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Factors Associated with Red Blood Cell, Platelet, and Plasma Transfusions among Inpatient Hospitalizations: A Nationally Representative Study in the United States

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Abstract

Background: Demographic and hospital-level factors associated with red blood cell (RBC), plasma, and platelet transfusions in hospitalized patients across the U.S. are not well characterized.

Methods: We conducted a retrospective analysis of the National Inpatient Sample (2014). The unit of analysis was a hospitalization; sampling weights were applied to generate nationally-representative estimates. The primary outcome was having ≥1 RBC transfusion procedure; plasma and platelet transfusions were similarly assessed as secondary outcomes. For each component, factors associated with transfusion were measured using adjusted prevalence-ratios(adjPR) and 95% confidence intervals (95%CI) estimated by multivariable-Poisson regression.

Results: The prevalence of RBC, plasma, and platelet transfusion was 5.8%, 0.9%, and 0.7%, respectively. RBC transfusions were associated with older age (≥65 vs. <18 years;adjPR=1.80;95%CI=1.66–1.96), female sex (adjPR=1.13;95%CI=1.12–1.14), minority race/ethnic status, and hospitalizations in rural hospitals compared to an urban teaching hospitals. Prevalence of RBC transfusion was lower among hospitalizations in the Midwest compared to the Northeast (adjPR=0.73;95%CI=0.67–0.80). All components were more likely to be transfused in patients with a primary hematologic diagnosis, patients with a higher number of total diagnoses,

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patients who experienced a higher number of other procedures, and patients who eventually died in the hospital. In contrast to RBC transfusions, prevalence of platelet transfusion was greater in urban teaching hospitals (vs. rural;adjPR=1.71;95% CI=1.49–1.98) and lower in Blacks (vs. whites;adjPR=0.80;95%CI=0.76–0.85).

Conclusions: Nationally, there is heterogeneity in factors associated with transfusion between each blood component, including by hospital type and location. This variability presents patient blood management programs with potential opportunities to reduce transfusions.

Keywords

Red blood cell; platelet; plasma; transfusion; United States; patient blood management

Introduction

Blood transfusions are among the most common hospital procedures in the United States (U.S.). However, there is clear evidence that red blood cell (RBC) and plasma transfusions have been decreasing across the nation.[1–4] The medical evidence to guide transfusion practice has dynamically evolved over the past two decades. The immediate decision to transfuse remains guided by bleeding and laboratory values, such as hemoglobin and hematocrit levels, the international normalized ratio for blood clotting tendency, and platelet counts, for the three primary components: RBCs, plasma, and platelets.

Factors associated with blood transfusion beyond active bleeding and pre-transfusion laboratory data remain poorly defined. Surveys conducted by the AABB and U.S. Centers for Disease Control and Prevention have indeed provided important data on blood component collections, hospital distributions, and transfusion trends in the United States.[3–6] However, these surveys do not account for important patient-level factors beyond basic demographics. Other studies examining predictors of transfusion have either been conducted among a limited number of hospitals and/or certain patient populations.[7–15] For instance, the Recipient Epidemiology and Donor Evaluation Study-III (REDS-III) program evaluated laboratory parameters, sociodemographic data and transfusion reactions associated with RBC and plasma transfusions but were limited to <15 hospitals for each component.[16,17] We are unaware of nationally representative studies evaluating non-laboratory predictors of RBC, plasma, or platelet transfusions in U.S. hospitalized patients while accounting for patient- and hospital-level factors.

In this study, we evaluate patient- and hospital-level factors associated with allogenic transfusions among adult and pediatric hospitalizations using nationally representative data.

Methods

Data Source:

The National Inpatient Sample (NIS) is the largest all-payer administrative database of inpatient hospitalizations in the U.S., and was developed as part of the Healthcare Cost and Utilization Project (HCUP) by the Agency for Healthcare Research and Quality (AHRQ). In 2012, the NIS began systematically sampling 20% of discharges from all non-long-term

acute care HCUP hospitals, stratified by Census division, hospital ownership, urban vs. rural location, teaching status, and bedsize categories.[18] This creates a self-weighted sample of hospitalizations (discharges) that represents 96% of the U.S. population.[19] Since the unit of observation is a hospital discharge (or hospitalization), patients may be included more than once in the database. Data from the 2014 NIS were used in this analysis, as this is the final year preceding the transition from ICD-9-CM to ICD-10-CM coding.

