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Risk Factors for Retrovirus and Hepatitis Virus Infections in Accepted Blood Donors

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Abstract

Background—Risk factor surveillance among infected blood donors provides information on the effectiveness of eligibility assessment and is critical for reducing risk of transfusion-transmitted infection (TTI).

Methods—American Red Cross, Blood Systems, New York Blood Center, and OneBlood participated in a case-control study from 2010–2013. Donors with serologic and nucleic acid testing (NAT) or NAT-only confirmed HIV, HBV, HCV, or serology confirmed HTLV infections (cases), and donors with false-positive results (controls) were interviewed for putative behavioral and demographic risks. Frequencies and adjusted odds ratios (AOR) from multivariable logistic regression analyses for each exposure in cases compared to controls are reported.

Results—In the study, 196 HIV, 292 HBV, 316 HCV, and 198 HTLV cases, and 1587 controls were interviewed. For HIV, sex with an HIV+ person [AOR=132, 95% Confidence Interval (CI) 27–650] and male-male sex [AOR=62, 95%CI 27–140] were primary risk factors. For HBV, first-time status (FT) [AOR=16, 95% CI 10–27], sex with an injection drug user (IDU) [AOR=11, 95%CI 5–28], and Black race [AOR=11, 95%CI 6–19] were primary. For HCV, IDU [AOR=42, 95%CI 13–136], FT [AOR=18, 95%CI 10–30], and a family member with hepatitis [AOR=15,

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95%CI 6–40] were primary. For HTLV, sex with an IDU [AOR=22, 95%CI 10–48], 55 years old or more [AOR=21, 95%CI 8–52], and FT [AOR=15, 95%CI 9–24] were primary.

Conclusions—Despite education efforts and risk screening, individuals with deferrable risks still donate; they may fail to understand, ignore, or do not believe they have risk. Recipients have potential TTI risk because of nondisclosure by donors.

INTRODUCTION

In the US, over 5 million patients receive transfusions each year. In 2011, recipients were transfused with nearly 20.9 million blood components (red blood cells, platelets, plasma, whole blood, cryoprecipitate or granulocytes) provided by >9 million voluntary allogeneic donors — 31% were first-time donors and 69% had donated previously.¹ Preventing transfusion-transmitted infections necessitates the selection of healthy blood donors along with laboratory testing of all donations for markers of HBV, HCV, HIV, and HTLV infections.² Since the introduction of nucleic acid testing (NAT) of all blood donations in 1999 (HIV and HCV) and in 2009 (HBV), the residual risk of transfusion transmission of each agent is estimated at <1 in 1 million units.^{3–5} The residual risk of HTLV based on serologic testing ranges from 1 in 500,000–3 million units.^{4,6}

Systematic surveillance of risk factors among infected blood donors provides information about the effectiveness of the donor history questionnaire (DHQ),⁷ but information on current risk factors in blood donors is largely unavailable in the US. Studies of risk factors among HIV-infected donors were conducted until the mid-1990s. Studies of HTLV and HCV-seropositive donors were conducted in the early 1990s.⁸ More recently, risk factors for new HCV infections in donors have been reported.⁹ Evaluation of current donation eligibility policies, such as consideration of changing the restriction that does not permit donation by men who disclose ever having sex with other men (MSM)^{10–12} requires an understanding of risk factors and trends in donor infections. The objective of this study was to determine current behavioral risk factors, including parenteral and sexual risks associated with HIV, HBV, HCV and HTLV infections in a broad sample of blood donors, using a case-control design.

METHODS

American Red Cross (ARC), Blood Systems Inc. (BSI), New York Blood Center (NYBC) and OneBlood conducted this study during 2010–2013; these organizations provide 53% (7,600,000/14,410,000 donations [20.9 million components/1.45 components/donation]) of transfused blood in the US. Donor eligibility is based on vital signs, hemoglobin concentration, and acceptable responses to the DHQ. All participating organizations use DHQs that are compliant with US FDA requirements¹³ and that meet AABB standards.¹⁴ Donations are tested for the presence of HIV and HCV RNA, HBV DNA, hepatitis B surface antigen (HBsAg) and serological response to infection (anti-HIV-1/2 plus group O, anti-HCV and anti-hepatitis B core antigen [HBc]). HTLV is assessed by anti-HTLV-I/II screening. All screening tests and algorithms used were FDA approved. Donations with reactive test results are not issued for transfusion and all donors are notified of deferral and counseled based on their test results. Donations that test repeat reactive are subjected to

additional confirmatory testing by different testing methods and reagents, including discriminatory and alternate NAT assays for HIV, HCV, and HBV, HBsAg neutralization, and alternate anti-HCV and anti-HTLV I/II assays. The study design assumed the response rate for HIV and HTLV eligible case interviews would be 50% and interviewing a smaller proportion of HBV and HCV cases was planned due to larger numbers of these infections in US donors.

