion rate, defined as the ratio of observed to predicted transfusions multiplied by the average annual RBC transfusion rate for 2009.

To evaluate the impact of transfusion practice on mortality, we evaluated 30-day mortality in patient groups previously studied in clinical trials and in other subgroups (anemic patients (nadir hemoglobin level < 10 g/dL) with a history of coronary artery disease). We also examined the role of RBC transfusion on mortality in a model similar to that of transfusion incidence, using 30-day mortality as the dependent variable and adding year of patient admission as an independent variable.

Statistical analyses were performed in Stata 11 (Stata Special Edition, Version 11.2, StataCorp, College Station, TX).

RESULTS

KPNC Transfusion Service Data

Across inpatient and outpatient settings at KPNC, 107,575 patients received a total of 526,507 RBC units during the study period (Appendix Figure 3). The number of RBC units transfused per 1000 adult members was stable from 2008 through 2010 (39.8 RBC units transfused per 1000 members; $p=0.55$) and then decreased each year thereafter to 30.3 RBC units transfused per 1000 members in 2013, representing a 8.1% annual decline from 2010 ($p<0.01$).

Inpatient Study Cohort

Our inpatient study cohort included 685,753 hospitalizations among 380,687 unique patients. RBC transfusions occurred in 60,783 patients (15.5%) and 89,018 hospitalizations (13.0%). Compared with non-transfused patients, those receiving RBC transfusions were older and had higher illness severity, comorbidity burden, length of stay, inpatient mortality, and 30-day mortality (Table 1).

The overall incidence of RBC transfusion per hospitalization was 13.0% and decreased from a peak of 14.5% in 2010 to 10.8% in 2013 ($p < 0.001$, Table 2). In transfused patients, the mean number of RBC units per hospitalization was 2.9 units ($SD \pm 2.7$) and did not change significantly from 2009 to 2013 ($p 0.45$ for trend).

Transfusion by hemoglobin level and year

Ranges of nadir hemoglobin level for the study population were as follows: <7 g/dL (n=22,306); 7-7.9 g/dL (n=43,234), 8-8.9 g/dL (n=73,057), 9-9.9 g/dL (n=92,409), 10 g/dL (n=444,894). Hemoglobin levels fell below 10 g/dL during hospitalization in nearly all (87,331 of 89,018 (98.1%)) transfused patients. The greatest decline in RBC transfusion over time occurred in patients with a nadir hemoglobin level between 8 g/dL and 9 g/dL (50.8% in 2009 to 19.3% in 2013; $p < 0.001$), though trends in all strata of nadir hemoglobin were statistically significant (Figure 1 & Appendix Figure 4; $p < 0.001$). Decline in RBC transfusion incidence for medical and surgical hospitalizations was seen for all admission conditions except gastrointestinal bleeding (Table 2).

From 2009 to 2013, inpatient pre-transfusion hemoglobin decreased from 8.1 g/dL to 7.6 g/dL with a significant decline seen in both medical and surgical admission conditions (Table 2; $p < 0.001$). This finding was true even in admission conditions with no decline in RBC transfusion incidence such as gastrointestinal bleeding (8.1 g/dL to 7.5 g/dL, $p < 0.001$) or in those showing only a small decline such as medical cardiovascular disease (8.3 g/dL to 7.8 g/dL, $p < 0.001$).

Predictive Model of RBC Transfusion

Figure 2 shows that in patients whose hemoglobin fell below 10 g/dL, the observed and predicted annual transfusion incidence rates diverged progressively: 2010 (42.9% and 43.7%, respectively), 2011 (38.2% and 44.8%, respectively), 2012 (34.6% and 45.5%, respectively), and 2013 (31.2% and 45.8%, respectively) (all p -values < 0.0001).

Following risk adjustment, the observed to predicted rate ratio of RBC transfusion ranged between 0.77 and 1.31 across hospitals in 2009. From January 2010 through June 2013, the standard deviation of risk adjusted RBC transfusion incidence across hospitals decreased by 44% (Figure 3; ANOVA $F = 17.8$, $p < 0.001$).

