REVIEW PAPER

The prevalence of HIV infection among blood donors: a systematic review and meta-analysis

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Abstract

Blood recipients, particularly frequent receivers, are at high-risk of receiving human immunodeficiency virus (HIV), and no current serologic tests eliminate this transmission risk. The current paper aimed to provide an updated comprehensive report on the prevalence of HIV infection among blood donors in different parts of the world.

HIV infection prevalence in blood donors was determined based on electronically published data through a systematic review of literature in international databases until February 2020. Studies published in Farsi and English reporting the prevalence of HIV were included. Meta-analysis was performed, and final results were classified according to World Health Organization (WHO) divisions of the world.

Out of 1,859 articles, 241 met the inclusion criteria. The prevalence of HIV was higher in first-time donors, males, and replacement therapy receivers. The pooled prevalence was 502.74 in 100,000. AFRO with 2,384.99 and Europe with 19.04 in 100,000 had the highest and the lowest rates, respectively. Gabon represented the highest rate of 20,623, while the USA showed the lowest rate, i.e., 4.33, among the countries.

Updated reports on the prevalence of HIV among blood donors help policy-makers and care providers realize the possible need for improving the screening, diagnostics, and treatment protocols. Although the prevalence has decreased in many parts of the world, improving the current protocols is still necessary to minimize the risks in transfusion systems.

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Introduction

The recognition of transfusion-transmissible infections (TTIs) has indicated a new horizon in blood transfusion practice all around the world, with an emphasis on two primary objectives, such as safety and protection of human life [1].

Blood safety has remained an issue of major concern, especially in regions where transfusion services, policies, infrastructure, trained staff, and financial resources are insuf-

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ficient. Blood recipients, particularly those who frequently receive transfusions, are at high-risk for acquiring TTIs, including human immunodeficiency virus (HIV) infection, and unfortunately, serologic tests do not eliminate the transmission risk of HIV [2, 3].

Accurate, current, and timely public health surveillance information on HIV prevalence is necessary to guide decisions for planning disease prevention, program evaluation, and allocation of resources at the local and national levels [4]. According to the literature, about 40 million patients are infected with HIV globally, and over 30 million have died due to this infection and its complications [5]. The most significant portion of this mortality rate is assigned to developing countries [5]. Ensuring blood safety in transfusions and implementing screening of HIV using nucleic acid testing (NAT), played a significant role in reducing the transmission rate, especially in pioneer countries, such as the United States, after 1999 [6]. Investigations both before and shortly after using NAT showed measurable advantages in the prevention of potential transfusion transmissions attributed to the reduction in window periods [5, 7-11].

TTIs have been drastically reduced in countries where routine serologic screening of donors was conducted [12, 13]. In Iran, screening of blood donations for HIV became mandatory in 1989. Another survey from Iran evaluating the general population in 1999 reported a prevalence of 0.86 in 10,000, while a newer official report of 2007 showed an increased rate of 2.3 in 10,000 identified cases of infection [14, 15]. According to the latest information, the proportion of blood donation in the transmission of the disease in Iran was 0.9%; however, more recent reports showed that although the prevalence is increasing at a slow pace, no case of HIV infection was diagnosed due to blood products [16].

Evaluation of the published literature on the prevalence of HIV among blood donors provides valuable data on the occurrence of this infection in population and, consequently, the safety of donated products in various regions. In this paper, we presented a brief review and a meta-analysis of the prevalence of HIV infection among blood donors all over the world, with the attempt to highlight the global burden of this TTI.

Material and methods

The prevalence of HIV infection in blood donors based on any published data from Iran and other countries all over the world was investigated through a comprehensive systematic review of the literature, followed by integrating of the data and analysis of the outcomes.

Search strategy and method

An electronic systematic search algorithm in international databases, such as PubMed, ISI, Scopus, and ProQuest were adopted for articles published till February 2020, using the following keywords: ("blood donors" OR "blood donation" OR "donor" OR "donation" OR "blood" OR "blood safety" OR "bloodborne" OR "residual risk" OR "transfusion-transmitted infections") AND ("prevalence" OR "epidemiology") in combination with ("HIV" OR "human immunodeficiency virus" OR "AIDS" OR "HIV/AIDS"). Google Scholar and Iranian databases, Scientific Information Database (SID, www.sid.ir), and Magiran (http://www.magiran.com) were searched for published articles in Farsi/Persian language. References of the reviews, systematic reviews, meta-analyses, and relevant retrieved articles were explored to increase the sensitivity. All the literature was imported into EndNote® software version X9, and screened for eligibility criteria. Inclusion criteria for consideration of the studies were based on preferred reporting items for systematic reviews and meta-analyses (PRISMA) checklist (Table 1). At first, titles and/or abstracts of studies were reviewed by a single reviewer (SAE). Only studies on blood donors published in English that measured the prevalence of HIV/AIDS were included in the systematic review. Exclusion criteria were insufficient statistical information about the prevalence and number of positive cases, and specific blood donors' population (i.e., studies that recruited only HBS-positive blood donors). Two reviewers (SH and AE) screened the abstracts and independently applied inclusion criteria to full texts. Duplicate and overlapping studies were also excluded.