Case Definition

Donors were classified as confirmed positive for HIV, HCV, or HBV if NAT reactive by viral-specific NAT and serologically confirmed, or if seronegative and NAT reactive and confirmed by virus-specific NAT using an independent sample.¹⁵ For each HTLV-seroreactive donor, confirmation was based on positivity using validated algorithms.¹⁶

Control Definition

Donations testing repeat reactive on one test but unconfirmed based on further serologic testing and NAT (HIV, HBV and HCV) or serologic testing only (HTLV) were classified as false positive; donors with such false-positive results were notified and deferred as part of routine blood center operations, and represent an appropriate convenience sample of the uninfected blood donor population. Having demonstrated that such donors are uninfected, multiple studies have used this strategy to identify controls for case-control studies.^{17–20} Donors defined as serologically “indeterminate” or for whom results were incomplete were excluded.²¹ Controls were not matched to cases on any characteristic to permit assessment of demographics associated with infection.

Risk Factor Questionnaire

In consultation with subject matter experts at the US Centers for Disease Control and Prevention (CDC) and National Heart, Lung, and Blood Institute, National Institutes of Health, a risk factor questionnaire focused on behaviors associated with human-to-human transmission of HIV, HCV, HBV, and HTLV was developed. Although the primary transmission routes vary for each of these viruses, all may be acquired by sexual contact, parenteral exposure (blood transfusion, injection drug use, tattooing, body piercing), transplantation, perinatal exposure, or via close personal contact by sharing items such as toothbrushes or razor blades. Routes of acquisition and risk factors for each infection are considered to be well-established.^{7,9,22–26} The questionnaire also included motivations for blood donation.

Donor Notification and Risk Factor Interview

State laws require attempts to notify all HIV confirmed-positive donors in person. The donor is asked to return to the blood center where notification and counseling take place by a trained medical professional or donor counselor. If the donor is unwilling to return to the blood center or cannot be reached, notification of test results and deferral are provided by letter. Letters are sent to all HCV, HBV, and HTLV reactive donors, whether confirmed or false positive (as well as HIV false-positives). Letters are specific to the various combinations of test results. Contact information is provided so that each donor can follow-

up with donor counselors. For this study, a study-specific information sheet was provided at the time of notification, indicating that the donor might be contacted by telephone for participation in the study. Both cases and controls were recruited in this manner. In most circumstances at least a month elapsed before donor counselors called potential participants; however, some HIV-positive donors were recruited at the time of their in-person counseling session. A maximum of three contact attempts were made by telephone, mail and/or email. Participation required that each respondent complete a telephone interview. Verbal consent was obtained and documented by signature of the counselor conducting the interview. All participants who completed the risk factor interview were provided a fixed participation reimbursement.

Cases and controls were enrolled by ARC, BSI, and NYBC. Midway through the study OneBlood was added as an additional site for HIV or HBV confirmed-positive donors. Completed questionnaires from all participating organizations were sent to Blood Systems Research Institute where data were entered into a single database using optical scanning (Teleform 10, Hewlett-Packard, San Jose, CA).

Protocol Approval

The study protocol was reviewed and approved by all institutions' Institutional Review Boards as well as receiving Office of Management and Budget clearance.

Statistical Analysis

For this analysis a repeat donor was defined as anyone who had donated previously to the same blood collection agency regardless of interdonation interval. Multiple sexual partners was defined as reporting more than one sexual partner in the year before blood donation. Frequencies and measures of central tendency of responses for each type of infection and for all controls were tabulated. The ratio of cases to controls varied according to the number of cases included in each analysis. Multivariable logistic regression was used to independently estimate the magnitude of the association between specific risk factors and each viral infection. Factors associated or marginally associated with each infection in univariate analyses ($p < 0.1$) were included in each multivariable analysis, with those factors maintaining statistical significance retained in each final model ($p < 0.05$). Some variables were forced into each model because of the potential importance to blood safety. For example, donor status (i.e., first-time or repeat) was included in each model. To estimate risk factors for each infection Stata 12.2 (Stata Corp, College Station, TX) was used.

RESULTS

During the study period, 196 HIV, 292 HBV, 316 HCV, and 198 HTLV cases, and 1587 controls were interviewed, representing about 40% of eligible study participants (Table 1). Overall, participating and non-participating donors were similar in age, gender and donor status (see Appendix Table 1 for comparisons of confirmed-positive cases by viral infection to non-participating cases). Participants were predominantly White non-Hispanic (NH; 63.6%) consistent with the donor population. Cases compared to controls showed differences in the demographics associated with each infection. HIV and HBV cases tended

to be younger than controls and HCV and HTLV cases, older (Table 2). HIV, HBV, and HCV infections were more common in males, whereas HTLV was more common in females. The proportion of US-born participants was similar for HIV and HCV cases and controls, but HBV and especially HTLV cases were disproportionately born outside of the US. Race/ethnicity varied by virus and in comparison to controls. Of HCV-infected donors, 71.2% were White NH versus lower percentages for other race/ethnicity groups; of HIV-infected donors, both White and Black NH had the highest proportions (38%) while Black NH had the highest proportions among HBV and HTLV infections (36–44%). Sixteen case participants had co-infections four each for HIV/HBV, HIV/HCV, HBV/HCV, and HCV/HTLV (see Appendix Table 2 for demographics of these donors).

