RESEARCH PAPER

Seroprevalence of Transfusion-Transmissible Infections and Their Association with Socio-Demographic and Personal Behavioural Factors among Blood Donors in Northern India

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ABSTRACT

Background: Transfusion-transmissible infections (TTIs) — hepatitis B (HBV), hepatitis C (HCV), HIV, syphilis and malaria — remain a major blood-safety challenge in resource-limited settings. Behavioural and demographic correlates of TTI seropositivity can help target donor screening and counselling in North India.

Methods: This cross-sectional study enrolled 1255 consecutive donors at a tertiary care hospital blood bank in Northern India (November 2024–April 2025). Socio-demographic and behavioural data were collected by structured, interviewer-administered questionnaire. HIV, HBsAg and HCV were screened by microwell ELISA, syphilis by a rapid treponemal immunochromatographic card test, and malaria by a pan-Plasmodium lactate dehydrogenase rapid antigen test. Associations with seropositivity were assessed from 2×2 tables using Fisher's exact test with exact (Cornfield) 95% confidence limits; $p<0.05$ was considered significant.

Results: Overall, 31/1255 donors (2.47%) were reactive for at least one TTI marker: HBV 1.12% (14/1255), syphilis 0.80% (10/1255), HCV 0.48% (6/1255), HIV 0.08% (1/1255); no donor was reactive for malaria. HBV accounted for 45.2% of reactive cases, syphilis 32.3% and HCV 19.4%. Of reactive donors, 30/31 (96.8%) were male, mirroring the 98.8% male composition of the donor pool; B-positive was the most frequent blood group among reactive donors (38.7%). Reactivity rose with age, from 1.90% (18–24 y) to 3.41% (>35 y). All six HCV-reactive donors were illiterate (6/277 vs 0/978 literate; exact $p<0.001$); because no literate donor was reactive the odds ratio is not finite, with an exact lower confidence limit of 4.21. Three of 46 pairwise comparisons reached nominal significance, close to the number expected by chance alone.

Conclusion: A small but consistent proportion of donors were reactive for TTI markers, predominantly HBV. HCV reactivity was confined to illiterate donors, an exploratory observation resting on six cases that requires confirmation in a larger sample before it is used to guide targeted counselling. Given the low number of reactive donors, larger multicentric studies with individual-level data are needed to establish behavioural risk factors.

Keywords: Blood Donors; Seroepidemiologic Studies; Hepatitis B; Hepatitis C; HIV Infections; Syphilis; Risk Factors; India

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INTRODUCTION

The concept of blood transfusion originates with William Harvey's description of the circulatory system in 1628.[1] Dr. Philip Syng Physick is credited with an early human blood transfusion in 1795, while the first transfusion specifically to treat haemorrhage was performed by Dr. James Blundell in England in 1818; the first dedicated blood bank was established in Leningrad in 1932.[1,2] Blood transfusion remains an effective, life-saving intervention: a single unit of donated blood can benefit up to three recipients, and globally an estimated 120.4 million blood donations are collected each year, of which voluntary unpaid donors contribute the majority in most high- and middle-income settings.[3] Blood donors are

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broadly classified as voluntary unpaid, replacement (family/friend), or paid donors, and whole blood donation remains the most common form of donation worldwide.[3]

Despite its benefits, transfusion is not without risk. Transfusion-transmissible infections (TTIs) — principally hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV), syphilis, and, in endemic regions, malaria — remain a major challenge for blood transfusion services, particularly in developing countries such as India where the prevalence of these infections is comparatively higher and the clinical demand for blood is substantial.[4,5,6] The World Health Organization recommends quality-assured screening of all donated blood for these infections prior to release for clinical use, and mandatory screening for HBV, HCV, HIV, and syphilis is now standard practice across Indian blood banks.[4]