Each hospitalization record (or discharge) included information on patient demographics (age, sex, and race), type of admission (elective vs. non-elective), patient outcomes (length of stay and in-patient mortality), up to 30 ICD-9-CM diagnosis code, up to 15 ICD-9-CM procedure codes, and hospital characteristics (census region, location and teaching status). The hospital location and teaching status variable was derived from either having an Accreditation Council for Graduate Medical Education (ACGME) approved residency program, membership in the Council of Teaching Hospitals (COTH), or a ratio of full-time equivalent interns and residents to beds of .25 or higher. No distinction was made by teaching status among rural hospitals as rural teaching hospitals were rare. The AHRQ also developed a clinical classification software (CCS) for use with HCUP data. This software categorizes ICD-9-CM codes into clinically meaningful diagnostic groups,[20] and multi-level CCS diagnostic categories are provided in the NIS database. For this analysis, multi-level CCS categories for the patient's primary diagnosis was collapsed into 13 groups. Data on laboratory values, number of units transfused, and pharmacological therapies administered during hospitalization were not available.

As the NIS is a de-identified, publicly available dataset, informed consent was not needed and Johns Hopkins Medical Institutions Institutional Review Board deemed the study exempt from review. HCUP data use agreement guidelines were followed.

Statistical Analyses:

Data analysis was performed using *svy* commands in Stata/MP, version 15.2 (Statacorp, College Station, TX). Sampling weights provided by HCUP were used to generate nationally-representative estimates. Taylor series linearization was used to estimate standard errors.

The unit of analysis was a hospitalization (i.e., not individual patients). The primary outcome was the percentage of hospitalizations with 1 or more allogenic RBC transfusion procedures, as the majority of transfusions are RBCs. Secondary outcomes included the percentage of hospitalizations with 1 or more plasma transfusions and 1 or more platelet transfusions. The ICD-9-CM procedure codes used to indicate RBC, plasma, and, platelet transfusions were 99.04, 99.07 and 99.05, respectively. This study focused on allogenic transfusions and did not include autologous, whole blood, or exchange transfusions as potential outcomes. For each blood component, the reported data do not reflect associations with the number of units transfused, but rather an overall decision to transfuse (versus no transfusion) during the entire course of a hospitalization.

Adjusted prevalence ratios (adjPR) and corresponding 95% confidence intervals (95%CI) were estimated by multivariable Poisson regression. The multivariable models included all

covariates determined to be clinically and/or operationally important *a priori*, including sex, age group, race, elective admission status, length of stay (days), total number of diagnoses, total number of non-transfusion-related procedures, in-patient mortality status, hospital teaching status and location, hospital census region, and the primary diagnostic CCS category. All multivariable models were assessed for multi-collinearity. All p-values are two-sided and the threshold of statistical significance was 0.05. We used a complete-case analytic approach such that persons with missing data were excluded from analysis.

Results

Of 7,071,762 hospitalizations recorded in 2014, 6,621,151 (93.6%) had complete data for analysis. The analytic sample for this study represents 33,105,765 hospitalizations in the United States. Weighted characteristics of the study population are shown in Table 1. The majority of hospitalizations were among patients who were female (57.3%), aged ≥45 years (60.2%), and white (65.9%). Most hospitalizations were non-elective admissions (78.4%). Among all hospitalizations, patients had a median of 9 diagnoses (interquartile range [IQR], 5–14) and a median 1 non-transfusion-related procedures (IQR, 0–2) during their hospital stay. Most hospitalizations were in urban settings (90.8%). Overall, the prevalence of 1 or more RBC transfusions was 5.8% (95% CI, 5.7%−6.0%), the prevalence of 1 or more platelet transfusions was 0.7% (95% CI, 0.7%−0.8%), and the prevalence of 1 or more plasma transfusions was 0.9% (95% CI, 0.8%−0.9%). Table 1 presents characteristics of the study population by a composite status for blood transfusion (1 or more RBC, plasma, or platelet transfusions).

