

BMJ Open Blood donation from 2006 to 2015 in Zhejiang Province, China: annual consecutive cross-sectional studies

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ABSTRACT

Objectives To describe the basic demographical characteristics of whole blood donors in Zhejiang Province, China, from 2006 to 2015 and to examine the trends in individual characteristics associated with blood donation and the relationship between weight and donation.

Design Cross-sectional study comparing characteristics of blood donors and annual donations for the period 2006 to 2015.

Setting Urban and rural communities in Zhejiang, China (11 cities, 89 districts or counties and 1379 townships).

Participants 3 226 571 volunteer blood donors.

Outcome measures Volume of each whole blood donation and donation frequency. All data were collected by trained staff and entered into a standardised electronic information system.

Results The number of blood donations generally trended up in Zhejiang Province from 2006 to 2015. Donors were predominately males aged 18 to 25 years, but this major donor age group shifted to the 26 to 45 year range by 2015. The rate of repeated blood donation was 30.8 per cent. The blood volume per donation concentrated in 200 mL and 400 mL categories has been gradually shifted to 300 mL and 400 mL. Approximately one-third of donors had a college education. The average weight of donors increased over time for both men and women. Both the blood volume of each donation and donation frequency were proportional to weight.

Conclusions The trend of voluntary non-remunerated blood donation in Zhejiang province is positive. However, given the expected growth in demand for whole blood, more research is needed to increase both the donor pool and the rate of repeated donation. The relationship between body weight and blood donation warrants further study because while improving nutritional status is associated with higher average donation volume and more frequent donations, overnutrition may lead to poorer quality of donated blood. Blood donation may present a unique opportunity for health education and body weight management to monitor and improve population health.

Sufficient and safe blood supply has always been a vital part of any healthcare system. A recent WHO report indicated that every year the median whole blood donation per 1000 population differs with different income levels, which was 32.1 in high-income countries, 14.9 in upper-middle-income countries,

Strengths and limitations of this study

- This study is the largest scale study in blood donation of any province in China in terms of sample size and time span.
- The provincial-wide blood donation information system provides consistent data in a large and well-defined geographical area.
- All donors with repeated donations were identified by the unique national identification number thus ensuring accurate information on repeated donations.
- To encourage blood donation and minimise respondent burden, the scope of data collection was limited.
- The study was conducted in Zhejiang province in China thus the results may not be generalisable to other parts of China.

7.8 in lower-middle-income countries and 4.6 in low-income countries.¹ South-East Asia had the highest percentage increase (75%) in voluntary non-remunerated blood donation (VNRBD) among 159 countries from 2008 to 2013,¹ whereas a downward trend was evident in some European countries.² As the world's most populous and the largest developing country, China has made great progress in blood donation. From 1998 to 2016, China's annual blood collection increased by 377% from 4 950 000 units to 23 600 000 units.^{3,4} The blood donation rate (median) per 1000 population in China has increased from 0.04 in 1998 to 10.5 in 2016,^{4,5} and blood component transfusion rate (proportion of blood component products transfused as the percentage of all blood transfusion) has reached 99.6%.⁴ In 2016, the blood donation rate (median) in Zhejiang province was 11.8 donations per 1000 population, higher than the national average of 10.5, but still falls short of meeting the need for clinical transfusion. In 2005, the proportion of blood donations from VNRBD reached 100% in Zhejiang province, earlier than the nation.⁶

To better understand donors, knowledge about donor characteristics, such as demographical profiles, is required to describe the composition of the donor population. Insight into donor characteristics is essential for targeted donor recruitment and donor retention.^{7–10} Demographical characteristics varied among countries or region. Data from 118 countries on the profile of blood donors show that, overall, 70% of blood donations were given by male donors, and 40% of donations were given by donors aged 25 to 44 years.¹ Among the 1.39 billion people in China in 2017, the number of seniors, aged 60 and above, reached 240.9 million, which accounted for 17.3% of the total population; aged 65 and above reached 158.31 million and accounted for 11.4%.¹¹ Due to the rapid economical development in China and the notable improvement in the quality of meals, people of all age groups in China have gained more body weight. The growth rate of body weight tends to increase with age.¹² Based on the assumption that blood volume can be estimated as 70 mL/kg, body weight was one of the key selection criterions. The American Association of Blood Banks (AABB) standard for minimum donor weight of 110 lb (50 kg) and to limit collection to 10.5 mL/kg is sufficient to protect most people, and to limit blood loss to no more than 15% of a person's total blood volume.^{13,14} Furthermore, body weight is a very important determinant of vasovagal reaction rates in first-time donors.^{15–17} However it does not mean that higher body weight is always beneficial to blood donation. Overnutrition and overweight also represent a negative impact on blood donation, since obesity causes or exacerbates a large number of health problems and is among the most significant contributors to poor health.¹⁸ As the rate of obesity in youth and young adults has approximately tripled in China, how to reverse the trend of increasing prevalence of obesity remains one of the biggest public health challenges among developing and middle-income countries.¹⁹ Despite the importance of body weight for individual and population health, research on the body weight has largely been focused on the adverse events of blood donation.^{15–17} Currently, few studies have examined the relationship between body weight and the frequency of blood donation. This paper describes demographical and anthropometrical factors associated with blood donation behaviour of VNRBD in Zhejiang province. It provides a specific analysis of blood donor demographical characteristics to increase repeated blood donations and ultimately to ensure adequate safe blood sources. This study is unique in several aspects. Zhejiang province is the only province in China with an integrated electronic donation information system since 2001. This system collects data covering the entire blood collecting, testing and distributing process. As a result, Zhejiang province has a unique advantage in blood donation data collection and statistical analysis. Also, the gender-specific body weight analysis offers insight into the future development of gender-specific donor recruitment and retention strategies as healthy lifestyles help maintain

healthy body weight, which in turn increases the base of healthy recruitable donors.

