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Demographic Correlates of Low Hemoglobin Deferral among Prospective Whole Blood Donors

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Abstract

BACKGROUND—Approximately 10% of attempted blood donations are not allowed because of low hemoglobin deferral.

STUDY DESIGN AND METHODS—Low hemoglobin deferrals were tracked in over 715,000 whole blood donors at six blood centers across the United States. A multivariable logistic regression model was developed to comprehensively assess demographic correlates for low hemoglobin deferral.

RESULTS—Demographic factors significantly associated with low hemoglobin deferral include female gender (11 times greater odds than males), increasing age in men (men over 80 have 29 times greater odds than men under 20); African American race (2–2.5 times greater odds than Caucasians); Hispanic ethnicity in women (1.29 times greater odds than Caucasian women) and weight in men (men under 124 pounds have 2.5 times greater odds than men over 200 pounds). Interestingly, increasing donation frequency is associated with decreased odds for low hemoglobin deferral (women with 1 donation in the previous 12 months have 2 times greater odds than those with 6 donations).

CONCLUSIONS—Low hemoglobin deferral is associated with female gender, older age, African-American race/ethnicity and lower body weight in men. An inverse association with donation frequency suggests a selection bias in favor of donors able to give more frequently. These data provide useful information that can be utilized to manage blood donors in order to limit low hemoglobin deferrals and assist in policy decisions such as changing the hemoglobin cut-off or permissible frequency of donation. They also generate hypotheses for new research of the causes of anemia in defined groups of donors.

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Introduction

Approximately 10% of all attempted blood donations in the United States result in low hemoglobin (or hematocrit) deferral.[1] Donations lost because of low hemoglobin deferral are multiplied because, once deferred, many donors do not return even if they previously were regular donors.[2] It has been estimated that donors deferred for low hemoglobin donate approximately 30% less blood over the following 4- to 5-year period than would have been donated had they not been deferred.[3] These individuals represent a large base of willing donors. The loss of their donations has a large cost to blood centers because of the time dedicated to recruiting and interviewing the potential donor as well as performing the hemoglobin or hematocrit testing.

Since donors deferred for low hemoglobin represent a significant percentage of the total donor pool, understanding the underlying causes of the deferrals and developing programs to prevent them represents a tremendous opportunity to improve the health of blood donors and increase the availability of blood in the United States. In order to better understand the underlying causes of low hemoglobin deferral, we have utilized the Retrovirus Epidemiology Donor Study-II (REDS-II) donation deferral database to define the susceptibility of different demographic groups for having low hemoglobin deferral.

REDS-II is a National Heart, Lung and Blood Institute (NHLBI) sponsored consortium of 6 blood centers located across the United States dedicated to improving the safety and availability of blood. The REDS-II blood centers recorded the following variables of interest for 1.26 million blood donation attempts by 715,311 individuals in 2007: age, gender race/ethnicity, education level, weight and previous donation history. This database was used to develop a multivariable logistic regression model to assess factors associated with low hemoglobin deferral. Because data were obtained from a very large number of individuals from multiple institutions this model provides a comprehensive assessment of the interrelationships of a wide variety of demographic risk factors for low hemoglobin deferral.

Methods

Data Source

Six blood centers participate in the Retrovirus Epidemiology Donor Study-II (REDS-II) program, providing donation and deferral data into a common research database. The REDS-II centers represent geographically and demographically diverse populations and collectively account for over 8% of annual blood collections in the United States. These analyses utilized data from over 2.5 million donations between January 2006 and December 2007. Data from calendar-year 2006 were used to establish 12-month donation history as a predictor variable. Donation attempts during the calendar-year of 2007 were used to measure the outcome variable of low hemoglobin deferral. Each year of data contains information from approximately 1.3 million donations from more than 700,000 individual donors.

