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Factors associated with donation frequency among new and experienced blood donors: health literacy, knowledge, attitudes, fear and motivation

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Abstract

Background.

Romania's voluntary, non-remunerated donors give repeatedly, and national policy has recently expanded material incentives, yet whether repeated donation brings a better grasp of who may donate, and what distinguishes frequent from infrequent donors, is unknown. Among Romanian donors reached through a national blood donation application, we asked whether donation experience is associated with eligibility knowledge and with fear, whether knowledge tracks acceptance of blood from specific groups, and what independently correlates with donation frequency, including material incentives against intrinsic motivation.

Methods.

This cross-sectional survey ran in a national donor application, 13 July to 1 October 2025, among users aged 18 to 65 who had donated since 2023. It used the Romanian HLS-EU-Q16, a knowledge scale (31 items after review against national eligibility regulation), and motivation, attitude, fear and pain items. Of 1,646 respondents, 1,489 passed an attention check; analyses used chi-square, analysis of variance, correlation and hierarchical regression.

Results.

Respondents were experienced, 92.3% having donated at least twice. Health literacy was high (14.50 of 16) and knowledge moderate (70.1% correct). Knowledge did not differ by donation experience ($\eta^2 < .001$), whereas fear was lower among experienced donors ($\eta^2 = .084$); women knew more and feared more than men but donated less often ($d = 0.30$, 0.33 and 0.59). Knowing a rule went with accepting blood from eligible groups and refusing it from deferred ones. Adjusted for demographics, frequency rose with lower fear ($\beta = -.144$), stronger intrinsic motivation ($\beta = .066$) and higher knowledge ($\beta = .060$), fell with interest in health-related incentives ($\beta = -.093$), and was unrelated to health literacy ($\beta = .012$) or material incentives ($\beta = .055$; $R^2 = .219$). Donors ranked free blood tests highest among incentives (6.13 of 10, 45.7% rating them 8 or above) and meal vouchers and refreshments lowest (4.24 and 3.88).

Conclusions. Among

app-registered donors, experience was accompanied by less fear but no better eligibility knowledge, and health information outweighed the material incentives policy has expanded. Donor education should be delivered at every donation, fear reduction concentrated on first-time donors, and incentives built on the health monitoring donors already value.

1. Background

Blood components remain some of the most sought-after medical products worldwide, with the predicted supply of blood products managing to cover only about 90% of the global demand [1]. Scarcity of blood donors is a public health issue which is predominantly evident in lower- and middle-income countries [2], but it can affect the health systems of upper-income states as well. An estimated 120 million blood donations were collected worldwide in 2023; high-income countries, home to 15% of the world's population, collected 36% of them, and the median whole blood donation rate ranged from 4.5 per 1,000 population in low-income countries to 28.9 per 1,000 in high-income countries, with the WHO European Region spanning 5.0 to 53.8 donations per 1,000 population and a median of 30.9 [3]. Europe is also the only WHO region in which total whole blood collections have fallen over the last decade, by 3% between 2013 and 2018 and by a further 4% between 2018 and 2023, a decline concentrated in its high-income countries while collections in its middle-income countries rose over both periods [3]. Part of the high-income decline reflects patient blood management and more restrictive transfusion practice, but where it is not a response to reduced demand it is attributed to low birth rates, an aging donor base with too few young donors to replace it, and recruitment that fails to reach new groups [3]. Longitudinal data from one German region illustrate both mechanisms: over ten years, donation numbers closely followed the shrinking of the donor-age population [4], and over fifteen years the donation rate per 1,000 inhabitants fell by a further 19%, a loss of motivation beyond demography that was sharpest among younger donors [5].

Romania's trajectory has diverged from the regional one only briefly. Between 2008 and 2018 it was one of ten countries in the WHO European Region that reported an increase in whole blood collections and voluntary non-remunerated donations, against a regional median annual change of −1% [6]; in the same WHO series the national total has since drifted down, from 428,140 whole blood donations in 2013 to 416,769 in 2018 and 411,171 in 2023, of which 299,075 came from repeat donors [3]. Romania reported 18 donors per 1,000 inhabitants in 2018, against a median of 22 among the Council of Europe members reporting to the European Directorate for the Quality of Medicines and HealthCare [7], and in 2023, 323,662 people donated whole blood or apheresis components at least once, 1.7% of a population of 19.06 million [8], one of the five lowest shares among the 27 European Union Member States (donors in 2023, or 2022 for Ireland and Luxembourg, divided by the population on 1 January 2023), although Romania is the sixth most populous of them. Across the 38 members reporting to the Directorate, active donors grew by 1.1% a year and whole blood units by 2.1% a year between 2020 and 2023, a recovery from the pandemic trough; Romania was one of 13 members with an uninterrupted rise in whole blood units, from 313,843 in 2020 to 416,549 in 2023, and in 2023 first-time donors made up 35% of its active donors, the highest proportion in the Union and double the European median of 17% [9,10]. Despite constant pushes from the government, the private sector, and the civil society to boost the number of blood donations, efforts which amassed some success especially in recent years [11], the blood supply still does not manage to cover the requirements in Romanian hospitals. The Ministry of Health's program indicators record 425,153 units collected and tested in 2023 and 487,966 in 2024 [12,13], a rise of 15% in the year after the donor voucher was increased, but the same reports do not count donors separately

from donations, so whether the rise came from new donors or from more frequent donation by existing ones cannot be read from them.

Blood is collected by 41 public civil blood establishments coordinated by the National Institute of Blood Transfusion, together with a military establishment in Bucharest, which between them supply around 330 hospitals [14]; the Institute lists fixed transfusion centers in 40 of the 41 counties and in Bucharest, with more than one site in Argeș and Hunedoara and none in Ilfov [15], and several establishments also provide the possibility for blood collection, such as blood drives in smaller cities or communes or at private establishments, and select hospitals [16,17]. Donor screening combines a written questionnaire on medical, sexual and substance use history, with emphasis on recent lifestyle changes, with a clinical examination and a hemoglobin test; donation itself lasts 10 to 20 minutes under close monitoring, and donors are asked not to leave immediately so that reactions such as dizziness, weakness or nausea can be managed [18], after which units are tested for blood-borne infections, separated into components and delivered to local and regional hospitals [19]. Blood donation, processing, distribution and quality assurance is overseen by the Romanian Ministry of Health through the National Blood Transfusion Institute [20]. Blood donations are considered by law voluntary and non-remunerated [21,22]; benefits for giving blood include meal vouchers, one free day off, 50% discount on the subscription for local public transport or free public transportation in certain special situations, as well as various gifts through partnerships between local blood banks and sponsors or non-governmental organizations [14,23]. The value of the meal vouchers rose from about 68 lei to 280 lei per donation, roughly 14 to 56 euros, on 1 January 2024 [24]; transfusion centers reported attendance up by 70 to 80% in the first working days of the new scheme [25] and Cluj reported 15% more donors over the following months [11].

Two assumptions underlie donor education and retention policy in this setting. The first is that people who give blood repeatedly have learned, through repeated screening and contact with transfusion staff, who may donate and who may not. The evidence for this is thin. A national survey of 5,178 Australians found knowledge of the donation criteria limited: 29% of non-donors were unaware that criteria existed, one in eight eligible respondents believed themselves ineligible, and knowledge of the deferral periods attached to common exclusion factors was poor [26]. Among 350 first-time and repeat donors in Ghana, only 36% knew the minimum age and 38% the maximum number of donations per year [27], and among 536 Jordanian donors, 82% of them with previous donations, more than half of the first-time donors named lack of awareness as the reason they had not donated before [28]. Across 12,606 university students in 16 countries, fewer than three in ten had good knowledge of donation and one in three named medical ineligibility as a barrier [29]. Part of the difficulty lies in the rules themselves. National regulation defines eligibility as a mixture of permanent exclusions, temporary deferrals whose length depends on the exposure, and conditions whose answer depends on treatment or on the judgment of the selecting physician [30], and a deferral that is not explained is often misunderstood and costs the service the donor: in a cluster randomized trial, tailored written and spoken information raised deferred donors' understanding of when they could return and the odds that they rebooked [31]. Knowledge of the criteria also shapes what donors believe about the safety of blood from others; in the Belgian general population, prior awareness of an exclusion criterion predicted refusal to accept blood from the group it

concerned [32], so gaps in eligibility knowledge carry consequences for attitudes toward recipients' safety as well as for donors' own behavior.

The second assumption is that material benefits raise donation without changing why people give. National policy has moved decisively in this direction, and the January 2024 voucher increase was followed by a 15% rise in collected units within a year. Whether material rewards undermine the altruistic motivation on which voluntary systems rest, a question that goes back to Titmuss, remains contested. A systematic review of experimental studies found that incentives, financial or not, had no measurable effect on the likelihood of donation [33]; a meta-analysis of observational studies and natural experiments estimated a small positive marginal effect of monetary rewards, inconsistent with short-term crowding-out but silent on long-term effects [34]; field evidence has been read as grounds to reconsider guidelines against economic rewards altogether [35]; and a survey of the behavioral economics literature concluded that rewards work when donation is anonymous and can backfire when donors' public image is at stake [36]. No incentive has yet been identified that every donor segment views favorably, that increases donation and that leaves blood safety untouched, although discounts, gifts and paid time off have the strongest evidence in voluntary systems [37]. In Romania the quantitative evidence comes from medical students, among whom neither incentives nor altruism dimensions predicted willingness to donate [38], and from a national online survey in which only 15% of donors named vouchers and 10% a day off as their reason for giving [39]. How sensitivity to incentives relates to actual donation frequency in the wider donor population has not been examined.

The constructs examined here are defined as follows. Health literacy is understood in the sense of the European Health Literacy Survey, as the knowledge, motivation and competences to access, understand, appraise and apply health information in order to make decisions about healthcare, disease prevention and health promotion [40]; it is measured with the 16-item HLS-EU-Q16 in the Romanian version validated by Coman et al. [41]. Donation knowledge is treated as two domains, following the Blood Donation Knowledge Questionnaire and the Jordanian donor survey: general knowledge, of the physiology and procedure of donation and of the testing of donated blood, and eligibility knowledge, of who may donate and who must be deferred under national regulation [28,42]. Knowledge, attitudes and practices are used in the sense of the KAP survey framework, in which what people know, what they believe and what they do are measured separately so that the gaps between them can be located [43 attitude and practice surveys]. Donation-related fear denotes fear of the stimuli specific to giving blood, having blood drawn, needles, the sight of blood, pain and fainting; it is reported at every level of donation experience, declines but does not disappear with repeated donation [44,45], and is associated with more pain and vasovagal symptoms, with weaker intention to donate again [44] and with the attrition of first-time donors [46]. Motivation is classified after self-determination theory into intrinsic motivation, acting for the value or satisfaction inherent in the act, and extrinsic motivation, acting for a separable outcome [47]; in donors the former takes the form of altruism and civic duty in their several varieties [48,49], while the latter is split here into material incentives, meal vouchers, refreshments and a day off work, and what we call pragmatic incentives, the health monitoring and convenience that donation can offer through free blood tests and mobile collection, a division that follows the separation

of monetary from non-monetary rewards in the incentive literature [37]. Voluntary non-remunerated donation is used in the WHO's sense, blood given of the donor's own free will without payment in cash or in kind that could be regarded as a substitute for money, with tokens of recognition, refreshments and reimbursement of direct costs regarded as compatible with it [50]; it is the model that Romanian law prescribes [21].

Few studies have examined the behavior of Romanian blood donors, and none has done so among active donors reached through a donation platform. This study describes health literacy, donation knowledge, attitudes, fear and donation practice among Romanian donors reached through a national blood donation application, and asks three questions: whether donation experience is associated with eligibility knowledge and with fear; whether eligibility knowledge is associated with the willingness to accept blood from specific groups of donors; and what independently correlates with lifetime donation frequency and with knowledge, including sensitivity to material incentives set against intrinsic motivation. It also reports how donors rank incentives and barriers, and whether interest in incentives is inversely related to intrinsic motivation. The Results take these in turn, and the Discussion sets them against the European and Romanian literature.