Frequencies of putative risk factors are reported separately for males and females with regard to sexual exposures and grouped together for other exposures (Table 3). Male HIV and HBV cases had similar numbers of female sexual partners as did controls (median 4, 6), but male HCV and HTLV cases reported higher numbers of female partners (15 and 10). Over 60% of male HIV cases report MSM behavior, including over 50% in the last 12 months; this was not common for HBV, HCV, HTLV or controls. For females, higher numbers of sexual partners were reported for HIV (10) and HCV (9) cases, but not for HBV and HTLV cases compared to controls. Sexually transmitted diseases were frequently reported by female HIV, HCV and HTLV-infected donors (35–36%); HCV and HTLV-infected female donors also frequently reported sex with an injection drug user (IDU). When both sexes were combined, HCV-infected donors reported the highest frequencies of injecting drugs, steroids or vitamins, or using non-injection drugs, or receiving a blood transfusion in the period of 1958–2011 with 50% of transfusions occurring 1990. Reporting having ever spent three or more days in jail, a detention center, shelter or group was associated with all four viral infections, but had highest frequency for HCV. In contrast, HBV-infected donors reported having lived abroad or immigrated to the US, or had an HBV or HCV infected family member.

HIV

Ever having had sex with an HIV-positive person was the factor most strongly associated with HIV infection in blood donors (Adjusted Odds Ratio (AOR) 132, 95% Confidence Interval (CI) 37 – 650) followed by MSM (AOR 62, 95%CI 28 – 140) (Table 4). Other factors independently associated with HIV included Black NH race, having exchanged money or drugs for sex, having spent 3 or more nights in jail, detention/shelter or a group home, having tattoo/body or 3 or more ear piercings, multiple sex partners, and lower income. Factors not significantly associated with HIV in our study included IDU ever, donor status, and age.

For HIV we also conducted separate multivariable analyses of risk factors in first time and repeat donors. Neither the primary risk factors for infection nor the magnitude of association changed in any material way (results not shown). The only change of note was that due to very small numbers; the relationship between HIV infection and IDU became even more uncertain (very wide confidence intervals).

HBV

HBV was associated with first-time blood donor status (AOR 16, 95% CI 10 – 27), Black NH (AOR 10.8, 95%CI 6.3 – 18.5), and Asian NH (AOR 6.7, 95%CI 3.7 – 12.3) compared to White NH race (Table 5). History of sex with an IDU (AOR 11.4, 95%CI 4.7 – 27.6), family member with hepatitis (AOR 8.1, 95%CI 3.5 – 18.7), and being born outside the US (AOR 6.1, 95%CI 3.7 – 10.2) were also associated with HBV infection. Other factors associated with HBV included being male, older age, having spent 3 or more nights in jail, detention/shelter or a group home, family/self having migrated from abroad, and lower income. MSM, tattoo/body or 3 or more ear piercings, and IDU were not associated with HBV.

HCV

History of IDU was the factor most strongly associated with HCV infection (AOR 42, 95%CI 13.0 – 136) followed by first-time donor status (AOR 17.5, 95%CI 10.2 – 30.0), and a family member with hepatitis (AOR 15.4, 95%CI 5.9 – 40.3) (Table 5). Sex with an IDU (AOR 9.7, 95%CI 4.4 – 21.2), a history of 3 or more nights in jail, detention/shelter or a group home (AOR 7.5, 95%CI 4.3 – 12.9) and reporting a history of blood transfusion (AOR 5.1, 95%CI 2.7 – 9.6) were associated with HCV infection. Older age, tattoo/body or 3 or more ear piercings, being male or born outside the US, lower income and education were also associated with HCV.

HTLV

Sex with an IDU (AOR 21.5, 95%CI 9.6 – 48.0), being a first-time donor (AOR 14.5, 95% CI 8.7 – 24.1), and Black NH race (AOR 13.2, 95% CI 7.3 – 23.4) were associated with HTLV infection (Table 6). Age was also strongly associated with HTLV; persons 55 or older (AOR 20.7, 95%CI 8.2 – 52.4) and persons 40–54 (AOR 13.2, 95% CI 5.5 – 31.7) had much higher odds ratio of infection compared to persons 18–24 years of age. Ever exchanging money or drugs for sex (AOR 6.4, 95% CI 1.3 – 30.7) and being born outside the US (AOR 4.4, 95% CI 2.3 – 8.3) were also associated with HTLV, as well multiple sexual partners for females, being female, and history of an STD.

Few recent infections based on being NAT-only confirmed were interviewed: five HIV, seven HCV and one HBV. The primary risk behaviors for the HIV and HCV infections were similar but not identical to the findings for prevalent infections. Of the five NAT-only HIV infections four were male. Two male respondents reported MSM and one male and the female respondent reported only heterosexual contact. The other male respondent reported having sex with someone who was HIV+. Of the seven NAT-only HCV infections all reported being heterosexual and four were male. Three respondents reported IDU, one reported a needlestick injury, one occupational exposure to patients with HCV, one tattooing/piercing, and one didn't disclose a recent exposure.

Many cases reported multiple different risk factors and contributing factors that could place individuals at higher risk for infection. For example, 64% of female HIV cases and 70% of male HIV cases reported at least two different sex-related risk factors. Undisclosed risks were relatively uncommon; only 2.6% of cases did not report a risk behavior.