Data collection and data items

One reviewer (LK) extracted the data and double-checked for the following items: authors' names, publication year, study period, location, sample size, prevalence of HIV/AIDS, and blood donation status (first time, lapsed, and regular blood donor). If ambiguity was present in a study information extraction, it was resolved by a statistician (MSM).

Table 1. Study inclusion criteria

Study population	Any individual who had donated blood
Geographical setting	No restrictions
Blood donation status	Individuals might have donated blood for first time, second time, or regularly
HIV screening	Antigen/antibody tests, nucleic acid testing
Study design	Any study design with data on the prevalence of HIV/AIDS in blood donors

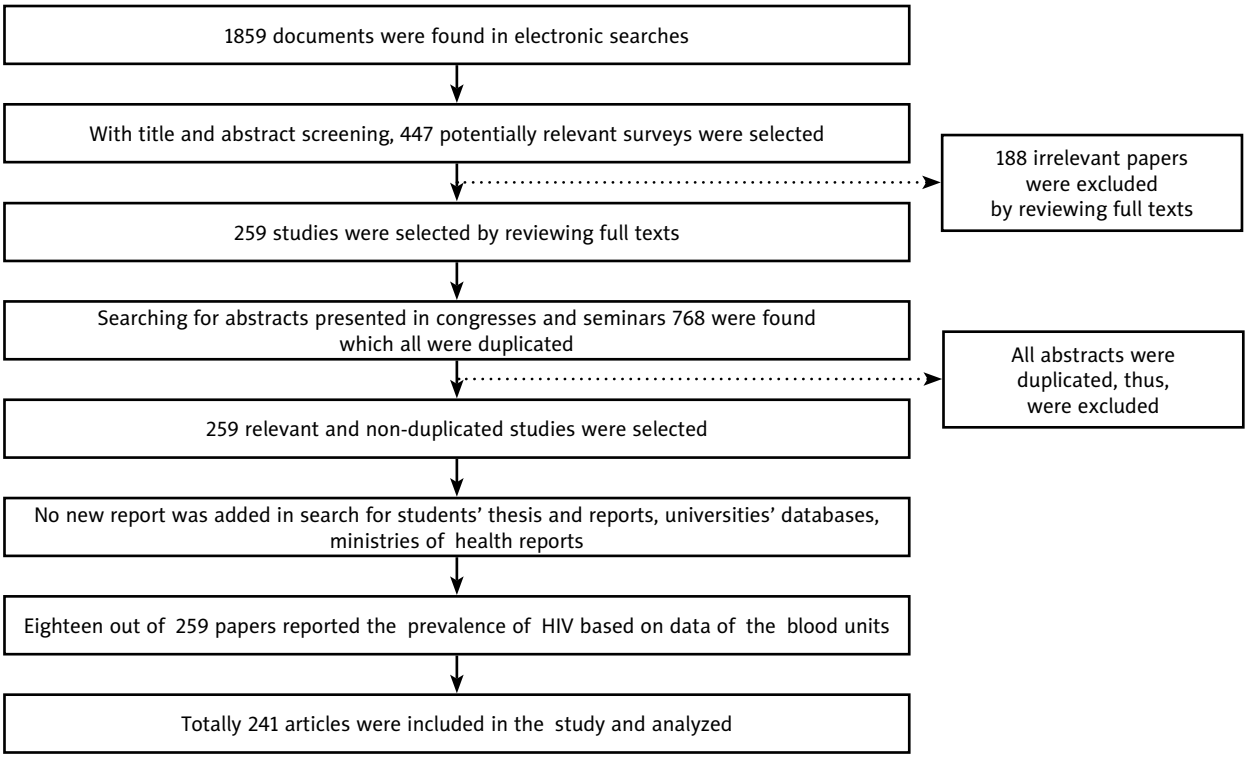

Figure 1. Flow diagram of systematic review and searches for HIV infection prevalence among blood donors in countries all over the world