2. Methods

2.1. Study Design and Setting

This study employed an observational, cross-sectional design to evaluate health literacy, knowledge, attitudes, practices, and fears regarding blood donation among Romanian donors reached through a national blood donation application. The instrument, adapted from questionnaires used in other countries and including the Romanian version of the European Health Literacy Survey Questionnaire, is described in section 2.6. The research was conducted at a national level through the digital infrastructure of the "BlooDoChallenge" mobile application, a donor management platform with over 200,000 registered users across Romania. Data collection was carried out over a two-and-a-half-month period between 13 July and 1 October 2025. The study is reported in accordance with the STROBE recommendations for cross-sectional studies (Additional file 1).

2.2. Participants & Eligibility

The target population comprised adult blood donors residing in Romania who were registered users of the application. Participants were eligible if they held an active registration on the BlooDoChallenge platform, were aged between 18 and 65 years, and had a documented history of at least one blood donation in 2023, 2024 or 2025. To ensure valid consent and comprehension, participation was restricted to individuals proficient in the Romanian language. The digital platform automatically filtered eligibility, presenting the survey landing page only to users meeting these donor activity criteria. The protocol specified a minimum of 385 respondents and anticipated at least 1,000; no upper limit was set, and every registered user who met the criteria during the collection window was invited.

2.3. Data Collection Procedure

Data collection was executed digitally via the BlooDoChallenge mobile application interface. Eligible users accessing the platform were presented with a study invitation and a digital informed consent form. Upon providing consent, participants gained access to the self-administered questionnaire. To encourage participation and mitigate non-response bias, a gamification incentive was employed: respondents were awarded 40 virtual points within the application upon survey completion. These points are part of the platform's existing reward system, allowing users to redeem coupons or discounts from partner entities. All response data were automatically captured and subsequently exported into a .csv format for analysis.

2.4. Quality Control & Exclusion

To identify careless responding, an instructed-response item was embedded within the survey. The 157 respondents who failed it were excluded, yielding a final analytical sample of 1,489 of 1,646 respondents.

2.5. Ethical Considerations

The study protocol was reviewed and approved by the Ethics Committee of the "Iuliu Haţieganu" University of Medicine and Pharmacy Cluj-Napoca (Approval No. AVZ 116 of 9 May 2025; study registration DEP96/12.03.2025). Data collection began on 13 July 2025, after approval had been granted. The research was conducted in full compliance with the Declaration of Helsinki and the General Data Protection Regulation (GDPR - EU 2016/679). Prior to accessing the questionnaire, all participants were provided with detailed information regarding the study's objectives, the voluntary nature of participation, and their right to withdraw at any time without consequence. Digital informed consent was obtained from all respondents before data collection commenced. All data were collected and processed in an anonymized format to ensure participant confidentiality.

2.6. Measures

The questionnaire comprised 120 items in six sections: socio-demographic characteristics, health literacy, donor knowledge, attitudes and motivation, donation practice, and fears and somatic experience. The instrument was assembled from existing measures rather than written de novo. Health literacy was measured with the Romanian version of the HLS-EU-Q16, used without modification [41]. The knowledge section was adapted from the Blood Donation Knowledge Questionnaire [42], and the demographic and motivation items from the Jordanian donor survey of Omaish et al. [28]; dichotomous scoring follows Enawgaw et al. [51]. The incentive items were adapted from Omaish et al. [28], and the fear and pain items from Bani et al. [45]. The attitude items, together with the design that pairs each eligibility criterion with willingness to accept blood from the corresponding donor group, follow Avau et al. [32]. Wording and response options were adjusted to Romanian regulation and practice, and items with no counterpart in these instruments, principally the eligibility scenarios keyed to Romanian deferral

criteria, were written for this study. The questionnaire was administered in Romanian throughout and is available from the corresponding author.

2.6.1. Socio-Demographic Characteristics

Socio-demographic characteristics were assessed using an 11-item section of the questionnaire. Participants reported their biological sex (male, female), nationality (Romanian, non-Romanian), and area of residence (urban, rural). Age was categorized into six groups: <20, 20–29, 30–39, 40–49, 50–59, and ≥ 60 years. Family and social status were evaluated through marital status and parental status (presence of children). Socio-economic indicators included the highest level of formal education completed (ranging from primary education to higher education) and current occupational status. Additionally, participants rated their self-perceived health status on a 4-point Likert scale ranging from "very bad" to "excellent". To determine geographic distribution, participants indicated the blood transfusion center where they donate most frequently and the center where they made their most recent donation. A "prefer not to answer" option was available for all sensitive demographic questions.

2.6.2. Health Literacy

Health literacy was assessed using the Romanian version of the European Health Literacy Survey Questionnaire (HLS-EU-Q16), translated and validated for Romania by Coman et al. [41]. This 16-item instrument evaluates the participants' perceived difficulty in accessing, understanding, appraising, and applying health information across three domains: healthcare, disease prevention, and health promotion. Specific items assessed competencies such as finding information on treatments, understanding medical instructions, and interpreting health warnings in the media. Responses were recorded on a 4-point Likert scale ranging from "very difficult" to "very easy". Scoring followed the procedure applied in the Romanian validation [41]: responses were dichotomized, with "very difficult" and "fairly difficult" scored 0 and "fairly easy" and "very easy" scored 1, and summed to yield a composite ranging from 0 to 16, with higher values indicating a higher level of health literacy. In the current sample, the scale demonstrated excellent internal consistency (Cronbach's $\alpha = 0.899$), exceeding the $\alpha = 0.841$ obtained in the Romanian validation sample [41].

2.6.3. Knowledge Scales

Donor knowledge was evaluated using a scale developed for the Romanian national context and aligned with national blood safety regulation. The instrument was constructed on the model of the Blood Donation Knowledge Questionnaire (BDKQ-Brazil) [42], which derives its items jointly from the donation requirements issued by the national health ministry and from beliefs current in the general population; our items were assembled in the same way, from Romanian donor eligibility regulation and from misconceptions encountered in Romanian donor education. About half of the items were adapted from that instrument, and the rest, principally the national testing panel and the eligibility scenarios keyed to Romanian deferral rules, were written for this study [28,42]. Items were dichotomized for analysis (1 = Correct, 0 = Incorrect), as in Enawgaw et al. [51], and "Don't Know" responses were recoded as incorrect

to measure definitive knowledge. Thirty-eight items were administered. Prior to analysis, all items were reviewed against the governing regulation (see Section 2.7.1), and seven were removed because they had no single verifiable correct answer. The analyzed scale therefore comprises 31 items across two sub-domains.

The General Knowledge subscale (17 items, scored 0 to 17) assessed understanding of the physiological and legal aspects of donation. Items covered the "universal donor" blood type, minimum weight requirements, the legality of paid donation, procedural details such as the duration of donation and the volume collected, and mandatory screening for transfusion-transmissible infections (HIV, hepatitis B, syphilis, HTLV and others). The Eligibility Knowledge subscale (14 items, scored 0 to 14) presented specific donor scenarios to test knowledge of deferral criteria, including temporary deferrals (recent travel, pregnancy, recent tattoo), permanent exclusions (history of cancer, intravenous drug use) and eligible but frequently misunderstood conditions (smokers, heavy machinery operators, medical staff). The deferral scenarios were chosen to match the categories on which donor attitudes were separately assessed (Section 2.6.6), following the design used by Avau et al. [32], who paired awareness of each exclusion criterion with willingness to accept blood from the corresponding group. A Total Knowledge Score (range 0–31) was calculated by summing the two subscales, with higher scores reflecting greater mastery of donation protocols.

2.6.4. Motivational Drivers

Motivational drivers for blood donation were assessed using a series of items derived from the literature on donor behavior, measuring both internal and external incentives. The items were adapted from those administered to Jordanian donors by Omaish et al. [28], with the incentives distributed across a material and a health-related dimension. Responses were recorded on a 10-point scale ranging from 1 ("not at all agree") to 10 ("totally agree"). Three distinct motivational constructs were operationalized.

Intrinsic motivation captured altruistic and civic-minded drivers, with items assessing the extent to which participants viewed blood donation as an "ethical act," a "civic duty to the country," and a "healthy personal habit"; the item on "mandatory donation" was excluded from the composite score to preserve the construct's focus on voluntary internal drive. Extrinsic (material) incentives measured responsiveness to tangible rewards, namely the likelihood of donating if offered "meal vouchers," "snacks/refreshments," or a "day off work." Pragmatic (health and access) incentives captured motivations related to logistical convenience and personal health monitoring, through the appeal of "free medical blood tests" and the availability of "mobile donation drives in public spaces."

2.6.5. Psychological Barriers (Fears & Somatic Experience)

Psychological barriers to donation were evaluated using a 5-item Fear Inventory adapted from Bani et al. [45,52]. Participants rated the intensity of fear triggered by five stimuli: the blood draw process from the arm, the needles used, the sight of blood, the sensation of pain, and the sensation of fainting or dizziness. Responses were captured on the 5-point scale used by Bani et al., ranging from 1 ("Not at all") to 5 ("Extremely") [45]. For analytical purposes, these items were summed to create the Composite Fear

Score (theoretical range: 5–25), where higher scores indicate a higher level of procedural anxiety. In the current study, this composite measure demonstrated strong internal consistency (α = 0.778). To evaluate the physical burden of donation, participants rated the intensity of pain experienced during their most recent donation. Two items assessed the pain of needle insertion and the discomfort experienced while the needle was in the arm, corresponding to the two pain ratings used by Bani et al. [45], recorded here on a visual analog-style scale ranging from 0 ("No pain") to 100 ("Excruciating pain").

2.6.6. Attitudes (Social Tolerance & Risk)

Donor attitudes regarding eligibility and blood safety were assessed using a series of hypothetical scenarios adapted from Avau et al. [32], who asked a general-population sample in Flanders to rate their willingness to accept donated blood from people in each of several deferred or contested categories, including people who had ever injected drugs, people who had ever engaged in prostitution, pregnant women, people who had recently traveled outside Europe, and people who had recently been tattooed. Participants were asked to rate their willingness to receive a blood transfusion from donors with specific behavioral or medical histories on the same 10-point scale used in that study, ranging from 1 ("Definitely would not accept") to 10 ("Definitely would accept"), and retaining its time-qualified item wording. Based on item analysis and reliability testing, two distinct attitudinal composite scores were derived.

The Social Tolerance scale evaluated willingness to accept blood from eligible but potentially socially stigmatized groups; the final composite included acceptance of smokers and heavy machinery operators. The Risk Acceptance scale assessed participants' scrutiny of high-risk behaviors that typically warrant deferral, and comprised acceptance of donors with a history of intravenous drug use (dating back 10 years) and a history of prostitution. Items with near-universal rejection rates, such as HIV-positive donors, were excluded from the composite risk score to ensure psychometric validity, though they were retained for individual frequency analysis.

2.6.7. Donation Practice

Donation behavior and history were assessed through self-reported measures focusing on frequency, context, and advocacy. Lifetime donation frequency was measured using an ordinal scale with five categories: 1 donation, 2–5 donations, 6–10 donations, 11–20 donations, and > 20 donations. For analytical purposes, these data were recoded into a three-level Donor Career Stage variable: "Novice" (first-time donors), "Regular" (2–10 donations), and "Veteran" (> 10 donations), reflecting the degree of habituation. The banding was adapted from the donation-history categories used by Bani et al. to stratify donors by experience [45].

To evaluate the context of donation, participants estimated the proportion of their lifetime donations that were directed (made for a specific person or acquaintance), measured on a 4-point scale from "None" to "More than two-thirds." This distinction corresponds to the voluntary versus replacement donor typology used by Enawgaw et al. [51]. A parallel item on voluntary (non-directed) donation was administered but is not reported; see Limitations. Social advocacy was assessed by a binary item asking whether the participant had ever actively encouraged others to donate blood.

2.7. Statistical Analysis

Data management and statistical analyses were performed using IBM SPSS Statistics (Version 31.0 for macOS; IBM Corp., Armonk, NY). Descriptive statistics were computed to characterize the sample, utilizing frequencies and percentages for categorical variables (e.g., gender, residence, donor career stage) and means with standard deviations (SD) for continuous variables (e.g., age, knowledge scores, motivational indices). Missing data were handled using listwise deletion for multivariate analyses to ensure consistent sample sizes across models, while valid percentages excluding missing cases were reported for descriptive indicators. Statistical significance was established at a threshold of $p < .05$ (two-tailed) for all tests.