DISCUSSION

This study identified current behavioral and demographic factors associated with HIV, HBV, HCV, and HTLV infections in blood donors. Factors primarily associated with each infection follow expected patterns. We were also able to identify common factors associated with all four infections. Thus, the results have implications for the policies that are focused on specific infections and more broadly on policies related to general donor eligibility and public health.

A notable finding was that HIV infection was the only one of the four infections not associated with first-time donor status. The lack of association between first-time status and HIV is not unexpected. Although HIV is more common in first-time rather than repeat blood donors, the ratio of infection in first-time to repeat donors is far lower than for HBV, HCV, or HTLV, and the absolute number of first-time and repeat donors with HIV are nearly equal,^{5,27} including during this study (see Table 2) where we observed ratios rounded to whole numbers of 1:1, 9:1, 6:1, and 6:1 for HIV, HBV, HCV and HTLV, respectively. Cases participated in this study in proportions that are generally consistent with the broader patterns in donors for each infection. Thus, the chances of interviewing a first-time or repeat donor were about the same for HIV. However, some additional aspects of each infection may have contributed. Cases with other infections may have been less aware of potential risk behaviors and participated, whether first-time or repeat donors, to help themselves identify possible reasons for infection. In addition, donors with HIV infection risk may self-defer further reducing their frequency as first-time donors. Finally, it is unclear the extent to which test seeking may have contributed to HIV-positive persons donating in the first place. While the interview included questions about test seeking, HIV-positive participants did not report this as a motivating factor in higher proportions than did persons with other infections.

While this study affirms that major routes of HIV, HBV, HCV, and HTLV infection in the general population are largely reflected in the donor population, HIV infection in blood donors is focused on two primary risks: sex with an HIV-positive partner, and MSM. In previous donor studies, risk factors reported by HIV-seropositive donors were more wide ranging for males and females. In males, MSM was most common followed by IDU, sex with an IDU, but previous studies found 27% of male respondents had no disclosed risk. In females, sex with males at risk for HIV was most common (81% were IDU) followed by IDU, but 41% had no disclosed risk.^{28,29} More recently, in the 2011 CDC HIV surveillance report, among males with HIV, 67% of infections were attributed to MSM, 13% to IDU, 11% to heterosexual contact, 7% to MSM contact *and* IDU, while among females with HIV, 72% of infections were attributed to heterosexual contact, 25% to IDU, and 2% to perinatal transmission.³⁰ In our study, we did not find significant associations between HIV infection and IDU or other drug use, or evidence of MSM and IDU together.

The 1988–1994 NHANES data (N=40,000) found that black race, increasing number of sexual partners, and non-US place of birth were highly associated with HBV infection.³¹ Our results are generally consistent with these findings. However, number of sexual partners was not associated with HBV infection. CDC surveillance data from 1990–2004 show that

the proportion of acute HBV cases reporting multiple sexual partners and MSM doubled over this time period.³² However, unless asymptomatic, persons with acute HBV infection would be unlikely to present to donate blood.

The results of our study are consistent with other studies of HCV in the general and blood donor population. NHANES 2001–2010 found that a history of IDU was the strongest risk factor for HCV infection.³³ Our study replicates NHANES where race and number of sexual partners were no longer associated with HCV infection. However, we did observe a significant association with history of blood transfusion. In other findings from a matched case-control study of 2,300 blood donors, IDU was highly associated with HCV seropositivity and was the most common risk factor (about 50%).²³ In another study, HCV-RNA confirmed positive, seronegative blood donors reported recent IDU (43%), followed by occupational exposure, sexual contact with an HCV-infected partner (who was an IDU), incarceration, and perinatal exposure.⁹

In a study of former blood donors (149 HTLV-I cases, 381 HTLV-II cases, and 936 controls) from nearly 20 years ago, blood transfusion, more than 7 lifetime sex partners, and any sex partner from an endemic area were highly associated with both HTLV-I and HTLV-II infection.³⁴ In addition, IDU and sex with an IDU were significant risk factors for HTLV-II infection. Our study shows that currently HTLV is most common in persons with IDU history, and that a strong age cohort that parallels HCV infection is evident.²⁷

This study has limitations. Of donors meeting the study inclusion criteria, 43% of HIV, 39% of HBV, 29% of HCV, 47% of HTLV cases, and 39% of controls were interviewed and analyzed. The risk behavior profile of participants may not be the same as non-participants, which if known, could shift the factors associated with each infection. Also a potential for recall bias exists because some respondents were not interviewed proximate to their blood donation. However, the average time to interview after donation for cases and controls was similar, 7.3 months for cases and 6.2 months for controls. Further, the methods of notification of cases and controls were similar. Consequently, the potential for differential recall should be minimal.

We interviewed very few cases of recent infection; i.e., NAT-only HIV, HBV, or HCV positive (data not shown). These infections remain the highest concern for recipient safety because of the risk of donation prior to detectable infection. In such a situation, transfusion-transmission in components produced from an infected donor could occur and go unnoticed until a recipient becomes symptomatic. Future surveillance will need to focus on donors with recently acquired infections including those that are NAT-confirmed, pre-seroconversion, although these are rare events in US donors.

Our findings need to be placed within the context that the risk of transmission of infectious agents from allogeneic blood transfusion is lower than ever; 1 per million transfused units or less and rare reports of confirmed breakthrough infection.⁵ However, blood donors with retrovirus and hepatitis infections still slip past the donor selection process. Such donors do have risk factors that, if disclosed, would have made them ineligible. Notably, even donors without infection (control donors in this study) fail to disclose deferrable behaviors.