Table 2. Demographic data of global prevalence of HIV infection among blood donors

Criterion/Condition	No. of studies	No. of blood donors	No. of infected donors	Prevalence of HIV in 100,000	95% confidence interval
Donation status					
First time	12	5,918,554	13,367	2,702	913-5,391
Regular	3	36,370,841	3,165	1,214	162-3,170
Gender					
Male	15	850,599	1,782	2,940	2,356-3,586
Female	13	482,402	1,153	2,412	1,579-3,389
Reason of donation					
Replacement	11	82,513	1,773	2,325	1,313-3,616
Voluntarily	8	43,369	176	1,378	355-2,990

Statistical analysis

Meta-analysis was conducted using Metaprop command in STATA version 14.0 (Stata Corp., College Station, TX, USA) [17]. The extracted data included first author, year of the study, location, sample population, sampling method and sample size, HIV/AIDS detection method, age, male to female ratio, and HIV point prevalence among the subjects. Cochrane Q-test was used with a significance level of less than 0.1 for statistical heterogeneity of the results. To assess the level of heterogeneity, a range of 0% (no heterogeneity) to 100% (significant heterogeneity) was considered during the analysis; values of 25%, 50%, and 75% were labeled as representing low, medium, and high heterogeneity, respectively [18]. Whenever heterogeneity of a study was significant ($p < 0.1$), a random effect meta-analysis was used; otherwise, a fixed effect meta-analysis was applied to combine the prevalence. Countries were grouped according to the World Health Organization (WHO) list of countries of each regional office, namely, African Regional Office (AFRO), Region of the Americas (AMRO), South-East Asia Regional Office (SEARO), European Region (EURO), Eastern Mediterranean Regional Office (EMRO), and Western Pacific Regional Office (WPRO) [19].

Table 3. Part 1: Prevalence of HIV in different regions of the world (according to WHO regional divisions), and in different countries based on published literature

Study	No. of studies	Prevalence	95% confidence interval		% weight	I^2	Reference
WPRO						99.8%	
China	5	78.746	76.792	80.701	2.96		[30-34]
Philippines	1	6.324	0.127	12.522	2.95		[35]
Pooled prevalence	6	42.597	–28.375	113.570	5.91		
SEARO						99.8%	
Bangladesh	2	4,203.224	3,641.436	4,765.012	0.10		[36, 37]
Bengal	2	212.991	194.489	231.493	2.87		[38, 39]
India	45	340.764	336.007	345.521	2.95		[40-84]
Indonesia	1	914.849	419.820	1,409.877	0.13		[83]
Nepal	1	20.027	5.193	34.861	2.90		[85]
Sri Lanka	2	32.719	19.049	46.389	2.91		[86, 87]
Thailand	3	476.814	423.517	530.110	2.35		[88-90]
Pooled prevalence	56	489.078	326.403	651.752	14.22		
AMRO						99.7%	
Brazil	8	157.927	149.593	166.262	2.94		[91-98]
Canada	1	30.979	–29.729	91.687	2.22		[99]
Ecuador	1	2,186.705	2,010.091	2,363.319	0.77		[100]
Mexico	4	99.455	83.600	115.310	2.89		[101-104]
Haiti	1	13.755	6.794	20.715	2.95		[105]
USA	1	4.333	3.853	4.814	2.96		[106, 107]
Venezuela	1	243.729	201.883	285.575	2.55		[107]
Pooled prevalence	17	246.710	180.959	312.460	17.29		
AFRO						99.9%	
Angola	1	1,744.979	1,656.588	1,833.370	1.73		[108]
Burkina Faso	2	390.505	328.546	452.463	2.19		[109, 110]
Cameron	6	2,305.511	2,074.563	2,536.459	0.51		[32, 111-115]
Congo	4	175.247	169.678	180.815	2.95		[116-119]
Côte d'Ivoire	1	3,832.174	3,774.276	3,890.072	2.27		[120]
Djibouti	1	1,943.149	1,658.064	2,228.234	0.35		[121]
Eritrea	2	313.116	195.195	431.037	1.31		[122, 123]
Ethiopia	17	895.087	853.242	936.931	2.55		[124-140]
Gabon Province	3	2.1e+04	1.8e+04	2.3e+04	0.01		[141-143]
Ghana	2	3,678.723	3,596.256	3,761.189	1.83		[144, 145]
Guiana	1	7,831.120	6,859.492	8,802.749	0.03		[146]
Kenya	5	3,797.200	3,251.594	4,342.806	0.11		[147-151]
Malawi	2	2,530.578	2,367.355	2,693.801	0.87		[152, 153]
Mali	2	2,481.995	2,315.651	2,648.340	0.84		[154, 155]
Namibia	1	302.896	234.449	371.342	2.08		[156]
Nigeria	15	2,954.379	2,874.456	3,034.303	1.87		[157-171]
Sierra Leone	1	2,804.625	2,555.444	3,053.806	0.45		[172]
South Africa	2	468.076	455.599	480.553	2.92		[173, 174]
Sudan	1	1,364.522	360.609	2,368.436	0.03		[175]
Tanzania	4	2,874.800	2,653.214	3,096.385	0.54		[176-179]
Zimbabwe	1	658.163	624.234	692.092	2.68		[180]
Pooled prevalence	74	2,348.989	2,016.136	2,681.843	28.12		