The residual risk of TTI transmission persists even with universal serological screening, largely because of the 'window period' — the interval between infection and detectable seroconversion — during which an infected but asymptomatic donor may test falsely non-reactive.[4] This residual risk is compounded where donor selection relies heavily on replacement or family donors rather than repeat voluntary non-remunerated donors, who are consistently shown to carry a lower TTI burden.[4,7] Identifying the socio-demographic and behavioural correlates of TTI seropositivity in a given donor population — for example age, sex, literacy, marital status, high-risk sexual behaviour, tattooing, and body piercing — can help blood banks refine donor selection, pre-donation counselling, and deferral criteria.[5,6]

Several Indian studies have reported TTI seroprevalence ranging from below 2% to over 3% depending on donor mix, region, and screening assay generation, with HBV consistently the most frequently detected infection.[5,6,8] However, associations between behavioural risk factors and specific TTIs are less consistently reported, partly because of the low absolute number of seropositive donors in single-centre studies. Data linking donor-level behavioural characteristics with specific TTI markers remain limited in North Indian blood donor populations. This study was undertaken to determine the seroprevalence of HBV, HCV, HIV, syphilis and malaria among blood donors at a tertiary care hospital in Northern India, and to examine their association with socio-demographic characteristics and self-reported personal behaviour.

MATERIALS AND METHODS

Study design, setting and period

This was a hospital-based, cross-sectional (descriptive and analytical) study conducted in the Department of Immunohematology and Blood Transfusion / Transfusion Medicine of a tertiary care hospital in Northern India, over a six-month period from November 2024 to April 2025. The study is reported in accordance with the STROBE statement for observational studies.[9]

Study population and sampling

All eligible blood donors presenting for voluntary, replacement, or camp-based donation during the study period were enrolled consecutively after obtaining informed consent and completion of the study questionnaire. Donors weighing <55 kg, aged <18 or >65 years, not meeting the national and institutional eligibility criteria, or unwilling to provide informed consent were excluded. Data were anonymised and analysed without personal identifiers. Donors found reactive for any TTI marker were counselled and referred to the appropriate health facility for confirmatory testing and further management, per institutional protocol and consistent with recommended practice.[10]

Sample size determination

The minimum required sample size was estimated using the standard formula for estimating a single population proportion: $n = Z^2\alpha/2 \times p(1-p) / d^2$, with a 95% confidence level ($Z\alpha/2 = 1.96$). Rather than the conservative p = 50% default (appropriate only when no prior estimate exists), an anticipated TTI prevalence of p = 2.5% was used, based on rates of approximately 2–3% reported in prior Indian blood donor studies.[5,6] With an absolute precision (d) of 1%, this yielded a minimum requirement of $n = (1.96)^2 \times 0.025 \times 0.975 / (0.01)^2 \approx 936.4$, rounded up to 937 donors. The achieved sample of 1255 donors exceeded this minimum, supporting adequate precision for the overall prevalence estimate. As detailed under Limitations, this calculation was powered for the primary prevalence estimate only; it does not imply adequate power for the per-variable subgroup comparisons in Table 4 and Supplementary Tables S1–S4, which involved far fewer events each.

Data and sample collection

Socio-demographic data, personal behavioural data (including history of tattooing, body piercing, and multiple sexual partners), and other relevant variables were collected using a pre-tested, structured, interviewer-administered questionnaire at the time of donation. A donor was classified as literate if able to both read and write the study questionnaire, or if they had completed at least secondary school education (10th grade); all others were classified as illiterate.

Blood samples were screened as follows: HIV-1 and HIV-2 by Microlisa HIV Ag & Ab, a fourth-generation microwell ELISA detecting HIV-1 p24 antigen together with antibodies to HIV-1 (including subgroups O and C) and HIV-2 (J. Mitra & Co. Pvt. Ltd., New Delhi, India); HBsAg by Hepalisa, a microwell ELISA for hepatitis B surface antigen (J. Mitra & Co. Pvt. Ltd., New Delhi, India); HCV by HCV Microlisa, a third-generation microwell ELISA for antibodies to hepatitis C virus (J. Mitra & Co. Pvt. Ltd., New Delhi, India); syphilis by the Syphilis/TP rapid card test, an immunochromatographic assay for IgM, IgG and IgA antibodies to Treponema pallidum (FastVue: MicroGene Diagnostic Systems (P) Ltd. and Medsource Ozone Biomedical (P) Ltd India); and