RBC Transfusion & Mortality

In patients with hemoglobin levels less than 10 g/dL, 30-day mortality rates did not change with divergence of the observed and predicted transfusion incidence rates ($p = 0.74$ for trend; Figure 2). In the subgroup of patients with a nadir hemoglobin level between 8 g/dL and 9 g/dL who experienced the most significant decline in RBC utilization, there was no significant change in 30-day mortality (7.6% in 2010 and 7.5% in 2013, respectively; $p = 0.65$ for trend) nor a difference in mortality rates between transfused or non-transfused patients over the study period (rate ratio 0.99, 95% CI 0.93–1.05; $p = 0.65$; Figure 4). The explanatory model for 30-day mortality had a pseudo- R^2 (Nagelkerke's) of 0.31 and a C-statistic of 0.88. RBC transfusion was not a significant predictor for 30-day mortality in the full cohort after adjusting for the other factors in the model (Odds Ratio = 0.98, 95% CI 0.93–1.02; $p = 0.33$).

RBC Transfusion & Mortality in Subgroups

Between 2010 and 2013, the RBC transfusion incidence, number of RBC units, and pretransfusion hemoglobin decreased in patient cohorts similar to those studied in clinical

trials (cardiac surgery, hip fracture with cardiovascular risk factors, and ICU admissions) except for patients with upper gastrointestinal bleeding (Table 3). A similar decline in transfusion incidence and pre-transfusion hemoglobin was seen in anemic patients (nadir hemoglobin level < 10 g/dL) with a history of coronary artery disease. In all subgroups, reductions were not associated with a significant change in 30-day mortality (Table 3).

DISCUSSION

Growing emphasis on blood utilization in relation to clinical outcomes, patient safety, and cost reduction has resulted in increased implementation of blood conservation programs. This increased focus was highlighted by the 2011 National Blood Collection and Utilization Survey in which approximately one third of hospitals responded that they were utilizing some elements of a blood conservation program.¹⁵ The National Blood Collection and Utilization Survey reported a 7.4% decline in the number of allogeneic RBC's transfused nationally compared to 2008, and similar declines have been observed in Canada and the United Kingdom.^{15,24,25}

Following implementation of blood conservation strategies, we found an 8.1% annual reduction in RBC utilization over three years and a concurrent drop in pre-transfusion hemoglobin levels. This reduction occurred across all KPNC facilities and was associated with decreased inter-hospital variability in inpatient transfusion rates. Declines in the number of RBC units transfused and the pre-transfusion hemoglobin levels were seen broadly in medical and surgical inpatients as well as in subgroups of patients with and without clinical trial data to support restrictive transfusion strategies. In these subgroups and the broader hospital population, we did not detect an impact of RBC transfusion or decreased RBC utilization due to more restrictive transfusion practice on 30 day mortality.²¹

In parallel to findings in studies of cardiac surgery in other institutions, blood conservation efforts within KPNC have resulted in decreased variation in RBC transfusion across hospitals (Figure 3).^{18,26} The divergence of observed and predicted transfusion rate and decreased variation across facilities after adjustment for predictors such as admitting diagnoses and hemoglobin levels support the notion that reduced usage is due to change in transfusion practice and not related to patient factors (Figures 2 and 3). While conservation efforts focusing on correcting pre-operative anemia and reducing operative blood loss are significant in surgical patients, the broader change in RBC utilization, especially in medical patients, is most likely due to the use of lower hemoglobin triggers for transfusion.

In our cohort, the largest declines in RBC utilization were seen in patient populations for whom strong clinical trial data supports restrictive transfusion strategies. In those trials, more restrictive transfusion practice was not associated with significant changes in 30 day mortality.¹⁻³ Our study demonstrates that similar reductions in RBC utilization are occurring in similar patient populations in community practice without impacting mortality.²⁷⁻²⁹ Observational studies also often evaluate a large heterogeneous patient population which includes clinically important subpopulations where clinical trial data are not yet available. In this large community hospital cohort, reductions in RBC utilization and concomitant decline in pre-transfusion hemoglobin levels to less than 8 g/dL in general medical and surgical

patients, as well as those with cardiovascular risk factors, were not associated with apparent changes in 30-day mortality. Our data supports the safety of broad application of clinical-trial based recommendations in a diverse community hospital population.

Ongoing changes in transfusion practice provide the opportunity to longitudinally study the impact of restrictive transfusion strategies. In our diverse population of adult inpatients, we did not identify a significant change in 30-day mortality in cohorts with greater than 10% and 20% absolute incidence reduction in RBC transfusion. RBC transfusion was not a significant factor in our predictive models for 30-day mortality, and we found no difference in standardized mortality ratios in transfused and non-transfused patients in this cohort.²¹ While these findings are reassuring, we caution that RBC transfusion may play an overall small role in patient outcomes and mortality in comparison to the myriad interventions that hospitalized patients often receive. Thus, we cannot exclude the possibility that a small effect on mortality would go undetected in our study. Additional studies will need to assess whether further reductions in RBC utilization and hemoglobin thresholds in large cohorts and unstudied subgroups have an impact on morbidity and mortality.