2.7.1. Psychometric Evaluation

The psychometric properties of the multi-item scales were evaluated using Cronbach's alpha (α); for the dichotomous knowledge items this is equivalent to the Kuder-Richardson 20 coefficient. Reliability was assessed for the Health Literacy Survey (HLS-EU-Q16), the Fear Inventory, the Knowledge scales (General, Eligibility and Total), the Motivational Driver scales (Intrinsic, Extrinsic, Pragmatic) and the Attitude scales (Social Tolerance, Risk Acceptance). An iterative item analysis was employed for the attitudinal scales to identify and remove items that reduced scale reliability. Separately, and prior to any analysis of scores, the 38 knowledge items were reviewed against the consolidated text of Order of the Minister of Health No. 1193/2007 on the admissibility of blood donors, in force as amended to 9 April 2015 [30]. Items whose correct response was conditional on information the item did not specify, or whose premise the regulation does not support, were judged to lack a single verifiable answer and were removed by author consensus. Seven items met these criteria. This review took place after data collection; it was driven by the regulatory text rather than by the observed data, and all analyses are reported for both the reduced and the full item sets.

2.7.2. Bivariate Analysis

Bivariate associations were examined to identify preliminary relationships between variables. Pearson's Chi-square tests of independence ($\chi 2$) were utilized to evaluate the concordance between categorical variables, specifically testing the association between the accuracy of eligibility knowledge (correct vs. incorrect) and the willingness to accept blood from specific donor profiles (accept vs. reject). Effect sizes for these associations were reported using the Phi coefficient (ϕ). Group differences in continuous outcome measures, such as Health Literacy scores and self-reported pain intensity, were assessed using Independent Samples t-tests for dichotomous grouping variables (e.g., Education Level, Gender) and One-Way Analysis of Variance (ANOVA) for polytomous variables (e.g., Age Group). Post-hoc comparisons for ANOVA were conducted using Tukey's HSD test to identify specific group differences. Where Levene's test indicated unequal variances, the Alexander-Govern test was computed as a check. Effect sizes are reported as η^2 for analysis of variance, Cohen's d for t-tests and ϕ for chi-square tests;

Spearman's ρ was used where a variable was ordinal. Acceptance ratings were dichotomized at the scale midpoint, with 6 to 10 coded as accept and 1 to 5 as reject.

2.7.3. Correlation Analysis

Pearson’s product-moment correlation coefficient (r) was calculated to examine the interrelationships between continuous psychometric variables and behavioral outcomes. Specifically, correlation matrices were generated to assess the strength and direction of associations between Health Literacy scores, specific domains of Knowledge (General and Eligibility), and Donation Frequency. Furthermore, correlations were utilized to test theoretical assumptions regarding the relationship between Intrinsic Motivation and the desire for Extrinsic or Pragmatic incentives. Finally, the association between anticipated psychological barriers (Fear scores) and somatic experience (self-reported Pain intensity) was analyzed to evaluate the potential psychological amplification of physical symptoms during the donation process.

2.7.4. Hierarchical Regression

To isolate the independent predictors of donation behavior and knowledge, hierarchical linear regression analyses were conducted. The primary model, predicting lifetime donation frequency, utilized a four-stage entry method to assess the incremental explanatory power (ΔR^2) of distinct theoretical domains. Socio-demographic controls (age, gender, student status, education, residence, self-perceived health, partnership status and parental status) were entered first as the structural baseline, followed by the competence measures (Total Knowledge Score and health literacy), then the psychological inhibitors (Composite Fear Score, social tolerance and risk acceptance), and finally the motivational constructs (intrinsic motivation and sensitivity to pragmatic and material incentives). The blocks were ordered so that each set of potentially modifiable factors was tested after the structural characteristics that precede it; the coefficients of the final model do not depend on the order of entry, only the increments in R^2 do.

A secondary three-stage hierarchical model was constructed to identify predictors of the Total Knowledge Score, entering gender, age, education, student status and residence first, health literacy and donation frequency second, and intrinsic motivation, sensitivity to pragmatic incentives and the Composite Fear Score third. Post-estimation diagnostics were performed for all models; multicollinearity was assessed using Variance Inflation Factors (VIF), with a threshold of < 5 indicating the absence of problematic collinearity. All VIF values fell between 1.01 and 1.68. Every model was estimated twice, once using the 31-item Total Knowledge Score and once using the full 38-item score, to establish whether the item reduction altered any inferential conclusion.

3. Results

3.1. Socio-Demographic Characteristics

The final analytical sample consisted of 1,489 blood donors. As shown in Table 1, the sample was predominantly male (62.3%) and resided in urban settings (81.5%). The largest proportions of donors fell

into the 30–39 age group (33.2%) and 40–49 age group (28.4%). A substantial majority of respondents (73.5%) reported having university-level education. Geographically, the sample was distributed across all development regions of Romania, with the highest participation from the North-West (28.5%), North-East (19.6%), and Bucharest-Ilfov (18.3%) regions.

Most respondents were experienced donors, with 43.0% classified as veterans (> 10 lifetime donations) and 49.4% as regular donors (2–10 donations). Only 7.7% were novice or first-time donors. Regarding donation context, 62.5% reported that none of their donations had been directed toward a specific acquaintance, 29.8% reported up to one third, 5.8% between one and two thirds, and 1.9% more than two thirds.

Table 1
Socio-Demographic and Donation Characteristics of the Study Sample

Characteristic	Category	N	%
Gender	Male	927	62.3
	Female	561	37.7
Age Group	< 20 years	61	4.1
	20–29 years	358	24.0
	30–39 years	495	33.2
	40–49 years	423	28.4
	50–59 years	146	9.8
	60 + years	6	0.4
Education Level	Non-University	392	26.5
	University	1,085	73.5
Marital Status	Married	791	53.1
	In a relationship	304	20.4
	Single	261	17.5
	Divorced/Widowed/Other	133	8.9
Area of Residence	Urban	1,208	81.5
	Rural	274	18.5
Region (Romania)	North-West	425	28.5
	North-East	292	19.6
	Bucharest-Ilfov	272	18.3
	Center	212	14.2
	West	178	12.0
	South-Muntenia	72	4.8
	South-West Oltenia	23	1.5
	South-East	15	1.0
Donor Career Stage	Novice (First-Time)	114	7.7

Note. N ranges from 1,477 to 1,489 due to occasional missing data. Percentages reported are valid percentages excluding missing cases.

Characteristic	Category	N	%
	Regular (2–10 donations)	735	49.4
	Veteran (> 10 donations)	640	43.0
Donation Context	Directed donations: none	930	62.5
	Directed donations: up to one third	444	29.8
	Directed donations: between one and two thirds	87	5.8
	Directed donations: more than two thirds	28	1.9
	Encouraged others to donate (Yes)	1,469	98.7

Note. N ranges from 1,477 to 1,489 due to occasional missing data. Percentages reported are valid percentages excluding missing cases.

3.2. Scale Reliability and Validation

Internal consistency was assessed using Cronbach's Alpha for all composite measures (Additional file 2: Table S1. Reliability Analysis and Composition of Study Scales). The 31-item Total Knowledge Scale demonstrated moderate reliability (α = 0.665). Examined as sub-domains, the 14-item Eligibility Knowledge subscale showed α = 0.578 and the 17-item General Knowledge subscale α = 0.517. The full 38-item scale administered before the content-validity review yielded α = 0.702, with subscale values of 0.663 (20 items) and 0.508 (18 items). The reduction is consistent with the change in test length: applying the Spearman-Brown prophecy formula, a 31-item test drawn from the 38-item scale would be expected to yield α = 0.658, against the 0.665 observed, and a 14-item Eligibility subscale would be expected to yield 0.579, against 0.578 observed. The General subscale improved on both the observed and the predicted value. Ceiling effects were pronounced, with 7 of the 31 items answered correctly by more than 90% of respondents and 4 by more than 95% (17 and 13 items, respectively, among respondents who gave a definite answer).

The Health Literacy Survey (HLS-EU-Q16) demonstrated excellent internal consistency (α = 0.899). The 5-item Fear Inventory (fears of needles, pain, fainting, etc.) demonstrated strong reliability (α = 0.778) and was summed into the Composite Fear Score used in the analyses.

Regarding motivational drivers, the **Extrinsic Incentive** scale (vouchers, snacks, time off) demonstrated acceptable reliability (α = 0.729). The **Pragmatic Incentive** scale (health tests, mobile access) showed lower consistency (α = 0.410) and the **Intrinsic Motivation** scale (ethical act, civic duty, healthy habit) low internal consistency (α = 0.351). Both composites were retained.

For the attitudinal dimensions, an iterative process was employed to refine the scales. The **Social Tolerance** scale (acceptance of smokers and heavy machinery operators) achieved marginal reliability (α =0.603) after item refinement. The **Risk Acceptance** scale (willingness to accept blood from past IV drug users and sex workers) showed improved consistency (α=0.677) after excluding the HIV item.

3.3. Descriptive Statistics of Study Measures

Table 2 presents the descriptive statistics for the key study variables, including composite scores and their constituent items. The sample demonstrated a high level of health literacy (M = 14.50, SD = 2.04), with 86.4% of participants classified as having adequate literacy. Knowledge of donation was moderate: participants answered 70.1% of the 31 scored items correctly (M = 21.74, SD = 3.55), with comparable performance on the General (M = 11.84, SD = 2.11; 69.6% correct) and Eligibility (M = 9.90, SD = 2.18; 70.7% correct) subscales.

Regarding motivation, donors exhibited strong **Intrinsic Motivation** (M = 8.65). Participants agreed most strongly that donation is an "ethical act" (M = 9.50) or a "healthy habit" (M = 9.50), and less strongly that it is a "civic duty to the country" (M = 6.96). **Extrinsic (Material) Motivation** was lower overall (M = 4.54); within it, a **day off work** (M = 5.51) was rated above meal vouchers (M = 4.24) and snacks (M = 3.88). **Pragmatic Motivation** (Health/Access) scored moderately (M = 5.72), with free medical blood tests rated highest (M = 6.13).

The Composite **Fear Score** (M = 6.46) was low (on a 5–25 scale); fear of pain (M = 1.33) and needles (M = 1.31) were marginally higher than the fear of the sight of blood (M = 1.23).

Social Tolerance was high (M = 8.15); acceptance of blood from heavy machinery operators was rated at M = 8.42. **Risk Acceptance** was low (M = 3.93), with past IV drug use (M = 4.00) rated slightly above past prostitution (M = 3.87).

Table 2
Descriptive Statistics of Scales and Constituent Items (N = 1,489)

Measure and Item Description		Mean	SD	Min	Max
Health Literacy	HLS-EU-Q16 Score	14.5	2.04	3	16
Knowledge Scores	Total Knowledge Score (Sum of General + Eligibility)	21.74	3.55	2	31
	General Knowledge Subscale (Donation process & safety)	11.84	2.11	1	17
	Eligibility Knowledge Subscale (Deferral criteria & risks)	9.90	2.18	1	14
Motivational Drivers (Scale: 1–10)	**Intrinsic Motivation (Composite Index)**	**8.65**	**1.52**	**1**	**10**
	Perception of donation as an ethical act	9.5	1.45	1	10
	Perception of donation as a healthy personal habit	9.5	1.3	1	10
	Perception of donation as a civic duty to the country	6.96	3.46	1	10
	Pragmatic Incentives (Composite Index)	**5.72**	**2.93**	**1**	**10**
	Incentive: Access to free medical blood tests	6.13	3.71	1	10
	Incentive: Convenience of mobile drives in public spaces	5.31	3.69	1	10
	Extrinsic Incentives (Composite Index)	**4.54**	**2.89**	**1**	**10**
	Incentive: Granting a day off work	5.51	3.88	1	10
	Incentive: Providing meal vouchers	4.24	3.44	1	10
	Incentive: Availability of snacks/refreshments	3.88	3.44	1	10
Barriers & Attitudes	**Composite Fear Score (Scale: 5–25)**	**6.46**	**2.44**	**5**	**25**
	Fear of pain during procedure (1–5)	1.33	0.65	1	5
	Fear of needles / injection (1–5)	1.31	0.7	1	5

Note. Values represent Means (M) and Standard Deviations (SD). **Motivation and Attitude items** were measured on a 10-point Likert scale ranging from 1 ("Strongly Disagree" or "Very Unlikely") to 10 ("Strongly Agree" or "Very Likely"). **Fear items** were measured on a 5-point scale ranging from 1 ("Not at all afraid") to 5 ("Extremely afraid"). Composite **Fear Score** is an additive index of the 5 fear items (range 5–25).