METHODS

Study setting and design

According to China's National Regulation of Blood Banks (2005),²⁰ blood banks are established by the local government health authorities based on the regional population, medical resources, clinical demand for blood and the development of local health planning. Blood banks are non-profit public health agencies responsible for the collection, preparation, storage of blood and supply blood to healthcare facilities. The government's Bureaus of Healthcare Administration are responsible for the planning, supervision and management of blood banks. There are a total of 38 blood banks in Zhejiang province, including one provincial blood centre, 11 municipal blood stations and 26 district blood banks or central blood banks or blood collection sites. Collections are conducted in fixed blood donation stations in urban areas and mobile collection vehicles (for collections at the worksite or temporary locations in rural areas).

According to China's national regulations on blood donation, after registration and physical examination on the donation site, professional staff will offer advice, and the donors can ultimately decide to donate 200 mL, 300 mL or 400 mL. The amount of blood donated is determined voluntarily. Blood donors must be between 18 and 55 years old (expanded to 60 in 2012). In 2012, 'blood donor health examination requirements' (GB18467-2011) was issued. Repeated blood donors who met the health check-up requirements and no previous adverse reaction, the age limit can be extended to 60 years old. Consistent with international practice, 200 mL plus or minus 10 per cent (180 to 220 mL) is classified as 200 mL, 300 mL plus or minus 10 per cent (270 to 330 mL) is classified as 300 mL, 400 mL plus or minus 10 per cent (360 to 440 mL) is classified as 400 mL and the rests are classified as non-standard amount. The minimum interval between the two whole blood donations is 6 months. The minimal body weight requirement is 50 kg for men and 45 kg for women.

The present study used a cross-sectional study design by comparing the characteristics of blood donors and annual donations for the period 2006 to 2015.

Patient and public involvement

There is no direct patient and public involvement in this study. This study utilised a retrospective analysis of an existing blood donation database to analyse the data of blood donors that have already been collected in the database. For this study, all whole blood donations (n=5 299 729) of 3 226 571 VNRBDs between 2006 and 2015 were extracted from the Zhejiang provincial blood management information system. This study period was chosen because no major system modification happened during this period, thus ensuring consistent information

collection and processing. Because of the different ways to donate and different donation interval requirements, all apheresis donations were excluded to eliminate interference.

Measures

The database includes donors' basic demographical characteristics such as age (in years), gender (male, female), education level (classification according to GB18467-2011), occupation (classification according to GB18467-2011), body weight (used for eligibility assessment, kg) and blood collection information, such as date (month/date/year), time (24 hours), volume (mL) and frequency of blood donations (one time, two times, etc).

Single-time blood donors are those who have donated blood only one time in their whole blood donation career. First-time blood donors are donors who donate blood for the first time regardless of whether the donor was a single-time donor or multiple-time donor.

Due to the complexity and privacy of occupations, 105 blood donors chose not to fill in the column of occupation. Because of this, their employment status information was missing. The occupation of these donors was included in the category 'other'.

Statistics analysis

Data extraction was performed by using structured query language. After data extraction, a retrospective analysis of the data, including descriptive statistics and logistical regression analysis, were performed by using IBM SPSS V.21. We used the Strengthening the Reporting of Observational Studies in Epidemiology checklist for cross-sectional studies to guide the structure of the written report.²¹

We performed a descriptive analysis of basic individual characteristics of blood donors using the 2006 to 2015 dataset and then examined the trend in donor characteristics and blood donated volume over time. To accurately reflect the proportion of people who donated blood in the trend analysis, only the second donation record was included for individuals who donated twice in a calendar year. We also use descriptive statistical methods to examine the characteristics of blood donors by body weight categories for men and women. Finally, we use logistical regression to examine the relationship between donor demographical characteristics and the volume and likelihood of repeated donation. Because the body weight eligibility criteria for blood donation differs by gender, we performed the regression analyses separately for men and women.

RESULTS

From 2006 to 2015, a total of 3 226 571 individuals donated 5 299 729 times of whole blood in Zhejiang province (table 1). Overall, the 18- to 25-year-old donor group accounted for 45% of the total blood donors, the 26- to 35-year-old group and 36- to 45-year-old group accounted for 28.4% and 19.1%, respectively. The proportion of

Table 1 Characteristics of whole blood donors in Zhejiang Province, China, 2006 to 2015 (n=3 226 571)

Variable	Number of blood donors	%
Age category, years		
18–25	1 451 025	45.0
26–35	914 745	28.4
36–45	617 108	19.1
46–55	236 807	7.3
56	6886	0.2
Gender		
Male	1 859 599	57.6
Female	1 366 972	42.4
Education		
Elementary school	71 755	2.2
Middle school	805 520	25.0
High school	829 755	25.7
University*	1 173 456	36.4
Postgraduate	26 228	0.8
Other†	254 799	7.9
Missing	65 058	2.0
Occupation		
Students	495 258	15.3
Clerk	450 757	14.0
Workers	330 120	10.2
Farmers	213 674	6.6
Medical worker	121 665	3.8
Public service	109 410	3.4
Other‡+	1 505 687	46.6
Male weight, kg		
50–59	309 616	16.6
60–69	741 369	39.9
70–79	548 789	29.5
80–89	204 912	11.0
≥90	54 913	3.0
Female weight, kg		
45–49	249 689	18.3
50–54	420 068	30.7
55–59	316 089	23.1
60–64	213 947	15.7
65–69	95 368	7.0
≥70	71 811	5.3
Donation frequency		
One	2 233 693	69.2
Two	525 215	16.3
Three or more	467 663	14.5
Donation volume per time, mL		

Continued

Table 1 Continued

Variable	Number of blood donors	%
200±200×10%	918 678	28.5
300±300×10%	1 144 307	35.5
400±400×10%	1 138 942	35.3
Non-standard amount	24 644	0.8

*'University' including junior college degree and bachelor degree.