Table 3. Part 1: Cont.

Study	No. of studies	Prevalence	95% confidence interval		% weight	I^2	Reference
EUROPE						98.9%	
France	1	19.105	15.795	22.414	2.96		[181]
Italy	1	6.077	5.641	6.514	2.96		[182]
Saxony	1	5.419	2.916	7.922	2.96		[183]
Serbia	1	12.952	11.221	14.683	2.96		[184]
Spain	1	65.780	59.461	72.100	2.95		[185]
Turkey	12	9.730	7.347	12.114	2.96		[186-197]
Pooled prevalence	17	19.041	11.720	26.363	17.74		
EMRO							
Egypt	2	11.094	5.283	16.904	2.95		[198, 199]
Iraq	2	49.605	29.338	69.873	2.85		[200, 201]
Pakistan	12	42.547	35.976	49.118	2.95		[202-213]
Palestine	1	7.636	5.327	9.946	2.96		[214]
Saudi Arabia	3	69.725	39.178	100.273	2.73		[215-217]
Yemen	4	419.874	363.205	476.543	2.29		[218-221]
Pooled prevalence	24	72.523	46.979	98.067	16.73		
Overall						99.9%	
Pooled prevalence	194	502.744	484.696	520.793	100.00		

Table 3. Part 2: Prevalence of HIV in different cities of Iran based on published literature

Study	No. of studies	Pooled prevalence	95% confidence interval		% weight	I^2	References
Bushehr	3	4.600	2.272	6.927	6.91	97.6%	[193, 222]
Chabahar	1	1,294.139	992.942	1,595.337	0.00		[223]
Fars	5	7.479	6.453	8.505	7.98		[224-228]
Qom	1	5.603	-5.378	16.583	1.51		[229]
Golestan	3	1.197	-0.462	2.855	7.53		[230-232]
Gilan	1	8.029	0.161	15.897	2.51		[233]
Hamedan	1	5.463	-5.244	16.169	1.58		[234]
Ilam	3	0.785	0.341	1.230	8.24		[235-237]
Isfahan	4	0.641	0.013	1.269	8.18		[238-241]
Kerman	2	1.816	0.829	2.803	8.01		[242, 243]
Kermanshah	1	13.420	-1.765	28.606	0.87		[244]
Mazandaran	2	1.097	-0.423	2.618	7.64		[245, 246]
Semnan	1	9.467	0.190	18.744	1.98		[247]
Tehran	6	7.093	6.687	7.500	8.24		[248-253]
Yazd	1	1.570	0.031	3.109	7.63		[254]
Kurdistan	1	6.074	2.637	9.510	5.77		[255]
Kohgiluyeh and Boyer-Ahmad	2	4.224	2.154	6.293	7.16		[256, 257]
Iran	2	3.966	3.754	4.177	8.28		[258, 259]
Ardebil	1	Excluded					[260]
Khorasan	2	Excluded					[261, 262]
Zanjan	1	Excluded					[263]
Qazvin	1	Excluded					[264]
Arak	1	Excluded					[265]
Yasuj	1	Excluded					[266]
Overall	47	3.745	2.250	5.240	100.00		

Results

In the electronic search of PubMed, Web of Science, Scopus, ProQuest, and local databases for HIV infections in different countries, 487, 518, 569, 223, and 62 papers were identified. After exclusion of duplicated articles (n = 671), reviews (n = 8), irrelevant articles (n = 765), and non-English and non-Persian papers (n = 21), by reviewing the titles and abstracts, articles with insufficient information (n = 76), and those with unrelated population (n = 59) were all excluded. In total, 259 out of 1,859 articles met the inclusion criteria. Of these, 18 papers reported the prevalence of HIV based on testing blood donors; thus, the exclusion of these papers reduced the final inclusion list to 241 papers (Figure 1).