Motivations for non-disclosure are difficult to discern, given that donors do understand the purpose of the DHQ;³⁵ self-assessment of risk is likely the primary reason. Studies conducted 10 years ago noted that the maximum efficiency of the DHQ had likely been reached; thus other approaches are needed to further reduce risk.^{36,37} Recipients are put at risk for transfusion-transmitted infection because deferrable behaviors are not being disclosed by donors at the time of donation. This study provides a baseline for current behavioral risks in the donor population should blood donor eligibility policies, such as MSM deferral, be modified in the near future.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1

Selected characteristics of participating study population in comparison to the eligible population, US Donor Risk Factor Study, 2010–2013.

Characteristic	Study population n= 2,573 (%)	Eligible population n= 6,744 (%) [*]
Confirmed positives	986 (38.3) [†]	2,695 (40.0)
HIV positive	196 (19.9)	458 (17.0)
HBV positive	292 (29.6)	741 (27.5)
HCV positive	316 (32.1)	1,085 (40.3)
HTLV positive	198 (20.1)	411 (15.3)
Age (years), mean (SD)	42.6 (15.5)	41.2 (15.3)
No. (%) 18–24 years	438 (17.0)	1,330 (19.7)
25–39	732 (28.5)	1,933 (28.7)
40–54	773 (30.0)	2,022 (30.0)
55 and older	630 (24.5)	1,459 (21.6)
No. (%) female	1,254 (48.7)	3,010 (44.6)
No. (%) white, non-Hispanic	1,636 (63.6)	3,771 (55.9)
No. (%) first-time donor	1,197 (46.5)	3,447 (51.1)

^{*} 94 donors with serologic-only positive infections were interviewed but excluded from the analyses per protocol eligibility criteria.

[†] Total number of cases is less than sum of all 4 infection groups because 16 donors had co-infections: 4 HIV/HBV infections, 4 HIV/HCV infections, 4 HBV/HCV infections, and 4 HCV/HTLV infections (see Appendix Table 2).

Table 2
Demographic characteristic, donation history, and motivations in participating blood donors by infection status *

<i>Demographic Characteristics</i>	HIV cases n=196 (%)	HBV cases n=292 (%)	HCV cases n=316 (%)	HTLV cases n=198 (%)	False-positive controls n=1,587 (%)
<i>Age (years)</i>					
Mean (SD)	32.0 (11.8)	37.8 (14.0)	44.7 (12.5)	50.1 (11.9)	41.7 (15.7)
18-24	74 (37.8)	65 (22.3)	32 (10.1)	8 (4.0)	299 (18.8)
25-39	75 (38.3)	106 (36.3)	66 (20.9)	30 (15.2)	461 (29.1)
40-55	40 (20.4)	82 (28.1)	149 (47.2)	88 (44.4)	455 (28.7)
55 and older	7 (3.6)	39 (13.4)	69 (21.8)	72 (36.4)	372 (23.4)
<i>Sex</i>					
Male	149 (76.0)	190 (65.1)	186 (58.9)	45 (22.7)	761 (48.0)
Female	47 (24.0)	102 (34.9)	130 (41.1)	153 (77.3)	825 (52.0)
Transgender	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.1)
<i>Country of birth</i>					
US	179 (91.3)	145 (49.7)	298 (94.3)	144 (72.7)	1,502 (94.6)
Foreign [†]	17 (8.7)	147 (50.3)	18 (5.7)	54 (27.3)	85 (5.4)
<i>Race/Ethnicity</i>					
White, NH	75 (38.3)	69 (23.6)	225 (71.2)	54 (27.3)	1,214 (76.5)
Black, NH	74 (37.8)	105 (36.0)	42 (13.3)	88 (44.4)	81 (5.1)
Asian, Native American, NH	6 (3.1)	85 (29.1)	6 (1.9)	3 (1.5)	26 (1.6)
Hispanic	2 (1.0)	5 (1.7)	4 (1.3)	3 (1.5)	15 (1.0)
Multi-race, mixed	5 (2.6)	10 (3.4)	12 (3.8)	9 (4.6)	27 (1.7)
Other, not specified	34 (17.4)	18 (6.2)	27 (8.5)	41 (20.7)	224 (14.1)
<i>Education</i>					
High school or less	125 (63.8)	155 (53.1)	237 (75.0)	106 (53.5)	662 (41.7)
College or above	71 (36.2)	137 (46.9)	79 (25.0)	92 (46.5)	925 (58.3)
<i>Annual household income</i>					
<\$30,000	49 (25.0)	60 (20.5)	96 (30.4)	51 (25.8)	130 (8.2)
\$30,000 or more	115 (58.7)	183 (62.7)	181 (57.3)	125 (63.1)	1,293 (81.5)
Not reported	32 (16.3)	49 (16.8)	39 (12.3)	22 (11.1)	164 (10.3)