†'Other' including lower than elementary school or higher than postgraduate.

‡'Other' including missing and other types of occupations.

kg, kilogram; mL, millilitre.

male donors remained stable (57.6%). College educated donors are the largest group of blood donors (36.4%), followed by those with high school (25.7%) and middle school (25%) education. The body weight of blood donors was concentrated in the 60 to 79 kg group (69.4%) for men and the 50 to 59 kg group (53.8%) for women.

Regarding repeated donation, the great majority (69.2%) of donors only donated once, 16.3% donated twice and 14.5% donated three or more times. Thus, the repeated donation rate of 30.8% is much lower than the world average of 50%.¹ Donors mainly donated blood volume of either 300 mL (35.5%) or 400 mL (35.3%) each time.

Trend

As shown in figure 1–8, the number of blood donors generally increased over the 10 year period reaching a maximum of 540 284 in 2015. The age structure of blood donors changed substantially from 2006 to 2015, with the average age rising from 28.6 years old to 32.8 years old over the study period, an increase of 4.2 years. As a result, the proportion of younger donors (18 to 25 years) decreased from 48.2% in 2006 to 30.7% in 2015. The 26- to 35-year-old group is the more stable donor group, with an average of about 30%. Interestingly, the proportion of people aged 36 to 45 and 46 to 55 increased significantly; the former increased 8.2 percentage points (from 17.7% in 2006 to 25.9% in 2015), while the latter increased 7.9 percentage points (from 4.9% to 12.8%). The results

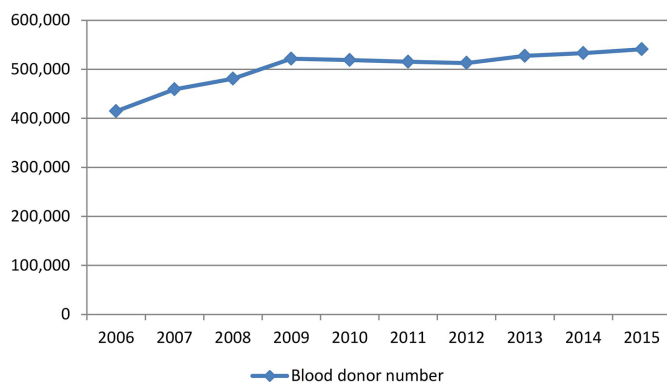


Figure 1 Blood donor numbers.

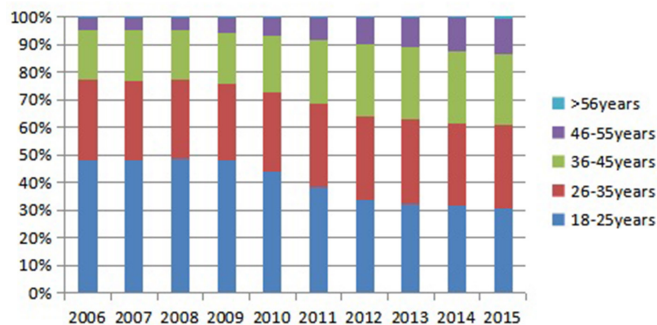


Figure 2 Age category (years).

show that the changing trend of the age structure of blood donors is the same as the direction of population ageing, with the focus shifted from the lower age group to the middle age group. Since 1 July, 2012, the proportion of people over the age of 56 increased slowly.

Regarding the trend of whole blood donation, men were consistently more likely to be donors as compared with women. For the female donor number, the year of 2009 seems to be a turning point, with upward trending until 2009 and downward trending after 2009. In the entire population, 1.02% of men in Zhejiang donated blood in 2006; the proportion rose to 1.34% in 2015. The corresponding rates were 0.76% and 0.88%, respectively, for women. Compared with men, this may relate to the fact that women are at risk for iron depletion because of menstruation ongoing blood loss, recent pregnancies and inadequate dietary iron.²² Female metabolic syndrome prevalence was 2.14 times higher in donors with high donation intensity compared with those with low donation intensity.²³

Regarding blood volume of each donation, the proportion of 200 mL showed a declining trend, 300 mL with an overall upward trend. The proportion of 400 mL dropped first and then increased, similar to Shenzhen.²⁴ This is related to the gradual promotion of 300 mL size of blood donation began in Zhejiang province in 2007. Regarding the trend of educational level, the proportion of universities increased with small fluctuations, accounted for nearly 40% by 2015, while the proportion of high schools dropped year by year, from 28.6% in 2006 to 22.5% in 2015, and others are relatively stable.

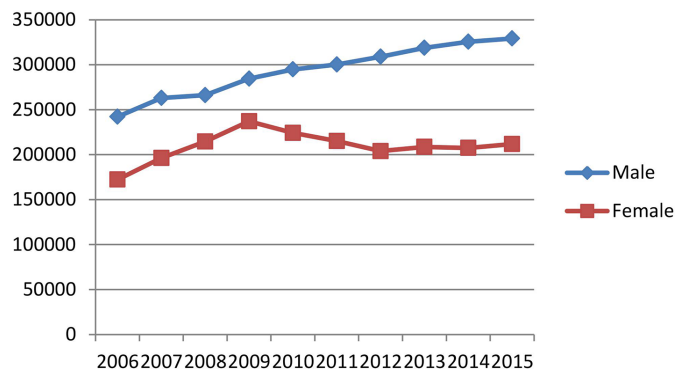


Figure 3 Gender.

