Prevalence and residual risk of HIV in volunteer blood donors of Zhejiang Province, China from 2018 to 2022

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Abstract

Background: Blood safety levels have been significantly improved since nucleic acid amplification technology (NAT) testing for blood donors was carried out, but the residual risk of transfusion transmission infections still exists. Here, the prevalence of HIV and residual risk of the HIV transmission in volunteer blood donors of Zhejiang Province, China for five years after NAT implementation were evaluated.

Materials and methods: All specimens and information were collected from voluntary unpaid donors at all blood services in Zhejiang Province,China from January 2018 to December 2022. HIV antibody/antigen and HIV RNA were detected by enzyme-linked immunosorbent assay and NAT. The residual risk of the HIV transmission was calculated using the incidence/window period model.

Results: A total of 3,375,678 voluntary blood donors were detected, and the HIV prevalence was 9.92/100000. The HIV prevalence of blood donors in twelve blood services in Zhejiang Province were 6.11, 6.98, 7.45, 8.21, 8.36, 8.94, 9.04, 9.66, 9.73, 10.22, 11.80 and 12.47 per 100000 donors, respectively, and the difference of all blood services was not statistically significant (P>0.05).The HIV prevalence of males (15.49/100,000) was significantly higher than that of females (1.95/100,000) (P<0.05). There was no significant difference in HIV prevalence among blood donors of all different age groups(P>0.05), but the HIV prevalence in 26 to 35 age group and 18 to 25 age group were significantly higher than that in 36 to 45 age group(P<0.05).The difference in HIV prevalence between the first-time blood donors (13.65/100,000) and repeat blood donors(6.78/100,000) was statistically significant(P<0.05). From 2018 to 2022, the HIV residual risk in blood transfusion transmission was 0.266/100000.

Conclusion: The prevalence of HIV among blood donors in Zhejiang Province, China is associated with age, gender and times of blood donation. The HIV residual risk in blood transfusion transmission is low in Zhejiang Province and increasing the rate of repeat blood donors is beneficial to improve blood safety.

Introduction

Blood transfusion therapy has important clinical significance, which can be used as a treatment method or supporting mean for surgical procedures, patients with hematological diseases,obstetric bleeding and so on[1–3]. However,the blood transfusion process also has some adverse reactions, one of which is the occurrence of transfusion transmitted infections (TTIs) caused by the pathogens[4]. Prevention of TTIs remains a key element of blood transfusion safety. Now various strategies were adopted to reduce the residual risk of TTIs in different countries[5, 6]. The residual risk of TTIs mainly depends on the type of blood donation, regional pathogen prevalence, detection indicators, detection methods and detection strategies[7–9]. Since 1998, China has fully implemented voluntary blood donation and mandatory testing for serological indicators of the hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV), and Treponema pallidum (TP) in blood donors[10]. However, blood screening by nucleic acid amplification technology (NAT) has been used to detect HBV DNA, HCV RNA and HIV RNA since 2016 in China[10, 11]. Therefore,the residual risk of TTIs has gradually decreased and the overall level of blood transfusion safety is constantly improving in China[12, 13].

HIV infection in TTIs is still one of the issues of great concern, which largely depends on the HIV prevalence among blood donors and the characteristics of HIV positive donors[14, 15]. According to the report of the United Nations acquired immune deficiency syndrome(AIDS) Programme, there will be 39 million people infection with HIV in the world by 2022, including 1.3 million new infections and 630000 deaths from AIDS related diseases in 2022[16]. The Chinese government has long and comprehensively promoted and implemented various strategies to control the spread of HIV[17, 18]. Since 2020, the number of HIV infection cases in China has started to decline year by year according to report data of Center for Disease Control and Prevention,China(https://www.chinacdc.cn/). By the end of 2020, 1.053 million people in China were infected with HIV, and 351000 people were reported to have died (https://weekly.chinacdc.cn/). However,there are significant differences in HIV prevalence rates among different provinces and regions in China[19, 20].Zhejiang Province is one of the provinces with low HIV prevalence in China, located in eastern China. By the end of October 2022, there are 39452 living HIV infected individuals in Zhejiang Province, with 4671 deaths (https://www.cdc.zj.cn/). Furthermore,105 newly reported student cases among them, 88.6% of which were infected through men who has sex with men (MSM) activity (https://www.cdc.zj.cn/). It was reported that HIV can be transmitted through sexual,blood and mother-to-child vertical transmission[20–22]. To effectively prevent HIV transmission through blood transfusion, now blood donors should be tested for HIV antibodies and HIV RNA according to the Chinese regulations[10], and only those blood tested negative can be used for transfusion, which helps to prevent the transmission of HIV through blood transfusions in China.

