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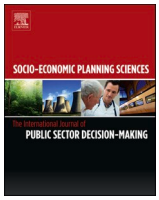

Socio-economic determinants of health literacy among blood donors: A cross-sectional study in Italy

Pietro Renzi [a,b,*], Alberto Franci [a,b]

[a] Department of Economics, Science, Engineering and Design, University of the Republic of San Marino, Via Consiglio Dei Sessanta, 99, Dogana of Serravalle, Republic of San Marino
[b] Department of Economics, Society, Politics, University of Urbino "Carlo Bo", Palazzo Battiferri, Via Saffi 42, Urbino, Italy

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ABSTRACT

Blood donation is a crucial service for healthcare systems and contributes to saving and improving lives. As a humanitarian act, it also symbolises social solidarity and individual responsibility. Health literacy (HL) is the ability to access, understand and use health information. This study aimed to assess HL levels among blood donors and compare them with those of the general population, thereby establishing whether individuals with higher HL are more likely to donate blood. It focused on 471 donors aged 18 or older and affiliated with AVIS (Italian Blood Donors Association) within a local health authority in the Marche Region. The HLS-EU-Q16 tool was administered via a web-based interview method, and its 16 items were aggregated into a General HL Index standardised on a scale from 0 to 50. Statistical analysis, including independent t-tests and multinomial logistic regression, was conducted to explore associations with sociodemographic factors. The results revealed a mean HL score for blood donors of 30.29 ± 7.11. Notably, 38% of donors demonstrated adequate HL, significantly higher than the 25% observed in the general Italian population. Higher HL levels were significantly associated with higher education, economic status, and better self-perceived health, while inadequate HL was more prevalent among those with chronic diseases. The potential reasons for this latter situation were explored. That HL scores for blood donors were higher than those for the general Italian population suggests that improving HL could serve as a strategic lever to enhance the donor base and the impact of increased blood donations.

1. Introduction

Blood donation for transfusion, as a life-sustaining procedure and an integral part of the health system, can save lives and improve the health of recipients. Donated blood, whether autologous (intended for later use by the donor) or allogeneic (intended for others), has many applications, including the management of pregnancy and delivery-related complications, congenital blood disorders, injuries, and severe childhood anaemia [1]. Globally, approximately 118 million blood donations are made each year, with high-income countries leading in this regard and contributing 40% of total global blood donations [2]. In addition, the whole blood donation rate, used as an indicator of general blood availability, shows a median of 31.5 donations per 1000 people in high-income countries, compared to only 5 per 1000 in low-income countries such as Afghanistan [3].

In Italy, in 2022, there were 1.7 million blood donors, of whom 1.4 million were regular donors and about 284,000 were first-time donors [4,5]. In the same year, 3 million donations were made, which resulted in 639,000 transfused patients and approximately 2.8 million transfusions. Furthermore, there are approximately 28 to 31 blood donors per 1000 inhabitants, and this safely surpasses the standard suggested by World Health Organization (10 per 1000). In summary, Italy is one of the highest-performing countries in Europe.

However, the demographic situation in Italy shows a continuing decline in the number of potential donors: from 2015 to 2024, the resident population aged between 18 and 65, the standard age range for blood donation in Italy, has decreased by 4.1%. However, it is important to clarify that Italian legislation (Decree of the Ministry of Health, 2 November 2015) allows regular donors to continue donating until the age of 65, and potentially up to 70, subject to the clinical evaluation of the transfusion doctor. Given that the over-65 population has increased by 11.3%, reaching 23% of the total, this senior cohort represents a vital reservoir. This trend is expected to strengthen further in the coming years, to the point that by 2050, as much as 35% of the resident

* Corresponding author..
E-mail address: pietro.renzi@unirsm.sm (P. Renzi).

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population in Italy will be aged 65 or over. Considering this scenario, a survey conducted by Nomisma [6] in May 2024 on a representative sample of the Italian population aimed to investigate what motivations are behind Italians' decisions to donate blood.

Nevertheless, despite the importance of this practice, the rate of participation in blood donation is still not high enough in many societies, especially in developed countries. To solve this problem, it is necessary to identify and investigate the factors that can affect the voluntary behaviour of individuals. The literature suggests health literacy (HL), altruism, the desire to help others, the opportunity for health screening and the great propensity to take risks. Among these factors, one of the most important is HL [7].

HL refers to the ability of individuals to access, understand and use health information to make informed decisions and improve their own and society's health. People with high HL are able to use available information more effectively and make informed choices in their health-related decisions, including blood donation.

Conversely, people with lower HL may refrain from participating in blood donation, due to inaccurate or inadequate information, fear or anxiety or a lack of understanding of the blood donation process.

Furthermore, research has shown that individuals with higher health literacy are more inclined to engage in social activities, including blood donation. This highlights the importance of education and health literacy promotion within communities, as increased knowledge about the benefits and necessities of blood donation can enhance participation rates. Overall, social commitment is considered another motivating factor for individuals to participate in blood donation activity. A sense of belonging to society and responsibility toward others' health can strongly encourage it [8,9].

The intersection between blood donation and HL is particularly significant when considering the donor's role within the healthcare system. Unlike the general patient, the blood donor acts as a proactive agent, who must constantly monitor their lifestyle and understand complex eligibility criteria to ensure the safety of the blood supply. Consequently, a high level of HL is not only a personal asset for the donor, but a systemic requirement for transfusion services. Low HL in this population could lead to misunderstood screening questionnaires, poor adherence to post-donation recommendations, or a lack of awareness regarding the social impact of their contribution [10]. Recent evidence suggests that individuals with higher HL levels are more likely to engage in preventive health behaviours and manage chronic conditions more effectively [11].

Based on these considerations, health literacy among blood donors is crucial to empowering individuals to critically assess health information. Indeed, people with high HL may be motivated to become donors, contributing to positive health behaviours and the well-being of others. However, it is important to recognise that the decision to donate is not solely influenced by knowledge or cognitive skills [12]. Some reasons among non-donors, such as fear, religiosity, unavailability of time and misinformation provided by the institution and health professionals are highlighted in the literature as a barrier to the donations [13].

A prominent example is represented by Jehovah's Witnesses, whose religious doctrines strictly prohibit the transfusion and donation of allogeneic blood and its primary components. In Italy, this group consists of approximately 250,000 members; while they represent a minority, their stance highlights how the choice to donate can be dictated by ethical and identity-related factors that lie entirely outside the scope of health information processing. However, it can be hypothesised that HL may increase the number of regular donors and help create a network of "ambassadors" capable of promoting blood donation on an ongoing basis.

In the contemporary health landscape, the transition towards the "Homo Digitalis" has led to an unprecedented availability of health-related data and digital tools. In health literacy initiatives, the impact of Artificial Intelligence (AI) cannot be overlooked. Specifically, the ability of AI to analyse large amounts of data and recognise complex data patterns can be a useful tool. For instance, AI can streamline repetitive administrative tasks, allowing staff to focus on more critical activities and improving efficiency. Furthermore, it can enhance patient care in the field of transfusion medicine, such as donor recruitment and retention in blood centres. The following strategies to streamline processes and attract donors on a sustained basis can be considered. Firstly, the attraction of young donors and motivating them to donate on a regular basis are especially important tasks. Therefore, digitalisation could assume a pivotal role because, in addition to conventional strategies such as telephone calls or text messaging, the usage of mobile smartphone applications opens a new perspective with regard to donor communication and invitation. In summary, this new technology may be more appealing to certain donors. On the other hand, it allows for the optimisation of resources used for donor management [14–16]. However, the effectiveness of these digital and AI-based strategies ultimately depends on donors' ability to access, understand and use the information conveyed — that is, on their health literacy. Assessing the level of HL among blood donors is therefore a necessary first step, and it constitutes the primary aim of the present study.