Factors of Interest

This analysis focused on donation attempts, whether successful or deferred, made in 2007. The occurrence of a deferred visit due to low hemoglobin was the outcome of interest. All visits deferred for other reasons were excluded in the analysis. Successful allogeneic donations were included while autologous, directed, therapeutic and other donations types were excluded. Information at the time of donation was reported from routine blood center data collection methods as well as from an additional, self-reported donor survey. Demographic factors included in the analysis are gender, age, race/ethnicity, education level (for donors aged 21+ years old) and weight. None of the REDS-II centers are at high altitude

(Boston, Atlanta, Pittsburgh, Milwaukee, Cincinnati, and San Francisco) so altitude differences were not included in the analyses.

Previous donation history was also considered as a predictive factor for a low hemoglobin deferral. Two derived variables defining how often a donor gave successful platelet and whole blood donations during the preceding 12 months were created. Whole blood donation intensity was defined as the number of successful whole blood donations in the previous 12 months. Donors who gave a double-red cell donation were considered to have given 2 successful whole blood donations. Donors who gave two successful whole blood donations less than 56 days apart were assumed to be undergoing therapeutic phlebotomy for iron overload and were excluded from the analysis. Platelet donation intensity was defined in a similar fashion, counting each successful platelet donation in the previous 12 months. All other apheresis procedures were excluded in the platelet intensity count as well as the analysis.

Hemoglobin testing

Both male and female blood donors in the United States are required to have hemoglobin ≥12.5 g/dL (hematocrit ≥ 38%) to donate whole blood. REDS-II blood centers uniformly draw fingerstick samples for testing hemoglobin or hematocrit levels. Analysis of the blood samples at the different REDS-II blood centers is performed using a variety of methods (Table 1). Capillary testing for hemoglobin/hematocrit correlates well, but not perfectly with peripheral blood testing.[4]

Statistics

Characteristics of the study population were first tabulated on a donor-specific basis. Next, the prevalence of low hemoglobin deferral was determined on a donation-specific basis in several demographic, body weight and donation frequency strata by dividing the number of hemoglobin deferrals by all donation attempts in each stratum. A multivariable logistic regression model incorporating several predictor variables and a binary outcome variable was then constructed to evaluate independent risk factors of low hemoglobin deferral (SAS 9.1.3 (2004) SAS Institute Inc, Cary NC).

Results

Over 715,000 individual donors presented to donate at one of six REDS-II blood centers in 2007; demographic information is shown in Table 2. There were slightly more female (52.7%) than male (47.3%) donors. Although roughly 85% of the donors were Caucasian, over 95,000 individuals from minority groups were represented in the database. The age of the donors ranged from 16 to over 80, including 17,592 over 71 years old. These donors provided a total of 1,263,131 donation attempts, including 1,008,900 successful whole blood donations, 67,931 successful double red cell donation and 61,679 successful platelet apheresis donations.

In 2007, a total of 124,621 deferred visits for low hemoglobin were reported by 96,493 individual donors (Table 2). Among these deferred donors, 47,956 also made at least one successful donation in 2007. Of the 38,210 deferred donors with no successful donations in 2007, 89.5% had one deferral, 8.2% had two, and 1.5% had three. Only 45 of these donors attempted to donate more than 5 times (maximum was 11 times) and had low hemoglobin deferral each time. There were 10,327 low hemoglobin deferred donors with no successful donations in 2007 who had a successful donation in the previous 12 months prior to their low hemoglobin deferral (Table 2). Consequently, 1.4% (10,327 of 715,311) of all donors exhibited a pattern of successful donation(s) prior to the low hemoglobin deferral(s) with no subsequent successful donations during the study period. Table 3 presents the number of low hemoglobin deferrals and their percentage of donation attempts by gender, race/ethnicity, age, education level, self-reported weight, whole blood donation intensity, and blood center. Adjusted odd ratios testing demographic associations between low hemoglobin deferral and demographic groups are presented in Table 4 and are discussed in the following paragraphs.