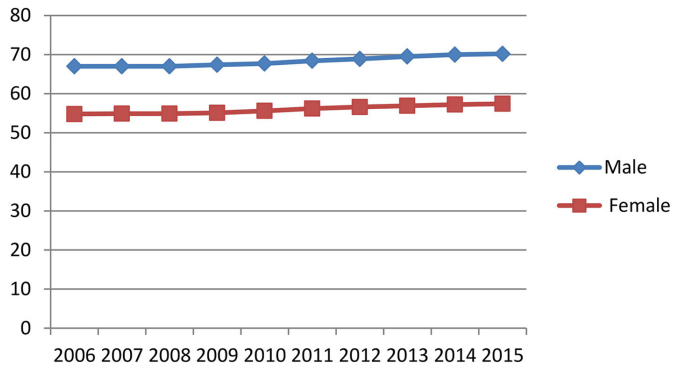


Figure 4 Average body weight (kg). kg, kilogram.

The trend in body weight is generally upward for both men and women between 2006 and 2015 (figure 4). The average body weight of male blood donors increased from 67.0 kg to 70.2 kg, an increase of 3.2 kg (4.8%) while that of women increased from 54.8 kg to 57.4 kg, an increase of 2.6 kg (4.7%). The major body weight among male donors gradually shifted from 60 to 69 kg to 70 to 79 kg, whereas female donors were still 50 to 59 kg, but body weight of female donors over 60 kg is gradually increasing. Among men, the proportion of lower-weight group decreased significantly (8.1 per cent in the 50 to 59 kg group and 6.1 per cent in the 60 to 69 kg group). In contrast, the proportion weighed between 70 and 79 kg had a 6.8% increase; the same increase proportion was 5.4 and 2.1 per cent for those weighed 80 to 89 kg and 90+ kg, respectively. Similar patterns of a decreasing proportion of lower-weight group and an increasing proportion of higher-weight group were observed among women.

Demographical factors and blood donation behaviour by gender

Table 2 shows that low body weight donors were younger and with low donation volume for both men and women. The rate of repeated donation gradually increased with body weight for both men and women. For men, the rate of repeated donation increased 19 per cent in the subgroups ranging from 50 to 59 kg to 80 to 89 kg, and that of women also increased 19 per cent in the subgroups ranging from 45 to 49 kg to over 70 kg. The rate of donating 400 mL per time was associated with increasing

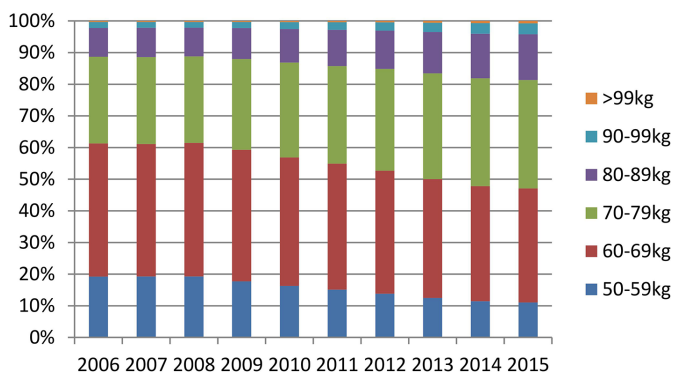


Figure 5 Male donor body weight category. kg, kilogram.

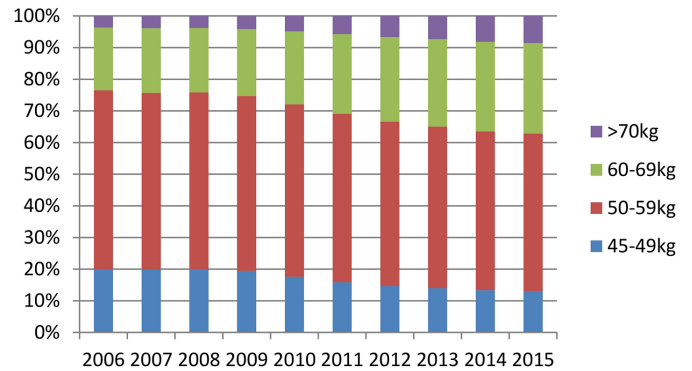


Figure 6 Female donor body weight category. kg, kilogram.

body weight too. For men, the rate of 400 mL donations increased 49.7 per cent from 50 to 59 kg to over 90 kg, and that of women also increased 47.9 per cent from 45 to 49 kg to more than 70 kg.

Table 3 and table 4 showed that all individual characteristics (age, body weight, education level and occupation) were independently associated with the volume of each donation and donation frequency for both men and women. The likelihood of repeated donation increased with age. For donors with high school or higher education, the likelihood of donating 300 mL or more decreased, but repeated donations increased. We also found that repeated donation and blood volume each donation for both male and female blood donors in Zhejiang were directly proportional to body weight, the heavier the blood donor is, the larger the likelihood of more volume of blood each donation is and more frequent the blood donation is. Among different occupations, medical workers showed a high likelihood of repeated donations.

DISCUSSION

Our study aimed to identify the trends in whole blood donation and examine the demographical characteristics associated with the volume and frequency of donations in Zhejiang from 2006 to 2015. The results revealed that the average age of blood donors increased, and the proportion of donors aged 18 to 25 declined over time. Body weight is generally proportional to donation volume and donation frequency.

