Donor health beyond donation: cardiovascular risk factors in blood donor populations. A cross-sectional study

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Background - Blood donors are often regarded as healthier than the general population, a phenomenon described as the "healthy donor effect". This perception arises from strict donor selection criteria and routine pre-donation screening, yet these evaluations focus largely on hemoglobin, vital signs, and a short medical history, thereby providing only a partial assessment of donor health. As cardiovascular disease (CVD) remains the leading global cause of mortality, assessing cardiovascular risk factors in blood donors provides an opportunity to evaluate whether this group is genuinely healthier or simply appears so due to selection bias.

Materials and methods - A cross-sectional study was conducted among 1,543 Slovenian blood donors. All donors completed a medical questionnaire, underwent a physical examination, and vital signs measurements. Body mass index (BMI) was calculated from self-reported weight and height. Information on diseases, medication use, smoking, and physical activity was also collected. A subgroup of 506 donors without reported illness and not taking medication was classified as "healthy". This subgroup underwent additional laboratory investigations, including complete blood count, lipoproteins, and high-sensitivity C-reactive protein. A composite CVD risk score was developed by integrating traditional and novel risk factors.

Results - Overall, 32% of donors reported at least one chronic condition and 19% reported medication use, most frequently antihypertensive therapy. Median BMI was 26.3 kg/m^2, with 56% of donors overweight or obese. Nearly 40% had elevated BP, including 7% with systolic BP ≥160 mmHg. According to the CVD risk score, 49% were low risk, 29% moderate, and 25% high, with men more often at increased risk.

Discussion - Despite eligibility screening, many donors exhibited subclinical CVD risk factors. These findings confirm that transfusion services can contribute beyond donor and recipient safety, offering a valuable platform for prevention and early detection, and strengthening public health surveillance.

Keywords: *blood donors, cardiovascular risk, lipoproteins, high sensitive C-reactive protein, donor health.*

Arrived: 2 September 2025
Revision accepted: 25 November 2025
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Blood Transfus 2026; 24(2):96-105 doi: 10.2450/BloodTransfus.1191
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INTRODUCTION

Blood donation is a cornerstone of modern healthcare, providing life-saving blood products for patients in need due to surgery, trauma, cancer treatment, or chronic conditions. It is therefore unsurprising that transfusion is among the most frequently performed medical interventions in hospitalized patients[1]. Its safety depends not only on rigorous testing of donated blood but also on maintaining a healthy and sustainable donor pool. Donors are selected based on strict eligibility criteria –covering age, weight, hemoglobin (Hb) concentration, and the absence of certain medical conditions or high-risk behaviours– to ensure both donor and recipient safety[2]. This selection process gives rise to the so-called "healthy donor effect", whereby donors tend to have better health indicators than the general population[3,4]. However, routine pre-donation screening –typically limited to questionnaires, vital signs, Hb levels, and occasionally ferritin– provides only a partial snapshot of donor health. Consequently, it remains unclear whether donors are genuinely healthier or simply appear so due to selection bias.

Health is shaped by the interplay of genetics, environment, and lifestyle. Unhealthy behaviours –such as poor diet, tobacco use, physical inactivity, and excessive alcohol consumption– contribute to obesity, dyslipidaemia, type 2 diabetes mellitus (T2DM), and arterial hypertension (AH), which are major risk factors for cardiovascular disease (CVD), the leading global cause of mortality[5]. According to WHO reports and projections, unhealthy lifestyles are on the rise. There is a noticeable increase in the prevalence of AH, obesity, and T2DM, while modern lifestyles have led to a marked decline in physical activity and overall mobility[6]. These interconnected trends underline the urgent need for more comprehensive health assessments, especially in contexts that regularly engage with healthy adult populations, such as blood donation services. Through their frequent contact with a broad segment of the population, these services present a unique opportunity to educate and implement enhanced screening for underlying CVD risks, thereby benefiting both donor and recipient safety while contributing to wider public health surveillance.