malaria by the Malaria Pan Test Device, a chromatographic immunoassay detecting pan-Plasmodium lactate dehydrogenase (pLDH) antigen common to P. falciparum, P. vivax, P. malariae and P. ovale (SureTest :Medsource Ozone Biomedicals Pvt. Ltd., Faridabad, Haryana, India). All assays were performed on serum or plasma according to the manufacturers' instructions.

Data quality management

All serological testing was performed by a laboratory technologist with a minimum of two years of relevant experience, following standard operating procedures with concurrent quality control materials for every batch. Questionnaire data were checked for completeness at the time of collection and were double-entered and cross-verified before analysis. There were no missing responses for variables included in the present analysis.

Statistical analysis

Statistical analyses were performed using Python version 3.11 with the SciPy library version 1.17 (scipy.stats). Categorical variables were summarised as frequencies and percentages. For each infection (HBV, HIV, HCV, syphilis), the association between seropositivity and each socio-demographic and behavioural variable was assessed from 2×2 contingency tables. Because the number of reactive donors was small for every infection and many strata contained no reactive donors, all inference was based on exact methods: p-values were obtained from Fisher's exact test,[11] and 95% confidence limits for the odds ratio were computed by the exact (Cornfield) method in preference to normal-approximation formulae, which are unreliable when cell counts are very small or zero.[12] Where a stratum contained no reactive donors the odds ratio is not finite and is reported as not estimable (NE); the corresponding exact confidence limit is retained because it remains interpretable. $p<0.05$ was considered statistically significant. Ten variables generated 46 pairwise comparisons across the four infections. No correction for multiple comparisons was applied; at $\alpha = 0.05$ approximately two to three nominally significant results would be expected by chance alone across 46 comparisons, and three were observed. All associations are therefore treated as exploratory and hypothesis-generating rather than confirmatory, and are interpreted accordingly throughout the Results and Discussion.

RESULTS

Donor recruitment and demographic profile

A total of 1255 blood donors were enrolled over the six-month study period. Table 1 shows the monthly distribution by donor category: replacement donors predominated in every month (984/1255, 78.41% overall), followed by voluntary donors (271/1255, 21.59% overall), the majority of whom donated in-house rather than at outreach camps.

Table 1. Monthly distribution of blood donors by donor category (November 2024–April 2025)

Donor Category	Nov'24	Dec'24	Jan'25	Feb'25	Mar'25	Apr'25	Total
Voluntary — in-house	67	40	24	16	17	11	175
Voluntary — outreach camp	44	0	0	25	0	27	96
Replacement	168	203	138	186	157	132	984
Total	279	243	162	227	174	170	1255

Note: *Voluntary donations are split by collection site (in-house vs outreach camp); the two rows sum to the 271 total voluntary donors reported in Table 2. Replacement donors were collected in-house only. Totals reconcile to N=1255.*

Table 2 summarises the socio-demographic profile. The cohort was overwhelmingly male (1240/1255, 98.80%). Replacement donors accounted for 984/1255 (78.41%) and voluntary donors for 271/1255 (21.59%); most donations were collected in-house (1159/1255, 92.35%) rather than at outreach camps (96/1255, 7.65%). Most donors were aged 25–34 years (616/1255, 49.08%), urban residents (892/1255, 71.08%), employed (943/1255, 75.14%), literate (978/1255, 77.93%) and married (840/1255, 66.93%). A minority reported multiple sexual partners (12/1255, 0.96%), tattooing (489/1255, 38.96%) or body piercing (152/1255, 12.11%).

Blood group B-positive was the most common group in this cohort (448/1255, 35.70%), followed by O-positive (353/1255, 28.13%), A-positive (262/1255, 20.88%) and AB-positive (132/1255, 10.52%); collectively the Rh-negative groups accounted for 60/1255 (4.78%), with AB-negative the least common single group (7/1255, 0.56%).