Measure and Item Description		Mean	SD	Min	Max
	Fear of fainting or dizziness (1–5)	1.31	0.71	1	5
	Fear of blood draw from the arm (1–5)	1.27	0.63	1	5
	Fear of sight of blood (1–5)	1.23	0.66	1	5
	Social Tolerance (Composite Index)	**8.15**	**2.35**	**1**	**10**
	Willingness to accept blood from heavy machinery operators	8.42	2.59	1	10
	Willingness to accept blood from smokers	7.88	2.94	1	10
	Risk Acceptance (Composite Index)	**3.93**	**3.04**	**1**	**10**
	Willingness to accept blood from past IV drug users	4	3.56	1	10
	Willingness to accept blood from past sex workers	3.87	3.43	1	10

Note. Values represent Means (M) and Standard Deviations (SD). **Motivation and Attitude items** were measured on a 10-point Likert scale ranging from 1 ("Strongly Disagree" or "Very Unlikely") to 10 ("Strongly Agree" or "Very Likely"). **Fear items** were measured on a 5-point scale ranging from 1 ("Not at all afraid") to 5 ("Extremely afraid"). Composite **Fear Score** is an additive index of the 5 fear items (range 5–25).

3.4. Association between Eligibility Knowledge and Willingness to Accept Blood

To evaluate the concordance between medical knowledge and donor attitudes, Pearson's Chi-square tests of independence were conducted across five donor scenarios for which a verifiable eligibility answer exists. The analysis compared participants' knowledge of eligibility criteria (Correct vs. Incorrect) against their willingness to accept blood from specific donor profiles (Accept vs. Reject). The results, detailed in Table 3, indicate significant associations in four of the five scenarios, with the direction of association varying by condition.

For the two eligible groups (smokers and heavy machinery operators), accurate knowledge was positively associated with higher acceptance rates. Among participants who correctly identified heavy machinery operators as eligible, 90.2% indicated willingness to accept blood, compared to only 35.4% among those with incorrect knowledge ($\chi^2 = 134.16$, $p < .001$). A moderate positive effect size was observed ($\phi = .32$).

For the two deferred groups, recent tattoo and past prostitution, the association ran the other way. Donors who knew these groups were deferred rejected their blood at high rates: 87.5% for recent tattoo and 92.6% for past prostitution. By contrast, 69.1% of donors who incorrectly believed a recently tattooed

person was eligible stated they would accept such blood (χ2 = 158.89, p < .001, ϕ = −.34). HIV status served as a validity control: rejection of HIV-positive blood was near-universal (99.4%) irrespective of knowledge (χ2 = 0.012, p = .911).

Table 3
Chi-Square Analysis of the Association Between Knowledge Accuracy and Willingness to Accept Blood (N = 955 to 1,464)

Scenario (Medical Status)	Knowledge Status	N	% Accepting Blood[a]	χ2 (1)	ϕ
Smoker (Eligible)	Correct	1,408	81.40%	69.67***	0.22
	Incorrect	28	17.90%		
Heavy machinery operator (Eligible)	Correct	1,298	90.20%	134.16***	0.32
	Incorrect	48	35.40%		
Recent Tattoo (Ineligible)	Correct	1,271	12.50%	158.89***	-0.34
	Incorrect	68	69.10%		
Past prostitution (Ineligible)	Correct	394	7.40%	230.49***	-0.49
	Incorrect	561	55.10%		
HIV (Ineligible)	Correct	1,462	0.60%	0.012 (ns)	0
	Incorrect	2	0.00%		

Note. Degrees of freedom (df) = 1 for all tests. Respondents answering 'don't know' to the knowledge item are excluded from that scenario. χ2 = Pearson Chi-Square statistic. ϕ = Phi coefficient (measure of effect size for 2 × 2 tables); ns = not significant; positive values indicate that Correct Knowledge is associated with Acceptance; negative values indicate Correct Knowledge is associated with Rejection. [a] Acceptance is dichotomized from a 10-point Likert scale, where scores of 6–10 indicate "Accept" and 1–5 indicate "Reject." *** p < .001

3.5. Health Literacy Profile and Association with Knowledge and Donation Behavior

The study population demonstrated a high level of health literacy (M = 14.50, SD = 2.04). We examined variations in this capacity based on socio-demographic factors and its relationship with domain-specific knowledge and donation behavior (Additional file 2: Table S2. Health Literacy Scores by Demographic Characteristics). Education level was not significantly associated with health literacy. Donors with university education scored marginally higher (M = 14.56, SD = 1.98) than those without university degrees (M = 14.33, SD = 2.18), but the difference did not reach statistical significance; t(1475) = -1.94, p = .052. Across the four education levels the Spearman correlation with health literacy was likewise small (ρ = .044, p = .094). Self-rated health, by contrast, was clearly associated with health literacy: donors reporting excellent health scored higher (M = 14.72, SD = 1.85) than those reporting moderate health (M = 13.91, SD = 2.34); t(1476) = 6.87, p < .001, d = 0.40 (a single respondent reported very bad health and is

excluded from this comparison). Health literacy did not differ by gender (women M = 14.61, SD = 1.80; men M = 14.43, SD = 2.16; t(1486) = 1.59, p = .112). Age groups also differed in health literacy (F(5, 1483) = 2.99, p = .011, η2 = .010). Post hoc Tukey comparisons showed that donors aged 50–59 (M = 14.86) had higher scores than those aged 20–29 (M = 14.23, p = .019), and the 40–49 age group (M = 14.65) scored higher than the 20–29 group (p = .050).

Bivariate Pearson correlation analyses were conducted to assess the interrelationships between health literacy, specific domains of donation knowledge, and donation frequency (Additional file 2: Table S3. Correlations Between Health Literacy, Knowledge Domains, and Donation Frequency). Health literacy showed a positive, statistically significant but very weak correlation with the Total Knowledge Score (r = .088, p < .001). Disaggregated by domain, health literacy correlated with both General Knowledge (r = .081, p = .002) and Eligibility Knowledge (r = .064, p = .013), with effect sizes below .10 in every case. Health literacy showed a comparably weak association with donation frequency (r = .058, p = .025). Neither the Total Knowledge Score (r = .021, p = .418) nor its General (r = .022, p = .388) or Eligibility (r = .013, p = .629) subscale was associated with donation frequency. All of these coefficients fall below r = .10 and none accounts for more than 1% of shared variance.

3.6. Determinants of Donation Frequency: A Hierarchical Analysis

A four-stage hierarchical linear regression analysis was conducted to examine the independent contributions of socio-demographic, cognitive, psychological, and motivational factors to lifetime donation frequency. The final model was statistically significant, F(16, 1447) = 25.36, p < .001, accounting for 21.9% of the variance in donation frequency (R2 = .219).

In the fully adjusted model, seven variables remained independently associated with lifetime donation frequency: age, gender, student status, total knowledge score, composite fear score, intrinsic motivation and sensitivity to health-related incentives (Table 4). Age was the strongest of these (β = .254, p < .001), followed by gender (β = .209, p < .001), with male donors reporting more frequent donation, and student status, which was associated with less frequent donation than non-student status (β = −.099, p < .001). Education, residence, partnership status and parental status were not associated with donation frequency at any stage of the model.

The socio-demographic block alone accounted for 18.5% of the variance (F(8, 1455) = 41.30, p < .001), and each subsequent block added a small but statistically significant increment. Competence measures contributed a further 0.6% (ΔR^2 = .006, Fchange(2, 1453) = 5.09, p = .006), through the total knowledge score (β = .069, p = .004 at entry; β = .060, p = .012 in the final model) rather than health literacy, which was unrelated to frequency (β = .028, p = .246 at entry; β = .012, p = .625 in the final model). Psychological barriers contributed 2.0% (ΔR^2 = .020, Fchange(3, 1450) = 12.08, p < .001), almost entirely through the composite fear score (β = −.144, p < .001); social tolerance and risk acceptance were not associated with frequency. Motivational constructs added the final 0.9% (ΔR^2 = .009, Fchange(3, 1447) = 5.29, p = .001), with intrinsic motivation positively associated with frequency (β = .066, p = .006) and

sensitivity to health-related incentives such as access to medical testing negatively associated with it (β = −.093, p = .002); sensitivity to material incentives was not statistically significant (β = .055, p = .067). Re-estimating the model with the full 38-item knowledge score left every coefficient unchanged in sign and significance (knowledge β = .065, p = .007; R^2 = .220).

Table 4
Hierarchical Linear Regression Analysis Predicting Lifetime Donation Frequency (N = 1,464)

Predictor	Model 1 (β)	Model 2 (β)	Model 3 (β)	Model 4 (β)
Socio-Demographic Factors				
Age Group	.267***	.268***	.245***	.254***
Gender (Reference: Female)	.228***	.239***	.214***	.209***
Occupation (Reference: Non-student)	– .106***	– .108***	– .099***	– .099***
Education Level (University)	.026	.021	.027	.021
Residence (Urban)	.006	.007	.011	.010
Self-Perceived Health (Excellent)	.048*	.037	.030	.024
Partnership Status (Reference: Not Partnered)	−.024	−.024	−.015	−.015
Parental Status (Reference: No Children)	.005	.006	−.005	−.008
Competence & Literacy				
Total Knowledge Score		.069**	.066**	.060*
Health Literacy (HLS-EU-Q16)		.028	.018	.012
Psychological Barriers				
Composite Fear Score			– .143***	– .144***
Social Tolerance			.026	.024
Risk Acceptance Score			.011	.014
Motivational Drivers				
Intrinsic Motivation (Duty/Ethics)				.066**
Sensitivity to Health Incentives				– .093**
Sensitivity to Material Incentives				.055
Model Summary				

Note. Values represent standardized beta coefficients (β). Age group was entered as an ordinal variable (six bands, < 20 to ≥ 60 years). Gender coded as 1 = Male, 0 = Female. Occupation coded as 1 = Student, 0 = Non-Student. Partnership status coded as 1 = in a stable relationship, 0 = not; parental status coded as 1 = has children, 0 = none. Significance levels: * p < .05, ** p < .01, *** p < .001.

Predictor	Model 1 (β)	Model 2 (β)	Model 3 (β)	Model 4 (β)
Socio-Demographic Factors				
R^2	.185	.191	.210	.219
ΔR^2 (Change)	.185***	.006**	.020***	.009**
Sig. F Change	< .001	.006	< .001	.001

Note. Values represent standardized beta coefficients (β). Age group was entered as an ordinal variable (six bands, < 20 to ≥ 60 years). Gender coded as 1 = Male, 0 = Female. Occupation coded as 1 = Student, 0 = Non-Student. Partnership status coded as 1 = in a stable relationship, 0 = not; parental status coded as 1 = has children, 0 = none. Significance levels: * p < .05, ** p < .01, *** p < .001.

3.7. Predictors of Donor Knowledge

To identify the determinants of domain-specific donation knowledge, a three-stage hierarchical linear regression analysis was performed predicting the Total Knowledge Score. The final model was statistically significant, F(10, 1458) = 7.30, p < .001, though the variance explained remained modest (R2 = .048).

In the fully adjusted model, gender, age, education, health literacy, donation frequency and intrinsic motivation were each independently associated with the total knowledge score (Table 5). Female donors scored higher than male donors (β = −.148, p < .001), the largest coefficient in the model; older age was associated with lower knowledge (β = −.086, p = .004) and university education with higher knowledge (β = .063, p = .021). Demographic variables alone explained 2.9% of the variance (F(5, 1463) = 8.83, p < .001). Adding competence and behavioral measures improved model fit (ΔR² = .015, Fchange(2, 1461) = 11.55, p < .001), with both health literacy (β = .092, p < .001) and donation frequency (β = .086, p = .002) positively associated with knowledge at entry (β = .085, p = .001 and β = .079, p = .006 in the final model). The motivational and attitudinal block did not add significantly to the model (ΔR² = .003, p = .169), although intrinsic motivation remained positively associated with knowledge within it (β = .058, p = .027); neither the composite fear score nor sensitivity to health incentives was associated with knowledge.

Re-estimating the model with the full 38-item score reproduced the same pattern of predictors, with the single exception of Education, which fell to the conventional significance threshold (β = .054, p = .049). The unstandardized coefficient for Education was marginally larger on the 38-item scale, so this reflects the position of a p-value relative to an arbitrary cut-off rather than any difference in the underlying association.