Busch MP et al.reported that the residual risk of HIV transmission through blood transfusion is 1 in 2 million per unit in the Units States[7]. However, HIV residual risk is higher in China as previously report, with 5.4 (95% CI,1.2–12.5) infections per million whole blood donations[23]. Shi L et al. reported the HIV infection status of blood donors in five different regions of China and found that the HIV prevalence rate among first-time donors was 680.4/1 million, but the data was sourced from 2013 to 2016[24]. Due to the decrease in the proportion of HIV infection among the general population from 2020 and the implement of HIV nucleic acid testing in blood services since 2016[10, 11], it is necessary to reassess the HIV prevalence and residual risk for blood donors in China. Therefore, we retrospectively analyzed the data of HIV testing of voluntary blood donors in Zhejiang Province from January 2018 to December 2022, which all blood donors have preformed the NAT for HBV DNA, HCV RNA and HIV RNA. The distribution of HIV positive donors among different groups of blood donors were compared with characterize by age, gender and number of blood donations. The incidence-window period model was also used to evaluate the residual risk of HIV transmission in blood donors in Zhejiang Province, China .

Materials and methods

Blood specimens

All study specimens were collected from voluntary unpaid donors at all blood services in Zhejiang Province from January 2018 to December 2022. According to administrative divisions, there are twelve blood services,including the blood center of Zhejiang Province (Hangzhou), blood station of Ningbo(Ningbo), blood station of Wenzhou(Wenzhou), blood station of Jiaxing(Jiaxing), blood station of Huzhou(Huzhou), blood station of Shaoxin (Shaoxin), blood station of Jinhua(Jinhua), blood station of Quzhou(Quzhou), blood station of Taizhou (Taizhou),blood station of Lishui(Lishui),blood station of Zhoushan (Zhoushan), blood station of Yiwu (Yiwu), respectively. Pre- and post-donation screening of blood donors were done according to our previous reports[11, 25]. All specimens were collected, stored, and handled according to the manufacturer instructions of the assays.

Information of the blood donors

All twelve blood services in Zhejiang Province use the same blood information management system according to the approval of the Health Administration Department of Zhejiang Province. Therefore, the Information of all blood donors were inputted to the same blood information management system,including the age,gender,number of blood donations an so on. The donors' identification card number was used as the unique flag. If the donor had two or more blood donations in each year, it only considered as one blood donor for analysis.

This is a retrospective study and was approved by the Ethical Scientific Committee of Zhejiang Provincial Blood Center, China according to the Helsinki declaration (approval No. 2023-016).

HIV antibody/antigen testing

HIV antibody/antigen screening tests were performed using two different manufacturers of enzyme-linked immunosorbent assay (ElISA) reagents, one of which was from the BIORAD company (Hercules, California, USA), the other reagent from various manufacturers (Beijing Wantai Biological Pharmaceutical Co., Ltd.,Being, China), Zhuhai Lizhu Reagent Co., Ltd, Zhuhai,China, and InTec,Xiamen,China) depends on the blood services. Strictly following the manufacturer instructions, if any one of the reagent test results for the reactivity, the specimen was finally judged as a positive reaction as previously reports[11].