Table 2. Socio-demographic and behavioural characteristics of blood donors (N=1255)

Characteristic	n	%
Age group: 18–24 y	316	25.18
Age group: 25–34 y	616	49.08
Age group: >35 y	323	25.74
Sex: Male	1240	98.80
Sex: Female	15	1.20

Characteristic	n	%
Residence: Urban	892	71.08
Residence: Rural	363	28.92
Occupation: Employed	943	75.14
Occupation: Unemployed	312	24.86
Education: Literate	978	77.93
Education: Illiterate	277	22.07
Marital status: Married	840	66.93
Marital status: Unmarried	415	33.07
Multiple sexual partners: Yes	12	0.96
Multiple sexual partners: No	1243	99.04
Tattoo: Yes	489	38.96
Tattoo: No	766	61.04
Body piercing: Yes	152	12.11
Body piercing: No	1103	87.89
Donor type: Replacement	984	78.41
Donor type: Voluntary	271	21.59
Donation site: In-house	1159	92.35
Donation site: Outreach camp	96	7.65
Blood group: B+	448	35.70
Blood group: O+	353	28.13
Blood group: A+	262	20.88
Blood group: AB+	132	10.52
Blood group: B−	19	1.51
Blood group: O−	18	1.43
Blood group: A−	16	1.27
Blood group: AB−	7	0.56

Seroprevalence of transfusion-transmissible infections

Of 1255 donors screened, 31 (2.47%) were reactive for at least one TTI marker. HBV was the most frequently detected infection (14/1255, 1.12%), followed by syphilis (10/1255, 0.80%), HCV (6/1255, 0.48%) and HIV (1/1255, 0.08%); no donor was reactive for malaria parasite antigen. Among the 31 reactive donors, HBV accounted for 45.16%, syphilis for 32.26%, HCV for 19.35% and HIV for 3.23% of all reactive cases. No donor was reactive for more than one marker.

Table 3. Seroprevalence of individual transfusion-transmissible infections

Infection (screening assay)	No. reactive	Seroprevalence (% of N=1255)	Share of all reactive donors (% of 31)
HBsAg (ELISA)	14	1.12%	45.16%
Syphilis (treponemal antibody, rapid test)	10	0.80%	32.26%
HCV (ELISA)	6	0.48%	19.35%
HIV (fourth-generation ELISA)	1	0.08%	3.23%
Malaria (pan-Plasmodium pLDH antigen)	0	0.00%	0.00%
Total reactive (≥1 marker)	31	2.47%	100.00%

Results represent screening reactivity on a single assay per infection; confirmatory testing was not performed as part of this study.

Among reactive donors, 30/31 (96.77%) were male and 1/31 (3.23%) — a single HCV-reactive donor — was female; this distribution mirrors the 98.80% male composition of the donor pool and does not in itself indicate a higher risk in men. B-positive was the most frequent blood group among reactive donors (12/31,

38.71%), consistent with its predominance in the overall donor population. TTI reactivity increased with donor age, from 1.90% (6/316) in the 18–24-year group, to 2.27% (14/616) in the 25–34-year group, to 3.41% (11/323) in donors older than 35 years.

Associations with socio-demographic and behavioural factors

Odds ratios with exact 95% confidence limits were calculated for each infection against ten socio-demographic and behavioural variables, giving 46 pairwise comparisons in total. Because the number of reactive donors was low for every infection (1–14 cases), 23 of the 46 comparisons contained a stratum with no reactive donors; in these the odds ratio is not finite and is reported as not estimable (NE), with the exact confidence limit retained. Three comparisons reached nominal statistical significance and are summarised in Table 4; full results for every variable and all four infections are provided in Supplementary Tables S1–S4. Given the number of comparisons performed and the small number of events, all of these should be read as exploratory.