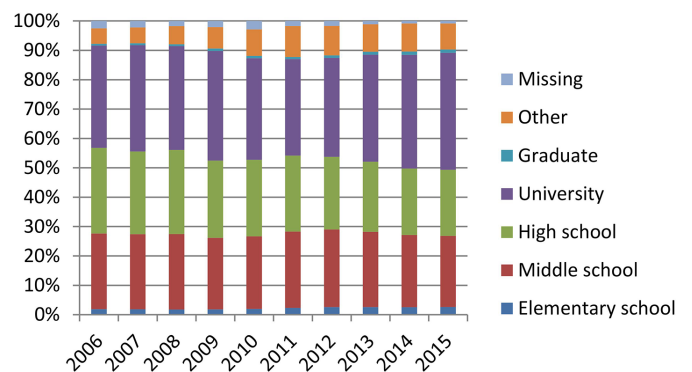


Figure 7 Education.

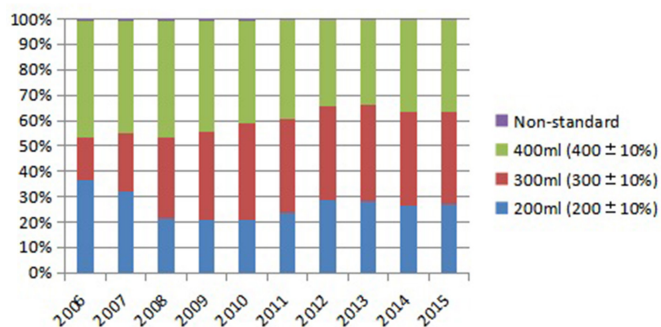


Figure 8 Donation volume per time (mL). mL, millilitre.

The proportion of male donors is similar to findings from Shenzhen and Hong Kong.^{24–27} Compared with data reported from a total of 80 countries (23 high-income, 18 upper-middle-income, 22 lower-middle-income and 17 low-income),¹ the overall age structure of Zhejiang blood donors was younger than the global average. This may be mainly related to the relatively younger age structure of the populations in developing countries.

The trend of blood donor number is a little different from the European Union (EU). The donor population of the EU rose significantly from 1994 to 2009, then stabilised thereafter, with a small decrease later in 2014.²⁸ This may partly be due to the widely used patient blood management in the EU, which emphasises on minimising the need for transfusion, thus reducing the potential risks and costs, and sparing limited resource.^{29–30} As we mentioned in the introduction, Zhejiang province was still far behind developed countries in terms of the number of donations per 1000 population, so it still belongs to the demand market. The measures to optimise recruitment, retention and transfusion in Zhejiang work, but not significantly.

The low repeated blood donation rate after the first donation appears to be a global phenomenon,^{31–35} with nearly half of first-time donors remaining single-time donors.³⁶ The loss of first-time blood donors in Zhejiang is serious. Donors' retention plays a very important role in increasing stable blood sources, reducing blood shortage and improving blood safety.^{37–40} Considering the loss of blood donors who only donate once, it is crucial to carry out recruitment measures to promote repeated blood donation. The finding that medical worker has a high likelihood of repeated donation may be attributable to better altruism and professional awareness, as well as province-wide campaigns such as the 'Angel guarding life'. Perhaps similar campaigns can be developed for other service occupations such as clerks and public service workers in the future.

Changes in the number of blood donations may be related to the overall changes in social environment, policy, major events (disasters, etc) and public sentiment. In 2009, The National Ministry of Health Department and the Red Cross Society of China published 'Revised National Guidelines for Non-monetary Rewards for Blood Donation'. The social atmosphere of blood donation was

good in 2008 and 2009, so the number of blood donors reached high in 2009. GB18467-2011 further expanded the age to 60 years old and raised the requirement of female haemoglobin from ≥ 110 g/L to 115 g/L. However, negative reports about the Red Cross in 2010 and 2011 led to a loss of confidence in blood donations, which resulted in a decrease in blood donor number. Female blood donors were reduced to the nadir in 2012. In response, blood banks have promoted transparency in blood management to the general public with regular updates and reports published. The number of blood donors has slowly risen year by year. Among them, there are three groups, donors aged 18 to 25 years, students and females, which have the same changing shape of the trend as the above overall blood donation. It showed that these three groups are greatly influenced by the public opinion. Social marketing strategies may be developed to strengthen positive public opinion and offer guidance and emotional support for blood donation. This is especially relevant in light of the finding that the proportion of female blood donation has been in a downward trend since 2009.

While provincial population data were not available for the entire study period, data from 2013 to 2015 show that the population base of 18 to 35 and 36 to 60 years old in Zhejiang province decreased,⁴¹ which may have accounted for the observed changes in the age structure of blood donors. Although the age group of 18 to 25 always dominated, the proportion of donors aged 18 to 25 declined obviously. Correspondingly, the proportion of people aged 36 and above continues to increase. The rate of blood donation among 18- to 35-year-old in Zhejiang province decreased first and then increased from 2013 to 2015, while that of 36- to 60-year-old increased slowly. This data suggests that the 18- to 25-year-old population participation rate show fluctuations. Although many people meet the conditions of blood donation, only a very small minority of people are donating blood.⁴² We also showed that population ageing is likely to reduce the number of prospective eligible donors in the legal age range.²⁵ The increase in average age of blood donor suggested that research is needed for maintaining the donor pool among young adults. While young adults remain the predominant basis for the present and future blood donation recruitment, education and research should examine how to promote voluntary blood donation for all age groups of the eligible population. Recruitment messages may need to be tailored to individuals from different age groups. Considering that the 18 to 25 years old are mainly college students who are likely to have different channels for media consumption and considering that the new generation has very different value systems and strong personalities, blood establishments should adapt their education tools and methods to accommodate this condition to increase their interests in blood donation.