A higher prevalence of RBC transfusion was associated with older patients (≥65 years compared to <18 years; adjPR, 1.80; 95% CI, 1.66–1.96), female sex (adjPR, 1.13; 95% CI, 1.12–1.14), and minority race/ethnic status (Table 2). White race was associated with the lowest prevalence of RBC transfusion (5.7%), and the highest prevalence of RBC transfusion was among hospitalizations of black patients (7.3%; adjPR, 1.39; 95% CI, 1.35–1.43). Having a higher number of diagnoses (adjPR 1.08; 95% CI, 1.08–1.08), higher number of non-transfusion procedures performed during the hospitalization (adjPR, 1.11; 95% CI, 1.10–1.11) and the occurrence of in-patient mortality (adjPR, 1.05; 95% CI, 1.03–1.08) were independent factors associated with a higher prevalence of RBC transfusion. Patients admitted with a primary hematologic diagnosis were the most common group to have a RBC transfusion. Upon geographic assessment, a lower prevalence of RBC transfusion was observed in hospitals based in the Midwest as compared to the Northeast (adjPR 0.73; 95% CI, 0.67–0.80). Hospitalizations in rural hospitals had a higher prevalence of RBC transfusion as compared with hospitalizations in urban teaching hospitals.

Similar to RBC transfusions, higher prevalences of platelet and plasma transfusions were associated with hospitalizations of patients with a greater number of total diagnoses and a greater number of non-transfusion procedures performed during their stay in the hospital (Table 3 and Table 4). The prevalence of platelet transfusion was also lower among hospitalizations in the Midwest compared to the Northeast region, and among hospitalizations in rural hospitals compared to urban hospitals. In contrast to RBC transfusions, however, the prevalence of platelet transfusion was lower among

hospitalizations of females compared to males (adjPR, 0.75; 95% CI, 0.74–0.77) and blacks compared to whites (adjPR, 0.80; 95% CI, 0.76–0.85) (Table 3). The prevalence of platelet transfusions was highest among hospitalizations in which the patient eventually died in the hospital (adjPR, 2.18; 95% CI, 2.08–2.28) and among hospitalizations of patients with a primary hematologic diagnosis. Compared to those with a benign hematologic primary diagnostic code, those with a malignant hematologic diagnosis (cancer of the lymphatic and hematopoietic tissue, Hodgkin's disease, Non-Hodgkin's lymphoma, leukemia, multiple myeloma, and secondary malignancy of the lymph nodes) were more likely to receive a platelet transfusion (18.8% vs. 6.8%; RR, 2.75; 95% CI, 2.52–2.99).

Discussion

This study utilized the largest, all-payer, in-patient national database in the U.S. to provide a comprehensive evaluation of non-laboratory factors associated with RBC, plasma, and platelet transfusions in hospitalized patients—while accounting for the influence of patient demographics, diagnoses and procedures, and hospital-level characteristics. In the past decade, a number of guidelines have been published for RBC, plasma and platelet transfusion.[21–26] Most of these recommendations have focused on laboratory parameters that vary with diagnosis. Despite these guidelines, significant variation in clinical transfusion practice persists. We provide evidence that various patient- and hospital-level characteristics may influence the inpatient transfusion decision and explain some of this variation.

Small studies of a few institutions in both the US and internationally have evaluated transfusions in hospitalized patients.[4,27–32] Roubinian et al. examined in-hospital determinants of RBC transfusions using the Kaiser Health system database using data from 21 hospitals over a four-year period (2008–2011). While the Kaiser study identified that pre-transfusion hemoglobin was indeed the most important determining factor, patient comorbidities and severity of illness were independent and significant predictors as well.[15] Similar to Roubinian, we find that RBC, platelet and plasma transfusions were all associated with increased number of total diagnoses and increased number of procedures. In this study, RBC transfusions were highest among rural (non-teaching) hospitals compared to urban teaching hospitals. This may be multifactorial, including different patient populations and blood banks that are often run by community practice pathologists that often focus on anatomic pathology with less focus on optimal transfusion thresholds and implementation of patient blood management programs. The higher risk of a RBC transfusion at small, rural hospitals may be an area of opportunity for further study (e.g., survey of community pathologists, evaluation of transfusion medicine training, etc.) and for implementing patient blood management initiatives. RBC, platelet and plasma transfusions were most common among hospitalizations of patients admitted with a hematologic diagnosis. RBC transfusions were also highest among hospitalizations of black patients, which may reflect the increased use of RBCs among those with hemoglobinopathies, while plasma and platelet transfusions were lowest among black patients. These associations have also been reported in the REDS III study.[16] It is unclear why hospitalizations are more often associated with a transfusion in the Northeast than hospitalizations in the Midwest. It is likely multifactorial that may partially be explained by a slightly different patient population (e.g., higher numbers of sickle cell clinics are located in the Northeast).[33]