Furthermore, our study places strong emphasis on the role of HL, with the primary aim of assessing HL in blood donors and comparing it with levels of HL in the general population. The first step toward achieving this objective involves developing tools to measure HL among blood donors and gradually introducing them to the values and importance of scientific research.

Among the existing tools proposed by the literature, especially those developed in the European countries by the European network *Measuring Population and Organizational Health Literacy (M-POHL)*, the most important are: the Health Literacy Survey – European Union – Questionnaire – 47 items (HLS-EU-Q47) and its derived versions HLS-EU-Q16, HLS-EU-Q12, HLS-EU-Q6. They are validated self-administered instruments developed in 2012 to measure perceived HL through 47, 16, 12 and 6 items rated on a Likert scale.

Considering these overall frameworks, the HLS-EU-Q16 stood out in our study for its innovative aspect in the donation landscape.

For these reasons, a clear picture of the main aims of our study emerges. They are.

a) To provide a concise description of HL and highlight its relevance among blood donors affiliated with AVIS (Italian Blood Donors Association) within a local health authority in the Marche Region, using the HLS-EU-Q16 (Health Literacy Survey – European Union – Questionnaire 16) tool.
b) To assess the level of HL among blood donors and compare it with that of the general population.
c) To investigate, through bivariate and multivariate analyses, the associations between general HL and donors' sociodemographic and economic characteristics.

2. Classification of health literacy and principal frameworks

HL is a multifaceted concept that influences how people interpret and act upon health-related information, navigate the healthcare system and make informed decisions about their wellbeing. When applied to the field of blood donation, HL plays a pivotal role in empowering potential donors to make informed and confident choices [17].

The definition of HL was recently revised in a study by Nutbeam and Muscat [18], which introduced two categories.

- Personal HL refers to the individual's ability to seek, understand and utilise health-related information and services for themselves and others.
- Organizational HL pertains to the degree to which institutions and organisations assist individuals in finding, understanding, and using health-related information and services.

HL must be understood within the broader context of public health, encompassing functional, communicative (or interactive), and critical dimensions, ranging from personal health management to the shaping of the Social Determinants of Health (S.D.O.H). Each of Parker and Ratzan's theory [19], Nutbeam's classification [20] and Sørensen framework [21,22] serve to emphasise the importance of individuals' ability to effectively use health information and make well-informed decisions in the blood donor landscape.

According to the WHO, Europeans with high HL enjoy better health and well-being, while those with weaker skills engage in risky behaviour and have poorer health. Better health is linked to productivity and indirectly to economic prosperity [23]. Conversely, low HL is not merely a problem affecting a minority of the population; on the contrary, it represents a major public health challenge, also in the donation scenario. Inadequate and limited HL can have a great impact on undermining peoples' willingness to participate in voluntary blood donation.

For measuring HL in this field, we referred to instruments developed by M-POHL and focused on the HLS-EU-Q16, whose feasibility and applicability — including among individuals with low literacy — have been documented in previous research [24].

This instrument comprises 16 questions and the responses are recorded according to a Likert scale with four responses, scored from 1 (very difficult) to 4 (very easy). The minimum possible test score is 16 while the maximum is 64 and then the scores are converted to a percentage. The HLS-EU allows categorisation of the study population with four levels of health literacy: test scores below 50% are taken as "inadequate HL". The test score of above 50% and equal or below 66% is taken as "problematic HL". The test score of above 66% and equal or below 84% is taken as "sufficient HL". Finally, the test score of above 84% is taken as "excellent HL" according to the method of the HLS-EU.

As further detailed in Section 3.2, these qualitative categories are mapped into a standardised score from 0 to 50 to allow for objective measurement and comparison.

From the utilisation of these instruments some interesting results emerged. Half of all Europeans have inadequate and problematic HL. This survey revealed that 12% of all respondents have inadequate general HL and 35% have problematic HL [25].

Further studies have indicated that over 50% of the population in Bulgaria, as well as Austria and Spain, have HL levels below the threshold for adequate health protection. According to the Italian HL survey, only 25% of respondents demonstrated adequate HL, while 75% were classified as having inadequate or problematic HL. Only 7% showed excellent HL. These results underscore HL significance as a crucial public health issue.

Given the above, the following should be noted.

a) Measuring HL remains a particularly challenging area of research, especially in the field of blood donation, and is still relatively unexplored in Italy.
b) The strategies typically adopted in the literature rely on indices derived from diverse types of questionnaires. Among the most widely used instruments are:
   1. The Test of Functional Health Literacy in Adults (TOFHLA) [26]: it includes a reading comprehension test based on passages with blanks to be filled by choosing among 4 options, and a numeracy test that evaluates the ability to understand information related to medication use (labels on bottles), appointment dates, or laboratory test results.
   2. The Rapid Estimate of Adult Literacy in Medicine (REALM) [27]: it consists of having the patient read a list of 66 medical terms taken from patient education tools.
   3. And the Newest Vital Sign (NVS) [28]: it measures the ability to read and to perform simple numerical calculations.

All primarily developed and applied in the United States.

In contrast, HL measurement in Europe has focused on tools developed by the European Health Literacy Consortium (HLS-EU-Q47, HLS-EU-Q16, and HLS-EU-Q6), easily transferable to the context of blood donors.

3. Study design and method

This cross-sectional, correlational study was conducted between November 2024 and February 2025 to explore the relationship between HL and donor characteristics. Inclusion criteria were being a donor affiliated with AVIS, aged 18+, and having donated at least once in the past year at the hospital transfusion centre of a local health authority in the Marche Region. Exclusion criteria were being registered with AVIS but not an active donor (aged 70+ or with health problems). The Italian version of the HLS-EU-Q16, previously validated for the Italian population, was administered using the CAWI (Computer Aided Web Interview) method via Microsoft Forms and data were stored on Microsoft OneDrive. The study was conducted within the framework of the official agreement (Disciplinare C) between ASUR Marche and AVIS Marche for 2022–2024, and was authorised by the U.O.C. Medicina Trasfusionale Senigallia-Jesi-Fabriano of AST Ancona (Marche Region) on 11 March 2024; it was further approved by the Board of Directors of AVIS of Senigallia on 23 November 2024. Participation was voluntary and anonymous, and the questionnaire collected no sensitive or identifying clinical data. All participants provided informed consent, and personal-data processing complied with the EU General Data Protection Regulation (Regulation 2016/679) and Italian Legislative Decree 196/2003 (as amended by Legislative Decree 101/2018). The study was conducted in accordance with the principles of the Declaration of Helsinki. As this non-interventional, anonymous survey was authorised through the institutional ASUR–AVIS convention rather than by a numbered ethics-committee protocol, no approval number is available; the relevant documentation is available from the authors upon request.

Given the elevated levels of inadequate HL in Europe, and particularly in Italy, this study aimed to explore the situation among blood donors, a strategically important yet under-investigated group. The tools developed by the M-POHL consortium are based on Sørensen's model and Nutbeam's classification of HL. Their questionnaires include various measurement scales that are widely recognised by the scientific community. The rationale for selecting the HLS-EU-Q16 among these instruments is detailed below.

Table 1 presents the conceptual matrix underlying the HLS-EU-Q16, where the four key processes of HL are distributed across the domains of healthcare (HC), disease prevention (DP), and health promotion (HP), resulting in 12 sub-dimensions. The matrix also incorporates Nutbeam's classification, functional, interactive, and critical HL, as overarching levels.