Body weight has a major impact on a person's blood donation volume per time and blood donation frequency. This finding has mixed public health implications in that

Table 2 Characteristics of blood donors by gender and body weight

	Number of blood donations (proportion)									
	Men					Women				
	50-59kg	60-69kg	70-79kg	80-89kg	90+ kg	45-49kg	50-59kg	60-69 kg	70+ kg	
Total	468 815 (100)	1 219 447 (100)	958 033 (100)	359 547 (100)	92 613 (100)	365 748 (100)	1 172 411 (100)	535 697 (100)	127 418 (100)	
Age category, years										
18-25	265 594 (56.7)	494 668 (40.6)	236 287 (24.7)	72 154 (20.1)	22 486 (24.3)	244 916 (67.0)	588 660 (50.2)	152 985 (28.6)	23 498 (18.4)	
26-35	132 466 (28.3)	387 082 (31.5)	328 644 (34.3)	128 950 (35.9)	35 022 (37.8)	80 941 (22.1)	289 835 (24.7)	136 393 (25.5)	33 462 (26.3)	
36-45	52 942 (11.3)	241 263 (19.8)	274 146 (28.6)	111 810 (31.1)	25 612 (27.7)	33 434 (9.1)	228 677 (19.5)	176 067 (32.9)	48 157 (37.8)	
46-55	17 228 (3.7)	92 806 (7.6)	114 618 (12.0)	45 016 (12.5)	9 196 (10.0)	6 342 (1.7)	64 091 (5.5)	69 136 (12.9)	21 885 (17.2)	
56+	585 (0.1)	3 628 (0.3)	4 338 (0.5)	1 617 (0.4)	297 (0.3)	115 (0.0)	11 148 (0.1)	1 116 (0.2)	416 (0.3)	
Donation frequency										
Once	249 714 (53.3)	530 991 (43.5)	347 766 (36.3)	123 406 (34.3)	33 472 (36.1)	191 041 (52.2)	519 372 (44.3)	195 634 (36.5)	42 297 (33.2)	
Twice or more	219 101 (46.7)	688 456 (56.5)	610 267 (63.7)	236 141 (65.7)	59 141 (63.9)	174 707 (47.8)	653 039 (55.7)	340 063 (63.5)	85 121 (66.8)	
Each time blood donation volume, mL										
200±200×10%	154 043 (32.9)	254 550 (20.9)	160 223 (16.7)	46 115 (12.8)	8 326 (9.0)	209 807 (57.4)	380 707 (28.1)	119 118 (22.2)	20 222 (15.9)	
300±300×10%	194 496 (41.5)	401 856 (33.0)	254 997 (26.6)	78 300 (21.8)	15 120 (16.3)	121 310 (33.1)	452 143 (37.2)	178 392 (33.3)	34 645 (27.2)	
400±400×10%	115 848 (24.7)	555 868 (44.6)	539 309 (56.3)	234 108 (65.1)	68 865 (74.4)	31 516 (8.6)	332 046 (34.2)	235 763 (44.0)	72 007 (56.5)	
Non-standard	4 428 (0.9)	7 173 (0.6)	3 504 (0.4)	1 024 (0.3)	302 (0.3)	3 115 (0.9)	75 15 (0.6)	242 4 (0.5)	544 (0.4)	
Education										
Elementary school	6 890 (1.5)	18 275 (1.5)	16 236 (1.7)	7 327 (2.0)	1 979 (2.1)	3 312 (0.9)	25 526 (2.2)	26 984 (5.0)	10 873 (8.5)	
Middle school	125 926 (26.9)	314 098 (25.8)	247 934 (25.9)	97 284 (27.1)	24 628 (26.6)	54 277 (14.8)	264 220 (22.6)	173 048 (32.3)	47 867 (37.5)	
High school	133 597 (28.5)	337 670 (27.7)	255 774 (26.7)	94 037 (26.2)	24 013 (25.9)	82 924 (22.7)	280 288 (23.9)	126 647 (23.6)	27 082 (21.3)	
University*	155 774 (33.2)	418 841 (34.3)	326 759 (34.1)	116 218 (32.3)	29 741 (32.1)	192 085 (52.5)	484 548 (41.3)	144 539 (27.0)	23 770 (18.7)	
Postgraduate	2 966 (0.6)	12 415 (1.0)	10 871 (1.1)	3 481 (1.0)	720 (0.8)	2 665 (0.7)	7 923 (0.7)	2 505 (0.5)	399 (0.3)	
Other†	35 287 (7.5)	97 731 (8.0)	85 443 (8.9)	35 802 (9.9)	10 301 (11.1)	23 694 (6.5)	89 529 (7.6)	52 373 (9.8)	15 416 (12.1)	
Missing	8 375 (1.8)	20 417 (1.7)	15 016 (1.6)	5 398 (1.5)	1 232 (1.3)	6 791 (1.9)	20 377 (1.7)	9 601 (1.8)	2 011 (1.6)	
Occupation										
Student	77 980 (16.6)	128 516 (10.5)	53 722 (5.6)	15 443 (4.3)	5 650 (6.1)	101 867 (27.9)	214 343 (18.3)	46 151 (8.6)	6 759 (5.3)	
Clerk	63 317 (13.5)	186 003 (15.3)	154 031 (16.1)	57 195 (15.9)	14 255 (15.4)	47 147 (12.9)	163 219 (13.8)	73 338 (13.7)	15 547 (12.2)	
Worker	57 941 (12.4)	147 786 (12.1)	111 612 (11.7)	39 894 (11.1)	9 746 (10.5)	20 682 (5.7)	87 198 (7.4)	48 157 (9.0)	11 894 (9.3)	
Farmer	30 726 (6.6)	88 012 (7.2)	76 870 (8.0)	30 070 (8.4)	7 092 (7.7)	13 571 (3.7)	71 578 (6.1)	55 753 (10.4)	17 234 (13.5)	
Medical worker	11 263 (2.4)	35 110 (2.9)	29 553 (3.1)	9 140 (2.5)	1 914 (2.1)	31 843 (8.7)	86 785 (7.4)	29 181 (5.4)	4 646 (3.6)	
Public service	11 867 (2.5)	59 260 (4.9)	68 201 (7.1)	25 512 (7.1)	5 352 (5.8)	8 220 (2.2)	29 665 (2.5)	12 516 (2.3)	2 168 (1.7)	
Other++	215 721 (46.0)	574 760 (47.1)	464 044 (48.4)	182 293 (50.7)	48 604 (52.5)	142 418 (38.9)	519 623 (44.3)	270 601 (50.5)	69 170 (54.2)	

*University including junior college degree and bachelor degree.