Table 4. Comparisons reaching nominal statistical significance (Fisher's exact p<0.05), all infections

Infection	Variable	Exposed (reactive/total)	Reference (reactive/total)	OR	Exact 95% CI	p
HBV	Occupation: Employed vs Unemployed	14/943	0/312	NE	1.11–∞	0.027
HBV	Tattoo: Yes vs No	0/489	14/766	NE	0–0.47	0.001
HCV	Education: Illiterate vs Literate	6/277	0/978	NE	4.21–∞	<0.001

NE = not estimable: one stratum contained no reactive donors, so the odds ratio is not finite. The exact confidence limit shown remains interpretable — for example, the HCV data are consistent with the odds of reactivity among illiterate donors being at least 4.21 times that among literate donors, with no upper bound. p-values are from Fisher's exact test; confidence limits are exact (Cornfield). Each of these three comparisons rests on very few reactive donors and none should be regarded as confirmatory. No variable reached nominal significance for HIV or syphilis. The inverse association between tattooing and HBV reactivity is addressed in the Discussion and should not be interpreted as evidence of a protective effect.

DISCUSSION

Blood is a scarce, non-substitutable therapeutic resource, and its safe use depends on rigorous donor selection and screening in addition to appropriate, guideline-based clinical prescribing.[3,4] In this cohort of 1255 donors from a tertiary care hospital in Northern India, the overall TTI seroprevalence was 2.47%, with HBV the leading infection (1.12%), followed by syphilis (0.80%), HCV (0.48%) and HIV (0.08%); no donor was reactive for malaria. This ranking — HBV as the dominant TTI — is consistent with the pattern reported across most Indian donor populations.[5,6,8]

Comparable single-centre Indian studies report a range of overall prevalence. A 2024 study from a rural tertiary hospital in North India (n=15,739; August 2020–July 2023) reported higher individual seroprevalence for HBV (2.89%), HCV (0.80%) and HIV (0.17%), but a lower rate for syphilis (0.06%).[5] A five-year study from a licensed blood bank in Haryana (n=2,896) reported an overall TTI prevalence of 1.87%, with HBV 1.00%, HCV 0.69%, syphilis 0.14% and HIV 0.03%, and reported significantly higher TTI positivity among male donors.[6] An earlier series from southern Haryana likewise found low overall rates of HIV, HBV, HCV and syphilis among blood donors.[13] Both the direction (HBV predominance) and the order of magnitude of the present findings are therefore broadly consistent with recent Indian data, while absolute rates vary with donor mix (voluntary vs replacement), region, and assay generation — a pattern also highlighted in a recent systematic review and meta-analysis of TTI seroprevalence among Indian blood donors.[8] In the present cohort, although 30 of 31 reactive donors were male, this reflects the composition of the donor pool rather than a demonstrable sex difference in risk: with only 15 female donors, the study had no power to compare the sexes, and no sex comparison reached significance for any infection.

Nearly all donors in this cohort were male (98.80%), and replacement donors outnumbered voluntary donors by roughly 3.6 to 1. Previous literature indicates that first-time and replacement donors generally have a higher TTI burden than repeat voluntary non-remunerated donors.[4,7] Increasing the proportion of voluntary, repeat donors — through structured donor recruitment and retention programmes — remains one of the most effective long-term strategies for reducing residual TTI risk in this setting, independent of any individual behavioural risk factor examined below.

Among the variables examined, HCV reactivity was confined entirely to illiterate donors: all six HCV-reactive donors were illiterate (6/277, 2.17%), whereas none of the 978 literate donors was reactive (exact p<0.001). Because one stratum contained no events, the odds ratio is not finite; the exact lower confidence limit of 4.21 indicates that the data are compatible with at least a four-fold

difference in odds, but no point estimate can legitimately be derived and there is no upper bound. This finding rests on six individuals who were also, without exception, urban, married and without tattoos, so the contribution of literacy cannot be separated from these correlated characteristics in a univariate analysis. The direction is plausible — lower health literacy is associated with reduced awareness of infection risk and lower uptake of preventive counselling — but confirmation in a larger sample, with adjustment for correlated socio-demographic factors, is required before any causal or programmatic interpretation is drawn.