3.1. Sample selection process

The study population consisted of blood donors aged 18 and over who had donated at least once at the transfusion centre in the past year. The sample size was calculated using OpenEpi, yielding a required sample of 471 individuals from a donor population of 1912. This calculation was based on an estimated prevalence of 31.6% for adequate HL (sufficient and excellent levels combined), a value derived from previous regional assessments in Italy. A 5% margin of error and a 99% confidence level were applied to ensure the precision of the estimate. Using a voluntary sampling method, 471 donors agreed to participate and completed the questionnaire, thus meeting the required sample size.

Sample representativeness was assessed for sex and age by comparing the sample distribution with that of the overall donor population.

3.2. Data collection instrument

The levels of HL were assessed using the Italian version of the HLS-

Table 1
Conceptual matrix of health literacy sub-dimensions based on the HLS-EU model.

Health literacy (16 items)	Accessibility to information (3 items)	Understanding the information (7 items)	Evaluation of information (3 items)	Application/Use of Information (3 items)	Indexes obtainable per row
Health care (7 items)	1. Ability to access medical or clinical information **(1 item)**	2. Ability to understand and evaluate medical information and derive meaning from it **(3 items)**	3. Ability to interpret and evaluate the doctor's information **(1 item)**	4. Ability to make informed decisions about medical problems **(2 items)**	**HLS-EU Sub-index Health Care**
Disease prevention (5 items)	5. Ability to access information on health risk factors **(1 item)**	6. Ability to understand information related to risk factors **(2 items)**	7. Ability to evaluate and interpret information on risk factors **(1 item)**	8. Ability to appraise the relevance of information on risk factors **(1 item)**	**HLS-EU Sub-index Disease Prevention**
Health promotion (4 items)	9. Ability to keep up to date on health problems **(1 item)**	10. Ability to understand health-related information and derive meaning from it **(2 items)**	11. Ability to evaluate and interpret information relating to health issues **(1 item)**	12. Ability to form an informed opinion on health problems **(0 items)**	**HLS-EU Sub-index Health Promotion**
Sub-index by dimension of HL	**HLS-EU Sub-index Find Information (Interactive HL)**	**HLS-EU Sub-index Understand Information (Functional HL)**	**HLS-EU Sub-index Appraise Information (Critical HL)**	**HLS-EU Sub-index Apply Information (Critical HL)**	**Index of general Health Literacy (HLS-EU-Q16)**

EU-Q16 instrument. This questionnaire was chosen as it has been previously validated for the Italian population, demonstrating high internal consistency and reliability in capturing the multi-dimensional nature of HL within the national context. The questionnaire was composed of several scales, which are recognised by the scientific community, and was structured across different domains.

3.2.1. *Health Literacy Survey - European Union - questionnaire 16-item (HLS-EU-Q16)*

The HLS-EU-Q16 is a 16-item tool designed to measure health literacy across three domains: healthcare, disease prevention, and health promotion [29]. The matrix referred to in Table 1 represents the starting point for the development of the questionnaire. The 12 sub-dimensions were considered equally relevant. Each sub-dimension is represented by 0 to 3 items, which, when appropriately combined, make up the 16-item scale. One sub-dimension currently has 0 items; it was retained for conceptual completeness because it defines the framework and guides future item development. The items were adapted from the existing HLS-EU-Q16 instrument, with some questions reworded for the blood donation context, without altering the structure or scoring of the validated instrument. The items are expressed in a direct form, using a Likert scale measuring perceived difficulty, ranging from “very difficult” (code 1) to “very easy” (code 4).

The 16 items assessing self-perceived HL were aggregated into a General HL Index (General HL), which provided an overall measure of HL levels. To achieve a better comparison with European data, the index was standardised on a scale from a minimum of 0 (lowest level of HL) to a maximum of 50 (best level of HL), using the formula:

$$\text{Index} = [(\text{IndexMean} - 1) \times] \qquad (50/3)$$

where IndexMean is the mean of the 16 items (each scored 1–4).

In line with European studies, three different thresholds were established to sort the respondents into four groups, which reflected their HL abilities (as described qualitatively in Section 2).

- Group 1 (“Inadequate HL”): 0 to 25
- Group 2 (“Problematic HL”): 25.01 to 33
- Group 3 (“Sufficient HL”): 33.01 to 42
- Group 4 (“Excellent HL”): 42.01 to 50

Groups 1 and 2 were considered to include respondents with limited HL skills.

The questionnaire also included two additional sections: personal information form (16 items) and health status, lifestyle behaviours and service utilisation domain (19 items), resulting in a total of 51 items.

3.2.2. *Personal information form*

This section was developed on the basis of the literature, following the set of socioeconomic and health variables adopted in previous research [30]. It consists of 16 questions: 8 concern sociodemographic characteristics, 3 investigate the level of education and the typology of occupation, and finally 5 relate to socioeconomic status of blood donors.

3.2.3. *Health status, lifestyle behaviours and service utilisation domain*

A 19-item section was employed to assess health status, the use of healthcare services and lifestyle behaviours. It evaluates, for example, self-reported health, chronic conditions, smoking and alcohol use and frequency of medical consultations.

The HLS-EU-Q16 was administered via a web-based interview (CAWI) through a secure professional platform (Microsoft Forms), selected following a thorough review of the literature, which highlights the efficiency and reliability of digital surveys in blood donor populations. The digital format allowed mandatory fields to prevent missing data in key sections, while ensuring anonymity through the assignment of unique alphanumeric codes to each participant. This approach was chosen for its effectiveness and its ability to reach the target population [31–33].

3.3. *Statistical analysis*

The coefficient of variation of the General HL Index was below 0.20, indicating acceptable measurement reliability [34], and normality was assessed using Normal Q-Q plots, detrended Q-Q plots, and histograms, together with skewness and kurtosis [35].

Independent t-tests and one-way ANOVA were used to compare the mean HL scores among independent groups.

To compare the general HL score of blood donors with the national benchmark, a one-sample *t*-test was performed. The national benchmark data for the Italian population are derived from the Italian branch of the HLS19 international survey, conducted between 2020 and 2021 as part of the M-POHL network initiatives. These data come from a representative sample of the Italian general population and allow for a direct comparison with the donor population examined in this study [36].

Bivariate and multivariate analyses, including chi-square tests and multinomial logistic regression, were used to explore associations between HL and sociodemographic or economic factors.

Data analysis was conducted using IBM SPSS Statistics version 26.0. Statistical significance was set at $p < 0.05$ for all analyses.

4. Results

4.1. *Sample representativeness*

To evaluate how representative the respondent sample was, a chi-square test was performed to verify whether the differences in sex and age distributions were statistically significant (Table 2). The results indicate that these differences were not statistically significant, supporting the conclusion that the sample reflected the broader population of blood donors.

Table 2
Sample representativeness of respondents.

Blood donors' sample	Sex	Number	%	Blood donors' population	Number	%	
	Female	163	34.61%		606	31.69%	Not sign.
	Male	308	65.39%		1306	68.31%	
	Total	**471**	**100%**		**1912**	**100%**	
Blood donors' sample	**Age**	**Number**	**%**	**Blood donors' population**	**Number**	**%**	
	18-24	15	3.18%		145	7.58%	Not sign.
	25-34	60	12.74%		344	17.99%	
	35-44	87	18.47%		383	20.03%	
	45-54	163	34.61%		575	30.07%	
	55+	146	31.00%		465	24.32%	
	Total	**471**	**100%**		**1912**	**100%**	

4.2. Sociodemographic characteristic of respondents

To better contextualise the analysis of HL levels, this section presents a detailed overview of the sociodemographic characteristics of the respondents.

Table 3 shows the largest group in each category: male (65.39%), aged 45–54 (34.61%), high school education (47.98%), full-time workers (69.43%), monthly income between €2950 and €3600 (18.30%), married (53.29%), and perceived social status level 7 on a 0–10 scale (33.40%).