As one would expect, factors associated with RBC and plasma transfusion were similar, and differed from factors associated with platelet transfusions. In contrast to RBC transfusions, platelet transfusions were less common at rural hospitals. This may be reflective of the difficulty of maintaining a low inventory of short-dated products and the distance from the blood supplier with limited storage time. In addition, as oncology centers are generally located in large hospitals and urban teaching centers, it is not surprising that platelet transfusions are seen more often in these centers.

There are limitations of this study. The data are derived from an administrative dataset that is primarily used for billing purposes, so concerns exist regarding the retrospective nature of the study and accuracy of the data. Hospital discharge codes have been shown to correlate well with self-report[34], and hospital discharge codes for RBC transfusions have been previously validated against blood bank transfusion records (83% sensitivity; 100% specificity) at one institution.[35] The NIS database has also produced comparable results to the National Hospital Discharge Survey and Medicare Provider Analysis and Review Files.[36] In addition, the NIS has also previously been used for transfusion-related research.[37] It is a limitation, however, that individual patients may be multiply represented since the unit of observation was a hospital discharge. Unfortunately, laboratory data (e.g., hemoglobin level, coagulation profile, platelet count, etc.) were not available. Therefore, the descriptive associations presented in this study may be confounded despite adjustment for patient and hospital-level factors. In addition, the NIS does not document how many units were transfused. Thus, these findings should be confirmed with data that can incorporate laboratory data and number of transfusions. Patient blood management programs have had a substantial impact on RBC use. The data in this manuscript are from a period when RBC and plasma use were substantially declining.[1] As these changes continue over time, the factors associated with transfusion may change as well, and this may limit the generalizability of these findings. Also, the these data among inpatient hospitalizations may not be applicable to outpatient settings.

While laboratory data are critically important to deciding when to transfuse patients, other variables are also appear to be associated with the decision to transfuse. There is significant heterogeneity between transfusion of RBCs and platelets among hospital types and locations. Further research is needed to understand these variations in practice, as this information may be valuable to the development and implementation of patient blood management programs.

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Table 1:

Characteristics of study population by transfusion status (red blood cells, platelets, or plasma).

Characteristic	Overall (N = 33105765)		Non-transfused (N = 30993004)		Transfused * (N = 2112761)	
	No.	%	No.	%	No.	%
Sex						
Male	14123169	42.7%	13173274	42.5%	949895	45.0%
Female	18982596	57.3%	17819730	57.5%	1162866	55.0%
Age group, years						
< 18	5023844	15.2%	4946134	16.0%	77710	3.7%
18–44	8157756	24.6%	7888546	25.5%	269210	12.7%
45–64	8240624	24.9%	7649553	24.7%	591070	28.0%
≥65	11683541	35.3%	10508770	33.9%	1174771	55.6%
Race						
White	21823627	65.9%	20447617	66.0%	1376011	65.1%
Black	4918867	14.9%	4539212	14.6%	379655	18.0%
Hispanic	4011811	12.1%	3795071	12.2%	216740	10.3%
Asian/Pacific Islander	960535	2.9%	899950	2.9%	60585	2.9%
Native American/Other	1390924	4.2%	1311154	4.2%	79770	3.8%
Admission type						
Non-elective	25939518	78.4%	24200917	78.1%	1738601	82.3%
Elective	7166247	21.6%	6792087	21.9%	374160	17.7%
Length of stay, days †	-	3 (2–5)	-	3 (2–5)	-	6 (3–10)
Number of diagnoses †	-	9 (5–14)	-	8 (4–14)	-	15 (10–20)
Number of procedures †‡	-	1 (0–2)	-	1 (0–2)	-	2 (1–4)
In-hospital mortality	631795	1.9%	503245	1.6%	128550	6.1%
Hospital location/teaching status						
Rural	3056717	9.2%	2883953	9.3%	172765	8.2%
Urban non-teaching	8813331	26.6%	8239852	26.6%	573480	27.1%
Urban teaching	21235716	64.1%	19869199	64.1%	1366517	64.7%
Hospital Census region						
Northeast	6502407	19.6%	6084482	19.6%	417925	19.8%
Midwest	6608279	20.0%	6246379	20.2%	361900	17.1%
South	13380773	40.4%	12475772	40.3%	905001	42.8%
West	6614306	20.0%	6186371	20.0%	427935	20.3%
Primary diagnosis category						
Hematology	504990	1.5%	249160	0.8%	255830	12.1%
Solid Tumors	1284886	3.9%	1132781	3.7%	152105	7.2%
Infectious Diseases	1625031	4.9%	1417070	4.6%	207960	9.8%
Endocrine	1218856	3.7%	1168036	3.8%	50820	2.4%
Mental Illness	1920679	5.8%	1898309	6.1%	22370	1.1%
Nervous/Sensory	804585	2.4%	788055	2.5%	16530	0.8%