Emerging biomarkers such as lipoprotein(a) [Lp(a)], apolipoprotein B (ApoB), and high-sensitivity C-reactive protein (hs-CRP) have gained recognition as independent predictors of atherosclerotic CVD, complementing traditional risk indicators such as blood pressure, body mass index (BMI), and standard lipid parameters. Elevated Lp(a) has been consistently linked to increased CVD risk, even at levels often overlooked in routine screening[7]. ApoB, representing the total number of atherogenic lipoprotein particles, typically predicts cardiovascular events more accurately than LDL cholesterol[8,9]. Meanwhile, hs-CRP serves as a robust, independent marker of systemic inflammation and is predictive of future cardiovascular events across diverse populations[10,11].

Recognising these gaps in routine donor health assessment and the escalating burden of cardiovascular risk factors, this study was conducted to assess whether blood donors truly exhibit the "healthy donor effect" or if unrecognized health issues persist. Standard donor screening was extended to include additional cardiovascular risk markers –specifically Lp(a), ApoB, and hs-CRP– and information on physical activity patterns. This approach enabled evaluation of the prevalence of key CVD risk factors among donors and determination of whether their perceived health advantage is confirmed by objective clinical measurements. Ultimately, the findings of this study aim to inform and refine donor health monitoring strategies and support safe, sustainable blood collection practices.

MATERIALS AND METHODS

This cross-sectional study included randomly selected blood donors. Prior to donation, all donors completed a medical questionnaire covering their current health status, medical history, medication use, lifestyle habits, and travel history. In addition, their blood pressure (BP), heart rate (HR), and Hb levels were measured, and their general health status was assessed by a medical professional (qualified nurse and/or physician). BP and HR were measured using automated vital signs monitor (Blood Pressure Kiosk, A&M Medical, Richardson, TX, USA), which is regularly calibrated. Hb concentration was measured with a point-of-care analyser (HemoCue 301, HemoCue AB, Ängelholm, Sweden), calibrated daily. From self-reported height and weight, BMI was calculated. Interpretation thresholds for systolic and diastolic BP, BMI, Lp(a), ApoA1, ApoB, and hs-CRP were

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applied according to established international clinical guidelines (see **Table I**).

To enhance the clarity and comparability of the results, a study-specific composite cardiovascular risk score was developed to stratify participants according to the number and severity of well-established cardiovascular risk factors. This approach followed the general principles applied in established risk prediction tools, such as the Framingham Risk Score and SCORE2, while adapting the variables to those available in the dataset of the present study[12,13]. The study was approved by the National Medical Ethics Committee of the Ministry of Health (approval No. 0120-209/2020/3). All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from participants prior to enrolment.

Table I - *Reference values for blood pressure, body mass index, lipoprotein a, apolipoproteins, and high sensitive CRP*

Parameter[ref.]	Category/Classification	Range
Systolic / Diastolic BP[44,45] [mm Hg]	Optimal	<120 / <80
	Normal	120-129 / <80-84
	Normal elevated	130-139 / 85-89
	Grade 1 hypertension	140-159 / 90-99
	Grade 2 hypertension	160-179 / 100-109
	Grade 3 hypertension	>180 / >110
BMI[46] [kg/m²]	Underweight	<18.5
	Normal weight	18.5-25
	Overweight	25-30
	Obesity class I	30-35
	Obesity class II	35-40
	Obesity class III	>40
Lp(a)[47,48] [mg/L]	Optimal (low CVD risk)	<300
	Elevated (intermediate CVD risk)	300-500
	High (high CVD risk)	>500
Apo A1[37] [g/L]	Reference range	1.2-1.6
Apo B[9,37,49] [g/L]	Optimal	<0.9
	Elevated	>0.9
Apo B/Apo A1[37,50] ratio	Optimal	<0.8
	Elevated	>0.8
hs-CRP[10] [mg/L]	Optimal	<1
	Elevated	1-3
	High	>3

BP: blood pressure, BMI: body mass index, Lp(a): lipoprotein a, Apo: apolipoprotein, hs-CRP: high sensitive C reactive protein.