As shown in Table 2, the prevalence rates of HIV were higher in first-time blood donors, males, and those receiving replacement therapies, globally. However, age and educational classifications were not recorded due to lack of data in the papers. The total number of HIV cases in the world excluding Iran's data was 78,324 (ranging from 0 to 19,646) among a total sample size of 44,785,054, ranging from 206 to 12,258,587. The pooled prevalence of HIV was 502.74 in 100,000 population (95% CI: 484.69-520.79%); test for heterogeneity: Q = 37343.16, df = 99.9%, $p < 0.001$, I^2 = 99.9%, Tau^2 = 5200.95). As presented in part 1 of Table 3, AFRO division showed the highest prevalence rate (3481.37 in 100,000), while Europe (19.04 in 100,000) presented the lowest prevalence rate. Among the countries, Gabon depicted the highest rate (20,623 in 100,000), while the USA showed the lowest prevalence (4.33 in 100,000). In part 2 of Table 3, in Iran, the pooled prevalence was 3.74 in 100,000 (95% CI: 2.25-5.24%; test for heterogeneity: Q = 646.74, df = 14%, $p < 0.001$, I^2 = 97.6%, Tau^2 = 54.95) with the highest rate in Chabahar (1,294.14 in 100,000) and the lowest in Isfahan (0.64 in 100,000) cities.

Discussion

The WHO suggests screening of all donated blood for infections prior to use. Examining the blood products for HIV, hepatitis B virus, hepatitis C virus, and syphilis should be mandatory and conducted regardless of the quality system requirements. Among reporting countries, more than 13 were unable to perform the screening tests for all donated blood units for at least one of the afore-mentioned infections [20]. According to the WHO's 2017 report, the prevalence rates of HIV infection in blood donations in high-income, upper-middle-income, lower-middle-income, and low-income countries are 0.003%, 0.08%, 0.20%, and 1.08%, respectively [20]. This report indicates that the economic situation and subsequent facilities of a country have a direct influence on the risk of infection in blood products.

The current study presented the prevalence of HIV infection considering the published data from countries all over the world, and compared the outcomes with the prevalence of HIV in Iranian population. As demonstrated, the EURO division had the lowest prevalence, which could be because of a better economic situation in European countries compared with other regions. Saxony territory had the most HIV-free blood units, and Spain had the highest HIV prevalence. Correspondingly, the poorest region, which is AFRO division, had the highest prevalence of all. Gabon appeared to be the most prevalent country for HIV-infected blood donations, and Congo had the lowest rate. In SEARO, Nepal showed the lowest prevalence, while Bangladesh, the poorest country in the region, demonstrated the highest rate. In AMRO, Ecuador and the USA had the highest and the lowest prevalence of HIV in blood units, respectively. However, the overall prevalence was low in WPRO division; Philippines and China had the lowest and the highest rates according to their published information, respectively. In EMRO, the lowest prevalence belonged to Iran, particularly in Isfahan Province, and the highest was observed in Yemen, which has been in a dire economic situation and even war during these years. These findings showed that the socio-economic status of a country, and the subsequent effects of economic situation on available facilities could have a direct impact on the prevalence of HIV as well as the provision of sufficient screening equipment. In order to achieve the eradication of the virus from blood units, several activities should be adopted, including improving healthcare policies, screening systems, and diagnostic methods, educating the staff and the population, providing sufficient treatment, and managing the sources of infection [21-24]. Behavioral changes, such as reducing multiple and concurrent partners apart from using protection have been noticed as the main tools to prevent AIDS epidemics in regions, such as African countries [25-29]. Preventive care should be implemented at all levels to reduce the incidence of HIV infection and its complications. The limitations of this study were an inadequate number of studies from various countries and the absence of records in many countries, which did not allow the delivery of a better evaluation and more comprehensive outcomes.

Conclusions

Our report demonstrated that the overall prevalence of HIV among blood donations has noticeably declined worldwide. However, compared with industrialized countries, the infection was high in developing regions, especially in AFRO division. In order to reduce the infection and increase blood donation safety, policy-makers must design comprehensive strategies according to updated academic literature. Developed countries should share their knowledge, experience, and facility with lower socio-economic countries to decrease the HIV infection among blood donors and the whole population, considering the fact that having the disease not controlled in one region may affect health status of the entire world.

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Conflict of interest

The authors declare no conflict of interest.

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