A number of limitations of our findings should be stressed. While our patient population is quite relevant in that it reflects the regional community practice of adult inpatients at 21 hospitals in Northern California, it may not reflect transfusion practice in other community or tertiary care hospitals, age groups, patient populations (e.g., transplant and obstetrics) and regions of the country. Our predictive models for RBC transfusion and 30-day mortality performed well by health services research standards; however, the potential for residual confounding and indication bias at a population level persists. Incorporating clinician indications for transfusion (e.g., acute bleeding) and the extent to which symptoms (chest pain or dyspnea) or patient comorbidities (e.g., cardiac ischemia) influenced the decision to transfuse may further refine our model and identify patient populations that could benefit from study in randomized clinical trials.

In conclusion, we report a recent and substantial decrease in red blood cell utilization with a concomitant decline in pre-transfusion hemoglobin levels across medical and surgical patients within a community hospital network. The reduced variation in transfusion incidence across 21 hospitals suggests that this reduction reflects a change in clinical practice as a result of educational, practice improvement, and clinical decision support projects implemented within KPNC. Consistent with randomized controlled trial data, decreased red blood cell utilization does not appear to have significantly impacted 30-day mortality.^{1-3,21}

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Study concept and design: All authors.

Acquisition of data: Roubinian, Escobar, Swain, Gardner.

Statistical analysis: Roubinian, Escobar, Liu, Kipnis, Murphy.

Analysis and interpretation of data: All authors.

Drafting of the manuscript: Roubinian, Escobar, Liu, Murphy.

Critical revision of the manuscript for important intellectual content: All authors.

Administrative, technical, or material support: Swain, Gardner

Obtained funding: Escobar, Triulzi, Murphy

Study supervision: Escobar, Triulzi, Gottschall, Wu, Carson, Kleinman, Murphy

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Figure 1. RBC Transfusion Incidence, Stratified by Nadir Hemoglobin Level (g/dL) Decreases in RBC transfusion incidence occurred in patients across each subgroup of nadir hemoglobin with the most prominent decline occurring in the 8 g/dL to 9 g/dL cohort (50.7% to 19.3%).

Figure 2.

Observed and Predicted RBC Transfusion Incidence and Unadjusted 30-day Mortality In patients whose hemoglobin level fell below 10 g/dL, observed and predicted RBC transfusion incidence were progressively divergent without a concomitant change in 30-day mortality rates.

Figure 3. Risk Adjusted RBC Transfusion Incidence at 21 Hospitals From 2010 to 2013, the standard deviation of risk adjusted RBC transfusion incidence across hospitals decreased by 44%.

Figure 4. RBC Transfusion Incidence and Unadjusted 30-Day Mortality. The most pronounced decline in RBC transfusion incidence occurred in patients with a nadir hemoglobin between 8 g/dL and 9 g/dL (n=76,392) and was not associated with differences in 30-day mortality rates when comparing transfused and non-transfused patients.

Table 1**Inpatient Cohort Characteristics**

Patient Characteristics¹	Transfused	Not transfused
No. patients	63,870	328,087
No. hospitalizations	89,018	596,734
% male	44.3	46.2
Age ¹	71 (60–81)	66 (52–78)
% ≥ 65 years	65.5	51.7
Laboratory Acute Physiology Score 2 ^{2,3}	68 (33–101)	48 (17–81)
Comorbidity Point Score 2 ^{2,4}	37 (10–78)	15 (10–51)
Emergency Admission (%)	72.5	67.8
Surgical Admission (%)	33.9	31.1
Prior Hospitalization within 6 months (%)	38.7	26.3
Inpatient Transfusion within 1 yr (%)	23.9	6.2
Admission Location (%)		
Floor	55.3	56.7
Operating Room	24.1	29.0
Intensive Care Unit	13.2	7.6
Transitional Care Unit	7.4	6.7
% with these Admission Conditions		
Gastrointestinal	18	14
Injury/Fracture	15	9
Circulatory	13	20
Infectious	12	10
Musculoskeletal	11	9
Neoplasm	10	9
Blood Diseases	6	1
Respiratory	5	8
Genitourinary	5	7
Other	5	13
Hospital Length of Stay ²	4.5 (2.8–8.4)	2.4 (1.5–4.1)
Mortality rate (%)		
In-hospital	6.1	2.5
30-day	8.8	4.6

¹ All comparisons of patient characteristics in transfused & not transfused groups with p-values < 0.001

² Median (IQR)

³ Increasing degrees of physiologic derangement are reflected in a higher LAPS2, which is a continuous variable that has a theoretical maximum of 414. The univariate association between LAPS2 and mortality is such that mortality rates for scores < 50 are less than 1.5% while scores above 125 are associated with mortality rates of 10–15% or more. In our dataset, the highest LAPS2 was 282.