Characteristic	Overall (N = 33105765)		Non-transfused (N = 30993004)		Transfused * (N = 2112761)	
	No.	%	No.	%	No.	%
Circulatory	4818822	14.6%	4537342	14.6%	281480	13.3%
Respiratory	2784481	8.4%	2671771	8.6%	112710	5.3%
Gastrointestinal/Genitourinary	4553392	13.8%	4089327	13.2%	464065	22.0%
Musculoskeletal	2586842	7.8%	2466267	8.0%	120575	5.7%
OB-GYN/Congenital	7482265	22.6%	7393775	23.9%	88490	4.2%
Injury/Poison	2618186	7.9%	2309026	7.5%	309160	14.6%
Other	902750	2.7%	872085	2.8%	30665	1.5%

*Refers to discharges with transfusion of allogenic red blood cells, platelets or plasma.

†Data are the median and the corresponding interquartile range.

‡Excludes codes for red blood cell, platelet, and plasma transfusions.

Table 2:

Factors associated with ≥1 red blood cell transfusion during an in-patient hospitalization.

Characteristic	No. Transfused	Percent Transfused	Univariable		Multivariable	
			PR (95% CI)	p-value	PR (95% CI)	p-value
Sex						
Male	846430	6.0%	Ref.		Ref.	
Female	1086256	5.7%	0.95 (0.95 – 0.96)	<0.001	1.13 (1.12–1.14)	<0.001
Age group, years						
< 18	70125	1.4%	Ref.		Ref.	
18–44	252435	3.1%	2.22 (1.99–2.47)	<0.001	1.26 (1.17–1.36)	<0.001
45–64	537450	6.5%	4.67 (4.17–5.24)	<0.001	1.44 (1.33–1.57)	<0.001
≥65	1072676	9.2%	6.58 (5.86–7.38)	<0.001	1.80 (1.66–1.96)	<0.001
Race						
White	1245286	5.7%	Ref.		Ref.	
Black	359930	7.3%	1.28 (1.24–1.32)	<0.001	1.39 (1.35–1.43)	<0.001
Hispanic	198400	5.0%	0.87 (0.83–0.91)	<0.001	1.23 (1.18–1.28)	<0.001
Asian/Pacific Islander	55930	5.8%	1.02 (0.95–1.10)	0.585	1.33 (1.24–1.44)	<0.001
Native American/Other	73140	5.3%	0.92 (0.87–0.97)	0.004	1.22 (1.17–1.28)	<0.001
Admission type						
Non-elective	1583311	6.1%	Ref.		Ref.	
Elective	349375	4.9%	0.80 (0.78–0.82)	<0.001	0.99 (0.96–1.01)	0.279
Length of stay (per day)	-	-	1.02 (1.02–1.02)	<0.001	1.01 (1.01–1.01)	<0.001
Number of diagnoses	-	-	1.12 (1.12–1.12)	<0.001	1.08 (1.08–1.08)	<0.001
Number of procedures *	-	-	1.20 (1.19–1.21)	<0.001	1.11 (1.10–1.11)	<0.001
In-hospital mortality						
No	1824301	5.6%	Ref.		Ref.	
Yes	108385	17.2%	3.05 (2.99–3.12)	<0.001	1.05 (1.03–1.08)	<0.001
Hospital location/teaching status						
Rural	162195	5.3%	Ref.		Ref.	
Urban non-teaching	528800	6.0%	1.13 (1.05–1.22)	0.001	0.98 (0.92–1.05)	0.525
Urban teaching	1241692	5.9%	1.10 (1.02–1.19)	0.014	0.84 (0.78–0.90)	<0.001
Hospital Census region						
Northeast	380380	5.9%	Ref.		Ref.	
Midwest	329340	5.0%	0.85 (0.77–0.95)	0.003	0.73 (0.67–0.80)	<0.001
South	838586	6.3%	1.07 (0.99–1.16)	0.085	1.01 (0.93–1.08)	0.879
West	384380	5.8%	0.99 (0.92–1.08)	0.873	0.94 (0.87–1.00)	0.056
Primary diagnosis category						
Hematology	242305	48.0%	Ref.		Ref.	
Solid Tumors	142435	11.1%	0.23 (0.22–0.24)	<0.001	0.22 (0.21–0.23)	<0.001
Infectious Diseases	187045	11.5%	0.24 (0.23–0.25)	<0.001	0.15 (0.14–0.15)	<0.001
Endocrine	47430	3.9%	0.08 (0.08–0.08)	<0.001	0.09 (0.08–0.09)	<0.001
Mental Illness	18775	1.0%	0.02 (0.02–0.02)	<0.001	0.03 (0.03–0.04)	<0.001