<i>Demographic Characteristics</i>	HIV cases n=196 (%)	HBV cases n=292 (%)	HCV cases n=316 (%)	HTLV cases n=198 (%)	False-positive controls n=1,587 (%)
Marital Status					
Single, never married	129 (65.8)	128 (43.8)	66 (20.9)	42 (21.2)	438 (27.6)
Married, living together	42 (21.4)	120 (41.1)	151 (47.8)	84 (42.4)	931 (58.7)
Separated, divorced	24 (12.2)	44 (15.1)	99 (31.3)	72 (36.4)	217 (13.7)
<i>Donation Characteristics</i>					
Donation history [‡]					
First-time	95 (48.5)	264 (90.4)	270 (85.4)	170 (85.9)	411 (25.9)
Repeat	101 (51.5)	28 (9.6)	46 (14.6)	28 (14.1)	1,176 (74.1)
Donation period					
2010–11	94 (48.0)	136 (46.6)	272 (86.1)	93 (47.0)	896 (56.5)
2012–13	102 (52.0)	156 (53.4)	44 (13.9)	105 (53.0)	691 (43.5)
<i>Reason for donation[§]</i>					
Help someone in need	179 (91.3)	276 (94.5)	300 (94.9)	180 (90.9)	1,524 (96.0)
Response to advertisement, call, letter	44 (22.5)	49 (16.8)	61 (19.3)	36 (18.2)	552 (34.8)
Encouraged by family/friends/other	49 (25.0)	70 (24.0)	72 (22.8)	49 (24.8)	414 (26.1)
Get test results	37 (18.9)	64 (21.9)	57 (18.0)	36 (18.2)	140 (8.8)
Incentives from blood bank [§]	32 (16.3)	41 (14.0)	30 (9.5)	28 (14.1)	141 (8.9)
<i>Influencing factors^{§§}</i>					
Confidential testing at blood center	50 (25.5)	79 (27.1)	70 (22.2)	46 (23.2)	284 (17.9)
Accurate testing	43 (21.9)	64 (21.9)	52 (16.5)	33 (16.7)	169 (10.7)
Free testing	45 (23.0)	88 (30.1)	81 (25.6)	48 (24.2)	293 (18.5)
Test will identify problems with blood	54 (27.5)	60 (20.6)	68 (21.5)	34 (17.2)	248 (15.6)
Blood donor eligibility policies					
Current policies are unfair	26 (13.3)	4 (1.4)	7 (2.2)	1 (0.5)	88 (5.6)
My opinion influenced decision to donate	18 (9.2)	18 (6.2)	23 (7.3)	12 (6.1)	74 (4.7)

* Cases are not mutually exclusive, 16 cases had co-infections.

[†] Top three countries in order are Mexico, Haiti, and Vietnam.

[‡] Donation history per blood center donation records.

Incentives include post-donation gifts such as t-shirts, hats, movie tickets and entries into raffles as tokens of appreciation for donation.

§§ Multiple answers could be selected for donation reason and influencing factors.

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Table 3

Sexual, behavioral and other risk factors for participating blood donors by infection status.

<i>Sexual risk behavior</i>	HIV cases n= 149 (%)	HBV cases n= 190 (%)	HCV cases n= 186 (%)	HTLV cases n= 45 (%)	False-positives controls n= 761 (%)
Males					
Number of female sexual partners, median (IQR)					
Lifetime	4 (1–13)	6 (2–13)	15 (7–30)	10 (5–29)	5 (2–10)
Last 5 years	1 (0–3)	1 (1–3)	2 (1–3)	2 (1–4)	1 (1–2)
Number of male sexual partners, median (IQR)					
Lifetime	2 (0–8)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Last 5 years	2 (0–5)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
MSM or Sex with MSM, ever					
Yes	92 (61.7)	11 (5.8)	9 (4.8)	2 (4.4)	13 (1.7)
Monogamous, last 12 months					
Yes	60 (40.3)	119 (62.6)	136 (73.1)	29 (64.4)	574 (75.4)
Male sexual partner, last 12 months					
Yes	78 (52.4)	7 (3.7)	2 (1.1)	0 (0.0)	2 (0.3)
Used condom, always*					
Yes	21 (26.9)	2 (28.6)	0 (0.0)	-	1 (50.0)
Sexually transmitted disease					
Yes	33 (22.3)	28 (14.7)	45 (24.2)	14 (31.1)	53 (7.0)
Sex for money or drugs					
Yes	5 (3.4)	6 (3.2)	4 (2.2)	5 (11.1)	9 (1.2)
Sex with injecting drug user					
Yes	7 (4.7)	18 (9.5)	49 (26.3)	7 (15.6)	15 (2.0)
Not specified, D/N*	20 (13.4)	19 (10.0)	17 (9.1)	5 (11.1)	26 (3.4)
Sex with hepatitis positive partner					
Yes	4 (2.7)	8 (4.2)	12 (6.5)	2 (4.4)	5 (0.7)
Not specified, D/N*	17 (11.4)	26 (13.7)	13 (7.0)	3 (6.7)	18 (2.4)
Sex with HIV-positive partner					
Yes	39 (26.2)	2 (1.1)	1 (0.5)	1 (2.2)	0 (0.0)
Not specified, D/N*	19 (12.8)	5 (2.6)	2 (1.1)	4 (8.9)	9 (1.2)