Two further comparisons reached nominal significance, both for HBV, and both require caution. All 14 HBV-reactive donors were employed while none of the 312 unemployed donors was reactive, so this odds ratio is likewise not finite and the association is more plausibly a marker of correlated age and donor-mix characteristics than of employment itself. More strikingly, an inverse association was observed between tattooing and HBV reactivity (0/489 tattooed vs 14/766 non-tattooed; exact p=0.001), and the same direction was seen for HCV and syphilis. A protective effect of tattooing against blood-borne infection is not biologically plausible and runs counter to the risk relationship consistently described in the literature. The most likely explanations are misclassification of self-reported tattoo status, residual confounding by age and donor category, or the effect of pre-donation deferral practice, which excludes donors with recent tattoos and may leave a tattooed donor group whose exposures are remote in time. This result should therefore be regarded as unexplained rather than as evidence of protection, and it warrants verification against source records before it is allowed to influence donor selection or counselling policy.

TTI reactivity in this cohort increased with donor age (1.90% at 18–24 years, 2.27% at 25–34 years, 3.41% in donors over 35 years), although no individual age comparison reached statistical significance. A plausible explanation is that cumulative lifetime exposure to blood-borne pathogens — via historical unsterile medical or dental procedures, prior transfusions, or long-standing chronic carrier states for HBV and HCV — accrues with age, a pattern recognised in several donor seroprevalence studies, even where younger donor sub-groups may separately report higher rates of high-risk behaviour. As with the comparisons above, this trend rests on small numbers within each age stratum and should be regarded as descriptive.

Taken together, these findings point to several practical implications for donor services in this and similar settings. Targeted, culturally appropriate health education for donors with lower literacy — delivered verbally rather than relying solely on written material — may improve risk awareness and screening uptake. Expanding structured recruitment and retention of repeat, voluntary, non-remunerated donors would reduce reliance on first-time replacement donors, who consistently carry a higher TTI burden. Where resources permit, phased introduction of nucleic acid testing (NAT) would narrow the serological window period that current assays cannot detect. Finally, robust systems for notifying and following up donors who screen reactive — linking them to confirmatory testing and appropriate care — remain an essential, though sometimes under-resourced, component of donor-centred blood banking in India.[10]

The predominance of blood group B-positive in this cohort (35.70% of all donors; 38.71% of reactive donors) is consistent with the known distribution of ABO blood groups in the North Indian population, where B-positive is typically the most common group, rather than O-positive as is more typical in Western populations; the modest over-representation of B-positive donors among reactive cases here is proportionate to its background frequency and does not, on this dataset, support a true biological association between ABO blood group and TTI susceptibility.

Limitations: This study has several limitations. First, the cross-sectional design and reliance on serological rather than nucleic acid testing (NAT) means that donors in the pre-seroconversion window period would be misclassified as non-reactive, so the true TTI burden is likely underestimated. Second, self-reported data on sexual behaviour and other stigmatised exposures are subject to social desirability bias; only 12 donors (0.96%) reported multiple sexual partners, a figure almost certainly lower than the true prevalence, and none of them was reactive, so this variable was uninformative. Third, and most importantly, the very low absolute number of reactive donors for HIV (n=1), HCV (n=6) and syphilis (n=10) severely limits statistical power; half of all comparisons contained a stratum with no events, no odds ratio could be estimated in those instances, and the exact confidence limits that could be computed are very wide. Fourth, multivariable (adjusted) analysis could not be performed because only aggregated summary counts, and not the individual donor-level dataset, were available; all reported associations are therefore unadjusted and may be confounded, which is particularly relevant given the tight clustering of characteristics among the six HCV-reactive donors. Fifth, results represent screening reactivity on a single assay per infection without confirmatory testing. The syphilis assay was a treponemal antibody test, which cannot distinguish active infection from past or successfully treated infection and may therefore overestimate active syphilis, while rapid immunochromatographic formats are generally less sensitive than treponemal ELISA or TPHA; malaria screening used a pan-Plasmodium pLDH antigen test, which has limited sensitivity for low-density asymptomatic parasitaemia, so the absence of reactive donors should be read as no donor testing reactive by that method rather than as the absence of malaria in this population. Finally, this single-centre, consecutively enrolled cohort's findings may not generalise to donor

populations with a different voluntary/replacement mix or regional risk profile.