A subgroup of healthy blood donors (inclusion criteria: no acute or chronic illness and no regular medication use, or only occasional therapy, within at least one month prior to donation) was further analyzed with complete blood count (CBC), blood lipoprotein profiling, and hs-CRP measurement, along with data on smoking status and exercise habits. Smoking status was defined as no, yes, and occasional. Exercise habits were self-report and defined by three parameters, intensity of exercise (intense *vs* non-intense), weekly frequency (more or less than 3×/week), and time in days from last more intense exercise (<1, 1-2, 2-3, or >3 days). CBC was measured using a hematology analyser (Cell-Dyn Ruby, Abbott, Lake Forest, IL, USA). Lipoproteins –Lp(a), ApoA1, ApoB, and the ApoB/ApoA1 ratio– were determined with a protein analyser (Atellica NEPH 630, Siemens, Munich, Germany). hs-CRP concentration was measured with a commercially available ELISA kit (#RAB0096, Sigma-Aldrich, Taufkirchen, Germania Germany) according to the manufacturer's instructions. The analytical cut-offs were determined according to the manufacturers' instructions for the reagents used. For the hematology parameters, we applied the Slovenian hematological guidelines for full blood count values.

Based on nine parameters (sex, age, systolic and diastolic BP, BMI, smoking status, Lp(a), ApoB, ApoB/ApoA1 ratio, and hs-CRP), a CVD risk score was developed. Each parameter was assigned points according to predefined thresholds derived from published clinical guidelines and relevant literature (*Online Supplementary* **Table SI**). The individual scores were summed to obtain a total risk score, which was subsequently classified into three categories (**Table II**). This approach allowed integration of multiple risk factors into a single, interpretable metric, while ensuring that clinically significant abnormalities were appropriately weighted.

Table II - *Cardiovascular risk score definition*

CVD risk score	Definition
High	A total score of 4.5 or higher, or the presence of two or more parameters in the "moderate" range (1 point each), or the presence of at least one parameter in the "high" range (2 points), or a BMI category 3 (≥40 kg/m², 3 points).
Moderate	A total score between 2.5 and 4.49, or the presence of a single parameter in the "moderate" range (1 point).
Low	A total score below 2.5, with no individual parameter falling into the "moderate" (1 point) or "high" (2–3 points) categories.

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Blood Transfus 2026; 24(2):96-105 doi: 10.2450/BloodTransfus.1191

Self-reported body weight, height, and exercise habits may introduce bias. Donors uncertain about their weight have the option to be weighed, and staff are instructed to re-measure in case of reported discrepancies. Physical activity was assessed only as an estimate and therefore had lower impact on the CVD score calculation.

Statistical analysis was performed using JASP software, version 0.19.3.0 (University of Amsterdam, Amsterdam, the Netherlands). Continuous variables were described using mean or median (M), while categorical variables were presented as frequency (No.) and proportion (%). Chi-square (χ^2) was used to compare the relationship between categorical variables. Differences between two groups of continuous variables were tested using the Mann-Whitney U test (non-parametric) or the Student's *t*-test (parametric). For comparisons among three or more groups, the Kruskal-Wallis test was applied. Associations between continuous variables were assessed using Spearman's rank correlation coefficient (ρ). The strength of association was classified as follows: none (0), weak (0 to ±0.33), moderate (±0.34 to ±0.63), strong (±0.64 to ±1), and complete (±1). Statistical significance was defined as $p<0.05$.

RESULTS

A total of 1,543 blood donors were included, of whom 159 (10%) were first-time donors. This proportion was slightly higher than the 5-year average (7.5%) owing to a concurrent donation promotion campaign in high schools. The cohort comprised 931 males (60%) and 611 females (40%), with a median age of 43 years. Demographic, clinical, and blood group data are presented in **Table III**. All donors tested negative for HIV, HBV, HCV, and syphilis, and no irregular red blood cell antibodies were detected (*data not shown*).