4.3. Characteristics of individuals regarding state of health and lifestyles

In addition to sociodemographic data, information on participants' health status and lifestyle behaviours was collected. Tables 4 and 5 show the most frequent category for each variable: good self-perceived health (67.94%), no chronic disease (80.89%), no activity limitations (72.61%). Furthermore, 86.62% reported no smoking habits, 87.26% reported consuming alcohol at least once a week in the last year, and 84.50% engaged in regular physical activity.

Finally, 71.34% did not use emergency services in the past two years, 84.50% accessed their general practitioner (GP), 52.23% did not experience hospital stays, and 85.35% used outpatient services in the past 12 months.

Table 3
Demographic and socioeconomic characteristics of blood donors.

Sex	Number	%	Economic status	Number	%
Female	163	34.61%	€800-	3	0.67%
Male	308	65.39%	€800 - €1350	31	6.92%
Age Groups	**Number**	**%**	€1350 - €1850	66	14.73%
18-24	15	3.18%	€ 1850 - € 2400	77	17.19%
25-34	60	12.74%	€ 2400 - € 2950	74	16.52%
35-44	87	18.47%	€ 2950 - € 3600	82	18.30%
45-54	163	34.61%	€ 3600 - € 4400	50	11.16%
55+	146	31.00%	€ 4400 - € 5250	30	6.70%
Education	**Number**	**%**	€ 5250 - € 6450	12	2.68%
Up to secondary school	36	7.64%	€ 6450+	23	5.13%
High school	226	47.98%	**Marital status**	**Number**	**%**
Bachelor's Degree	45	9.55%	Single	220	46.71%
Master's Degree	164	34.82%	Married	251	53.29%
Occupation	**Number**	**%**	**Perceived social status**	**Number**	**%**
Full time	327	69.43%	Level 3	6	1.28%
Part time	79	16.77%	Level 4	29	6.17%
Unemployed	19	4.03%	Level 5	83	17.66%
Students	15	3.18%	Level 6	119	25.32%
Retired	31	6.58%	Level 7	157	33.40%
			Level 8	63	13.40%
			Level 9	5	1.06%
			Level 10	8	1.70%

Table 4
Health status characteristics of blood donors.

Self-perceived health	Number	%
Bad	2	0.42%
Sufficient	54	11.46%
Good	320	67.94%
Very Good	95	20.17%
Chronic disease	**Number**	**%**
No	381	80.89%
Yes	90	19.11%
Activity limitations	**Number**	**%**
No	342	72.61%
Yes, but not severe	120	25.48%
Yes, severe	9	1.91%

Table 5
Lifestyle and access to health services among blood donors.

Smoking	Number	%	Used emergency care in past 2 years	Number	%
No	408	86.62%	No	336	71.34%
Yes	63	13.38%	Yes	135	28.66%
Drinking (any alcoholic beverage at least once a week in past 12 months)	**Number**	**%**	**Used GP services in past 12 months**	**Number**	**%**
No	60	12.74%	No	73	15.50%
Yes	411	87.26%	Yes	398	84.50%
Physical activity (at least 150 min of physical activity a week in past 12 month)	**Number**	**%**	**Used hospital services in past 12 months**	**Number**	**%**
No	73	15.50%	No	246	52.23%
Yes	398	84.50%	Yes	225	47.77%
			Used outpatient department in past 12 months	**Number**	**%**
			No	69	14.65%
			Yes	402	85.35%

The mean HL score for blood donors was 30.29 ± 7.11 (95% CI: 29.65–30.94). This value is slightly, though not significantly, higher than the national average of 30.05. Consequently, the comparison of mean scores alone fails to capture the differences in HL levels between

the two populations.

Moreover, further insights emerge from Fig. 1. With reference to blood donors, 62% demonstrated limited HL (inadequate 21% + problematic 41%) and 38% adequate (sufficient 30% + excellent 8%). By contrast, in the Italian general population, 75% demonstrated limited HL (inadequate 26% + problematic 49%) and 25% adequate (sufficient 18% + excellent 7%) [36]. A chi-square test revealed a significant difference ($p < 0.05$) in the distribution of limited and adequate HL between blood donors and the general Italian population, indicating that donors tend to be more health-literate overall.

4.4. The main difficulties encountered by donors

The percentages of blood donors who answered "very difficult" or "difficult" to the individual items of the HLS-EU-Q16 are illustrated in Fig. 2. The values range from a minimum of 5.3% ("How easy or difficult is it for you to understand health warnings about behaviours such as smoking, low physical activity, and excessive drinking?") to a maximum of 54.6% ("How easy or difficult is it for you to find information on how to manage your mental health problems?"). This marked gap shows that, while donors easily process warnings about everyday lifestyle behaviours, accessing information on mental health management remains a critical difficulty. This suggests that, even among blood donors with relatively higher HL, mental health information is a weak point in the population investigated [37].

Table 6 and Fig. 3 illustrate the HL competencies across domains using two different approaches. The results obtained in Table 6 show that blood donors achieve high scores in appraising information about health promotion (34.6 ± 11.2) and understanding information about disease prevention (36.9 ± 9.7), reflecting the proactive health-seeking behaviour typical of the donor population. Yet, within disease prevention, they face more challenges in finding (23.7 ± 13.8) and appraising (24.7 ± 13.6) information. Furthermore, Fig. 3 confirms this pattern, showing that the main difficulties concentrate in the disease prevention domain.

4.5. Differences between independent variables and HL

The comparison of participant characteristics with mean HL scores, using Student's t-test and ANOVA, is shown in Tables 7 and 8.

Table 7 reveals no significant differences across sex, age groups, marital status, and occupation. Regarding sex, our results appear to be consistent with those found in the literature. The mean health literacy scores consistently fell within the 29.42 - 31.67 range across all age groups. This observation suggests that the high level of health literacy among blood donors is independent of the age distribution within the population investigated [38,39].

Conversely, significant differences were observed for education, economic status, perceived social status, self-perceived health, presence of chronic diseases, and activity limitations. Regarding education level, the results highlighted that HL increased with higher education. Therefore, interventions aimed at increasing HL levels among those with lower levels of education may help increase the number of donors. Similarly, donors with low-to-medium economic status and lower perceived social status showed lower levels of HL.

An interpretation of Table 8 suggests that lower HL was associated with higher alcohol consumption, less physical activity, and more frequent use of emergency services, general practitioners, and hospital services. A summary of the lifestyle findings shows that the average HL score of donors tended to be higher in those who led healthier lifestyles (no alcohol consumption and regular physical activity).

Finally, regarding accessibility to health services, the results confirmed the more recent literature, showing that higher HL scores were predictors of less frequent access to services [30].

4.6. Determinants of general HL

The bivariate analyses regarding the determinants of general HL are shown in Table 9. Most of the variables examined were significantly associated with HL levels, in particular education level, economic status, perceived social status, self-perceived health, the presence of chronic diseases, and activity limitations.

Specifically, HL levels increased with higher education ($p = 0.001$), higher economic status ($p < 0.001$), higher perceived social status ($p = 0.001$), and better self-perceived health ($p < 0.001$). Conversely, HL levels decreased in the presence of chronic diseases ($p = 0.02$) and activity limitations ($p = 0.017$).

Regarding lifestyle and healthcare access, the bivariate analysis largely confirmed the previous findings: lower HL was significantly associated with higher alcohol consumption, lower physical activity, and more frequent use of general practitioner services, whereas the associations with emergency and hospital service use did not reach statistical significance in this analysis.