Characteristic	No. Transfused	Percent Transfused	Univariable		Multivariable	
			PR (95% CI)	p-value	PR (95% CI)	p-value
Nervous/Sensory	13830	1.7%	0.04 (0.03–0.04)	<0.001	0.04 (0.04–0.05)	<0.001
Circulatory	244330	5.1%	0.11 (0.10–0.11)	<0.001	0.08 (0.08–0.09)	<0.001
Respiratory	103035	3.7%	0.08 (0.07–0.08)	<0.001	0.08 (0.07–0.06)	<0.001
Gastrointestinal/Genitourinary	432555	9.5%	0.20 (0.19–0.20)	<0.001	0.21 (0.20–0.21)	<0.001
Musculoskeletal	112900	4.4%	0.09 (0.09–0.09)	<0.001	0.11 (0.11–0.12)	<0.001
OB-GYN/Congenital	82775	1.1%	0.02 (0.02–0.02)	<0.001	0.05 (0.05–0.06)	<0.001
Injury/Poison	277425	10.6%	0.22 (0.22–0.23)	<0.001	0.21 (0.20–0.21)	<0.001
Other	27845	3.1%	0.06 (0.06–0.07)	<0.001	0.06 (0.06–0.07)	<0.001

*Excludes codes for red blood cell, platelet, and plasma transfusions.

Abbreviations: PR, prevalence ratio; CI, confidence interval

Table 3:

Factors associated with ≥1 platelet transfusion during an in-patient hospitalization.