Gender and Age Effects

The dominant determinant of low hemoglobin deferral was gender; 1.6% of donation attempts made by males were deferred, while 17.7% of donation attempts made by females were deferred (Table 3). Overall, women had on average 11 times higher odds for a low hemoglobin deferral compared to men (Table 4). In men, there was a progressive increase in the odds for low hemoglobin deferral with age, detectable in each 10 year age category. Roughly, there is a 1.5 times higher odds for low hemoglobin deferral for every 10 years of age in male donors. Further, 0.8 % of donation attempts made by men ≤ 50 years old were deferred for low hemoglobin, while 3.0% of donation attempts made by males 51 years and older were deferred. Women <18 years old had a low hemoglobin deferral rate of 18.2%, comparable to the overall female rate of 17.7%, hence age exerts a less significant effect in women than in men. The high deferral rate in young women decreases by about 25% in post-menopausal women between ages 51 and 60, and then begins to progressively increase in women over 61, presumably due to an effect of aging similar to what occurs in men, although the increase is slower. There is an apparent 1.2 times higher odds for low hemoglobin deferral for every 10 years of age beyond 60 years old in female donors. It is of note that post-menopausal women aged 51–60 are still deferred about 5 times more frequently than men of the same age (OR =5.0, 95% CI 4.8, 5.2). Despite the increased prevalence of low hemoglobin in the elderly, many older individuals (both men and women) are able to continue to donate blood into their 70s and 80s, and some continue to donate frequently. In 2007, 3,468 donors over the age of 71 gave 4 or more whole blood donations at the 6 REDS-II blood centers.

Race/ethnicity and Education

The race/ethnicity associations on low hemoglobin deferral were similar by gender. African American women had 2.11 times the odds for low hemoglobin deferral as Caucasian women, and African American men had 2.42 times the odds for low hemoglobin deferral as Caucasian men (Table 4). Hispanic women were deferred for low hemoglobin at 1.29 times the odds as Caucasians. There was a slight increase in the odds for low hemoglobin deferral in donors over 21 who did not graduate from high school.

Body Weight and Donation Intensity

In men, there was a mild inverse relation between body weight and hemoglobin deferral (Table 4). A similar pattern was not present among females, and women below 124 pounds had only 1.16 times the odds of having a low hemoglobin deferral as women over 200 pounds (Table 4). Whole blood donation intensity has a subtle, yet statistically significant ($p<0.0001$), impact on low hemoglobin deferral, with a differential impact by gender. In men, there was a slight decrease in deferral odds for those with one (OR=0.72) or two (OR=0.84) donations in the previous 12 months compared to those with zero, followed by a return towards unity with higher donation intensity (Table 4). In women, lower odds of deferral did not appear until donation intensity reached five (OR=0.76) or six (OR=0.45) donations in the previous year. Low hemoglobin deferral rates were lower for donors with high platelet donation intensity (4+) compared to donors with low platelet donation intensity (OR=1.74, 95% CI 1.57, 1.89).

Blood Center

There was substantial variation in hemoglobin deferral rates across the six blood centers after adjustment for demographics and body weight, with odds ratios ranging from 0.85 to 1.42 (Table 4). These different rates translate to thousands of additional deferrals per year in the high deferral centers. The two centers with the lowest deferral rates repeat the hemoglobin test a second time if the first test would result in a low hemoglobin deferral. Since this results in acceptance of more donors with borderline hemoglobin, it may partially explain the differences between centers. There were no obvious correlation between the hemoglobin deferral rate and different operational procedures, including the use of copper sulfate, spun hematocrit or hemoglobin testing, volume of blood donation, type of lancet used or number of low hemoglobin deferrals per donor or length of deferral for low hemoglobin that could further explain differences in deferral rates at other centers (Table 1).

Discussion

The “restoration time” for recovery of iron stores following blood donation has been described by Boulton as depending on the relative quantity bled, the frequency of donation, dietary and supplement intake, age and gender.[5] The data from the study presented here define and quantify demographic characteristics that contribute to low hemoglobin deferral and by inference to the “restoration time” for iron stores in repeat blood donors.