Evaluation using the standardized medical questionnaire and clinical examination showed that approximately 32% of donors reported at least one chronic condition, while 4% reported two or more. The most common

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Table III - *Blood donors' cohort characteristics*

Parameter	Unit/category	No. (%)	Median	Males *vs* females	
				Median	p
First time donors*	All	159 (10)			
	Male	81 (5)			
	Female	78 (5)			
Sex	Male	931 (60)			
	Female	611 (40)			
Age	Years		43	44 *vs* 42	p=0.142
Height	m		1.75	1,8 *vs* 1.69	p<0.001
Weight	kg		81	87 *vs* 72	p<0.001
Body mass index	kg/m^2		26.26	26.81 *vs* 25.10	p<0.001
Hemoglobin	g/L		146	151 *vs* 136	p<0.001
Systolic blood pressure	mm Hg		135	138 *vs* 131	p<0.001
Diastolic blood pressure	mm Hg		79	81 *vs* 78	p<0.001
Heart rate	beats/min		76	74 *vs* 80	p<0.001
ABO**	O	668 (43.3)			
	A	569 (36.9)			
	B	213 (13.8)			
	AB	92 (6.0)			
D**	D-	368 (23.9)			
	D+	1,174 (76.1)			
K**	K-	1,439 (93.3)			
	K+	103 (6.7)			

** the frequencies of blood groups differ slightly from those in the general population due to the active recruitment of donors with specific blood groups.

self-reported diagnoses were allergy (38%), arterial hypertension (26%), and hyperlipidaemia (11%) (**Figure 1**, **A1-2**). Furthermore, 18% of donors reported taking medication (**Figure 1**, **B1-4**). Statistical analysis revealed no significant associations, except for a significant age-related increase in the prevalence of chronic conditions (p=0.0001) and medication use (p=0.000001).

Healthy cohort

Based on medical examination, absence of chronic or acute disease, and no medication use, 506 donors were classified as healthy and analyzed in greater detail. This subgroup comprised 267 males (53%) and 239 females (47%), with a median age of 43 years. Demographic, and clinical data with laboratory values are presented in **Table IV**.

Complete blood count, lipoproteins, and hs-CRP

Median CBC values were representative of the healthy Slovenian population (*Online Supplementary* **Table SII**). Although Hb levels were measured at the point of care analyzer for all donors, comparison with CBC results revealed 35 donors (27 females, 8 males) below the donation threshold (males <135 g/L; females <125 g/L). Lp(a) concentration was below the detection limit