In the multinomial logistic regression analysis (Table 10), most of the previously described determinants were confirmed. In all models, "sufficient HL" was used as the reference category, and odds ratios (OR) are

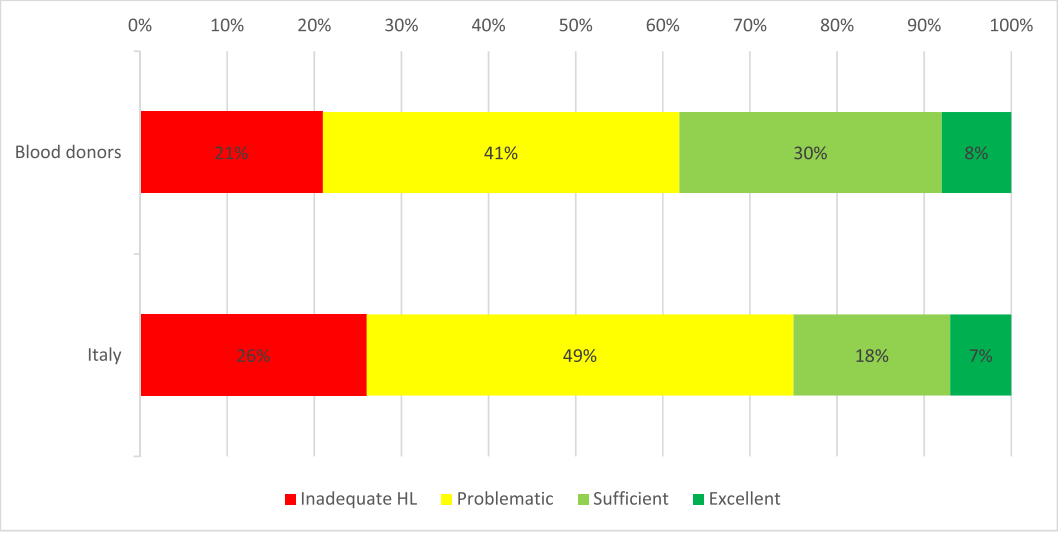

Fig. 1. Percentage of respondents divided by categories level of gen-HL index of HLS-EU-Q16 (blood donors and Italy). Significant difference ($p < 0.05$) in levels of HL – Source: Pelikan et al., 2022 for Italian data.

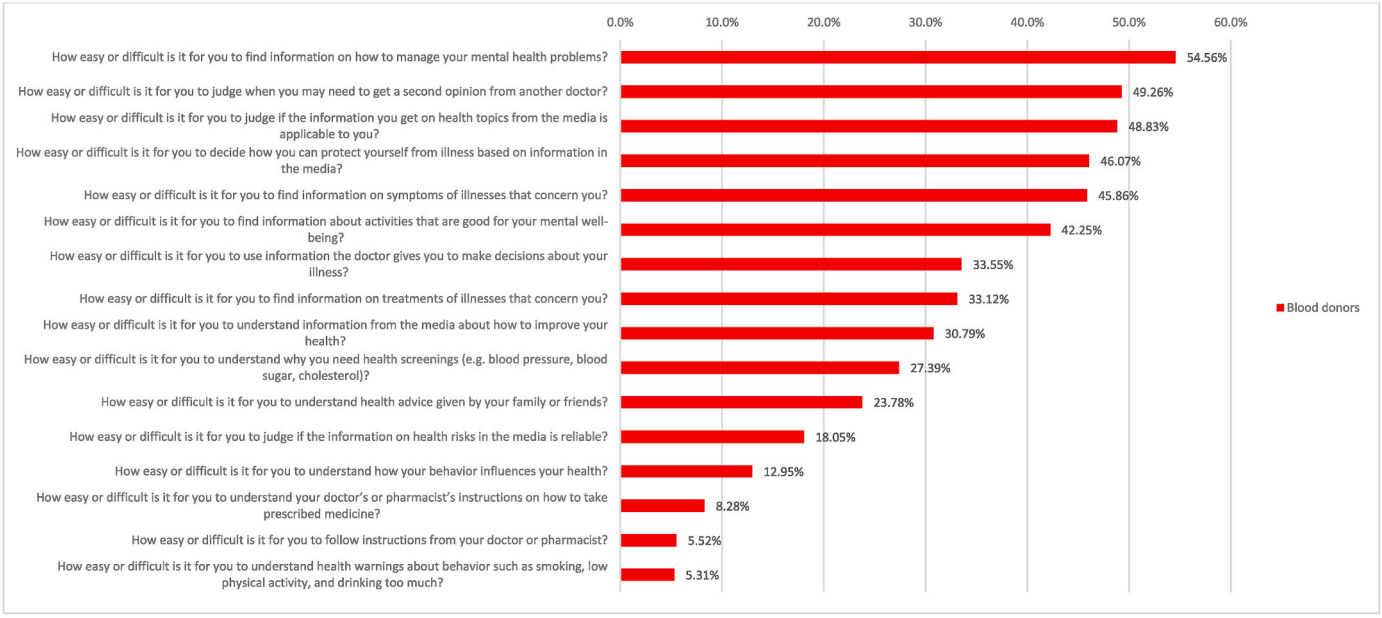

Fig. 2. Percentage of "Very Difficult" or "Difficult" Responses for Each HLS-EU-Q16 item, ranked from most to least difficult.

Table 6
Health literacy competencies and overall HL indices.

	Find/Access	Understand	Appraise	Apply	All
Health Care	28.6 ± 10.6	32.2 ± 8.6	25.1 ± 12.1	32 ± 9.3	30.6 ± 7.4
Disease Prevention	23.7 ± 13.8	36.9 ± 9.7	24.7 ± 13.6	25.4 ± 13.5	29.5 ± 8.8
Health Promotion	27.1 ± 12.1	30.7 ± 10.3	34.6 ± 11.2	Not available, no data existing	30.8 ± 8.8
All	26.5 ± 9.3	33.1 ± 7.4	28.1 ± 9	29.8 ± 8.8	30.3 ± 7.1

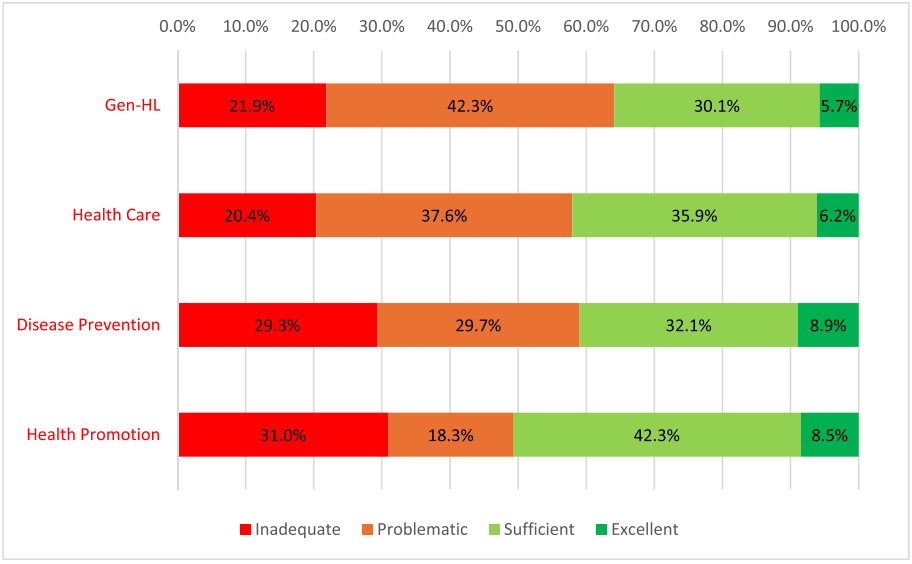

Fig. 3. Percentage of respondents by HL domains.

expressed relative to it.