Effects of gender on low hemoglobin deferral

As expected, female gender is a strong predictor for low hemoglobin deferral. Women have 11 times greater odds for low hemoglobin deferral than men. Its most important cause is low iron stores in women due to menstruation and pregnancy. Blood donation removes 200–250 mg of iron form the donor, an amount sufficient to totally deplete the average women’s stores.[6] Thus, after only one whole blood donation many women are dependent on absorption of dietary iron to produce new red blood cells. In contrast, men typically have two-to-four times larger iron stores that can be utilized to produce new red blood cells following multiple donations.[7] Additional causes for higher hemoglobin in men include higher testosterone levels in men that produce increased hemoglobin,[8] as well as cigarette smoking associated increase in hemoglobin that is more prevalent in men than women.[9]

Another reason that female gender is a strong predictor of hemoglobin deferral is because the same hemoglobin (12.5 g/dL)/hematocrit (38%) cutoff value is used to qualify male and female donors despite differences in normal range values for men and women. In the 1960s the World Health Organization defined hemoglobin values below which anemia could be considered to exist as 13 g/dL for adult males and 12 g/dL for adult females. While widely accepted, these lower limits were determined using inadequate methods and limited data sets. In 2006, Beutler and Waalen[10] analyzed two large data sets, the third NHANES and Scripps-Kaiser databases and proposed lower limits for hemoglobin values of 13.7 g/dL for white men, 12.9 g/dL for African American men, 12.2 g/dL for white women and 11.5 g/dL for African American women. Thus, the current hemoglobin/hematocrit cut-off values used to qualify blood donors allow anemic men to donate whole blood while non-anemic women are deferred, further contributing to the large discrepancy in the rate of low hemoglobin deferral between men and women. Given that otherwise healthy men with unexplained anemia are at significant risk for colon cancer or other gastrointestinal lesion,[11,12] a strong case can be made for increasing the male hemoglobin/hematocrit value to the lower limit of the reference interval. However, decreases in the cut-of value for women should be made with caution. Iron deficiency, even in the absence of anemia, has been shown to have multiple detrimental side effects. These include fatigue,[13] decreased exercise capacity,[14] pica[15] and restless leg syndrome.[16] In addition, studies performed in both adolescent and adult women have shown that iron deficiency is associated with decreased cognitive performance over a broad range of tasks.[17,18] Of particular concern is recent changes in the law of over 30 states that allow 16 year-olds to donate blood with parental consent. Since blood drives are often held twice per year at an individual high school, blood donation starting at age 16 will result in adolescents who donate four to six times before they graduate from high school, many of whom will consequently become iron deficient from donating blood at an age when neurocognitive development is still occurring.[19]

Effects of age on low hemoglobin deferral

The odds for low hemoglobin deferral steadily increase in men as they age. In women this effect is muted because of menstrual blood loss and pregnancy in younger women. Yet, similar to men there are progressively increasing odds for low hemoglobin deferral as women age beyond 60 years. This increase in low hemoglobin deferral is consistent with the increased prevalence of anemia in community dwelling elderly populations.[20] Known causes of anemia in the elderly include nutritional deficiency (iron, B12, folate) and an underlying medical condition (arthritis or kidney disease). Also, the phenomenon known as the "anemia of aging" has been identified with an etiology that is unclear. Possible causes include inadequate increase in erythropoietin to compensate for aging marrow cells, increased prevalence of sub-clinical myelodysplastic syndrome, loss of hematopoietic stem cell reserve and decreased hormonal (testosterone) effect on blood cell production.[8,20–22] It is likely that these same causes underlie the increase in low hemoglobin deferral that occurs with aging in male blood donors. Since there are many thousands of elderly blood donors that have increased erythropoietic stress on their bone marrow following blood donation, they represent a potentially very useful group for further study of the physiological causes of the anemia of aging.