Table 5
Hierarchical Linear Regression Analysis Predicting Total Knowledge Score (N = 1,469)

Predictor	Model 1 (β)	Model 2 (β)	Model 3 (β)
Socio-Demographic Factors			
Gender (Reference: Female)	− .134***	− .149***	− .148***
Age Group	− .058*	− .089**	− .086**
Education Level (University)	.070**	.064*	.063*
Occupation: Student	.028	.036	.036
Residence (Urban)	− .008	− .006	− .005
Competence & Experience			
Health Literacy (HLS-EU-Q16)		.092***	.085**
Donation Frequency		.086**	.079**
Motivational & Psychological			
Intrinsic Motivation (Duty/Ethics)			.058*
Sensitivity to Health Incentives			− .009
Composite Fear Score			− .006
Model Summary			
R^2	.029	.044	.048
ΔR^2 (Change)	.029***	.015***	.003
Sig. F Change	< .001	< .001	.169

Note. Values represent standardized beta coefficients (β). Age group was entered as an ordinal variable (six bands, < 20 to ≥ 60 years). Gender coded as 1 = Male, 0 = Female (Negative Beta indicates Females score higher). Significance levels: * p < .05, ** p < .01, *** p < .001.

3.8. Hierarchy of Incentives and Barriers

We analyzed the self-reported impact of various incentives and the intensity of specific fears. As shown in Additional file 2: Table S4. Descriptive Statistics of Donor Incentives and Fears, donors rated free blood tests highest (*M* = 6.13, *SD* = 3.71), with 45.7% of respondents rating them 8 or higher, followed by a day off work (*M* = 5.51, *SD* = 3.88) and mobile drives in public spaces (*M* = 5.31). Meal vouchers (*M* = 4.24) and snacks (*M* = 3.88) were rated lowest.

Incentive ratings differed by education. Donors without a university education rated meal vouchers higher (M = 4.72) than their university-educated counterparts (M = 4.05); t(1475) = 3.33, p < .001. The

same pattern held for the composite of health and access incentives (M = 6.08, SD = 2.87 versus M = 5.57, SD = 2.94; t(1475) = 2.99, p = .003). The value placed on a day off work did not differ between education groups (p = .572).

Women rated mobile drives in public spaces higher (*M* = 5.67) than men (*M* = 5.10; *t(1486)* = 2.90, *p* = .004), whereas urban and rural donors did not differ (t(1480) = 0.17, p = .861).

Intrinsic motivation was not inversely related to interest in incentives: it showed a weak but statistically significant positive correlation with the desire for meal vouchers (r = .068, p = .008) and no significant relationship with the desire for a day off (p = .218).

Fear levels were low (item means 1.23–1.33 on a 5-point scale). Fear of pain (M = 1.33) and fear of needles (M = 1.31) were the highest-rated items; the sight of blood was the least reported fear (M = 1.23).

3.9. Reported Pain and Anticipated Fear

Self-reported pain intensity (0–100 scale) was examined in relation to anticipated fear (1–5 scale; Additional file 2: Table S5. Descriptive Statistics and Correlations of Pain and Fear).

Mean pain intensity for the venipuncture (needle insertion) was low (M = 11.48, SD = 12.79 on a 0–100 scale), and the overall procedural discomfort was lower (M = 5.86, SD = 10.05).

Anticipated fear of pain was positively correlated with reported insertion pain (r = .343, p < .001), as was fear of needles (r = .256, p < .001).

Reported pain did not differ by gender. Women reported nearly identical needle insertion pain (M = 11.58) to men (M = 11.44; t(1486) = 0.20, p = .838), and overall procedural discomfort did not differ either (p = .595).

3.10. Donation Experience, Fear and Knowledge

We compared novice (1 donation, n = 114), regular (2–10 donations, n = 735) and veteran (> 10 donations, n = 640) donors on both the Total Knowledge Score and the Composite Fear Score using one-way ANOVA.

Knowledge did not differ across experience levels. Novice donors scored M = 21.83 (SD = 3.69), regular donors M = 21.65 (SD = 3.60) and veteran donors M = 21.83 (SD = 3.48); F(2, 1486) = 0.51, p = .598, η2 = .0007. The same null result was obtained using the full 38-item score, F(2, 1486) = 0.56, p = .571.

Fear, by contrast, declined markedly with experience. The Composite Fear Score fell from M = 8.69 among novice donors to M = 6.55 among regular donors and M = 5.95 among veterans, F(2, 1486) = 68.10, p < .001, η2 = .084. The same gradient was observed for each constituent item: fear of fainting (M = 1.91, 1.34, 1.17; F = 58.36, p < .001, η2 = .073), fear of needles (M = 1.82, 1.32, 1.20; F = 39.75, p < .001, η2 = .051) and fear of pain (M = 1.73, 1.34, 1.25; F = 27.22, p < .001, η2 = .035). Levene's test indicated

unequal variances for all fear measures, so Alexander-Govern tests, which do not assume equal variances, were also computed; these confirmed the effect in every case (Composite Fear Score, A = 63.03, p < .001). Across the whole sample, anticipated fear correlated negatively with lifetime donation frequency (r = − .255, p < .001), and interest in free blood tests declined modestly with frequency (r = − .057, p = .027).

The effect size for fear is more than a hundred times that observed for knowledge (η2 = .084 versus η2 = .0007).

3.11. Differences by Sex, Age and Education

Donation frequency, fear and knowledge were compared across sex, age and education (Additional file 2: Table S6. Differences in Donation Frequency, Fear, Knowledge, Health Literacy and Incentive Preferences by Sex, Age and Education). Men reported more lifetime donations than women (M = 3.51, SD = 1.23 versus M = 2.78, SD = 1.22 on the five-point scale; t(1486) = 11.08, p < .001, d = 0.59), and donation frequency rose with age (Spearman ρ = .337, p < .001). Women reported higher anticipatory fear than men (Composite Fear Score M = 6.95, SD = 3.01 versus M = 6.15, SD = 1.95; t(1486) = 6.22, p < .001, d = 0.33). Knowledge ran the other way: women scored higher than men on the Total Knowledge Score (M = 22.40, SD = 3.18 versus M = 21.34, SD = 3.71; t(1486) = 5.62, p < .001, d = 0.30), knowledge declined slightly with age (ρ = −.084, p = .001), and university graduates scored marginally higher than non-graduates (M = 21.89, SD = 3.52 versus M = 21.45, SD = 3.47; t(1475) = 2.14, p = .032, d = 0.13). Women, younger donors and graduates therefore combined higher knowledge with lower donation frequency.

4. Discussion

This study examined health literacy, donation knowledge, attitudes, practices and fear among Romanian donors reached through a national blood donation application, and asked whether donation experience is associated with knowledge and with fear, whether eligibility knowledge is associated with the willingness to accept blood from specific groups, and what independently correlates with donation frequency. Data collection was performed entirely online, through a mobile application facilitating blood donation, with responses obtained from donors across all eligible age groups and spanning all developmental regions of Romania.

This is a primarily urban, highly educated set of respondents, with the ratios of urban to rural citizens and persons with a university degree to donors with other levels of education being approximately 4:1 and 3:1, respectively. Participants are preponderantly experienced donors, with over 90% having given blood at least twice before answering the questions; directed donation was uncommon, with 62.5% of respondents reporting that none of their donations had been made for a specific acquaintance and a further 29.8% reporting that up to one third had been, while almost all respondents who completed the survey had made the point to encourage someone else to give blood at a certain time. This suggests participants understand the importance of blood donation and blood transfusions for patients, both by

setting a personal example in giving, and by communicating the need for blood to their peers in an attempt to increase the donor pool.

Several donor characteristics were associated with distinct motivational and behavioral profiles. Women donated less frequently than men (M = 2.78 versus 3.51 on the five-point frequency scale, $p < .001$) and reported higher anticipatory fear (M = 6.95 versus 6.15, $p < .001$), consistent with the finding of Kosowski [53] that Polish women scored higher than men on every subscale of the Blood Donation Fears Inventory (total score M = 8.73 versus 6.81, Mann-Whitney U, $p < .001$, $r = .33$), a study in which donors also scored lower than non-donors on every subscale (total M = 6.19 versus 9.96, $p < .001$, $r = .62$). A reason for this could be the fact that the number of maximum yearly donations for women is one less than that for men [54]; moreover, physiological barriers such as menstruation and breastfeeding, deferrals for iron deficiency leading to decreased donor retention, and a smaller propensity to donate with aging are also factors contributing to the smaller number of donations in women, according to Meher [55,56]. Donors without a university education reported greater responsiveness to material incentives than graduates, both for meal vouchers (M = 4.72 versus 4.05, $p < .001$) and for the pragmatic incentive composite (M = 6.08 versus 5.57, $p = .003$). A correlation between a lower level of education and a tendency to prefer financial incentives was found in other studies as well, such as those of Romero-Domínguez et al [57] and Kasraian and Maghsudlu [58]. This highlights the importance of a perceived transactional nature of blood donation, as it represents an opportunity to receive certain material and health benefits for the deed done and the invested time and effort. Anticipatory fear fell steadily as donation experience accumulated ($r = -.255$, $p < .001$), while interest in free blood tests declined modestly with frequency ($r = -.057$, $p = .027$). The two gradients are mutually consistent: donors who give regularly become habituated to the procedure and, being screened at every visit, have less need of donation as a route to health monitoring. The relationship between frequent donation and good health is reciprocal, since giving blood is both a healthy [59,60] and a perceivably healthy activity [61], and donors in good health are more likely to return [62].

Several factors have been associated with a higher donation frequency in our study: men donate more often than women, due to reasons mentioned when comparing the highly educated male and female donors above. We believe a greater age means more opportunities to give blood, as well as more exposure to information displayed and told at blood banks, leading to better knowledge regarding blood donation; this, in turn, makes donors understand they are suitable candidates to replenish blood requirements, leading to their return. This interpretation should be stated carefully. Donation frequency and knowledge were not correlated at the bivariate level ($r = .021$, $p = .418$), and the association emerged only once age, gender, education, residence, occupation and health literacy were held constant ($\beta = .086$, $p = .002$). Because older donors give more often but score lower on knowledge, the two effects offset one another until age is controlled. A greater intrinsic motivation may make donors more prone to visit blood banks to help their peers, while a lower anticipatory fear will not deter them from giving blood. Moreover, a higher number of donations could accustom donors to the process and to the environment at the blood bank, which would in turn decrease their anxiety ahead of future visits. We also found students to donate less frequently than non-students. Explanations for this could include the irregular

schedule of their curriculum, a greater interest for other "studently" activities, and a smaller number of acquaintances who might require a blood transfusion, either due to students' young age, or to a small inner circle for people studying outside of their hometowns. Increased donation frequency was also associated in literature with long-term residency [63], greater body mass index [64], and support for organ donation [65].

Participants in the study exhibited high health literacy, being able to easily navigate notions of health and healthcare (M = 14.50, SD = 2.04 on the HLS-EU-Q16), with 86.4% classified as having adequate literacy. The instrument has been validated for use in Romania [41] and forms part of an ongoing program of health literacy survey adaptation in the country [66]. Health literacy showed a statistically significant but very weak association with donation frequency ($r = .058$, $p = .025$), and did not remain a predictor once demographic and behavioral variables were entered alongside it ($\beta = .012$, $p = .625$). The same pattern held for knowledge: health literacy correlated with the Total Knowledge Score at $r = .088$ ($p < .001$), an association accounting for under 1% of shared variance. We therefore treat health literacy as weakly rather than meaningfully related to donation behavior in this sample.

The association between eligibility knowledge and willingness to accept blood ran in opposite directions depending on the group in question, and the two directions carry different meanings. For donors who are eligible but attract some social suspicion, smokers and operators of heavy machinery, accurate knowledge went with greater acceptance: 90.2% of respondents who correctly identified machinery operators as eligible would accept their blood, against 35.4% of those who did not. Here knowledge works as a facilitator, dispelling occupational and lifestyle myths that would otherwise narrow the pool of donors the public is willing to receive blood from. For groups the regulations defer, recent tattooing and a history of paid sexual activity, the association reversed: donors who knew the rule rejected the blood, and those who did not were permissive, with 69.1% of donors who wrongly believed a recently tattooed person eligible willing to accept that person's blood against 12.5% of those who answered correctly. Here the same knowledge works as a safety gatekeeper rather than a facilitator. The scenario involving HIV behaved as a floor rather than a test: rejection was near-universal at 99.4% whether or not the respondent answered the corresponding knowledge item correctly, which left too little variance for the comparison to be informative and serves mainly to confirm that respondents were reading the acceptance items attentively.