†Other including lower than elementary school or higher than postgraduate.

‡Other including missing and other types of occupations. kg, kilogram; mL, millilitre.

Table 3 Logistical regression models predicting donations of 300 mL or more per donation by gender

Independent variables	Male		Female	
	OR (95% CI)	P values	OR (95% CI)	P values
Age , reference category: 18-25		< 0.001		< 0.001
26-35	0.92 (0.92 to 0.93)	< 0.001	0.83 (0.82 to 0.83)	< 0.001
36-45	0.91 (0.90 to 0.92)	< 0.001	0.77 (0.76 to 0.77)	< 0.001
46-55	0.78 (0.77 to 0.78)	< 0.001	0.68 (0.67 to 0.69)	< 0.001
56+	0.91 (0.86 to 0.95)	< 0.001	1.07 (0.98 to 1.18)	0.131
Male weight , reference category: 50-59 kg		< 0.001		
60-69 kg	2.05 (2.03 to 2.06)	< 0.001		
70-79 kg	2.87 (2.85 to 2.90)	< 0.001		
80-89 kg	3.92 (3.87 to 3.97)	< 0.001		
90+ kg	5.58 (5.44 to 5.73)	< 0.001		
Female weight , reference category: 45-50 kg				< 0.001
50-59 kg			2.90 (2.88 to 2.92)	< 0.001
60-69 kg			4.78 (4.78 to 4.83)	< 0.001
70+ kg			7.11 (6.99 to 7.23)	< 0.001
Education , reference category: elementary school		< 0.001		< 0.001
Middle school	1.05 (1.03 to 1.08)	< 0.001	1.09 (1.06 to 1.11)	< 0.001
High school	0.78 (0.76 to 0.80)	< 0.001	0.89 (0.87 to 0.91)	< 0.001
University*	0.50 (0.48 to 0.51)	< 0.001	0.54 (0.53 to 0.55)	< 0.001
Postgraduate	0.29 (0.28 to 0.30)	< 0.001	0.34 (0.33 to 0.36)	< 0.001
Other+	0.70 (0.68 to 0.72)	< 0.001	0.66 (0.65 to 0.68)	< 0.001
Occupation , reference category: student		< 0.001		< 0.001
Clerk	0.74 (0.73 to 0.75)	< 0.001	1.17 (1.15 to 1.18)	< 0.001
Workers	0.86 (0.84 to 0.87)	< 0.001	1.21 (1.19 to 1.23)	< 0.001
farmers	0.76 (0.75 to 0.78)	< 0.001	1.28 (1.26 to 1.30)	< 0.001
Medical worker	0.39 (0.39 to 0.40)	< 0.001	0.58 (0.58 to 0.59)	< 0.001
Public service	0.48 (0.47 to 0.49)	< 0.001	0.71 (0.69 to 0.72)	< 0.001
Other++	0.74 (0.73 to 0.75)	< 0.001	1.21 (1.19 to 1.22)	< 0.001
Year , reference category: 2006		< 0.001		< 0.001
2007	1.26 (1.24 to 1.27)	< 0.001	1.25 (1.23 to 1.27)	< 0.001
2008	2.18 (2.15 to 2.21)	< 0.001	2.23 (2.20 to 2.26)	< 0.001
2009	2.39 (2.36 to 2.43)	< 0.001	2.37 (2.33 to 2.40)	< 0.001
2010	2.30 (2.27 to 2.34)	< 0.001	2.11 (2.08 to 2.14)	< 0.001
2011	1.85 (1.83 to 1.87)	< 0.001	1.67 (1.65 to 1.70)	< 0.001
2012	1.46 (1.44 to 1.48)	< 0.001	1.23 (1.21 to 1.25)	< 0.001
2013	1.52 (1.50 to 1.54)	< 0.001	1.24 (1.22 to 1.26)	< 0.001
2014	1.71 (1.68 to 1.73)	< 0.001	1.36 (1.34 to 1.37)	< 0.001
2015	1.70 (1.68 to 1.72)	< 0.001	1.32 (1.30 to 1.34)	< 0.001
Constant	2.31	< 0.001	0.68	< 0.001

kg, kilogram; mL, millilitre.

while the pattern of increasing body weight is positive in the short-term because of the increased likelihood of repeated donations among donors and more volume donated each time, it may also reduce the likelihood that donors will be healthy enough to meet the physical

health eligibility criteria for blood donation. Based on the assumption that blood volume can be estimated as 70 mL/kg, therefore, the heavier the body weight, the greater the amount volume of blood, the less impact of blood donation on the body. Given that the blood volume