Effects of race/ethnicity on low hemoglobin deferral

The lower average hemoglobin level in African Americans compared to Caucasians is reflected in the odds for low hemoglobin deferral among African American women being 2.11 times higher than Caucasian women and the odds for African American men being 2.42 times higher than Caucasian men. Data from the NHANES study obtained from 1999–2002 found the prevalence of iron deficiency in African American women to be 12.2% compared to 2.8% in Caucasian women.[23] Thus, the lower hemoglobin levels in African American women are partially, but not totally, caused by iron deficiency due to the higher prevalence of leiomyoma and heavy menstrual bleeding among African American than White women.[24,25] African Americans also have a high prevalence of α-thalassemia that accounts for about one-third of the difference in the hemoglobin levels between African Americans and Caucasians.[26] Even after excluding iron deficiency and α-thalassemia, there are many African Americans for whom the cause of anemia remains unknown. It does not appear to be related to chronic renal disease, β-thalassemia or sickle trait; instead, it is likely that multiple genetic factors contribute to the lower hemoglobin levels observed.[26] For example, common variants in TMPRSS6, a membrane associated serine protease that regulates hepcidin expression in the liver, have recently been associated with changes in blood hemoglobin levels of about 0.15 g/dl.[27–29] The apparently lower genetic set point for hemoglobin results in many African American women not being able to donate blood even though they are iron replete. It has been suggested that the hematocrit cut-off value for African American men be lowered to 36% and African American women to 34%.[30] Setting different cut-offs for different ethnic groups would be complicated by the mixture of ethnicity in many individuals in the United States. In addition, the use of racial/ethnic based cutoff values can be justified only if the adverse consequences of anemia occur at different hemoglobin levels in the different racial/ethnic groups.[20] This has not been demonstrated and further studies are needed before racial/ethnic specific cut-off values can be

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recommended. Hispanic women, but not Hispanic men, have slightly increased odds for low hemoglobin deferral. This statistically significant increase reflects the high prevalence of anemia in Mexican American women (8.7%), in this case due almost entirely to iron deficiency.[23]

Effects of body weight and education on low hemoglobin deferral

As with age, the effect of body weight on low hemoglobin deferral differs by gender. There was a strong inverse association between higher body weight and lower odds for hemoglobin deferral in men, while a weaker inverse association was seen in women. These differences are likely a result of the smaller total blood volume in the lower weight individuals with consequent larger percentage of total blood volume and total body iron stores removed with each donation. It may be that a pattern similar to one for male donors is actually present among female donors but is constrained by differences in menstrual blood loss that occur independent of the donor's weight. Only minor effects of education were observed on low hemoglobin deferral, suggesting that socioeconomic and nutritional factors have relatively little impact on low hemoglobin deferral among blood donors in a developed country such as the United States.

High intensity donors are a self-selected population with decreased odds for low hemoglobin deferral

Whole blood donation is allowed much more frequently in the United States than in other countries. The 56 day interval allows one to theoretically donate 6.5 times per year in the United States, while in Europe, Japan and Australia donations typically are limited to 2 to 4 times per year, with many countries limiting donation by women to only 2 times per year. In addition, many blood centers in the United States have increased the whole blood collection volume from 450 ml to over 500 ml in recent years. Since a blood donation removes 200 to 250 mg of iron from the donor, these larger volume donations require an individual donating blood 4 to 6 times per year to absorb dietary iron at close to or above maximal physiological limits to replace that lost from donation.[9,317] A consequence of this stress on iron stores is that many regular donors develop iron deficiency and iron deficiency anemia and are deferred for low hemoglobin when they subsequently attempt to donate blood.[18]