<i>Sexual risk behavior</i>	HIV cases n= 149 (%)	HBV cases n= 190 (%)	HCV cases n= 186 (%)	HTLV cases n= 45 (%)	False-positives controls n= 761 (%)
Males					
Sex with blood transfusion recipient					
Yes	1 (0.7)	4 (2.1)	10 (5.4)	1 (2.2)	26 (3.4)
Not specified, D/N*	20 (13.4)	15 (7.9)	18 (9.7)	6 (13.3)	46 (6.0)
Females					
Number of male sexual partners, median (IQR)					
Lifetime	10 (4–15)	3 (1–10)	9 (4–20)	5 (3–10)	4 (1–7)
Last 5 years	3 (1–5)	1 (1–2)	1 (1–2)	1 (1–2)	1 (1–1)
Number of female sexual partners, median (IQR)					
Lifetime	0 (0–1)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Last 5 years	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Sex with MSM, ever					
Yes	3 (6.4)	3 (2.9)	4 (3.1)	11 (7.2)	11 (1.3)
Monogamous, last 12 months					
Yes	28 (59.6)	71 (69.6)	86 (66.2)	88 (57.5)	653 (79.2)
Male sexual partner, last 12 months					
Yes	43 (91.5)	76 (74.5)	91 (70.0)	97 (63.4)	676 (81.9)
Used condom, always [†]					
Yes	6 (14.0)	13 (17.1)	9 (9.9)	8 (8.3)	92 (13.6)
Sexually transmitted disease					
Yes	17 (36.2)	13 (12.8)	48 (36.9)	53 (34.6)	106 (12.9)
Sex for money or drugs					
Yes	10 (21.3)	4 (3.9)	12 (9.2)	11 (7.2)	0 (0.0)
Sex with injecting drug user					
Yes	6 (12.8)	10 (9.8)	60 (46.2)	44 (28.8)	19 (2.3)
Not specified, D/N*	6 (12.8)	5 (4.9)	9 (6.9)	13 (8.5)	32 (3.9)
Sex with hepatitis positive partner					
Yes	3 (6.4)	6 (5.9)	19 (14.6)	13 (8.5)	15 (1.8)
Not specified, D/N*	3 (6.4)	11 (10.8)	8 (6.2)	8 (5.2)	21 (2.6)

Females	HIV cases n= 47 (%)	HBV cases n= 102 (%)	HCV cases n= 130 (%)	HTLV cases n= 153 (%)	False-positives controls n= 825 (%)
Sex with HIV-positive partner					
Yes	13 (27.7)	1 (1.0)	0 (0.0)	1 (0.7)	3 (0.4)
Not specified, D/N*	5 (10.6)	1 (1.0)	1 (0.8)	6 (3.9)	13 (1.6)
Sex with blood transfusion recipient					
Yes	1 (2.1)	6 (5.9)	9 (6.9)	19 (12.4)	41 (5.0)
Not specified, D/N*	3 (6.4)	8 (7.8)	12 (9.2)	19 (12.4)	39 (4.7)
Both sexes, lifetime (ever)	HIV cases n= 196 (%)	HBV cases n= 292 (%)	HCV cases n= 316 (%)	HTLV cases n= 198 (%)	False-positives controls n= 1,587 (%)
Other exposures					
Injected illegal drugs, steroid or vitamins					
Yes	6 (3.1)	14 (4.8)	116 (36.7)	8 (4.0)	6 (0.4)
Any illegal drug use (non-injecting)					
Yes	48 (24.5)	59 (20.2)	197 (62.3)	45 (22.7)	193 (12.2)
Tattoo or body piercing [‡]					
Yes	128 (65.3)	124 (42.5)	218 (69.0)	104 (52.5)	671 (42.3)
Jail, prison, detention, shelter or group home (3 nights or more)					
Yes	47 (24.0)	54 (18.5)	181 (57.3)	36 (18.2)	83 (5.2)
Blood transfusion					
Yes	5 (2.6)	20 (6.9)	57 (18.0)	28 (14.1)	105 (6.6)
Medical or dental exposure [§]					
Yes	166 (84.7)	235 (80.5)	308 (97.5)	190 (96.0)	1,477 (93.1)
HCV/HBV infected member in the household					
Yes	3 (1.5)	44 (15.1)	37 (11.7)	18 (9.1)	30 (1.9)
Family/self living abroad or immigrated to the US					
Yes	21 (10.7)	149 (51.0)	13 (4.1)	57 (28.8)	88 (5.6)

* Not specified, D/N is included as a category when 10% of cases or controls did not respond or selected “don’t know” in response for this topic

[‡] Always used condom with male sexual partners if had one or more male partners in the last 12 months

[‡] Tattoo or body piercing or 3+ ear piercings

[§] Includes any IM/IV injections, tissue or organ transplant, endoscopy, colonoscopy, dental injection, acupuncture, needle stick injury or body fluid exposure ever

Table 4

Adjusted odds ratios (AOR) from multivariable logistic regression analysis of factors associated with HIV infection*