Table 4 Logistical regression models predicting repeated donations by gender

Independent variables	Male		Female	
	Repeated donations		Repeated donations	
	OR (95% CI)	P values	OR (95% CI)	P values
Age , reference category: 18–25		< 0.001		< 0.001
26–35	1.77 (1.76 to 1.78)	< 0.001	1.64 (1.62 to 1.65)	< 0.001
36–45	2.71 (2.69 to 2.73)	< 0.001	2.49 (2.47 to 2.51)	< 0.001
46–55	3.29 (3.26 to 3.33)	< 0.001	2.83 (2.80 to 2.87)	< 0.001
56+	11.93 (11.14 to 12.77)	< 0.001	14.06 (12.26 to 16.13)	< 0.001
Male weight , reference category: 50–59 kg		< 0.001		
60–69 kg	1.25 (1.24 to 1.26)	< 0.001		
70–79 kg	1.43 (1.42 to 1.45)	< 0.001		
80–89 kg	1.53 (1.51 to 1.54)	< 0.001		
90+ kg	1.55 (1.53 to 1.58)	< 0.001		
Female weight , reference category: 45–50 kg				< 0.001
50–59 kg			1.23 (1.22 to 1.24)	< 0.001
60–69 kg			1.47 (1.45 to 1.47)	< 0.001
70+ kg			1.64 (1.62 to 1.67)	< 0.001
Education , reference category: elementary school		< 0.001		< 0.001
Middle school	1.54 (1.51 to 1.57)	< 0.001	1.30 (1.23 to 1.33)	< 0.001
High school	1.75 (1.72 to 1.78)	< 0.001	1.47 (1.44 to 1.49)	< 0.001
University*	2.13 (2.09 to 2.17)	< 0.001	1.90 (1.86 to 1.93)	< 0.001
Postgraduate	1.72 (1.67 to 1.77)	< 0.001	1.47 (1.41 to 1.53)	< 0.001
Other+	1.95 (1.91 to 1.99)	< 0.001	1.63 (1.60 to 1.67)	< 0.001
Occupation , reference category: student		< 0.001		< 0.001
Clerk	2.17 (2.15 to 2.19)	< 0.001	1.92 (1.90 to 1.94)	< 0.001
Workers	1.83 (1.81 to 1.85)	< 0.001	1.39 (1.37 to 1.41)	< 0.001
farmers	2.12 (2.09 to 2.15)	< 0.001	2.01 (1.98 to 2.04)	< 0.001
Medical worker	3.65 (3.58 to 3.72)	< 0.001	3.11 (3.06 to 3.15)	< 0.001
Public service	2.87 (2.83 to 2.91)	< 0.001	1.87 (1.84 to 1.91)	< 0.001
Other++	1.78 (1.76 to 1.79)	< 0.001	1.70 (1.68 to 1.72)	< 0.001
Year , reference category: 2006		< 0.001		< 0.001
2007	1.26 (1.29 to 1.28)	< 0.001	1.30 (1.28 to 1.32)	< 0.001
2008	1.42 (1.40 to 1.44)	< 0.001	1.42 (1.40 to 1.44)	< 0.001
2009	1.53 (1.51 to 1.54)	< 0.001	1.47 (1.45 to 1.49)	< 0.001
2010	1.48 (1.46 to 1.49)	< 0.001	1.45 (1.43 to 1.47)	< 0.001
2011	1.31 (1.29 to 1.32)	< 0.001	1.29 (1.27 to 1.31)	< 0.001
2012	1.19 (1.18 to 1.20)	< 0.001	1.22 (1.20 to 1.24)	< 0.001
2013	1.15 (1.13–1.16)	< 0.001	1.14 (1.12 to 1.15)	< 0.001
2014	1.05 (1.04 to 1.06)	< 0.001	1.00 (0.99 to 1.02)	0.57
2015	0.78 (0.77 to 0.79)	< 0.001	0.72 (0.71 to 0.73)	< 0.001
Constant	0.17	< 0.001	0.24	< 0.001

This is multivariable logistical regression model.

*'University' including junior college degree and bachelor.

+ 'other' including lower than elementary school or higher than postgraduate.

++ 'other' including missing and other types of occupations.

kg, kilogram; mL, millilitre.

of each donation is changing gradually from 200 mL to 300 mL or 400 mL, we might say that long-term blood donation publicity in Zhejiang has played a positive role.

Additionally, the body weight gain year by year has played a positive role in influencing the choice of high volume blood donation and the possibility to participate in

multiple blood donations. According to the 2015 report on Nutrition and Chronic Diseases of Chinese people, the average height of adult males and females aged 18 years and above in China was 167.1 cm and 155.8 cm, respectively, with average body weights of 66.2 kg and 57.3 kg, respectively.⁴³ Compared with the average body weight of donors (figure 4-7), male donors are a little heavier than the average population, but female donors are a little lighter than the average population. However, as we mentioned, overnutrition and overweight were among the most significant contributors to ill-health.¹⁸ Most obese people can not pass the blood screen even if they want to donate. Controlling body weight within a reasonable range is beneficial to individual health and helpful for expanding the pool of potential donors.

Results from the multivariable regression analysis suggest future donor recruitment and retention approaches should consider tailoring messages based on demographical characteristics such as age, gender and body weight. For example, for donors with all ages, recruitment messages should focus on the benefit of repeated donation. We should strengthen the education that donating 300 mL or more does not affect health through the relationship analysis between donation volume and health, etc. For the majority of lower weight donors (young adults), the message should focus on promoting a healthy diet for better nutrition and health. On the other hand, public health messages for the middle-aged individuals should include a healthy diet and active lifestyle due to high prevalence of unhealthy body weight gain due in large part to rapid changing economical, social and physical environment, as well as to a diet that is high in calorie-dense-nutrition-poor foods.

This study has several limitations. The 38 blood banks in Zhejiang province may not be representative of blood centres in other regions in China. While these 38 blood banks are geographically diverse, they all represent relatively developed areas in eastern China. Less economically developed provinces were not included in this study. In addition, only limited demographical information were collected by the blood donation data management system due to protection of donor privacy and promotion of blood donation collection efficiency. Future studies should expand the data collection such as height and so on, to help better understand the individual and group level facilitators and barriers to whole blood donation.

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