The difference in the nature of participants' motivators to give blood is stark. Composite motivation indices showed intrinsic drivers were being regarded as most important (M = 8.65), whereas pragmatic (M = 5.72) motivators and extrinsic drivers (M = 4.54) followed considerably behind. Indeed, when reviewing the drivers and barriers affecting blood donation, Monteiro et al [67] identified altruism as the most frequent motivator among donors. Viewed in detail, intrinsic motivators revealed a strong desire of donors of our study to give blood for people in need; however, this would stem from an interhuman wish to help others rather than from a patriotic sentiment (donation as an ethical act, M = 9.50, against duty to one's country, M = 6.96).

Upon the prospect of receiving something in return for their donation, respondents would prefer personal wellness guarantees, such as blood tests (M = 6.13) and a day off work (M = 5.51), as opposed to material or financial benefits (meal vouchers, M = 4.24; snacks, M = 3.88). Extrinsic and pragmatic incentives were perceived differently in the context of varying demographic traits: food vouchers scored higher among respondents without a higher education (M = 4.72 versus 4.05, $p < .001$), a group for whom the fixed monetary value of the voucher is likely to represent a larger share of household income. Blood drives were more welcomed by female respondents (M = 5.67 versus 5.10, $p = .004$), which could be explained by the fact that women make up only one third of drivers in Romania. Interestingly, we found no statistically significant difference in the preference for blood drives among respondents from rural and urban backgrounds ($p = .861$). While rural donors would require these because of the lack of nearby blood banks, urban ones could benefit from the convenience of giving blood during organized events in locations close to their homes or at their workplaces. A day off work was deemed just as important for respondents with and without a college degree ($p = .572$), which demonstrates the physical toll of giving blood, as well as the need for post donation recovery regardless of studies and workplace. A free day was viewed as the most important bargaining chip for giving blood among all evaluated extrinsic drivers. Our results are similar to the findings of Chell et al [37], whose review on the impact of extrinsic motivators highlighted that among countries with a voluntary, non-remunerated blood donation, health benefits outweigh material incentives.

We also found a positive association between the intrinsic motivation score and the extrinsic motivator of receiving vouchers ($r = .068$, $p = .008$). Some had postulated that altruism-driven donations are preferrable to motivators in the form of incentives from moral, financial and blood quality standpoints [68]; moreover, incentives would impact the attitudes of altruistic donors, as these could feel no longer required [68]. Further studies are required to evaluate the validity of the latter claim, though in their review and meta-analysis on whether blood quality decreases and is financially unsound when incentivizing donors, Niza et al [33] found both that the financial effort made through incentives does not yield a greater number of donations, and that extrinsic motivators had little impact on donation quality.

Although respondents exhibited small levels of fear ahead of blood donations, primarily due to the great number of experienced donors, we identified a positive correlation between anticipatory fear of needle insertion pain and the actual pain experienced during the insertion of the needle ($r = .343$, $p < .001$). One reading is a cycle of psychological amplification, in which a higher pain level during a donation raises anticipatory fear for the next, which in turn intensifies the pain experienced; the cross-sectional design cannot separate the two directions. Bani et al [45] also found a correlation between donation fear and both insertion pain and pain while the needle is in the vein when they studied several potential elements which could cause donation anxiety, while France et al [69] identified fear to lead to increased needle insertion pain.

We found no difference between the pain levels among men and women ($p = .838$). This is contrary to results of a paper by France et al [52] who, upon examining a relationship between family history of hypertension and the emergence of pain during blood donation, found that the perceived pain upon

needle insertion was lower among males compared to female participants. Moreover, in a study on the adverse effects after giving blood, Newman et al [70] discovered women had a significantly higher rate than men when it comes to getting a sore arm, a bruise or a hematoma, and are significantly more prone to having adverse reactions.

4.1 Knowledge, attitudes, practices and fears among European donors

Assessment of donor knowledge and behavior in a defined geographic area is valuable, because it reveals the profile of the people who actually give blood. Surveys have been conducted in several countries of Eastern Europe, among them Croatia [71], Estonia [72], Hungary [73], Ukraine [74], Poland [75,76] and Serbia [77], but they address narrow and largely unconnected questions: sexual risk behavior escaping donor screening, first-time donor lapse, the marketing of student blood drives, donation fears among students, awareness of blood groups, and donor satisfaction. Most report descriptive statistics only, and the comparative picture for the region remains fragmented.

In a 2025 survey of 385 members of the Georgian public, Chikobava et al [78] found that only 35% had good knowledge of blood donation and 38% held a positive attitude; knowledge, attitude and willingness to donate in the future were each significantly associated with younger age, higher education and residence in Tbilisi, and attitude and willingness additionally with female sex. Among Lithuanian donors, Buciuniene et al [79] reported in 2006, as Lithuania moved from a remunerated to a voluntary system on EU accession, that the non-remunerated minority (10.1% of 400 donors) were far more likely than paid donors to consider remuneration unnecessary (64.7%) and to be content with appreciation of the act alone (55.9%), while regular donation was much commoner among paid donors (93% versus 20.6%). Kosowski [53] produced a Polish adaptation of the Blood Donation Fears Inventory [80] in 409 respondents, 194 donors and 214 non-donors, confirming the instrument's four factors (fear of syncopal symptoms, of blood and needles, of social evaluation, and of health screen results) with reliability coefficients between .92 and .97. In 1,000 students drawn from 14 faculties of the University of Novi Sad in Vojvodina, Kocic et al [81] found that regular donors answered 84.3% of the donation knowledge questions correctly against 59.7% for first-time donors and 59.2% for non-donors, and expressed positive attitudes more often (89.1%, 76.9% and 58.6% respectively); helping others in need was the leading reason for donating (47.5%) and fear of needles the commonest barrier (41.4%). Among 385 Ege University students in İzmir, Batu et al [82] found that 89.6% held positive views of blood donation and 76.8% regarded it as a social responsibility, but 70.4% doubted that donated blood reaches those who need it; women donated more often than men, and several attitudes differed significantly by sex. Ekşi et al [83] applied the Blood Donation Attitude Scale [84], which measures social responsibility, anxiety, and social opinion and understanding, to 269 nurses at a Turkish training and research hospital, and found that those who had received training on blood donation scored higher, particularly on social opinion and understanding. Keten et al [85] surveyed 396 medical students at Gaziantep University and recorded a mean knowledge score of 16.4 out of 30, with no difference between men and women but significantly

higher scores among fifth-year students and among those who had received training in the field; training also predicted having actually donated. Karacan et al [86] surveyed 189 male volunteer donors in Ankara and extracted three motivational factors from their motivation measure (values and moral duty, positive feelings and esteem, and self-benefit and external reasons); among the predictor scales, only social responsibility predicted donation motivation independently of age, income and education.

In Thessaloniki, Sousos et al [87] surveyed 291 non-physician healthcare workers at the Ippokrateio General Hospital and found that a positive attitude toward family replacement donation predicted both regular and voluntary donation, with male sex additionally predicting the latter; the authors describe an explicit inconsistency between knowledge, attitude and practice in this group. Among 330 Greek undergraduate medical laboratory students, Papagiannis et al [88] reported that 24% had donated at least once, that men were 4.62 times more likely than women to be donors, that voluntary non-remunerated donors were more likely to be repeat donors, and that a quarter of all students would give blood for a monetary reward, men more readily than women. In 800 Greek citizens surveyed in Athens, Kalargirou et al [89] found that 88% regarded donation as an "offer" but that only 10% were active donors, 31.3% occasional, 15% rare and 36.6% non-donors; safety (36%) and fear (24%) were the leading reasons for not donating and need (77.9%) the leading reason for donating, from which the authors conclude that recruitment in Greece should be built on need rather than on altruism.

Using the 2014 Eurobarometer round (n = 22,348 across 28 member states), Huis in 't Veld et al [90] modeled willingness to donate separately for people with and without a donation history. Male, younger and employed respondents were more willing in both groups. Among non-donors only, more years of education and never having difficulty paying bills predicted willingness; among donors only, having a partner, having children and living in a country with a higher Human Development Index did so. In both groups willingness rose with the belief that transfusion is safe and with willingness to accept a transfusion oneself. Incentives were unrelated to willingness; non-donors who considered cash an acceptable reward were in fact less likely to be willing to donate, and adding incentives worsened model fit. Country-specific patterns were nonetheless visible: Slovakian non-donors were significantly more likely than Slovakian donors to cite helping family and friends, whereas Latvian donors were significantly more likely than Latvian non-donors to cite alleviating shortages. Graf et al [91] combined the same Eurobarometer wave with country-level confidence in the healthcare system taken from the 1999 and 2008 rounds of the European Values Survey, and found that country-level public trust predicted an individual's probability of ever having donated ($b = 0.114$, $p < .001$) while two objective measures of healthcare quality did not; at the individual level, older, male, employed and more educated respondents and those living with a partner were more likely to have donated, although because the outcome is lifetime donation the age effect partly reflects cumulative exposure.

These papers show that even within the same region each country's donor pattern is unique, a conclusion reinforced by the cross-national analysis of Wittock et al [92], which traced variation in donor demographics both between European countries and across two decades. The results of our study are accordingly both similar to and different from those presented above, which is itself the argument for

conducting research on donor identity nationally, since only local data can identify the needs that have to be addressed locally.

4.2 Health literacy and blood donation

Nutbeam and Lloyd [93] argue that health literacy consists of the skills which allow people to obtain, understand, appraise and use information in order to act on and decide about their health. The questions evaluating health literacy in our survey comprise the HLS-EU-Q16, a tool used at European level that yields information falling into three categories: disease prevention, health promotion and healthcare. The applicability of the HLS-EU-Q16 in the Romanian population was validated in 2022 in a representative stratified sample of 1,622 adults from the North-West Region of the country [41], which identified age, gender, education and self-reported health status as determinants of health literacy.

Our findings agree with that study on one of these four and diverge on the other three. Age was associated with health literacy in our sample, $F(5, 1483) = 2.99$, $p = .011$, $\eta^2 = .010$, but in the opposite direction: Coman et al found health literacy to decline with age, whereas here two pairwise comparisons favored the older groups: donors aged 40 to 49 and 50 to 59 scored higher than those aged 20 to 29 (mean differences 0.42, $p = .050$, and 0.63, $p = .019$). Self-rated health was associated with health literacy in the same direction as in that study, and strongly so by the standards of this dataset: donors reporting excellent health scored 14.72 against 13.91 for those reporting moderate health, $t = 6.87$, $p < .001$, $d = 0.40$. By contrast, education was not associated with health literacy in our sample (non-university 14.33, university 14.56; $t = -1.94$, $p = .052$; Spearman $\rho = .044$ across the full education scale, $p = .094$), nor was gender ($t = 1.59$, $p = .112$). Our sample consists entirely of blood donors and is skewed toward higher education, which compresses the variance on both variables relative to the general-population sample used in the Romanian validation study.

Few papers describe the relationship between health literacy and blood donation. Şentürk et al [94], using the HLS-EU-derived Turkish Health Literacy Scale in blood donors presenting to a university blood center, found a mean score of 34.64 (95% CI 33.9 to 35.4) against 29.5 (95% CI 28.8 to 30.3) for the Turkish general population, $p < .001$, with 53% of donors reaching adequate or excellent health literacy. Renzi and Franci [95] applied the HLS-EU-Q16 in an Italian donor cohort; while mean scores for donors and the general population were similar, the proportion with adequate health literacy was significantly higher among donors. That study also reported an association between donors' health literacy and their education level and physical activity, and negative associations with income, social status, activity limitations, chronic disease, alcohol consumption and frequent need for medical attention.

In our sample, health literacy was associated with donation knowledge ($r = .088$ on the 31-item scale, $p < .001$; $r = .081$ for the general knowledge subscale and $r = .064$ for the eligibility subscale) and with donation frequency ($r = .058$, $p = .025$). Both associations are statistically significant at $n = 1,489$ and negligible in magnitude, each accounting for under 1% of shared variance. The association with donation frequency did not survive adjustment: once age, gender, education, residence, occupation, self-rated health, knowledge, fear, social tolerance and the motivational drivers were entered, health literacy was

not a significant predictor (β = .012, p = .625). The bivariate association is therefore attributable to age, which predicts both a longer donation history and slightly higher health literacy. We report it as a null rather than as a mechanism: understanding health information does not, on these data, make a donor more frequent.