The risk of having inadequate HL decreased among those with a bachelor's degree (OR = 0.386) and a master's degree (OR = 0.179). Furthermore, it decreased with higher perceived social status (OR = 0.493) and among those who reported having good (OR = 0.094) or very good health (OR = 0.439). Conversely, the risk of having inadequate HL increased among those with chronic diseases (OR = 2.558). These results warrant particular attention and serve as a stimulus for further research aimed at measuring HL levels both in patients with chronic disease and their caregivers.

The risk of having problematic HL decreased with higher perceived social status (OR = 0.788) and among those who reported having good (OR = 0.379) or very good health (OR = 0.459).

The probability of having excellent HL was higher among donors with a bachelor's degree (OR = 5.645) and among those with higher economic status, with significant odds ratios across several income

Table 7
Comparison of blood donors' sociodemographic characteristics according to HLS-EU-Q16 score averages.

Table 7 - Comparison of blood donors' sociodemographic characteristics according to HLS-EU-Q16 score averages

		N	Mean ± SD	t/F	p	
	HL-EU-Q16 Score Means	471	30,29 ± 7,11			
Demographic Characteristics	**Gender**					
	Female	163	30,46±6,40	0,366	0,714	
	Male	308	30,20±7,47			
	Age groups					
	18-24	15	31,67±4,66	0,785	0,535	
	25-34	60	29,74±6,11			
	35-44	87	29,42±7,10			
	45-54	162	30,81±7,63			
	55+	146	30,40±7,08			
	Marital status					
	Married	251	30,78±7,28	1,582	0,114	
	Single	220	29,74±6,89			
Socioeconomic Characteristics	**Education**					
	Up to secondary school	36	29,75±7,97	7,060	0,000	*
	High school	226	29,17±6,77			
	Bachelor's Degree	45	29,03±6,72			
	Master's Degree	164	32,31±7,09			
	Occupation					
	Full time	327	30,37±7,14	0,684	0,603	
	Part time	79	30,76±7,21			
	Non lavoratori	19	27,85±6,30			
	Studenti	15	30,00±5,61			
	Pensionati	31	29,91±7,72			
	Economic status					
	€800-	3	27,08±9,94	3,455	0,000	*
	€800 - €1,350	31	26,79±7,53			
	€1,350 - €1,850	66	29,67±7,63			
	€ 1,850 - € 2,400	77	29,65±6,14			
	€ 2,400 - € 2,950	74	29,48±6,93			
	€ 2,950 - € 3,600	82	30,03±5,99			
	€ 3,600 - € 4,400	50	31,25±7,29			
	€ 4,400 - € 5,250	30	32,08±6,37			
	€ 5,250 - € 6,450	12	36,98±10,26			
	6,450€+	23	33,88±7,85			
	Social Status					
	3	6	27,95±15,10	4,863	0,000	*
	4	29	26,19±5,15			
	5	83	29,46±7,60			
	6	119	29,05±6,59			
	7	157	29,91±6,23			
	8	63	32,87±7,35			
	9	5	37,92±7,16			
	10	8	36,33±7,56			
Health Status	**Self perceived health**					
	Bad	2	18,75±11,79	14,735	0,000	*
	Sufficient	54	26,04±8,42			
	Good	320	30,21±6,24			
	Very Good	95	33,21±7,56			
	Chronic disease					
	No	381	30,64±6,58	2,177	0,03	*
	Yes	90	28,83±8,92			
	Activity limitations					
	No	342	30,91±6,58	5,138	0,006	*
	Yes, but not severe	120	28,82±8,30			
	Yes, severe	9	26,62±5,80			

*Statistically significant variables ($p < 0.05$), based on differences in General HL Index means across categories, using Student's t-test and ANOVA.

Table 8
Comparison of blood donors' health related choices according to HLS-EU-Q16 score averages.

		N	Mean ± SD	t/F	p	
	HL-EU-Q16 Score Means	471	30,29 ± 7,11			
	Smoking					
	No	408	30,27±7,08	-0,177	0,86	
	Yes	63	30,44±7,36			
Health Behaviors	**Alcohol consumption**					
	No	60	31,99±8,19	1,791	0,048	*
	Yes	411	30,05±6,78			
	Physical activity					
	No	73	27,71±7,61	-3,413	0,001	*
	Yes	398	30,77±6,92			
	Access to emergency care					
	No	336	30,73±7,06	2,111	0,035	*
	Yes	135	29,21±7,14			
	Access to GP					
	No	73	32,73±6,73	3,224	0,001	*
Access to Healthcare Services	Yes	398	29,84±7,09			
	Access to hospital					
	No	246	30,91±6,69	1,982	0,048	*
	Yes	225	29,62±7,50			
	Access to outpatient departement					
	No	69	31,57±6,67	1,615	0,107	
	Yes	402	30,07±7,17			

* Statistically significant variables ($p < 0.05$), based on differences in General HL Index means across categories, using Student's t-test and ANOVA.

brackets. Similarly, it was higher among donors who reported very good health (OR = 2.519).

Furthermore, the analysis also focused on specific HL-related health behaviours (Table 11), namely alcohol consumption and physical activity. In the first case, the likelihood of weekly alcohol consumption was higher among donors with problematic HL (OR = 1.890), and lower among those with excellent HL (OR = 0.412). In the second case, donors with inadequate HL were less likely to engage in regular physical activity (OR = 0.463).

Finally, regarding healthcare service use, particularly general practitioner visits, individuals with inadequate HL were more likely to use general practitioner services frequently (OR = 2.842).

5. Discussion

This study assessed HL among blood donors. Conducted directly on donors, it provides further support for previous evidence suggesting that individuals with higher HL are more inclined to engage in social activities, including blood donation [40], and tend to adopt healthier lifestyles [41]. Studies on blood donors are also essential to identify the main motivational drivers [42,43]. Since healthier lifestyles have been linked to a stronger commitment to donation, improving HL among donors could enhance the social impact of blood donor associations [44,45]. According to the HL survey conducted in Italy [36], 26% of respondents reported inadequate HL, 49% problematic, 18% sufficient, and 7% excellent: the fact that 7.5 out of 10 individuals show problematic or inadequate HL underscores the relevance of HL as a critical public health issue in our country.

There was no statistically significant difference between the mean HL scores of donors and the Italian general population; however, a more in-depth analysis revealed a significantly higher proportion of individuals with adequate HL (sufficient and excellent) among donors. This disparity may be explained by the tendency of individuals with healthier lifestyles to donate blood, primarily motivated by concern for the health of others.

Nevertheless, improving HL should not be seen merely as a goal for existing donors, but as a broader strategic lever. On one hand, strengthening HL among current donors reinforces their social role and long-term commitment. On the other hand, targeted communication campaigns designed for individuals with lower HL could serve a dual purpose: they can act as a powerful recruitment tool for non-donors while simultaneously functioning as an educational intervention. By simplifying complex health information and highlighting the tangible benefits of donation, such campaigns can bridge the gap for those with limited health literacy, effectively using blood donation as a gateway to broader health empowerment and system engagement [46].

Viewed from the perspective of the urgent need to bolster the donor base, this finding suggests that further research is needed to validate the relationship between HL and blood donation. In this context, the role of HL is fundamental for "active ageing" in blood donation. While current rules already allow for some flexibility up to age 70, a further extension of the donation age, aligned with increasing life expectancy and improved health status, could significantly mitigate the demographic decline. High HL levels among older donors would ensure they remain informed about their eligibility and the ongoing benefits of their contribution, effectively turning an ageing population into a sustainable resource for the Italian national health system.

The analysis of sociodemographic determinants of general HL among donors once again revealed a social gradient: lower HL was associated with lower education, financial hardship, and low perceived social status. These results align with previous research showing how socioeconomic and health-status determinants shape HL levels in other populations. A further insight emerged from the multinomial logistic regression analysis, which showed that the risk of having inadequate HL decreased with higher education and greater perceived social status [47,48].