⁴ Longitudinal, diagnosis-based score associated with a theoretical maximum of 1,014. The univariate association between COPS2 and mortality is such that mortality rates for scores < 50 are less than 2%, while scores above 100 are associated with mortality rates of 5% or more. In our dataset, the highest COPS2 was 306.

Table 2

Trends in RBC Transfusion Incidence & Pre-Transfusion Hemoglobin Levels by Condition

Admission Condition¹	RBC Transfusion Incidence (%)²					Pre-Transfusion Hemoglobin^{3,4}	
	2009	2010	2011	2012	2013	2009	2013
All Hospitalizations (N=685,753)	14.0	14.5	13.4	12.1	10.8	8.1 (7.5,8.8)	7.6 (6.8,8.2)
Medical Admissions (N=470,176)	14.2	14.5	11.9	11.4	10.2	8.0 (7.3,8.7)	7.4 (6.7,8.1)
Surgical Admissions (N=215,577)	13.3	14.3	16.2	13.3	11.9	8.3 (7.7,8.9)	7.8 (7.1,8.5)
Gastrointestinal Bleeding (N=19,054)	55.5	57.3	58.5	57.6	56.5	8.1 (7.3,8.9)	7.5 (6.6,8.3)
Orthopedic Surgery (N=44,885)	32.7	33.6	26.5	17.9	12.7	8.3 (7.8,8.7)	7.9 (7.3,8.4)
Malignancy (N=40,816)	21.7	22.6	19.4	19.4	19.5	8.1 (7.4,8.8)	7.6 (6.9,8.3)
Infection (N=92,969)	12.5	13.6	12.2	11.8	10.1	8.1 (7.5,8.6)	7.5 (6.8,8.0)
Medical Cardiovascular (N=70,189)	8.1	8.2	7.6	7.3	6.1	8.3 (7.6,8.9)	7.8 (7.2,8.6)
All Others (N=441,623)	10.8	11.1	10.5	9.4	8.6	8.0 (7.3,8.7)	7.5 (6.8,8.2)

¹ See Methods and Appendix Methods 2 for definitions of grouped admission conditions² These data reflect unadjusted annual transfusion incidence. Declines in RBC Transfusion Incidence from 2009 through 2013 for listed Admission Conditions are all statistically significant (p<0.001) except for Gastrointestinal Bleeding (p 0.49)³ Median hemoglobin(IQR) in g/dL⁴ All trends with p-values <0.01

Table 3

RBC Utilization, Hemoglobin Levels, & 30 Day Mortality in Subgroup Conditions

<u>Admission Condition</u> ¹	<u>% Reduction in RBC TX</u> ^{2,3}		<u>Pre-TX Hemoglobin</u> ^{3,4}		<u>30 Day Mortality (%)</u>		
	<u>TX Inc</u>	<u>Units TX</u>	<u>2010</u>	<u>2013</u>	<u>2010</u>	<u>2013</u>	<u>P-value</u> ⁵
Intensive Care Unit (n=25,117)	19.0	15.5	8.1	7.6	18.7	17.8	0.18
CAD & Anemia (n=65,481)	27.3	27.4	8.4	7.7	10.3	10.5	0.57
Cardiac Surgery (n=6,592)	41.7	41.1	8.3	7.5	1.6	1.2	0.53
Upper GI Bleeding (n=6,579)	-0.1	-8.8	7.9	7.5	2.8	3.7	0.21
High Risk Hip Fracture (n=4,163)	25.7	34.7	8.4	7.9	7.2	6.7	0.60

¹ See Methods and Appendix Methods 3 for definitions of grouped admission conditions² Relative reduction (%) of Incidence of RBC Transfusion (TX Inc) and total number of RBC Units Transfused (Units TX) to all patients with these diagnoses from 2010 to 2013³ All changes from 2010 to 2013 with p-value <0.001 except for Upper GI Bleeding cohort – Inc TX (p0.80); Units Tx (p 0.11)⁴ Hemoglobin levels presented as median values in g/dL⁵ P-values for change in 30-day mortality from 2010 to 2013