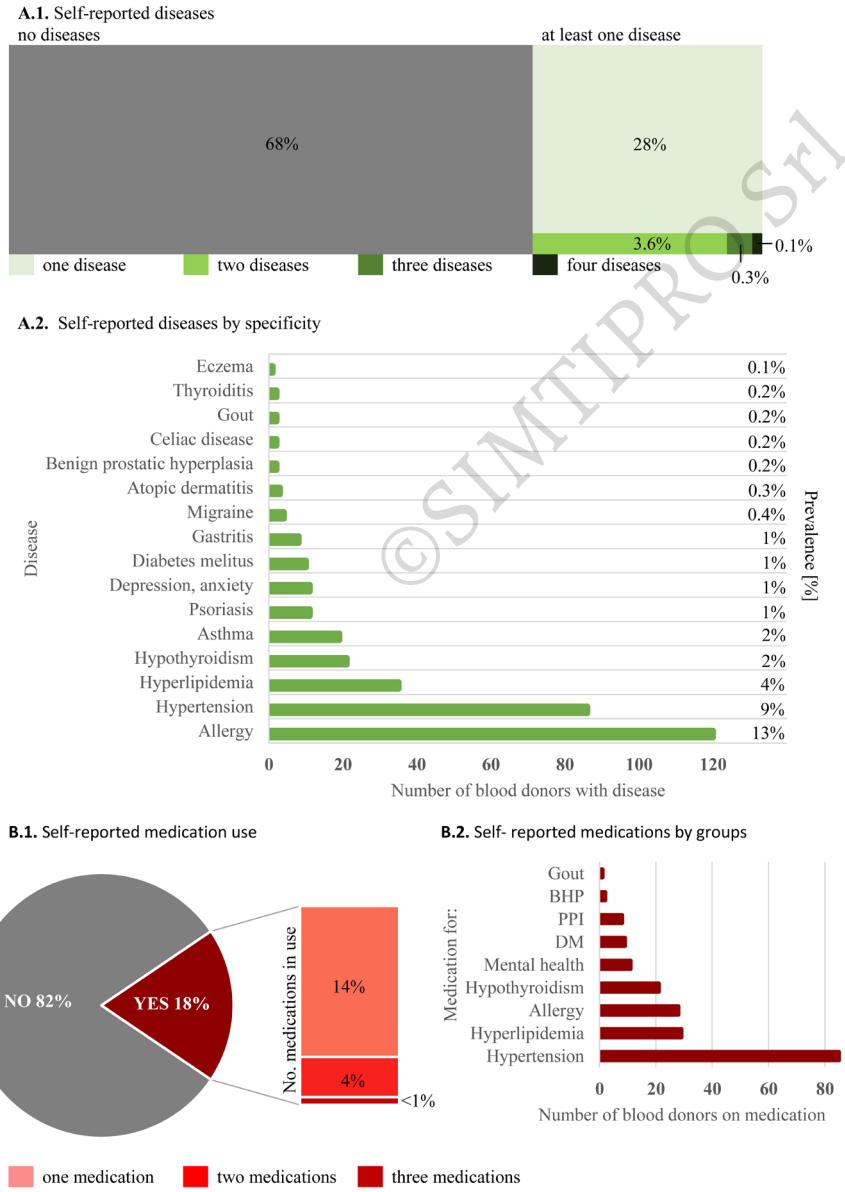


Figure 1 - Self-reported diseases (A) and medication use (B) in blood donors

A.1) The percentage of blood donors without a self-reported disease (gray; 68%) and with at least one disease (green, 32%). Blood donors who reported a disease (green) are further divided by the number of self-reported diseases; 28% have one disease, 3.6% have two diseases, 0.3% have three diseases, and 0.1% have four diseases.
A.2) List of self-reported diseases; [%] is percentage of blood donors with self-reported specific disease.
B.1) Percentage of blood donors without and medication (gray, 82%), and with at least one medication (red, 18%). Percentage of blood donors based on number of how many different medications are they using; 14% one medication, 4% two medications, and <0.1 three medications.
B.2) List of self-reported medications, combined by groups of medications based on what they treat. Medications for hypertension are further divided according to how intensively the therapy is indicated; 79% monotherapy, 19% dual therapy, and 2% triple therapy.

BHP: benign prostatic hyperplasia;
PPI: proton pump inhibitors;
DM: diabetes melitus.

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Table IV - *"Healthy" cohort characteristics*

Parameter	Unit/category	Median	%
Sex	Male		53
	Female		47
Age	Years	43	
Height	m	1.74	
Weight	kg	79	
Body mass index	kg/m²	25.61	
Hemoglobin	g/L	143	
Systolic blood pressure	mm Hg	135	
Diastolic blood pressure	mm Hg	78	
Heart rate	beats/min	76	
Smoking	Daily		17
	Occasional		5
	None		78
Lipoprotein a	mg/L	236*	
Apolipoprotein A1	g/L	1.62	
Apolipoprotein B	g/L	0.92	
ApoB/Apo A1 ratio		0.56	
hs-CRP	µg/mL	0.92	

*only 265 donor had values above detection limit (80mg/L); hs-CRP: high sensitive C-reactive protein.

(80 mg/L) in 265 donors (52%), while the remainder had a median concentration of 236 mg/L. Median ApoA1 was 1.62 g/L, ApoB 0.92 g/L, and the ApoB/ApoA1 ratio 0.56. Median hs-CRP was 0.92 µg/mL (**Table IV**).