4.3 What we know about Romanian blood donors

In 2025, Gheorghe et al [38] published their work evaluating the type of altruism of medical students, attempting to identify an association with their incentives to give blood, and finding whether altruism and motivators can serve as potential predictors for returning to donate. They used a model of five dimensions of altruism of blood donors first developed by Evans and Ferguson [48], which defines reluctant altruism (giving blood because of insufficient donations among other members of society), self-regarding altruism (the rewards and the reputational benefits associated with blood donation), egalitarian warm-glow (the positive mental and physical feeling derived from giving blood, as well as fulfillment of the social responsibility of donating), impure altruism (donating both to be of help to others and to attain a positive mental and physical feeling from doing so), and kinship altruism (donating for the benefit of family and friends). In the study cohort, Gheorghe et al demonstrated that a higher score for self-regarding altruism was correlated with preferring recognition incentives and free refreshments, with a moderate effect size, while medical screening and vouchers were also associated with this type of altruism, albeit with a small effect size. Higher preference for a free day after giving blood was correlated with higher egalitarian warm-glow and impure altruism scores.

This study also examined whether there is a difference in incentives for novice and experienced donors; however, no statistically significant results were found, suggesting all donor types regarded motivators as having similar value. Incentives regarded as of high importance by the greatest percentage of both novice and experienced donors were a free day post donation and obtaining travel compensation, while low value was placed on recognition incentives and refreshments available at the blood bank.

Interestingly, the study identified no significant predictors for willingness to give blood in the next six months when analyzing motivators, altruism types, and the relationship between them. However, another relevant paper regarding Romanian donors published a year prior [96], which evaluates the same study population while analyzing donors' perceived meaning in life (their sense of purpose, fulfillment and direction) and its relationship with their types of altruism and with their willingness to give blood again, found that meaning in life is the mediator between type of altruism and the intention to return to donate.

The Romanian Society for Marketing and Public Opinion Research (SORMA) conducted an online study in 2023 [39] in which over 1,000 people were surveyed, of whom 69% donors and 31% non-donors, regarding their attitudes toward blood donation. Among prior donors, reasons for which they give blood include awareness of the great need (74%), helping friends and family (52%) and a good feeling (39%), which shows an important prevalence of reluctant altruism, kinship altruism, and impure altruism or egalitarian warm-glow among the respondents; only 15% and 10% regarded vouchers and a free day as the reason for giving blood, indicating a small self-regarding altruism score in the donor cohort. On the

other hand, non-donors argued the reasons why they would start giving blood were donating for family (54%) and friends (46%), as well as a greater emphasis on raising awareness (blood donation campaigns and higher amounts of information made available regarding donation, 37% and 36% respectively); this shows that non-donors prioritize directed donations but are susceptible to actions to raise awareness. When asked about the main figures in promoting blood donation, the study cohort indicated that people who had received blood (48%) and doctors (42%) should be the driving force. The key phrase for potential blood campaigns was deemed to be "the importance of saving a life", as regarded by 38% of the cohort.

4.4 Improving donation rates in Romania: lessons to be learned

Studies such as ours and other national studies, as well as papers examining donor psychology, are important for increasing the number of donors while limiting the resources needed to do so. Several measures could improve donation rates in Romania. Our sample is drawn from users of a digital platform rather than from the donor population at large, but the lessons it suggests can reasonably be applied more widely. The first concerns knowledge. Health literacy and health status are closely connected [97], so raising the population's health literacy should improve health and, by extension, the proportion of the population eligible to donate. Ciaușescu et al [98] argue that because blood and blood products are essential resources, children should be taught about donation from the first years of school, and Gheorghe et al [38] make the same case for the formative years in their work on Romanian medical students. The tenth strategy of the World Health Organization's Towards 100% Voluntary Blood Donation: a global framework for action [50] sets out the role of television, radio and social media in advertising donation, providing accurate information and correcting misconceptions, alongside donation campaigns and awareness-raising at community events.

In our study the groups with the best donation knowledge were women (22.40 versus 21.34 of 31 items, $t = 5.62$, $p < .001$), younger respondents (Spearman $\rho = -.084$, $p = .001$) and, to a much smaller degree, university graduates (21.89 versus 21.45, $t = 2.14$, $p = .032$). These are the same groups that donated least: women reported fewer donations than men ($t = 11.08$, $p < .001$) and donation counts rose steadily with age ($\rho = .337$, $p < .001$). Knowing most and donating least is not a paradox to be explained away; it is the clearest evidence in our data that information alone will not move donation rates, and that the groups who already understand donation need different interventions from the groups who do not. In his review of donation among women, Meher [55] identifies clinics for temporarily deferred donors, action on anemia in the general population, child-friendly facilities at blood banks and reduction of adverse reactions as measures that would make donation more accessible to women. Our own data point the same way on access: mobile drives were rated higher by women than by men (5.67 versus 5.10 on a ten-point scale, $t = 2.90$, $p = .004$), which argues for organizing them in both densely populated urban areas and rural localities.

Students and young people should be among the main groups to whom donation is promoted, since they may acquire the habit and donate for life. In their review, van Teunenbroek et al [99] propose four types of intervention for recruiting and retaining young donors: environmental and social planning, which offers donation in a familiar setting among peers such as a university, with stress-mitigation measures like virtual reality headsets; guidelines, which improve the work of those running the transfusion system; service provision, meaning the investment, logistics and tools needed to recruit and retain young donors; and communication and marketing, which addresses misinformation and promotes donation as sociable and companionably competitive. For Romanian medical students specifically, Gheorghe et al [96] argue that they can carry the message effectively, particularly by emphasizing that donation saves lives, which appeals to a sense of purpose more directly than appeals to altruism.

The SORMA survey [39] is informative about the attitudes and motivations of Romanians. The leading reason both donors and non-donors give for donating is helping family members or friends. Donors' responses show awareness of the scale of need. It is worth being clear that this awareness does not extend to the eligibility rules: in our sample, knowledge did not differ between novice, regular and veteran donors, $F(2, 1486) = 0.51$, $p = .598$, $\eta^2 = .0007$, so repeated attendance at a blood center does not by itself teach donors what they need to know. Non-donors may respond to greater exposure to donation, including through social media and school and university events [100]. Recruitment and retention efforts should also make use of messages from transfusion recipients and from doctors, the two sources the SORMA respondents named as the most credible advocates.

Among pragmatic motivators, free blood tests were rated the most attractive return for donating in the sample as a whole (mean 6.13 of 10; 45.7% scored 8 or above), ahead of a day off work (5.51), mobile drives (5.31), meal vouchers (4.24) and refreshments (3.88). Romania already offers testing for transfusion-transmissible infections at every donation and, in selected cases, a full blood count and several biochemical tests. Extending the panel offered, or arranging partnerships with laboratories for discounted tests, would build on an incentive donors already value most. Among extrinsic motivators, paid time off work was the clear favorite; allowing donors to choose which day they take would cost little and may add to satisfaction.

Blood donation in Romania is voluntary and non-remunerated by law [21], with donor entitlements set by government decision [23]. Until December 2023 these comprised one day off work and seven meal vouchers worth about 10 lei each, some 68 lei or 14 euros per donation. From 1 January 2024 the voucher value rose to 40 lei, or 280 lei (about 56 euros) per session, alongside the day off work and a 50% discount on the subscription for local public transport or free public transportation in certain special situations. The Bucharest transfusion center reported a 70 to 80% increase in donors in the first working days of 2024 compared with the same days a year earlier, and close to a doubling on one day [25]. This sits awkwardly beside our own finding that sensitivity to material incentives did not predict donation frequency ($\beta = .055$, $p = .067$) while intrinsic motivation did ($\beta = .066$, $p = .006$), and that vouchers ranked fourth of five incentives in stated preference. The two are not really in conflict. What donors say motivates them and what a change in the schedule of benefits actually produces are different quantities,

and a cross-sectional survey cannot capture the response to a policy shock. The honest reading is that vouchers are weak as a stated preference and evidently potent as a policy lever, and that the durability of the 2024 increase is a question for routine national data rather than for this study.

Discomfort matters to donors. Several measures could improve how the process is experienced: topical anesthesia before venipuncture [101], instruction in applied muscle tension together with adequate water and salt intake to prevent presyncopal reactions [102], and giving donors information that addresses their fears [67]. Given that fear was the strongest modifiable correlate of lower frequency in our model ($\beta = -.144$, $p < .001$) and that it falls steeply with donation experience ($\eta^2 = .084$) while knowledge does not, measures aimed at the first donation are likely to yield more than measures aimed at the informed.

Finally, donation appears to respond to how the health system itself is regarded. Graf et al [91] found that country-level public trust in the healthcare system predicted an individual's probability of having donated blood, while two objective measures of healthcare quality did not. Improving public confidence in Romanian healthcare is therefore not a separate problem from building the donor base.

4.5 The role of digital platforms in blood donation

eHealth technologies used in blood donation include social media platforms, telephone communication, text messaging, videos, email, smart approaches such as radio-frequency identification tags and electronic donor cards, software applications and mobile applications [103,104]. These technologies have been shown to improve donor knowledge and to help with donation rates and donor retention. Applications in particular have been associated with reduced deferral rates, greater satisfaction in maintaining contact with blood banks and a shorter interval to the next donation [103]; people more willing to donate regularly are also more likely to want an application that tracks their donation history [105]. A large number of mobile applications have been developed, supporting donor recruitment and retention, identifying potential donors and alerting them to acute need, and scheduling future donations [105]. Ease of use and a wide range of functions have made them welcome to donors, with the advantages of appealing to younger people and shortening the time needed to find a donor [104], though uptake is lower among older donors and occasional technical problems arise [103].

Gamification means applying game design concepts in a non-game setting [106]. Several of its mechanisms can be turned to blood donation: a storyline, here the scale of unmet need; a mechanic, using points or another measure to make progress visible within the application; and a reward capable of holding interest, whether physical or virtual [104]. Applications combining these with donation exist. Espinoza Chamorro et al [107] designed an application for previously deferred donors and for people at risk of deferral, aiming to improve knowledge, soften the experience of rejection and sustain motivation, by awarding points for completed challenges and for interaction with the donor community; points could be exchanged for in-application rewards. Users said they would not use it regularly, but reported that it had taught them about donation quickly. In Malaysian donors deferred for low hemoglobin, participants who used a mobile application designed to educate donors about iron and hemoglobin, alongside oral

iron supplementation and a short counseling session, had higher return rates and a greater rise in hemoglobin than those who did not [108].

The BlooDoChallenge application through which our questionnaire was administered also uses gamification alongside its standard functions. Donors accumulate points by donating or by completing challenges such as registering with the Romanian Stem Cell Donor Registry or inviting others to donate; points can be exchanged for benefits from the application's partners and contribute to a user ranking. Other Romanian applications, including Donorium [109], build gamification into their recruitment and retention strategies in the same way. Whether gamification itself drives return donation cannot be established from our data: our respondents are users of such a platform, and platform use in Romania is at least partly a matter of convenience, since appointment booking is now the normal route into a transfusion center. What our data do support is the narrower claim that a gamified platform reaches an engaged and unusually health-literate donor population, and that this population is reachable for education in a way the general donor pool may not be.

4.6 Implications for practice, policy and research

Three findings carry direct implications for how blood donation is organized in Romania. The first is that experience does not teach eligibility. Knowledge of the deferral rules was the same among novice, regular and veteran donors, whereas fear fell steeply from one career stage to the next. Repeated attendance at a transfusion center habituates donors to the procedure but leaves their understanding of who may donate untouched, and the two problems call for different responses. Eligibility information has to be delivered deliberately, at every donation and to donors of every seniority, rather than left to accumulate with visits. The gap has a safety dimension. Donors who wrongly believed that a recently tattooed person is eligible were also willing to accept that person's blood, so the misconceptions that shape attitudes to receiving blood may equally shape how a donor judges their own eligibility at the screening interview. Applications such as the one used here already reach donors before each appointment and could carry a short eligibility module based on the national regulation [103]. Whether such a module changes what donors know is a question the platform itself is well placed to answer.