The specimens with HIV antibody positive reaction in the screening tests by the blood services were then sent to the local Center for Disease Control and Prevention,China[10]. If the Centers for Disease Control and Prevention confirms that a person is HIV-positive or has tested positive for HIV RNA, the donor will be considered HIV-positive, and if not, the donor will be considered HIV-negative.

HIV RNA testing

The HIV NAT assays were performed according to our previous reports[11, 25]. Various manufacturers were used depends on the situation of blood services, including 6 mini pools NAT (Roche Diagnostics, Manheim, Germany),8 mini pools NAT (Haoyuan, Shanghai, China) and individual NAT (ID-NAT,Novartis Diagnostics, Emeryville, CA, USA). All operation procedures were followed the manufacturer instructions.

Statistical analysis

The prevalence of HIV was calculated by dividing the number of positive (confirmation HIV antibody or HIV RNA) donors in a calendar year by the total number of donors in that year and was expressed per 100,000 donors. The HIV residual risk in blood transfusion transmission was calculated using the incidence/window-period model[26].

Statistical parameters analysis was performed with the SPSS 24.0 version software, and comparison for the rate of difference groups was performed with the Chi square test. The p level of significance for each analysis was set at 0.05.

Results

Comparison of HIV prevalence among blood donors from 2018 to 2022

From 2018 to 2022, the total blood donors in the Zhejiang Province was 3 375 678 (Table 1), of which 335 were HIV positive, including 326 donors who were both HIV antibody and HIV RNA positive, and 9 donors who were HIV antibody negative but HIV RNA positive (all of them was male).

The overall HIV prevalence of blood donors is 9.9 per 100,000 donors. The distribution of HIV prevalence of blood donors from different blood services is shown in Table 1, and the difference of all blood services was not statistically significant($\chi2=9.933$, $P=0.536$). In the pairwise comparative analysis of each blood service (Table 1), only the highest(blood station of Ningbo) and the lowest(blood station of Huzhou) had statistically significant difference($\chi2=4.501$, $P=0.034$). The HIV prevalence in different blood services fluctuates in different years, as shown in Figure 1.

Table 1 The HIV prevalence of blood donors from different blood services in Zhejiang province,China

Blood services*		Huzhou	Quzhou	Zhoushan	Yiwu	Jiaxing	Jinhua	Lishui	Taizhou	Shaoxin	Hangzhou	Wenzhou	Nin
2018	Number of positives	1	3	0	1	7	3	2	12	5	20	14	17
	Number of donors	30368	23185	12894	12854	49599	50728	31617	45479	45404	150662	89558	822
	Prevalence#	3.29	12.94	0.000	7.78	14.11	5.91	6.33	26.39	11.01	13.27	15.63	20.
2019	Number of positives	3	2	1	1	4	8	6	1	1	13	12	10
	Number of donors	30636	24944	13220	13074	53586	54433	32341	48553	47201	158996	97501	876
	Prevalence#	9.79	8.02	7.56	7.65	7.46	14.70	18.55	2.06	2.12	8.18	12.31	11.
2020	Number of positives	1	2	2	0	4	7	3	4	4	20	15	10
	Number of donors	32753	25292	13005	14569	54499	59325	33408	45206	46496	160724	96126	890
	Prevalence#	3.05	7.91	15.38	0.000	7.34	11.80	8.98	8.85	8.60	12.44	15.60	11.
2021	Number of positives	4	1	0	3	2	5	2	5	10	13	7	8
	Number of donors	34178	27015	14018	15841	56787	62710	33392	48137	47660	169929	98268	911
	Prevalence#	11.70	3.70	0.000	18.94	3.52	7.97	5.99	10.39	20.98	7.65	7.12	8.7
2022	Number of positives	1	1	2	1	6	3	2	1	3	17	9	10
	Number of donors	35861	28493	13985	16782	60512	63574	35107	50784	49694	171821	101758	910
	Prevalence#	2.79	3.51	14.30	5.96	9.92	4.72	5.70	1.97	6.04	9.89	8.84	10.
Total	Number of positives	10	9	5	6	23	26	15	23	23	83	57	55
	Number of donors	163796	128929	67122	73120	274983	290770	165865	238159	236455	812132	483211	441
	Prevalence#	6.11	6.98	7.45	8.21	8.36	8.94	9.04	9.66	9.73	10.22	11.80	12.