Examination of the association between low hemoglobin deferral and donation intensity demonstrates that a woman who has donated six times in the previous 12 months has less than one-half the odds of low hemoglobin deferral as a woman who donated only once. This finding suggests a strong selection either by donors themselves, or by blood center recruitment procedures, in favor of donors capable of donating frequently without developing iron deficiency anemia. The reasons for this lower susceptibility to iron deficiency anemia are not entirely clear. Some, but not all, of these high intensity donors regularly take iron supplements, partially accounting for the selection process.[9] Previous studies have demonstrated that major mutations associated with hemochromatosis are present in the high intensity donors at the same frequency as the normal population, indicating that a selection process for donors with hemochromatosis or heterozygous mutations in the *HFE* gene is not responsible for the selection process.[9,32] With the recent advances in the understanding of iron metabolism that have resulted from the discovery and characterization of the biological activity of hepcidin,[33] this self-selected group of high intensity donors represents a very interesting population for further studies that could provide valuable new information about genetic modifiers of hepcidin expression and iron absorption.[34]

Center specific differences in low hemoglobin deferral

A somewhat surprising finding of this study is the differences in low hemoglobin deferral rates at different blood centers that persisted after adjustment for demographic covariates indicating that important demographic factors for low hemoglobin deferral remain to be identified. A portion of these differences can be attributed to the performance of a repeat test on donors who do not qualify with the first test result. Other center-specific differences may be due to procedural factors, such as differences in how staffs are trained to collect blood and perform hemoglobin testing, variations in sampling methods and equipment calibration. Regional differences in hemoglobin values within the United States also could account for a proportion of variability in hemoglobin deferral rates. Other factors that were not accounted for include such things as regional differences in cigarette smoking, which has a profound influence on hemoglobin/hematocrit values.[9]

Conclusion

A very large database of blood donors at six blood centers across the USA has been used to develop a multivariable logistic regression model that defines and quantifies demographic correlates of low hemoglobin deferral while controlling for differences in other demographic variables. These data provide useful information that can be utilized to manage blood donors in order to limit low hemoglobin deferrals and assist in policy decisions such as changing the hemoglobin cut-off or permissible frequency of donation. They also generate hypotheses for new research of the causes of anemia in defined groups of donors.

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Table 1

Listing of donor center methods for performing hemoglobin/hematocrit testing

Blood Center	Bag Size/ Amount Drawn	Length of Deferral	Analyte Methodology	Sample Procurement
A	450ml/450ml	1 day	ClearCrit	75mm, 1.1ID, Lancet: 1.8mm, 21g
B	500ml/500ml (483 for 110–125lbs)	1 day	UltraCrit	Lancet 21g
C	500ml/470ml (max draw 525)	1 day	Hemocue	Lancet, Unistick 2 Extra
D	500ml/475ml (draw 465 for HS)	4 weeks*	UltraCrit	Unistick 2, 21g, 3mm depth
E	500ml/500ml (450 for min weight)	3 weeks (female) 3 months (male)	Copper Sulfate then Hemocue	SurgiLance 22g, 2.2mm depth
F	500ml/470ml (max draw 525)	1 day	Hemocue	Lancet, Unistick 2 Extra

*If donor returns within the 4 weeks and passes, they are allowed to donate.

Table 2

Demographic Information (Donor-level information in 2007)