Table 9
Determinants associated with HLS-EU-Q16 levels – Bivariate Analysis.

Whole population		Inadequate	Problematic	Sufficient	Excellent
		103 (21.87%)	199 (42.25%)	142 (30.15%)	27 (5.73%)
		p = 0.453			
Gender	**Female**	26 (29.5%)	82 (38.3%)	46 (32.4%)	9 (33.3%)
	Male	62 (70.5%)	132 (61.7%)	96 (67.6%)	18 (66.7%)
		p = 0.429			
Age	**18–24**	1 (1.1%)	6 (2.8%)	8 (5.6%)	0 (0.0%)
	25–34	10 (11.5%)	31 (14.5%)	17 (12.0%)	2 (7.4%)
	35–44	21 (24.1%)	41 (19.2%)	21 (14.8%)	4 (14.8%)
	45–54	25 (28.7%)	70 (32.7%)	56 (39.4%)	11 (40.7%)
	55+	30 (34.5%)	66 (30.8%)	40 (28.2%)	10 (37.0%)
		p = 0.317			
Marital status	**Married**	42 (47.7%)	118 (55.1%)	73 (51.4%)	18 (66.7%)
	Single	46 (52.3%)	96 (44.9%)	69 (48.6%)	9 (33.3%)
		p=0.001*			
Education	**Up tosecondary school**	7 (8.0)	17 (7.9%)	10 (7.0%)	2 (7.4%)
	High school	52 (59.1%)	101 (47.2%)	69 (48.6%)	4 (14.8%)
	Bachelor's Degree	13 (14.8%)	21 (9.8%)	8 (5.6%)	3 (11.1%)
	Master's Degree	16 (18.2%)	75 (35.0%)	55 (38.7%)	18 (66.7%)
		p = 0.578			
Occupation	**Full time**	64 (72.7%)	143 (66.8%)	98 (69.0%)	22 (81.5%)
	Part time	8 (9.1%)	40 (18.7%)	28 (19.7%)	3 (11.1%)
	Non-Employed	5 (5.7%)	10 (4.7%)	4 (2.8%)	0 (0.0%)
	Students	3 (3.4%)	8 (3.7%)	4 (2.8%)	0 (0.0%)
	Retired	8 (9.1%)	13 (6.1%)	8 (5.6%)	2 (7.4%)
		p < 0.001*			
Economic status	**€800-**	1 (1.2%)	1 (0.5%)	1 (0.7%)	0 (0.0%)
	€800 - €1.350	12 (14.1%)	11 (5.3%)	9 (6.7%)	0 (0.0%)
	€1.350 - €1.850	14 (16.5%)	30 (14.6%)	19 (14.1%)	3 (12.0%)
	€ 1.850 - € 2.400	18 (21.2%)	30 (14.6%)	28 (20.7%)	1 (4.0%)
	€ 2.400 - € 2.950	13 (15.3%)	40 (19.4%)	18 (13.3%)	3 (12.0%)
	€ 2.950 - € 3.600	13 (15.3%)	46 (22.3%)	22 (16.3%)	2 (8.0%)
	€ 3.600 - € 4.400	8 (9.4%)	22 (10.7%)	16 (11.9%)	5 (20.0%)
	€ 4.400 - € 5.250	1 (1.2%)	15 (7.3%)	13 (9.6%)	1 (4.0%)
	€ 5.250 - € 6.450	3 (3.5%)	0 (0%)	4 (3%)	5 (20.0%)
	6.450€+	2 (2.4%)	11 (5.3%)	5 (3.7%)	5 (20.0%)
Social status [from 1 to 10]	**Mean (SD)**	6.1 (1.3)	6.2 (1.2)	6.6 (1.2)	7.0 (1.5)
		p < 0.001*			
Self perceived health	**Bad**	1 (1.1%)	1 (0.5%)	1 (0.0%)	0 (0.0%)
	Sufficient	2 (27.3%)	24 (8.9%)	19 (6.3%)	9 (7.4%)
	Good	3 (60.2%)	53 (75.7%)	162 (65.5%)	93 (44.4%)
	Very Good	4 (11.4%)	10 (15.0%)	32 (28.2%)	40 (48.1%)
		p=0.02*			
Chronic disease	**No**	62 (70.5%)	177 (82.7%)	122 (85.9%)	20 (74.1%)
	Yes	26 (29.5%)	37 (17.3%)	20 (14.1%)	7 (25.9%)
		p=0.017*			
Activity limitations	**No**	50 (56.8%)	163 (76.2%)	109 (76.8%)	20 (74.1%)
	Yes, but not severe	35 (39.8%)	46 (21.5%)	32 (22.5%)	7 (25.9%)
	Yes, severe	3 (3.4%)	5 (2.3%)	1 (0.7%)	0 (0%)
		p = 0.904			
Smoking	**No**	78 (88.6%)	184 (86%)	122 (85.9%)	24 (88.9%)
	Yes	10 (11.4%)	30 (14%)	20 (14.1%)	3 (11.1%)

(*continued on next page*)

Table 9 (*continued*)

Whole population		Inadequate	Problematic	Sufficient	Excellent
		103 (21.87%)	199 (42.25%)	142 (30.15%)	27 (5.73%)
		p=0.010*			
Alchool	**No**	13 (14.8%)	18 (8.4%)	21 (14.8%)	8 (29.6%)
	Yes	75 (85.2%)	196 (91.6%)	121 (85.2%)	19 (70.4%)
		p=0.022*			
Physical activity	**No**	22 (25%)	31 (14.5%)	19 (13.4%)	1 (3.7%)
	Yes	66 (75%)	183 (85.5%)	123 (86.6%)	26 (96.3%)
		p = 0.074			
Access toemergency care	**No**	56 (63.6%)	149 (69.6%)	108 (76.1%)	23 (85.2%)
	Yes	32 (36.4%)	65 (30.4%)	34 (23.9%)	4 (14.8%)
		p=0.017*			
Access to GP	**No**	7 (8%)	30 (14%)	28 (19.7%)	8 (29.6%)
	Yes	81 (92%)	184 (86%)	114 (80.3%)	19 (70.4%)
		p = 0.166			
Access to hospital	**No**	39 (44.3%)	109 (50.9%)	84 (59.2%)	14 (51.9%)
	Yes	49 (55.7%)	105 (49.1%)	58 (40.8%)	13 (48.1%)
		p = 0.142			
Access tooutpatient departement	**No**	11 (12.5%)	26 (12.1%)	29 (20.4%)	3 (11.1%)
	Yes	77 (87.5%)	188 (87.9%)	113 (79.6%)	24 (88.9%)

Significance: $p < 0.05$, based on Chi-square test for differences in proportions across categories.

5.1. Strengths, weaknesses and future research

To the best of our knowledge, our research represents the first investigation into HL levels among blood donors in Italy. The results showed that a significantly higher proportion of donors had adequate HL than the general population, even though the difference in mean scores was not significant. Our findings are consistent with the existing literature, which indicates that individuals with higher HL tend to adopt healthier lifestyle behaviours [49] and that a relationship exists between HL and blood donation [45,50]. Accordingly, we posit that heightened HL among blood donors could play a pivotal role in bolstering the pool of donors [51], although further research is needed to investigate this relationship.

Our study has several limitations that should be acknowledged. First, the participants represent a subgroup of blood donors from a single local health authority within one Italian region, which limits the generalisability of the findings and warrants caution in their interpretation. Second, certain health behaviours were measured in a simplified way: variables such as “Drinking” and “Physical activity” were recorded without a specific gradient of frequency or intensity, so this binary approach does not distinguish between moderate and heavy alcohol consumption, nor between light and vigorous physical exercise. Finally, attitudes toward blood donation can be deeply influenced by cultural, religious and personal beliefs; in line with this, our results suggest that HL is not merely an individual skill but is also shaped by social and cultural factors.