*Huzhou: blood station of Huzhou; Quzhou: blood station of Quzhou; Zhoushan: blood station of Zhoushan; Yiwu: blood station of Yiwu; Jiaxing: blood station of Jiaxing; Jinhua: blood station of Jinhua; Lishui: blood station of Lishui; Taizhou: blood station of Taizhou;Shaoxin: blood station of Shaoxin;Hangzhou: The blood center of zhejiang province;Wenzhou: blood station of Wenzhou;Ningbo:blood station of Ningbo.

#Prevalence: number per 100,000 donors.

Table 2 HIV Prevalence in the donors by gender, age, number of donations

Variable		Hangzhou			Wenzhou			Ningbo			Jinghua		
		N*	donors	Prevalence (95% CI)	N*	donors	Prevalence (95% CI)	N*	donors	Prevalence (95% CI)	N*	donors	Prevalence (95% CI)
Gender	Men	76	477773	1.591 (1.233-1.948)	52	290223	1.792 (1.305-2.278)	52	260808	1.994 (1.452-2.535)	25	165799	1.508 (0.917-2.099)
	Women	7	334359	0.209 (0.054-0.364)	5	192988	0.259 (0.032-0.486)	3	180328	0.166 (-0.022-0.355)	1	124971	0.08 (-0.077-0.237)
Age	18-25	33	310785	1.062 (0.700-1.424)	19	123324	1.541 (0.848-2.233)	19	126746	1.499 (0.825-2.173)	11	87860	1.252 (0.512-1.992)
	26-35	27	224408	1.203 (0.749-1.657)	22	156510	1.406 (0.818-1.993)	20	147069	1.36(0.764-1.956)	4	67619	0.592 (0.012-1.171)
	36-45	12	171051	0.702 (0.305-1.098)	9	136797	0.658 (0.228-1.088)	11	109326	1.006 (0.412-1.601)	6	73714	0.814 (0.163-1.465)
	46-55	10	99554	1.004 (0.382-1.627)	7	65164	1.074 (0.278-1.87)	5	55642	0.899 (0.111-1.686)	4	56712	0.705 (0.014-1.396)
	>55	1	6334	1.579 (-1.516-4.673)	0	1416	0	0	2353	0	1	4865	2.055 (-1.974-6.084)
Number of donations	1	54	400120	1.35(0.99-1.709)	41	237273	1.728 (1.199-2.257)	36	206895	1.74(1.172-2.308)	14	128234	1.092(0.52-1.663)
	≧2	29	412012	0.704 (0.448-0.96)	16	245938	0.651 (0.332-0.969)	19	234241	0.811 (0.446-1.176)	12	162536	0.738 (0.321-1.156)