Health status

Although median values for most parameters were within or just above the normal range, several donors had out-of-range values. BMI ranged from 17.6 to 44.4 kg/m², with 44% in the recommended range (17.5-25 kg/m²), 42% overweight, 10% in obesity class I, 3.5% in class II, and 0.5% in class III. Normal systolic BP (<140 mmHg) was recorded in 61% of donors, while 7% had systolic BP ≥160 mmHg. Regarding smoking, 17% were regular smokers and 5% occasional smokers, consistent with national statistics[14]. Physical activity was generally low: 81% reported rarely exercising, 73% engaged in low-intensity activity, and 76% had not performed vigorous exercise in the previous 3 days (**Figure 2**).

Age correlated positively with BMI (ρ=0.219, p<0.001), BP (ρ=0.194, p<0.001; ρ=0.189, p<0.001), ApoB (ρ=0.403, p<0.001) and the ApoB/ApoA1 ratio (ρ=0.272, p<0.001), and negatively with HR (ρ=−0.123, p=0.006), while BMI itself correlated positively with BP (ρ=0.430, p<0.001;

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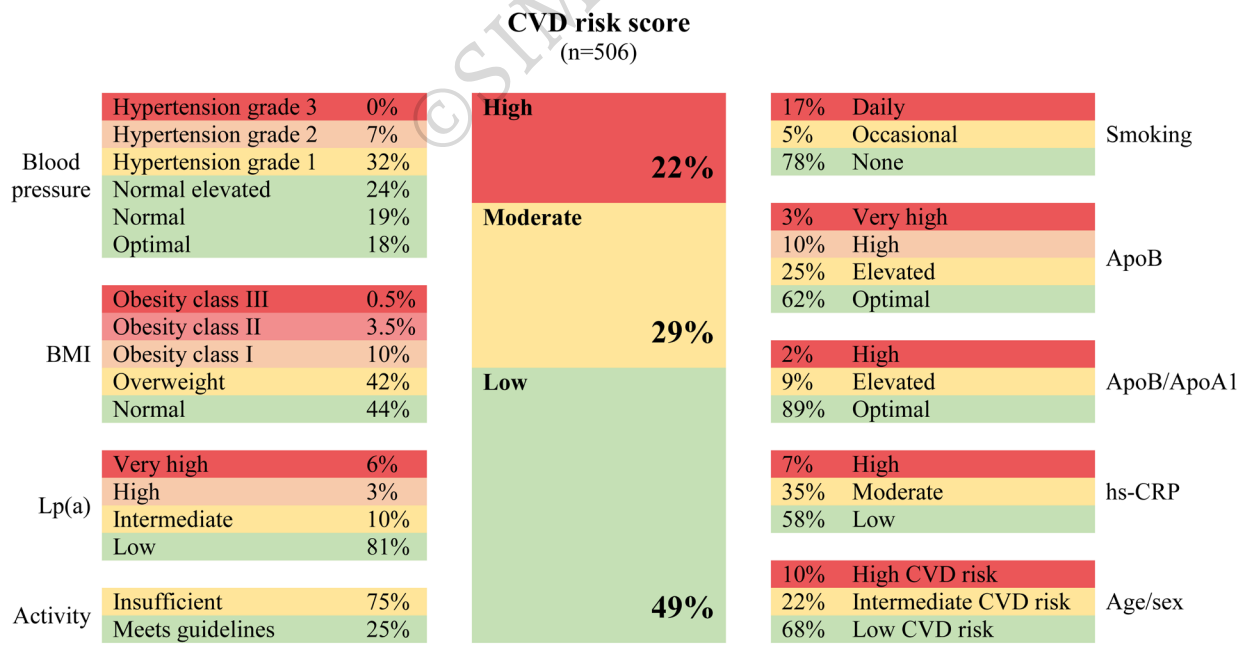


Figure 2 - Cardiovascular risk score with nine observed parameters
CVD: cardiovascular disease; BMI; body mass index; Lp(a): lipoprotein a; ApoB/A1: apolipoprotein B/A1; hs-CRP: high sensitive C-reactive protein.