Several directions for future research emerge from these limitations. First, further studies should investigate the relationship between HL in donors and non-donors and analyse the impact of intervention programmes aimed at enhancing HL on blood donation behaviour, in order to confirm whether individuals with higher HL are indeed more inclined to engage in social activities, including blood donation; this would underline the importance of education and HL promotion within the community as a strategy to enhance participation rates. Second, future research should explore how technological advances, such as AI and machine learning, can improve patient care in transfusion medicine and donor management systems, with the potential to enhance operational efficiency, donor engagement, and safety [52,53]. Third, further investigation into donors' motivational sources is needed, assessing the extent to which subjective well-being and the underlying drivers of donation influence actual donation behaviour, also considering that donation may be beneficial for donors' own health [54]. Finally, future studies should explore the psychological and cognitive mechanisms behind the link between HL and chronic diseases — for instance, whether the observed lower HL reflects cognitive overload or a strategic narrowing of health interests toward one's own pathology — since tools distinguishing general from condition-specific HL could provide a deeper understanding of this dynamic.

6. Conclusions

Blood transfusion is a crucial service of healthcare systems that contributes to saving and improving many lives every year. Given the increasing complexity of medical and surgical interventions, it improves both the life expectancy and the quality of life of blood recipients. Blood transfusion and organ donation are two critical areas in medicine where HL proves indispensable: within the context of blood transfusion, HL plays a critical role in facilitating patients' understanding of complex procedures, potential risks, and treatment options. Our research, based on a comprehensive literature review, underscores its vital role in healthcare.

Our study encompassed blood donors aged 18 years and over who presented at the transfusion centre between November 2024 and February 2025. From a methodological perspective, this work has shown how the HLS-EU-Q16 questionnaire is well suited to capturing the different levels of HL demonstrated by donors.

The main findings can be summarised as follows.

- The proportion of individuals with adequate HL was significantly higher in blood donors than in the general Italian population (chi-

Table 10
Factors associated with HLS-EU-Q16 categories – Multivariate analysis.

		Inadequate	Problematic	Excellent
Education	**Up to secondary school**	Ref.	Ref.	Ref.
	High school	0.416	0.802	1.636
	Bachelor's Degree	**0.386***	0.932	**5.645***
	Master's Degree	**0.179****	0.519	0.873
Economic status	**€800-**	Ref.	Ref.	
	€800 - €1.350	0.4	2.2	
	€1.350 - €1.850	0.3	1.8	Ref.
	€ 1.850 - € 2.400	0.543	1.393	**9.667****
	€ 2.400 - € 2.950	0.622	2.053	**28****
	€ 2.950 - € 3.600	0.554	0.99	**6***
	€ 3.600 - € 4.400	0.677	1.052	**11****
	€ 4.400 - € 5.250	0.8	1.6	3.2
	€ 5.250 - € 6.450	5.2	1.907	**13***
	6.450€+	0.533		0.8
Social status (+1 point)		**0.493****	**0.788***	1.193
Self perceived health	**Bad**	Ref.	Ref.	
	Sufficient			Ref.
	Good	**0.094*****	**0.379***	1.463
	Very Good	**0.439***	**0.459****	**2.519***
Chronic disease	**No**	Ref.	Ref.	Ref.
	Yes	**2.558****	1.275	2.135
Activity limitations	**No**	Ref.	Ref.	Ref.
	Yes, but not severe	6.54	3.344	1.192
	Yes, severe	2.743	3.478	

*p < 0.05; **p < 0.01; ***p < 0.001; (Ref.: O.R. = 1) Reference category in the model: Sufficient HL.

Table 11
Relationship between levels of HL, lifestyle behaviours, and access to health services – Multivariate analysis.

	Alcohol
Sufficient	Ref.
Inadequate	1.001
Problematic	**1.890***
Excellent	**0.412***
	Physical activity
Sufficient	Ref.
Inadequate	**0.463***
Problematic	0.912
Excellent	4.016
	Access to GP
Sufficient	Ref.
Inadequate	**2.842****
Problematic	1.506
Excellent	0.583

*p < 0.05; **p < 0.01; ***p < 0.001; (Ref.: O.R. = 1).

square test). A likely reason is the inclination of individuals with a healthy lifestyle to donate blood and their tendency toward benevolent behaviour. As the literature on this topic is still limited, we advocate large-scale studies assessing HL levels in both donors and non-donors, as well as investigations into the impact of intervention programmes aimed at improving HL on blood donation behaviour.

- Bivariate analyses showed that the variables significantly associated with HL levels were education level, economic status, perceived social status, self-perceived health, presence of chronic diseases, and activity limitations.
- The multinomial logistic regression analysis showed that the risk of having inadequate HL decreased among those with a bachelor's or master's degree, higher perceived social status, and better self-perceived health, whereas it increased among those with chronic diseases.

We acknowledge that our study focused on blood donors within a specific local health authority of the Marche Region, which may limit the generalisability of the findings; nonetheless, it makes a meaningful contribution to the literature by clarifying the relationship between HL and blood donation behaviour. Finally, the impact of artificial intelligence and machine learning on the healthcare sector cannot be underestimated: in the field of blood donation, tailoring communication to the needs and preferences of individual donors, supported by the analysis of large amounts of communication data, could play an important role in improving recruitment.

Informed consent

Interviewees were invited to read the informed consent before completing the questionnaire.

Ethical approval

The study was conducted within the framework of the official agreement (Disciplinare C) between ASUR Marche and AVIS Marche for 2022–2024, and was authorised by the U.O.C. Medicina Trasfusionale Senigallia-Jesi-Fabriano of AST Ancona (Marche Region) on 11 March 2024; it was further approved by the Board of Directors of AVIS of Senigallia on 23 November 2024. Participation was voluntary and anonymous, and the questionnaire collected no sensitive or identifying clinical data. All participants provided informed consent, and personal-data processing complied with the EU General Data Protection Regulation (Regulation 2016/679) and Italian Legislative Decree 196/2003 (as amended by Legislative Decree 101/2018). The study was conducted in accordance with the principles of the Declaration of Helsinki. As this non-interventional, anonymous survey was authorised through the institutional ASUR–AVIS convention rather than by a numbered ethics-committee protocol, no approval number is available; the relevant documentation is available from the authors upon request.

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CRediT authorship contribution statement

Pietro Renzi: Data curation, Formal analysis, Funding acquisition, Project administration, Resources, Software, Validation, Visualization, Writing – review & editing. **Alberto Franci:** Conceptualization, Investigation, Methodology, Supervision, Writing – original draft.

Data availability

The authors do not have permission to share data.

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Pietro Renzi is a professor of Statistics and Information Processing Systems at the University of the Republic of San Marino and at the University of Urbino "Carlo Bo". He holds a degree in Telecommunications Engineering from the University of Bologna and a PhD in Economic-Management Engineering. His research applies social statistics to health and social services, focusing on performance evaluation (EGIPSS model), the measurement of health inequalities, and health literacy. He has published in journals including Social Indicators Research and Quality & Quantity, and coordinates research projects on health inequalities and their determinants.

Alberto Franci is Full Professor of Social Statistics at the University of Urbino "Carlo Bo" and professor at the University of the Republic of San Marino. At Urbino he has taught since the early 1970s and directed the Methodological, Economic and Statistical Institute (IMES). Appointed full professor in 2000, his research addresses the programming, management, and evaluation of social and health services, with particular attention to health-system performance, quality of care, and the measurement of health inequalities. He has published extensively, including in Social Indicators Research and the British Journal of Healthcare Management.