Variable		Jinghua			Taizhou			Jiaxing			Lishui		
		N*	donors	Prevalence (95% CI)	N*	donors	Prevalence (95% CI)	N*	donors	Prevalence (95% CI)	N*	donors	Prevalence (95% CI)
Gender	Men	25	165799	1.508 (0.917-2.099)	16	137186	1.166 (0.595-1.738)	23	166158	1.384 (0.818-1.95)	14	99652	1.405 (0.669-2.141)
	Women	1	124971	0.08 (-0.077-0.237)	7	100973	0.693(0.18-1.207)	0	108825	0	1	66213	0.151 (-0.145-0.447)
Age	18-25	11	87860	1.252 (0.512-1.992)	3	44162	0.679 (-0.089-1.448)	4	75285	0.531 (0.011-1.052)	3	37002	0.811 (-0.107-1.728)
	26-35	4	67619	0.592 (0.012-1.171)	8	62207	1.286 (0.395-2.177)	12	95861	1.252 (0.544-1.96)	6	39570	1.516 (0.303-2.729)
	36-45	6	73714	0.814 (0.163-1.465)	7	72924	0.96(0.249-1.671)	6	65536	0.916 (0.183-1.648)	3	47015	0.638 (-0.084-1.36)
	46-55	4	56712	0.705 (0.014-1.396)	4	55482	0.721 (0.014-1.427)	1	36309	0.275 (-0.264-0.815)	3	40043	0.749 (-0.099-1.597)
	>55	1	4865	2.055 (-1.974-6.084)	1	3384	2.955 (-2.838-8.746)	0	1992	0	0	2235	0
Number of donations	1	14	128234	1.092(0.52-1.663)	16	96677	1.655 (0.844-2.466)	15	134167	1.118 (0.552-1.684)	7	58547	1.196(0.31-2.081)
	≧2	12	162536	0.738 (0.321-1.156)	7	141482	0.495 (0.128-0.861)	8	140816	0.568 (0.174-0.962)	8	107318	0.745 (0.229-1.262)

	Shaoxing			Quzhou			Huzhou			Zhoushan		
	N*	donors	Prevalence	N*	donors	Prevalence	N*	donors	Prevalence	N*	donors	Prevalence

				95% CI)			95% CI)			95% CI)			95% CI)
Gender	Men	23	136526	1.685 0.996-2.373	7	75453	0.928 0.241-1.615	10	95827	1.044 0.397-1.69	4	41364	0.967 0.019-1.915
	Women	0	99929	0	2	53476	0.374 -0.144-0.892	0	67969	0	1	25758	0.388 -0.373-1.149
Age	18-25	8	76632	1.044 0.321-1.767	3	31547	0.951 -0.125-2.027	5	47380	1.055 0.13-1.98	2	24518	0.816 -0.315-1.946
	26-35	5	60338	0.829 0.102-1.555	0	31190	0	4	51578	0.776 0.016-1.535	0	19161	0
	36-45	4	57716	0.693 0.014-1.372	3	34578	0.868 -0.114-1.849	1	39837	0.251 -0.241-0.743	2	14592	1.371 -0.529-3.27
	46-55	6	39124	1.534 0.307-2.76	3	29234	1.026 -0.135-2.187	0	23642	0	1	8296	1.205 -1.157-3.568
	>55	0	2645	0	0	2380	0	0	1359	0	0	555	0
Number of donations	1	12	97941	1.225 0.532-1.918	4	49029	0.816 0.016-1.615	7	71359	0.981 0.254-1.708	1	30684	0.326 -0.313-0.965
	≧2	11	138514	0.794 0.325-1.263	5	79900	0.626 0.077-1.174	3	92437	0.325 -0.043-0.692	4	36438	1.098 0.022-2.173

		Yiwu			Total		
		N*	donors	Prevalence 95% CI)	N*	donors	Prevalence 95% CI)
Gender	Men	6	41775	1.436 0.287-2.585	308	1988544	1.549 1.376-1.722
	Women	0	31345	0	27	1387134	0.195 0.121-0.268
Age	18-25	2	18820	1.063 -0.41-2.535	112	1004061	1.115 0.909-1.322
	26-35	2	21195	0.944 -0.364-2.251	110	976706	1.126 0.916-1.337
	36-45	1	19557	0.511 -0.491-1.514	65	842643	0.771 0.584-0.959
	46-55	1	12663	0.79 -0.758-2.338	45	521865	0.862 0.61-1.114
	>55	0	885	0	3	30403	0.987 -0.13-2.103
Number of donations	1	4	34734	1.152 0.023-2.28	211	1545660	1.365 1.181-1.549
	≧2	2	38386	0.521 -0.201-1.243	124	1830018	0.678 0.558-0.797

Abbreviations: CI, confidence interval

HIV prevalence in the donors characterized by gender

In all blood services, the HIV prevalence of males was higher than that of females. Totally,the HIV prevalence of male blood donors was 15.49/100,000, and that of female blood donors was 1.95/100,000 (Table 2). The HIV prevalence of males was significantly higher than that of females ($\chi 2=151.020$, $P<0.001$).