CONCLUSIONS

In this cohort of 1255 blood donors at a tertiary care hospital in Northern India, 2.47% were reactive for at least one transfusion-transmissible infection marker, with HBV responsible for the largest share (45.2%) of reactive cases, followed by syphilis (32.3%), HCV (19.4%) and HIV (3.2%). HCV reactivity was confined to illiterate donors; this is an exploratory observation based on six cases, inseparable from correlated socio-demographic characteristics, and it requires confirmation in a larger sample before it is used to justify targeted interventions. Given the predominance of replacement donors in this cohort, continued investment in voluntary, repeat, non-remunerated donor recruitment — alongside consistent implementation of stringent donor selection and sensitive serological and, where feasible, NAT-based screening — remains central to reducing the residual risk of TTI transmission. Because the number of reactive donors was small and half of all subgroup comparisons could not yield an estimable odds ratio, larger, ideally multicentric, prospective studies with individual-level datasets are needed to establish the behavioural and demographic correlates of TTI seropositivity.

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AUTHOR CONTRIBUTIONS

AT: conceptualisation, data collection, formal analysis, writing (original draft). MT: supervision, methodology, writing (review & editing). All authors read and approved the final manuscript, per ICMJE authorship criteria.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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SUPPLEMENTARY MATERIAL

Supplementary Tables S1–S4 give the complete results for every socio-demographic and behavioural variable tested against each of the four infections; Table 4 in the main text summarises only the three comparisons that reached nominal significance. Odds ratios are reported with exact (Cornfield) 95% confidence limits and Fisher's exact p-values. Where a stratum contained no reactive donors the odds ratio is not finite and is reported as not estimable

(NE); the exact confidence limit is retained because it remains interpretable. No correction for multiple comparisons was applied and all results are exploratory.

Supplementary Table S1. Associations with HBV seropositivity (14/1255 reactive)

Variable	Exposed (reactive/total)	Reference (reactive/total)	OR	Exact 95% CI	p
Age 25–34 y vs 18–24 y	5/616	4/316	0.64	0.14–3.24	0.497
Age >35 y vs 18–24 y	5/323	4/316	1.23	0.26–6.24	1.000
Sex: Male vs Female	14/1240	0/15	NE	0.04–∞	1.000
Residence: Urban vs Rural	12/892	2/363	2.46	0.54–22.74	0.373
Occupation: Employed vs Unemployed	14/943	0/312	NE	1.11–∞	0.027*
Education: Illiterate vs Literate	1/277	13/978	0.27	0.01–1.81	0.327
Marital status: Unmarried vs Married	3/415	11/840	0.55	0.10–2.09	0.568
Multiple sexual partners: Yes vs No	0/12	14/1243	NE	0–35.27	1.000
Tattoo: Yes vs No	0/489	14/766	NE	0–0.47	0.001*
Body piercing: Yes vs No	2/152	12/1103	1.21	0.13–5.52	0.683
Blood group A+ vs O+	5/262	4/353	1.70	0.36–8.63	0.506
Blood group B+ vs O+	4/448	4/353	0.79	0.15–4.25	0.737
Blood group AB+ vs O+	1/132	4/353	0.67	0.01–6.82	1.000

**p<0.05. Both nominally significant comparisons involve a stratum with no reactive donors, so neither odds ratio is finite. Donor category (voluntary vs replacement) could not be analysed because infection-specific counts by donor type were not available.*

Supplementary Table S2. Associations with HIV seropositivity (1/1255 reactive)