	Number of Unique Donors (%)	
	715,311 (100%)	
Blood Center		
A	98,104 (13.7)	
B	69,350 (9.7)	
C	178,747 (25.0)	
D	51,204 (7.2)	
E	87,777 (12.3)	
F	230,129 (32.2)	
Gender		
Male	338,045 (47.3)	
Female	377,266 (52.7)	
Age (in years)	**Male**	**Female**
<18 yrs	29,423 (8.7)	38,015 (10.1)
18–20	35,780 (10.6)	42,239 (11.2)
21–30	43,418 (12.8)	58,027 (15.4)
31–40	47,783 (14.1)	56,407 (15.0)
41–50	73,760 (21.8)	82,391 (21.8)
51–60	67,887 (20.1)	67,356 (17.8)
61–70	29,914 (8.8)	25,319 (6.7)
71–80	8,982 (2.7)	6,721 (1.8)
81+	1,098 (0.3)	791 (0.2)
Race/Ethnicity	**Male**	**Female**
White	293,000 (86.7)	318,561 (84.4)
Asian	8,364 (2.5)	7,795 (2.1)
Black	15,709 (4.6)	24,934 (6.6)
Hispanic	11,474 (3.4)	14,660 (3.9)
Other	5,653 (1.7)	6,704 (1.8)
Missing	3,845 (1.1)	4,612 (1.2)
Education (among 21+ yr olds)		
< High School	10,208 (1.8)	
≥ High School	539,839 (94.7)	
Missing	19,807 (3.5)	
Individual Donor Activity		
Donors with no low hemoglobin deferrals	618,818 (86.5)	
•Whole Blood Donation(s) only	605,998 (84.7)	
•Platelet Donation(s) only	9,813 (1.4)	
•Whole Blood & Platelet Donation(s)	3,007 (0.4)	
Donors with low hemoglobin deferrals	96,493 (13.5)	
•with other Donation(s)* in 2007	47,956 (6.7)	

	Number of Unique Donors (%)
•no donations in previous 12 months and no other donations in 2007	38,210 (5.4)
•some donations in previous 12 months but no other donations in 2007	10,327 (1.4)

* "with other Donation(s)" includes donors who had at least one successful platelet and/or whole blood donation in 2007.

Table 3

Low Hemoglobin Deferral Rates (donation attempt level)

	Number of Donation Attempts		Number of Donation Attempts Resulting in Low Hemoglobin Deferral (Percentage of Donation Attempts Resulting in Low Hemoglobin Deferral)	
All Donation Attempts	1,263,131		124,621 (9.9)	
Blood Center				
A	201,728		23,440 (11.6)	
B	124,756		15,415 (12.4)	
C	289,853		29,248 (10.1)	
D	85,078		7,838 (9.2)	
E	152,843		14,414 (9.4)	
F	408,873		34,297 (8.4)	
Gender				
Male	615,284		9,864 (1.6)	
Female	647,847		114,757 (17.7)	
Age (in years)	**Male**	**Female**	**Male**	**Female**
<18 yrs	37,254	50,247	147 (0.4)	9,163 (18.2)
18–20	45,127	57,349	183 (0.4)	12,434 (21.7)
21–30	64,399	86,442	390 (0.6)	16,104 (18.6)
31–40	81,073	92,127	636 (0.8)	17,811 (19.3)
41–50	144,479	153,511	1,761 (1.2)	28,853 (18.8)
51–60	148,912	136,967	2,899 (2.0)	19,488 (14.2)
61–70	69,165	54,386	2,213 (3.2)	7,936 (14.6)
71–80	22,238	15,155	1,351 (6.1)	2,620 (17.3)
81+	2,637	1,663	284 (10.8)	348 (20.9)
Race/Ethnicity	**Male**	**Female**	**Male**	**Female**
White	549,410	563,635	8,784 (1.6)	93,372 (16.6)
Asian	12,854	11,930	169 (1.3)	2,440 (20.4)
Black	22,839	35,263	543 (2.4)	10,305 (29.2)
Hispanic	17,169	21,825	194 (1.1)	4,932 (22.6)
Other	8,656	9,953	104 (1.2)	2,137 (21.5)
Education (among 21+ yr olds)				
< High School	17,752		1,854 (10.4)	
≥ High School	1,031,277		96,356 (9.3)	

	Number of Donation Attempts		Deferred for Low Hemoglobin	
Weight (in pounds)	**Male**	**Female**	**Male**	**Female**
≤109	747	835	20 (2.7)	158 (18.9)
110–124	1,939	53,350	36 (1.8)	9,916 (18.6)
125–149	30,900	196,012	525 (1.7)	32,747 (16.7)
150–174	119,949	161,988	1,909 (1.6)	25,151 (15.5)
175–199	173,545	91,572	2,404 (1.4)	13,794 (15.1)
≥200	245,479	90,764	3,357 (1.4)	15,017 (16.5)