The second concerns fear. Fear was the strongest modifiable correlate of lower donation frequency in the adjusted model, it was highest among first-time donors, and anticipated pain was associated with the pain donors reported at venipuncture. Measures aimed at the first and second donation, when fear is at its peak, are therefore likely to yield more than measures aimed at experienced donors: information that addresses the specific fears measured here, of needles, pain and fainting [67], instruction in applied muscle tension with adequate fluid intake [102], and attention to comfort at the donation chair. Fear at a first donation also predicts whether a donor returns [69]. First-time donors were only 7.7% of our respondents, which suggests that the platform reaches them poorly, so recruitment through a gamified application may need to be paired with deliberate outreach to people who have never donated.

The third concerns incentives. Donors ranked free blood tests above every other return and meal vouchers and refreshments last, and sensitivity to material incentives did not predict donation frequency

while intrinsic motivation did. For a system that already tests every donation, extending the laboratory panel reported back to donors, or arranging discounted testing, would build on the return donors value most at modest cost. The voucher increase of January 2024 [24] was followed by a sharp short-term rise in attendance in Bucharest. Whether it produced a durable national rise cannot be settled from the published annual indicators: the Ministry of Health reports 425,153 units collected and tested in 2023 [12] and 487,966 in 2024, a rise of 15% [13], but both reports give the same number for donors and for donations in 2023 and no donor count for 2024, so the increase cannot be separated into more donors and more donations per donor, and a cross-sectional survey cannot answer the question either. Vouchers appealed more to donors without a university degree and mobile drives more to women, so incentive design and outreach can be differentiated by group rather than applied uniformly.

For research, the sample defines the limits of the conclusions and points to the next studies. Respondents were users of a donor application: urban, highly educated, experienced and unusually health literate. Health literacy, measured with a validated instrument, was not associated with donation frequency once age was taken into account, so the HLS-EU-Q16 is unlikely to be the lever for donor retention that it is for other health behaviors. Donation-specific knowledge discriminated better, and within it the eligibility scenarios discriminated best, since three general knowledge items were answered correctly by more than 95% of respondents. Three studies follow directly. A randomized comparison of in-application eligibility education against usual contact, with the knowledge scale as the outcome, would test the first implication. A prospective follow-up of first-time donors, with fear measured before the first donation and return measured after it, would test the second. A comparison with donors recruited outside the platform would establish how far an application population represents the Romanian donor pool. Finally, the change in voucher value in January 2024 is a natural experiment, and an interrupted time series of national collection data would settle a question that stated preferences cannot.

4.7 Limitations of our study

Several limitations should be considered when interpreting these findings.

First, the design is cross-sectional, so no causal inference can be drawn from the observed associations. The relationship between donation experience and fear is open to two readings: repeated donation may reduce anxiety, or less anxious individuals may be more likely to become repeat donors. The point is sharpened by how experience was measured. Donation history was recorded as lifetime donation count, not as time since first donation or as recency of the last donation, so what we describe as donor career stage is a volume variable rather than a temporal one. Longitudinal data would be required to separate habituation from self-selection.

Second, the sample was recruited through a mobile application for registered donors and is therefore not representative of the general population, nor of donors who do not use digital platforms. Participants were active and predominantly experienced donors, which is reflected in pronounced ceiling effects: of the scored knowledge items, 7 were answered correctly by more than 90% of respondents, which leaves

little variance available for detecting associations. Two features of the recruitment route deserve to be named explicitly. Eligibility extended to anyone who had donated within three years of the study opening, so an unknown proportion of respondents had not donated for a considerable period; because donation recency was not collected, these respondents cannot be identified or examined separately. And because booking an appointment is now the ordinary route into a Romanian transfusion center, use of a donation platform is to some degree a matter of practical necessity rather than of engagement with the platform itself. We therefore have no comparison group of non-users, and no basis for inferring that features of the platform, including its gamification component, cause donors to return.

Third, seven of the 38 knowledge items administered were removed prior to analysis because they lacked a single verifiable correct answer under the governing regulation, Order of the Minister of Public Health no. 1193/2007 in its consolidated form [30]. This review was conducted after data collection. While it was driven by the regulatory text rather than by the observed data, and while all analyses are reported for both the reduced and the full item sets, the decision was not pre-specified. The reduced scale showed internal consistency consistent with what test length alone would predict, and no inferential conclusion differed between the two versions.

Fourth, the internal consistency of the knowledge scales was modest ($\alpha = 0.665$ for the 31-item total). Knowledge inventories sample heterogeneous factual content rather than indicators of a single latent construct, and internal consistency is accordingly a weak criterion for such measures. The ceiling effects noted above compound this: items answered correctly by almost everyone cannot covary with anything, so a coefficient computed across them is bounded well below what the same items would yield in a less expert sample. The scores should be interpreted as indices of breadth of knowledge rather than as measurements of a unitary trait. The two-item pragmatic incentive scale ($\alpha = 0.410$) and the three-item intrinsic motivation scale ($\alpha = 0.351$) were weaker still, so their coefficients in the regression models should be interpreted with caution.

Fifth, an item asking what proportion of donations had been voluntary (non-directed) could not be analyzed. Owing to an error in the fielded instrument, its first response option was carried over unchanged from the preceding item and read "I have not donated specifically for an acquaintance", which does not express a proportion of voluntary donations. Of the 690 participants selecting this option, 655 (94.9%) also selected the equivalent option on the preceding item, indicating that it was understood as referring to directed rather than voluntary donation. Because the two proportions are complementary, directed donation is reported alone without loss of information.

Sixth, the instrument was long, comprising 120 items, and completion was incentivized within the application. Both raise the possibility of careless or hurried responding. Of approximately 2,900 users who began the questionnaire, 1,646 (56.8%) submitted a complete response, and progress was saved when users left the platform. An instructed-response item was embedded in the questionnaire; 157 of the 1,646 complete responses (9.5%) failed it and were excluded, leaving the analytic sample of 1,489. A

failure rate of roughly one in ten indicates that some careless responding is likely to remain in the analytic sample.

Seventh, because participants could leave and return to the platform at will, the knowledge and health literacy items were open to consultation of external sources, which would inflate scores on both. Participants were also aware that they were taking part in a study about blood donation, delivered through a platform they use for that purpose, which may have encouraged socially approved answers on the attitude items.

Eighth, an exploratory two-step cluster analysis was conducted but is not reported. Solutions were unstable across specifications and, where a solution was obtained, clusters corresponded directly to demographic categories rather than to distinct donor profiles; measures of cluster separation did not support a typological interpretation. We therefore report continuous associations rather than a donor taxonomy, and no recommendation in this paper rests on a typology.

Ninth, all measures were self-reported, including donation history, which is subject to recall and social desirability bias. Knowledge was assessed with a dichotomous format that does not distinguish confident correct answers from correct guesses.

Finally, the study data were collected after January 2024, so the whole of the observation window falls after the increase in the value of donor meal vouchers that took effect that month. Attitudes to incentives, and the weight donors place on them, may differ between the periods before and after that change, and our data speak only to the later regime. A comparison across the two periods would be informative about how Romanian donors respond to a change in material benefits, and is a natural subject for future work.

5. Conclusions

This study describes a large sample of Romanian donors reached through a national blood donation application. Respondents were health literate, knew the general facts of donation well and the eligibility rules less well, feared the procedure little, and were moved above all by the wish to help. Two findings matter most for the organization of donation. Experience reduced fear but did not improve knowledge, so eligibility education cannot be left to accumulate with visits. And what donors said would bring them back was information about their own health rather than material reward, although the attendance that followed the 2024 voucher increase shows that stated preference and behavior can diverge. Health literacy, high as it was, did not distinguish frequent from occasional donors. The sample is a platform population and the design cross-sectional, so these findings describe engaged donors rather than the Romanian public and cannot establish cause. They do show where effort is likely to count: in teaching eligibility deliberately, in easing the first donation, and in evaluating incentive policy with national collection data rather than with survey responses alone.

Abbreviations

ANOVA: analysis of variance; CI: confidence interval; EDQM: European Directorate for the Quality of Medicines & HealthCare; GDPR: General Data Protection Regulation; HIV: human immunodeficiency virus; HLS-EU-Q16: European Health Literacy Survey Questionnaire, 16-item version; HSD: honestly significant difference; HTLV: human T-lymphotropic virus; INTS: Institutul Național de Transfuzie Sanguină (National Institute of Blood Transfusion); IV: intravenous; KAP: knowledge, attitudes and practices; M: mean; SD: standard deviation; SORMA: Societatea Română de Marketing și Cercetarea Opiniei Publice (Romanian Society for Marketing and Public Opinion Research); SPSS: Statistical Package for the Social Sciences; VIF: variance inflation factor; WHO: World Health Organization.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved on 9 May 2025 by the Ethics Committee of the "Iuliu Hațieganu" University of Medicine and Pharmacy Cluj-Napoca, Romania (approval No. AVZ 116; study registration No. DEP96/12.03.2025). All participants were adults aged 18 to 65 years.

Electronic informed consent was obtained from every respondent before access to the questionnaire was granted; participation was voluntary, and consent could be withdrawn at any point, either by discontinuing the questionnaire or by notifying the research team, without penalty. Responses were collected and processed in anonymized form and were accessible only to the investigators, in accordance with Regulation (EU) 2016/679 (GDPR).

Consent for publication

Not applicable. The manuscript reports aggregate data only and contains no individual-level details, images or other material from which a participant could be identified.

Availability of data and materials

The dataset analyzed during the current study is not publicly available, because the informed consent obtained from participants does not extend to public deposition of individual-level records and the protocol approved by the Ethics Committee restricts access to the investigators. The dataset and the IBM SPSS syntax underlying all reported analyses are available from the corresponding author (A.S.B.) on reasonable request, with requests honored subject to the consent terms and to Regulation (EU) 2016/679 (GDPR). The derived scale definitions are described in the Methods and in Additional file 2 (Table S1. Reliability Analysis and Composition of Study Scales).

Competing interests

The survey was administered through the BlooDoChallenge mobile application, an existing Romanian donor platform developed and operated by Asociația MedX. A.O. and P.M.G. are affiliated with Asociația MedX rather than with a university, and A.O. is credited as the application's originator; both therefore stand to benefit professionally from the platform's continued use and visibility. As safeguards, the study was designed, and the statistical analysis and the interpretation of the results were carried out, by the university-affiliated authors; the analysis dataset was exported in anonymized form and analyzed only by that team; and neither the platform nor its operator had any role in deciding which findings to report or in the decision to submit the manuscript for publication. The remaining authors declare that they have no competing interests.

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This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors. The BlooDoChallenge platform, through which the questionnaire was distributed, is an existing service and was made available to the study at no cost. Respondents received 40 virtual points within the application on completing the questionnaire, drawn from the platform's standing reward scheme; no author received payment in connection with the study.

Authors' contributions

M.-T.D., A.S.B., K.I.C. and *A.-I.F*. conceived the study (Conceptualization). *M.-T.D., A.S.B., K.I.C*. and *A.-I.F.* designed the methodology. *M.-T.D., A.O., P.M.G*. and *A.-I.F.* developed the software and the data collection platform. All authors contributed to validation. *A.-I.F., M.-T.D.* and *A.S.* performed the formal analysis. *M.-T.D., K.I.C., A.S., A.O.* and *P.M.G*. carried out the investigation. All authors provided resources. *M.-T.D., A.-I.F.* and *A.O.* curated the data. *M.-T.D., K.I.C.* and *A.-I.F.* wrote the *original draft*. All authors reviewed and edited the manuscript. *M.-T.D.* and *A.-I.F.* prepared the visualization. *A.S.B.* and *A.-I.F.* supervised the study. *M.-T.D., A.S.B.* and *A.-I.F.* administered the project. *Funding acquisition* is not applicable. *All authors read and approved the final manuscript*.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used Claude (Anthropic; Claude Opus 4.8, Claude Opus 5, Claude Fable 5 and Claude Fable 5.1) in order to organize the structure of sections and tables, draft tabular content, edit language, verify citations and reference metadata against the original records, and assist with IBM SPSS syntax during data preparation and analysis. All analyses were specified, run and checked by the authors, and the interpretation of the findings is the authors' own. No identifiable

participant data were entered into the tool. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Clinical Trial Number

Not applicable.

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