Variable	Exposed (reactive/total)	Reference (reactive/total)	OR	Exact 95% CI	p
Age >35 y vs 18–24 y	1/323	0/316	NE	0.03–∞	1.000
Sex: Male vs Female	1/1240	0/15	NE	0.00–∞	1.000
Residence: Urban vs Rural	1/892	0/363	NE	0.01–∞	1.000
Occupation: Employed vs Unemployed	1/943	0/312	NE	0.01–∞	1.000
Education: Illiterate vs Literate	1/277	0/978	NE	0.09–∞	0.221
Marital status: Unmarried	0/415	1/840	NE	0–78.94	1.000

vs Married					
Multiple sexual partners: Yes vs No	0/12	1/1243	NE	0–4040	1.000
Tattoo: Yes vs No	1/489	0/766	NE	0.04–∞	0.390
Body piercing: Yes vs No	0/152	1/1103	NE	0–283	1.000

With a single reactive donor in the entire cohort, every comparison in this table is descriptive only; no odds ratio is estimable and no confidence limit is informative. Presented for completeness.

Supplementary Table S3. Associations with HCV seropositivity (6/1255 reactive)

Variable	Exposed (reactive/total)	Reference (reactive/total)	OR	Exact 95% CI	p
Age 25–34 y vs 18–24 y	2/616	0/316	NE	0.10–∞	0.551
Age >35 y vs 18–24 y	4/323	0/316	NE	0.65–∞	0.124
Sex: Male vs Female	5/1240	1/15	0.06	0.01–2.87	0.070
Residence: Urban vs Rural	6/892	0/363	NE	0.48–∞	0.190
Occupation: Employed vs Unemployed	5/943	1/312	1.66	0.18–78.66	1.000
Education: Illiterate vs Literate	6/277	0/978	NE	4.21–∞	<0.001*
Marital status: Unmarried vs Married	0/415	6/840	NE	0–1.72	0.186
Multiple sexual partners: Yes vs No	0/12	6/1243	NE	0–97.04	1.000
Tattoo: Yes vs No	0/489	6/766	NE	0–1.33	0.087
Body piercing: Yes vs No	1/152	5/1103	1.45	0.03–13.12	0.540
Blood group B+ vs O+	5/448	1/353	3.97	0.44–188	0.237

**p<0.05. All six HCV-reactive donors were illiterate, urban, married and without tattoos, so these comparisons are not mutually independent and no single variable can be isolated as the correlate of HCV reactivity.*

Supplementary Table S4. Associations with syphilis seropositivity (10/1255 reactive)

Variable	Exposed (reactive/total)	Reference (reactive/total)	OR	Exact 95% CI	p
Age 25–34 y vs 18–24 y	7/616	2/316	1.80	0.34–17.89	0.726
Age >35 y vs 18–24 y	1/323	2/316	0.49	0.01–9.42	0.620
Sex: Male vs Female	10/1240	0/15	NE	0.02–∞	1.000
Residence: Urban vs Rural	8/892	2/363	1.63	0.32–15.86	0.733
Occupation: Employed vs Unemployed	9/943	1/312	3.00	0.41–132	0.466
Education: Illiterate vs Literate	0/277	10/978	NE	0–1.57	0.130
Marital status: Unmarried vs Married	2/415	8/840	0.50	0.05–2.54	0.511
Multiple sexual partners: Yes vs No	0/12	10/1243	NE	0–51.86	1.000

Tattoo: Yes vs No	1/489	9/766	0.17	0.00–1.25	0.099
Body piercing: Yes vs No	2/152	8/1103	1.82	0.19–9.26	0.346
Blood group A+ vs O+	3/262	3/353	1.35	0.18–10.17	0.703
Blood group B+ vs O+	3/448	3/353	0.79	0.10–5.91	1.000
Blood group AB+ vs O+	1/132	3/353	0.89	0.02–11.21	1.000

No variable reached nominal statistical significance for syphilis in this dataset.