	Number of Donation Attempts		Deferred for Low Hemoglobin	
Weight (in pounds)	**Male**	**Female**	**Male**	**Female**
Whole Blood Intensity	**Male**	**Female**	**Male**	**Female**
0 donations	218,266	269,861	2,931 (1.3)	49,025 (18.2)
1 donations	116,991	153,403	1,304 (1.1)	26,783 (17.5)
2 donations	97,710	101,623	1,456 (1.5)	18,431 (18.1)
3 donations	73,978	65,356	1,517 (2.0)	11,821 (18.1)
4 donations	63,920	37,881	1,477 (2.3)	6,219 (16.4)
5 donations	32,957	16,047	860 (2.6)	2,154 (13.4)
6+ donations	11,462	3,676	319 (2.8)	324 (8.8)
Platelet Intensity				
0 donations	1,198,896		119,705 (10.0)	
1–3 donations	20,541		2,470 (12.0)	
4+ donations	43,694		2,446 (5.6)	

Table 4

Logistic Regression by Low Hemoglobin Deferral (donation attempt level)

	Adjusted ORs (95% CI)	
Blood Center		
A	1.30 (1.28–1.33)	
B	1.42 (1.39–1.46)	
C	0.85 (0.84–0.87)	
D	1.08 (1.05–1.11)	
E	1.11 (1.09–1.14)	
F	1.0	
Gender		
Male	1.0	
Female	11.27 (10.09–12.59)	
Age (in years)	**Male**	**Female**
<18 yrs	0.25 (0.21–0.29)	0.85 (0.83–0.88)
18–20	0.29 (0.25–0.34)	1.17 (1.14–1.20)
21–30	0.46 (0.41–0.52)	0.96 (0.94–0.98)
31–40	0.62 (0.57–0.68)	1.01 (0.99–1.04)
41–50	1.0	1.0
51–60	1.60 (1.50–1.69)	0.72 (0.71–0.74)
61–70	2.59 (2.43–2.76)	0.75 (0.73–0.77)
71–80	4.82 (4.48–5.19)	0.89 (0.85–0.93)
81+	8.39 (7.34–9.60)	1.11 (0.98–1.25)
Race/Ethnicity	**Male**	**Female**
White	1.0	1.0
Asian	1.10 (0.94–1.28)	1.05 (1.00–1.10)
Black	2.42 (2.21–2.65)	2.11 (2.06–2.16)
Hispanic	1.06 (0.92–1.23)	1.29 (1.25–1.34)
Other	1.15 (0.95–1.40)	1.27 (1.21–1.33)
Education		
< High School	1.13 (1.07–1.19)	
≥ High School	1.0	
Weight (in pounds)	**Male**	**Female**
110–124	2.45 (1.75–3.44)	1.16 (1.12–1.19)
125–149	1.86 (1.69–2.04)	1.03 (1.01–1.05)
150–174	1.24 (1.17–1.31)	0.95 (0.93–0.97)
175–199	0.98 (0.93–1.03)	0.92 (0.89–0.94)
≥200	1.0	1.0
Whole Blood Intensity	**Male**	**Female**
0 donations	1.0	1.0
1 donations	0.72 (0.67–0.77)	0.99 (0.98–1.01)
2 donations	0.84 (0.79–0.90)	1.07 (1.05–1.09)

	Adjusted ORs (95% CI)	
3 donations	1.04 (0.97–1.11)	1.09 (1.06–1.12)
4 donations	1.08 (1.01–1.15)	0.97 (0.94–1.00)
5 donations	1.07 (0.99–1.16)	0.76 (0.73–0.80)
6+ donations	1.00 (0.89–1.13)	0.45 (0.40–0.51)
Platelet Intensity		
0 donations	1.0	
1–3 donations	1.18 (1.12–1.23)	
4+ donations	0.68 (0.65–0.71)	