HIV prevalence in the donors with different age

Totally,there was no significant difference in HIV prevalence among blood donors of different ages ($\chi2=8.334$, P=0.080), but the HIV prevalence in 26 to 35 age group and 18 to 25 age group were significantly higher than that in 36 to 45 age group ($\chi2=5.923$, P=0.015; $\chi2=5.656$,P=0.017).

HIV Prevalence in the first-time blood donors and repeat blood donors

In all blood services, the HIV prevalence of the first-time blood donors was higher than that of the repeat blood donors except for blood station of Zhoushan. Totally, the HIV prevalence was 13.65/100,000 in the first-time blood donors and 6.78/100,000 in the repeat blood donors (Table 2), and the difference between the first-time blood donors and repeat blood donors was statistically significant ($\chi2=39.916$, P<0.001).

HIV transmission Residual risk estimates

From 2018 to 2022, the HIV residual risk in blood transfusion transmission was 0.266/100 000 and the results are shown in table 3.

Table 3 HIV residual risk in blood transfusion transmission

	donors	donations	positive	Incidence (1/100,00)	vDWP	residual risk	N	Totally Residual risk (95% CI) (1/1000,000)
First-time donors	1545660	1545660	211	/	0.0219	0.148	0.348	0.266(0.219-0.313)
Repeat donors	1830018	2349472	124	8.99	0.0219	0.4455	0.6886	

Abbreviations: vDWP,viraemic phase of the diagnostic window period; CI, confidence interval; N,number of vDWP blood donations

Discussion

Detecting the indicators of HIV infection in blood donors can effectively prevent the HIV transmission through blood transfusion. Currently, HIV antibodies/p24 antigens (HIV Ag/Ab1+2) and HIV RNA tests have mandatory used for blood donors in blood services in China, which effectively ensured the blood safety[10]. In most cases, serology test and NAT are preformed in the same blood services in China, but centralized NAT was implemented in Zhejiang Province,China from 2016[11,25]. The samples of the blood donors from the original 12 blood services were centralized for NAT in four blood services(Hangzhou, Ningbo, Jinhua, and Wenzhou)[11].In additional, a unified blood information management system has established for all blood services in the Zhejiang Province, which facilitates comprehensive analysis of all blood donors information in the Zhejiang Province[11,25,27]. In this study, we retrospectively analyze the HIV testing results of all blood donors in the Zhejiang Province over the past 5 years based on a large size of samples using the blood information management system,which will help improving blood donors recruitment strategy and improving HIV prevention and control strategies.

At the end of 2021, the total number of people infected with HIV was about 1.038 million in Chinese mainland (https://weekly.chinacdc.cn/).Among them, 77.4% were men and 22.6% were women. The proportion of male donors was significantly higher than that of female donors in our study, which is consistent with that in the general population[19]. However,the HIV infection rate of blood donors in Zhejiang Province was significantly lower than that of the Chinese mainland donors in the previous report[23,24]. According to the 5-year data in our study, the HIV infection rate of blood donors in Zhejiang Province shows a downward trend. This may be related to the measures continuous taken by the blood services in Zhejiang Province to prevent the spread of HIV in recent years. The blood services can effectively reduce the number of HIV infected individuals among blood donors through measures such as improvement of public awareness and understanding of blood donation and blood safety,self exclusion of blood donors, and exclude the positive blood donors through blood information management system[28-30]. Other reasons were that a low HIV prevalence was existed in Zhejiang Province and the HIV infection rate among the general population has been decreasing since 2020 (https://www.cdc.zj.cn/). It is reported that HIV new infection individuals decreased by 11.4% from January to October 2022 in Zhejiang Province when compared to the same period in 2021(https://www.cdc.zj.cn/).