Characteristic	No. Transfused	Percent Transfused	Univariable		Multivariable	
			PR (95% CI)	p-value	PR (95% CI)	p-value
Sex						
Male	133965	1.0%	Ref.		Ref.	
Female	102125	0.5%	0.57 (0.56–0.58)	<0.001	0.75 (0.74–0.77)	<0.001
Age group, years						
< 18	20790	0.4%	Ref.		Ref.	
18–44	29680	0.4%	0.88 (0.76–1.01)	0.076	0.54 (0.49–0.60)	<0.001
45–64	78580	1.0%	2.30 (1.98–2.68)	<0.001	0.65 (0.58–0.72)	<0.001
≥65	107040	0.9%	2.21 (1.91–2.57)	<0.001	0.53 (0.47–0.60)	<0.001
Race						
White	156730	0.7%	Ref.		Ref.	
Black	29940	0.6%	0.85 (0.81–0.89)	<0.001	0.80 (0.76–0.85)	<0.001
Hispanic	29480	0.7%	1.02 (0.95–1.10)	0.555	1.18 (1.12–1.26)	<0.001
Asian/Pacific Islander	9205	1.0%	1.33 (1.20–1.48)	<0.001	1.29 (1.16–1.44)	<0.001
Native American/Other	10735	0.8%	1.07 (0.97–1.19)	0.177	1.19 (1.10–1.28)	<0.001
Admission type						
Non-elective	185920	0.7%	Ref.		Ref.	
Elective	50170	0.7%	0.98 (0.92–1.04)	0.447	1.39 (1.32–1.47)	<0.001
Length of stay (per day)	-	-	1.02 (1.02–1.02)	<0.001	1.01 (1.00–1.01)	<0.001
Number of diagnoses	-	-	1.14 (1.14–1.14)	<0.001	1.09 (1.09–1.10)	<0.001
Number of procedures *	-	-	1.29 (1.28–1.30)	<0.001	1.13 (1.12–1.14)	<0.001
In-hospital mortality						
No	204365	0.6%	Ref.		Ref.	
Yes	31725	5.0%	7.98 (7.70–8.27)	<0.001	2.18 (2.08–2.28)	<0.001
Hospital location/teaching status						
Rural	9440	0.3%	Ref.		Ref.	
Urban non-teaching	46735	0.5%	1.72 (1.47–2.00)	<0.001	1.38 (1.20–1.58)	<0.001
Urban teaching	179915	0.9%	2.74 (2.34–3.22)	<0.001	1.71 (1.49–1.98)	<0.001
Hospital Census region						
Northeast	48080	0.7%	Ref.		Ref.	
Midwest	41575	0.6%	0.85 (0.68–1.06)	0.150	0.74 (0.62–0.88)	0.001
South	87165	0.7%	0.88 (0.76–1.03)	0.103	0.88 (0.77–1.00)	0.048
West	59270	0.9%	1.21 (1.03–1.43)	0.024	1.12 (0.99–1.27)	0.080
Primary diagnosis category						
Hematology	46680	9.2%	Ref.		Ref.	
Solid Tumors	19385	1.5%	0.16 (0.16–0.17)	<0.001	0.13 (0.13–0.14)	<0.001
Infectious Diseases	28210	1.7%	0.19 (0.18–0.20)	<0.001	0.11 (0.10–0.11)	<0.001
Endocrine	2590	0.2%	0.02 (0.02–0.03)	<0.001	0.03 (0.02–0.03)	<0.001
Mental Illness	4105	0.2%	0.02 (0.02–0.03)	<0.001	0.04 (0.04–0.05)	<0.001

Characteristic	No. Transfused	Percent Transfused	Univariable		Multivariable	
			PR (95% CI)	p-value	PR (95% CI)	p-value
Nervous/Sensory	1805	0.2%	0.02 (0.02–0.03)	<0.001	0.03 (0.03–0.04)	<0.001
Circulatory	45770	1.0%	0.10 (0.09–0.11)	<0.001	0.09 (0.08–0.09)	<0.001
Respiratory	8365	0.3%	0.03 (0.03–0.03)	<0.001	0.04 (0.03–0.04)	<0.001
Gastrointestinal/Genitourinary	29045	0.6%	0.07 (0.06–0.07)	<0.001	0.08 (0.08–0.09)	<0.001
Musculoskeletal	5320	0.2%	0.02 (0.02–0.02)	<0.001	0.03 (0.03–0.03)	<0.001
OB-GYN/Congenital	12915	0.2%	0.02 (0.02–0.02)	<0.001	0.03 (0.03–0.04)	<0.001
Injury/Poison	30265	1.2%	0.13 (0.12–0.13)	<0.001	0.12 (0.11–0.12)	<0.001
Other	1635	0.2%	0.02 (0.02–0.02)	<0.001	0.02 (0.02–0.02)	<0.001

* Excludes codes for red blood cell, platelet, and plasma transfusions.

Abbreviations: PR, prevalence ratio; CI, confidence interval

Table 4:

Factors associated with ≥1 plasma transfusion during an in-patient hospitalization.