Risk Factor	Adjusted Odds Ratio	95% Confidence Interval	p-value
First-time donor (Ref. repeat)	1.0	0.6–1.7	0.87
Age group, years (Ref. 18–24)			
25–39	1.6	0.8–3.2	0.15
40–54	1.1	0.5–2.3	0.83
55 and older	0.7	0.2–2.0	0.48
Race/ethnicity (Ref. White, NH)			
Black, NH	10.7	5.9–19.4	<0.001
Asian, Native American, other, NH	1.7	0.7–4.5	0.27
Hispanic	1.4	0.7–2.7	0.34
Low income (Ref. \$30,000 or more)	2.4	1.3–4.5	0.01
Male (Ref. female)	1.8	1.0–3.1	0.05
MSM or sex with MSM, ever (Ref. never)			
Males	62.3	27.6–140.4	<0.001
Females	0.5	0.0–8.8	0.63
Multiple partners, last year (Ref. monogamous)	2.3	1.4–3.8	<0.01
Sex for money or drugs, ever	5.2	1.4–19.9	0.02
Sex with HIV positive partner, ever	131.7	26.7–650.1	<0.001
Injecting drug use, ever	3.1	0.3–28.5	0.31
Detention, jail or group home, ever [†]	2.4	1.2–4.8	0.01
Tattoo or body piercing or 3+ ear piercing	2.8	1.6–4.8	<0.001

* Adjusted for all variables listed in the table as well as donation period and missing categories for “low income” and “sex with HIV-positive partner”

[†] Spent 3 or more nights in a row in jail, prison, a detention center, a shelter, or a group home.

Table 5
Adjusted odds ratios (AOR) from multivariable logistic regression analysis of factors associated with HBV and HCV infection *

Risk Factor	HBV			HCV		
	Adjusted Odds Ratio	95% CI	p-value	Adjusted Odds Ratio	95% CI	p-value
First-time donor (Ref. repeat)	16.3	9.9–27.0	<0.001	17.5	10.2–30.0	<0.001
Age group, years (Ref. 18–24)						
25–39	1.3	0.7–2.3	0.37	1.5	0.7–3.2	0.25
40–54	2.9	1.6–5.5	<0.01	5.3	2.6–10.6	<0.001
55 and older	3.6	1.8–7.3	<0.001	5.9	2.5–13.7	<0.001
Race/ethnicity (Ref. White, NH)						
Black, NH	10.8	6.3–18.5	<0.001	1.3	0.6–2.8	0.44
Asian, Native American, other, NH	6.7	3.7–12.3	<0.001	1.3	0.5–3.3	0.54
Hispanic	0.6	0.3–1.3	0.22	0.9	0.4–1.8	0.72
Male (Ref. female)	1.7	1.1–2.6	0.01	2.3	1.4–3.8	<0.01
Low education (Ref. college or above)	--	--	--	2.8	1.7–4.6	<0.001
Low income (Ref. \$30,000 or more)	2.5	1.4–4.4	<0.01	2.9	1.6–5.2	<0.001
Injecting drug use, ever	3.3	0.8–14.4	0.11	42.1	13.0–136.3	<0.001
Sex with injecting drug user, ever	11.4	4.7–27.6	<0.001	9.7	4.4–21.2	<0.001
Family member with hepatitis, ever	8.1	3.5–18.7	<0.001	15.4	5.9–40.3	<0.001
Detention, jail or group home, ever	2.3	1.3–4.2	<0.01	7.5	4.3–12.9	<0.001
Tattoo or body piercing or 3+ ear piercing	--	--	--	3.5	2.0–5.9	<0.001
Born outside of US (Ref. US born)	6.1	3.7–10.2	<0.001	3.3	1.4–7.9	<0.01
Family/self migrated from abroad (Ref. none)	1.5	1.1–2.1	0.01	--	--	--
Blood transfusion, ever	--	--	--	5.1	2.7–9.6	<0.001

* Adjusted for all variables listed in the table as well as donation period and missing categories for low income and sex with injecting drug user; low education, tattoo/body piercing and blood transfusion were not included in the HBV model; family migration was not included in the HCV model.

Table 6

Adjusted odds ratios (AOR) from multivariable logistic regression analysis of factors associated with HTLV infection*

Risk Factor	Adjusted Odds Ratio	95% CI	p-value
First-time donor (Ref. repeat)	14.5	8.7–24.1	<0.001
Age group, years (Ref. 18–24)			
25–39	2.8	1.1–7.2	0.03
40–54	13.2	5.5–31.7	<0.001
55 and older	20.7	8.2–52.4	<0.001
Race/ethnicity (Ref. White, NH)			
Black, NH	13.1	7.3–23.4	<0.001
Asian, Native American, other, NH	2.4	1.0–5.9	0.12
Hispanic	2.3	1.3–4.4	0.04
Male (Ref. female)	0.4	0.2–0.7	<0.01
Multiple Partner, last 12 months			
Males (Ref. monogamous males)	1.3	0.5–3.1	0.62
Females (Ref. monogamous females)	4.3	2.3–7.8	<0.001
Sex with injecting drug user, ever	21.5	9.6–48.0	<0.001
Sex for money or drug, ever	6.4	1.3–30.7	0.02
STD, ever	2.7	1.5–4.7	<0.01
Born outside of US (Ref. US born)	4.4	2.3–8.3	<0.001
Family/self migrated from abroad (Ref. none)	1.7	1.1–2.4	<0.01

* Adjusted for all variables listed in the table as well as donation period and missing category for sex with injecting drug user.