Previous studies have reported that the HIV infection rate of first-time blood donors is significantly higher than that of repeat blood donors[24,31], and our data also supports this viewpoint. Therefore, from the perspective of blood safety, it is necessary to strengthen the retention of blood donors and strive to make them as regular donors as much as possible, thereby increasing the rate of repeat donors, which will be beneficial for improving blood safety. It was reported that the age distribution of HIV infected individuals shows a trend of youthfulness in China, with people aged 20 to 29 being at high risk of HIV infection[32,33].In our study, the HIV prevalence was relatively high among blood donors aged 18 to 25 and 26 to 35 groups. In additional, nine male specimens showed HIV antibody negative and HIV nucleic acid positive. Although we did not track these specimens, it may be mainly due to MSM transmission based on the previous similar data [34,35].Now the proportion of MSM infection HIV is increasing in China, especially among young students[34,35]. Reduce this MSM risk through publicity and education is worthy for research in the future.

Although HIV infectious markers have been tested for blood donors, there are some factors to impact on accuracy of the HIV testing, such as window period and technical limitations[7]. Therefore, there is still a HIV residue risk in the blood transfusion transmission [7-9].This residual risk value always used as a monitoring indicator of blood safety in blood services. Studies have shown that the HIV residue risk in the blood transfusion transmission is various in different countries and regions[7-9]. The data in our study showed that the HIV residue risk in the blood transfusion transmission in Zhejiang Province is lower than standard for prevention of transfusion related HIV transmission risk of the World Health Organization (less than 0.5 cases per 1 million units of blood transfusion). Furthermore, the HIV residual risk in this study is significantly lower than that of the previously reported data from the Chinese

population[23], indicating that the HIV residue risk in the blood transfusion transmission in China has been decreased through effective management measures. However,it should be noted that there are significant differences for HIV prevalence in the different regions, and its HIV residual risks may also be various in China.

In conclusion, we firstly analyzed the HIV prevalence rate from all blood services in Zhejiang Province,China, which has implemented of HIV nucleic acid testing in blood services since 2016. The prevalence of HIV among blood donors is associated with age,gender and times of blood donation were also analyzed. Based on the data, the HIV residue risk in the blood transfusion transmission is relatively low in Zhejiang Province,indicating that the blood testing strategy we used can meet the requirements of ensuring blood safety. Therefore, it is necessary to maintain and consolidate the published testing strategy in order to continuously improve the blood safety.

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Blood Center of Zhejiang Province, China. All participants provided written informed consent. To guarantee donor confdentiality, donors were anonymized via de-identifcation (through the use of codes). All methods were carried out in accordance with the principles of the Declaration of Helsinki. Anti-HIV reactive samples underwent confrmation tests by the local Center for Disease Control and Prevention, China, in accordance with China's state regulations.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Authors'contributions

Hong Zhu performed the experiments, analyzed data and wrote the paper. WD,XZ,YH,JD,YW and DW performed the experiments. YW analyzed data. JL designed and conceptualized the study. FZ designed and conceptualized the study and wrote the paper. All authors read and approved the final manuscript.

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Figures

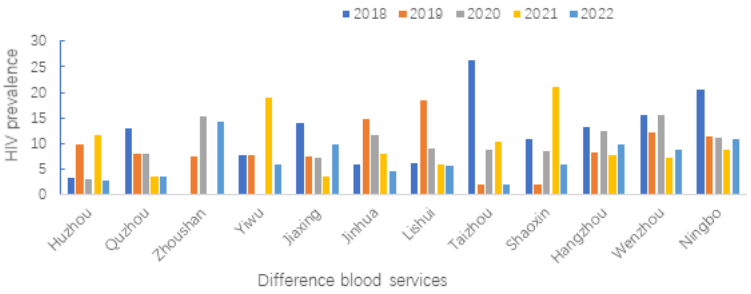

Figure 1 HIV prevalence in different blood services from 2018 to 2022

Figure 1

See image above for figure legend.