ρ=0.389, p<0.001) and ApoB (ρ=0.338, p<0.001) but negatively with ApoA1 (ρ=–0.262, p<0.001). Systolic and diastolic BP were strongly interrelated (ρ=0.753, p<0.001) and both associated with higher HR (ρ=0.208, p<0.001; ρ=0.314, p<0.001) and ApoB (ρ=0.268, p<0.001; ρ=262, p<0.001). hs-CRP correlated with BMI (ρ=0.455, p<0.001) and BP (ρ=0.283, p<0.001; ρ=0.194, p=0.005).

In subgroup comparisons, women had lower BMI (p<0.001) and systolic BP (p<0.001) but higher HR (p<0.001), higher ApoA1 (p<0.001) and lower ApoB (p<0.001), resulting in a more favourable ApoB/ApoA1 ratio (p<0.001). D-negative donors had slightly lower BMI (p=0.037). Fasting donors were more often men (p=0.012), smokers (p=0.004), and physically active (p=0.019). Donors with higher exercise intensity or frequency tended to be younger (p=0.003), with lower HR (p<0.001).

CVD risk score

Based on the composite cardiovascular risk score, 49% of donors were classified as low risk, 29% as moderate risk, and 22% as high risk. When comparing by sex, more women were in the lower-risk category, while more men were classified as moderate or high risk (p<0.001) (**Figure 2**).

DISCUSSION

Blood donors represent a unique subset of the population, commonly perceived as healthier than the general public, a premise examined in this study. Beyond routine health assessments, additional health-related factors were investigated, with particular focus on CVD risk. Findings regarding the prevalence of chronic conditions and medication use among donors are consistent with the existing literature[15,16]. Notably, self-reported histories may underestimate true prevalence, as some studies identified discrepancies with objective findings, particularly for psychotropic drugs[17].

Although median values for most parameters were within or slightly above reference ranges, many donors showed significant deviations. Although BMI in this study was derived from self-reported weight and height, similar results have been observed in other blood donor studies[18-22]. Although a single measurement cannot establish a definitive diagnosis of arterial hypertension, some values were alarmingly high. Comparable results have been reported elsewhere, though cross-study comparisons are limited by genetic, ethnic, and lifestyle differences[21,23,24]. Elevated BP in donors without known hypertension remains a concern. Surveys from the UK and Angola report substantial proportions of donors with previously undetected hypertensive-range values, and incidental detection has led to donor deferral[25-27]. Some cases may reflect white coat syndrome, yet even this is associated with increased risk of developing true hypertension and CVD complications[28,29]. These findings underscore the value of routine BP screening during donation and the potential role of donation centres in raising hypertension awareness.

Within the healthy donor cohort, additional lipid and inflammatory markers were analyzed, including Lp(a), ApoB, the ApoB/ApoA1 ratio, and hs-CRP. These biomarkers are increasingly recognized as independent predictors of CVD risk, offering additional discriminatory value in apparently healthy populations. Our results are consistent with existing literature, which shows that while blood donors typically have lower levels of traditional lipid markers, they are not entirely protected from newer, independent CVD risk factors[9,30-33]. Elevated Lp(a) is a well-established genetically determined risk factor, largely unresponsive to lifestyle modification or standard lipid-lowering therapy[34,35]. Although median Lp(a) levels were within reference ranges in our cohort, some individuals showed markedly elevated values, indicating higher genetic risk even among ostensibly healthy adults. ApoB, reflecting the number of atherogenic lipoprotein particles, is considered a stronger predictor of CVD events than LDL cholesterol. In our sample, most values were within desirable limits; however, ApoB correlated significantly with other risk factors such as BMI and BP, consistent with prior findings emphasising its role in atherogenesis. The ApoB/ApoA1 ratio, reflecting the balance between atherogenic and protective lipoproteins, is among the strongest predictors of myocardial infarction in population studies[36,37]. While the ratio was within recommended limits for most donors, those with higher values represent a subgroup at increased risk. Similarly, hs-CRP, a marker of subclinical inflammation central to atherogenesis, was within the low range for most donors, but exceeded 3 mg/L in some, meeting criteria for high cardiovascular risk. This heterogeneity within an

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otherwise healthy cohort supports the utility of hs-CRP in screening strategies.