Characteristic	No. Transfused	Percent Transfused	Univariable		Multivariable	
			PR (95% CI)	p-value	PR (95% CI)	p-value
Sex						
Male	161060	1.1%	Ref.		Ref.	
Female	131685	0.7%	0.61 (0.60–0.62)	<0.001	0.79 (0.77–0.80)	<0.001
Age group, years						
< 18	10430	0.2%	Ref.		Ref.	
18–44	30850	0.4%	1.82 (1.58–2.10)	<0.001	1.04 (0.93–1.17)	0.469
45–64	86355	1.1%	5.05 (4.36–5.84)	<0.001	1.33 (1.18–1.49)	<0.001
≥65	165110	1.4%	6.81 (5.87–7.89)	<0.001	1.50 (1.33–1.69)	<0.001
Race						
White	205105	0.9%	Ref.		Ref.	
Black	37895	0.8%	0.82 (0.78–0.86)	<0.001	0.93 (0.89–0.97)	0.002
Hispanic	30110	0.8%	0.80 (0.75–0.85)	<0.001	1.08 (1.02–1.14)	0.009
Asian/Pacific Islander	08025	0.8%	0.89 (0.80–0.98)	0.002	1.01 (0.91–1.12)	0.820
Native American/Other	11610	0.8%	0.89 (0.82–0.96)	0.004	1.12 (1.03–1.21)	0.005
Admission type						
Non-elective	248995	1.0%	Ref.		Ref.	
Elective	43750	0.1%	0.64 (0.57–0.71)	<0.001	0.92 (0.84–1.00)	0.054
Length of stay (per day)	-	-	1.02 (1.02–1.02)	<0.001	1.00 (1.00–1.00)†	0.027
Number of diagnoses	-	-	1.16 (1.16–1.17)	<0.001	1.11 (1.11–1.12)	<0.001
Number of procedures*	-	-	1.30 (1.29–1.31)	<0.001	1.16 (1.15–1.17)	<0.001
In-hospital mortality						
No	250150	0.8%	Ref.		Ref.	
Yes	42595	6.7%	8.75 (8.45–9.07)	<0.001	2.30 (2.21–2.38)	<0.001
Hospital location/teaching status						
Rural	19045	0.6%	Ref.		Ref.	
Urban non-teaching	72865	0.8%	1.33 (1.18–1.49)	<0.001	1.03 (0.93–1.14)	0.547
Urban teaching	200835	1.0%	1.52 (1.34–1.71)	<0.001	1.03 (0.92–1.15)	0.586
Hospital Census region						
Northeast	56625	0.9%	Ref.		Ref.	
Midwest	52780	0.8%	0.92 (0.78–1.08)	0.298	0.70 (0.61–0.81)	<0.001
South	109730	0.8%	0.94 (0.82–1.08)	0.376	0.88 (0.77–1.00)	0.056
West	73610	1.1%	1.28 (1.12–1.46)	<0.001	1.15 (1.02–1.30)	0.023
Primary diagnosis category						
Hematology	10395	2.1%	Ref.		Ref.	
Solid Tumors	15435	1.2%	0.58 (0.55–0.62)	<0.001	0.51 (0.48–0.55)	<0.001
Infectious Diseases	36745	2.3%	1.10 (1.04–1.16)	<0.001	0.49 (0.45–0.52)	<0.001
Endocrine	4210	0.4%	0.17 (0.15–0.18)	<0.001	0.19 (0.17–0.21)	<0.001
Mental Illness	7230	0.4%	0.18 (0.17–0.20)	<0.001	0.39 (0.36–0.43)	<0.001

Characteristic	No. Transfused	Percent Transfused	Univariable		Multivariable	
			PR (95% CI)	p-value	PR (95% CI)	p-value
Nervous/Sensory	2635	0.3%	0.16 (0.14–0.18)	<0.001	0.22 (0.20–0.24)	<0.001
Circulatory	55975	1.2%	0.56 (0.53–0.60)	<0.001	0.40 (0.37–0.43)	<0.001
Respiratory	13635	0.5%	0.24 (0.22–0.25)	<0.001	0.24 (0.22–0.25)	<0.001
Gastrointestinal/Genitourinary	71670	1.6%	0.76 (0.73–0.81)	<0.001	0.85 (0.80–0.91)	<0.001
Musculoskeletal	11120	0.4%	0.21 (0.15–0.30)	<0.001	0.30 (0.22–0.43)	<0.001
OBGYN/Congenital	12490	0.2%	0.08 (0.07–0.09)	<0.001	0.29 (0.22–0.43)	<0.001
Injury/Poison	47830	1.8%	0.89 (0.83–0.95)	<0.001	0.76 (0.70–0.81)	<0.001
Other	3375	0.4%	0.18 (0.17–0.20)	<0.001	0.20 (0.18–0.22)	<0.001

*Excludes codes for red blood cell, platelet, and plasma transfusions.

†The estimate prior to rounding is: 1.0014 (95% CI, 1.0002–1.0025)

Abbreviations: PR, prevalence ratio; CI, confidence interval