To integrate individual risk factors in this study, a composite CVD risk score that combined both traditional and novel markers was developed. Results showed that approximately one-quarter of donors classified as "healthy" fell into the high-risk category, with men more frequently affected than women– reflecting established sex differences in lipid metabolism, blood pressure, and hormonal protection before menopause. These findings confirm that even within healthy donor populations, a substantial prevalence of subclinical CVD risk exists. Based on available data, relatively few studies have specifically examined the risk of cardiovascular complications in blood donors. One large Italian screening study –the CARDIORISK study– assessed healthy donors aged 35-65 using Framingham-based risk scoring. While the majority (81.7%) had low cardiovascular risk, approximately 5.8% were classified as high risk. Strikingly, nearly all individuals in the high-risk group were men (357 men *vs* 2 women), highlighting not only the presence of subclinical risk but also it is markedly higher prevalence among male donors[38]. A more recent Italian study using a comparable cardiovascular risk scoring system reported that over 20% of donors exhibited moderate to high CVD risk. Specifically, 35% of male donors –but only 4% of female donors– had an estimated 10-year risk exceeding 3%, reinforcing the sex-related disparity in baseline cardiovascular predisposition within donor populations[32]. Large-scale databases such as SCANDAT offer a valuable resource to monitor long-term health outcomes in blood donors. Combined with routine donation screening, such data can support early identification of cardiovascular risk and reinforce the role of transfusion services in preventive health interventions[39,40]. This underscores the dual role of blood donation services: ensuring donor and recipient safety while simultaneously contributing to broader public health surveillance by facilitating early identification of at-risk individuals. On the other hand, although subclinical CVD risk is evident, several studies have explored whether frequent blood donation may offer a protective effect against future cardiovascular events. However, the evidence remains inconclusive and does not directly address baseline cardiovascular risk in otherwise healthy blood donors[41-43].

Although comprehensive, this study has some limitations. Data on diseases, medication use, BMI, and physical activity were self-reported, which may introduce recall and reporting bias. Importantly, blood pressure was assessed from a single measurement; therefore, a diagnosis of hypertension cannot be inferred, and higher values were accordingly weighted less in the CVD risk score. For example, hypertension grade 1 and overweight were considered of comparable importance and therefore scored equally. In contrast, although BMI was also self-reported, but it is likely to reflect the true status more accurately and was therefore given greater weight in risk scoring. The cross-sectional design limits causal interpretation and long-term prognostic insights. Future studies should include longitudinal follow-up, genetic profiling of risk markers such as Lp(a), and objective measures of lifestyle behaviours. Linking donor data with national health registries could yield deeper insights into cardiovascular trajectories in this population.

Beyond methodological considerations, transfusion services represent a valuable platform for health promotion and screening. With daily contact with a defined segment of the population, donation centres are ideally placed to deliver preventive interventions and integrate targeted screening programmes for conditions contributing substantially to the public health burden. In particular, regular repeat donors –who donate once or several times each year– provide an ideal cohort for longitudinal health monitoring, offering opportunities for early identification of risk factors and the promotion of sustained healthy behaviours. Ultimately, healthy blood donors remain the cornerstone of a safe and sustainable blood supply, and safeguarding their well-being is essential not only for donor and recipient safety but also for the resilience of healthcare systems.

CONCLUSIONS

Blood donors, while often considered healthier than the general population, exhibit a notable prevalence of subclinical CVD risk factors. Although median biomarker values were within reference ranges, a significant minority displayed elevated Lp(a), ApoB, ApoB/ApoA1 ratio, hs-CRP, BMI, or BP. A quarter of ostensibly healthy donors were classified as high risk using the composite CVD risk score, with men more frequently affected. These

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findings highlight the potential of blood donation services not only to safeguard transfusion safety but also to serve as platforms for early detection, prevention, and public health surveillance.

The Author declares no conflicts of interest.

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