

Seroprevalence of Transfusion Transmitted Infections among Blood Donors Attending a Tertiary Care Hospital of Western Odisha

Shuvankar Mukherjee¹, Santosh Kumar Agarwal², Shreekant Tiwari³

¹Department of Microbiology, Hitech Medical College, Rourkela, Odisha, India. ²Hitech Medical College, Rourkela, Odisha, India. ³Department of Microbiology, Hitech Medical College, Rourkela, Odisha, India.

ABSTRACT

BACKGROUND

Blood transfusion is an important lifesaving intervention, but it poses the risk of transmission of different infections like hepatitis B, hepatitis C, human immunodeficiency virus (HIV), *Treponema pallidum* (causing syphilis) and *Plasmodium spp.* (causing malaria) to the recipient. Seroprevalence of different transfusion transmitted infection (TTI) among blood donors is an indirect measure of these infections in the community. This study was conducted to assess the seroprevalence of different TTIs in blood donors attending blood bank of a tertiary care hospital of Western Odisha.

METHODS

12,241 samples over 8 years from both voluntary and replacement donors were processed for HBsAg, HCV, HIV by ELISA method and for syphilis by RPR test, for malaria by rapid card test. Positive samples were confirmed by PCR method for HBsAg, HCV, HIV and by TPHA test for Syphilis and by peripheral smear study for malaria. All the positive samples were rejected for transfusion and the seroreactive blood donors were sent to appropriate department for treatment.

RESULTS

Among 12241 samples 0.96% (118/12241) samples were positive for TTI. 2.70% (328/12241) were voluntary donors and 1.87% (229/12241) were female donors. Seroprevalence of hepatitis B, hepatitis C, HIV, Syphilis and malaria were 0.62, 0.044%, 0.073%, 0.1% and 0.12% respectively. Hepatitis B showed significant decrease of annual prevalence over 8 years.

CONCLUSIONS

Seroprevalence of TTI was lower compared to other studies of India. Highest seroprevalence was seen in hepatitis B. Awareness about hepatitis B vaccination should be increased in that area. Voluntary blood donation and female participation should be encouraged in that area.

KEY WORDS

Seroprevalence, TTI (Transfusion Transmitted Infections), Blood Donors, Trends

Corresponding Author:

Shuvankar Mukherjee,
Room No. 27, Staff Quarters,
Hitech Medical College,
Rourkela, Odisha, India.

E-mail:

shuvankar.mukherjee963@gmail.com

DOI: 10.14260/jemds/2020/109

Financial or Other Competing Interests:
None.

How to Cite This Article:

Mukherjee S, Agarwal SK, Tiwari S.
Seroprevalence of transfusion transmitted
infections among blood donors attending a
tertiary care hospital of Western Odisha. *J.
Evolution Med. Dent. Sci.* 2020;9 (08):483-
487, DOI: 10.14260/jemds/2020/109

Submission 24-12-2019,
Peer Review 29-01-2020,
Acceptance 05-02-2020,
Published 24-02-2020.



BACKGROUND

Blood transfusion is a lifesaving intervention in an accident, in case of anaemia and other haematological diseases. It was discovered by Dr James Bundell in 1818¹. Like all other medical interventions, it also has different adverse effects and risks. Most important risk is chances of acquiring transfusion transmitted infections. There is 1% chance of adverse effects including TTI with every unit of blood.² Screening of blood Donors was first started in 1947.³ Government of India has started screening of blood unit for hepatitis B virus since 1971; HIV since 1989; hepatitis C virus since 2001.^{4,5} In spite of screening we cannot detect these diseases in their Window Period. Risk of getting blood within Window period of different diseases are 1 in 493000 in case of HIV; 1 in 103000 in case of hepatitis C virus and 1 in 63000 in case of hepatitis B virus.⁶ India lies in an intermediate zone of HBV endemicity with prevalence of 2% to 8% in general population and 1% to 2% in blood Donors.^{7,8,9} There are about 50 million hepatitis B virus carriers and that makes India the second largest pool of chronic hepatitis B virus carrier in the world.⁷

Seroprevalence of hepatitis C virus in blood donors in India is 0.12% to 2.5% and in general population it is less than 2%.^{10,11} HCV prevalence is 3% in the world with 170 million people at risk.¹² Global seroprevalence of HCV in blood donors is 0.4% to 19.2%. The human immunodeficiency virus (HIV) is a retrovirus, an enveloped RNA virus, which is transmitted through parenteral and sexual route. It is found in blood and other body fluids. Target cell of HIV is lymphocyte where it replicates. The RNA of HIV integrates into the host cell DNA. HIV virus is classified into different groups and subtypes (Clades) that have significant antigenic differences; HIV-1 and HIV-2 are the two major distinct virus types and there is significant cross-reactivity between them. HIV-1 is endemic in many parts of the world including India. HIV-1 group M is responsible for most of the infections worldwide. The prevalence of HIV-2 is mainly restricted to West African region and India. Additionally, a few infections with HIV group O and group N have been observed in Africa.¹³ Seroprevalence of HIV in adult population is 0.26% in 2015 with 2.39 million people living with HIV or AIDS.¹⁴ There is about 1% of chance of getting HIV during blood transfusion. Seroprevalence of malaria and syphilis in blood donors are variable in different geographical area.

Transfusion transmitted infection not only cause morbidity, mortality in recipient but also it is a threat to his/her family and community as most of the TTI except malaria are sexually transmitted diseases. Estimation of TTI in blood donors is indirect indicator of disease burden in community as blood donors are asymptomatic individuals from community. Considering paucity of data about TTI in blood donors in Western Odisha we have conducted research to find out seroprevalence of different TTI in blood donors attending blood bank of a tertiary care hospital of Western Odisha.

METHODS

This prospective observational study was conducted in the blood bank of Hitech Medical College, Rourkela, in collaboration with Microbiology Department over a period of 8 years from Jan 2012 to Dec 2019 among replacement and voluntary blood donors. 2 ml of blood was collected from all blood donors and serum was separated.

Inclusion Criteria

1. Healthy men and non-pregnant non lactating women.
2. Age 18 to 60 years,
3. Weight at least 45 kg,
4. Haemoglobin levels at least 12.5 g/dL (females) and 13.5 g/dL (males)
5. No history of hepatitis B, hepatitis C, HIV, syphilis and malaria in patient.
6. No history of STD in sexual partners.

Exclusion Criteria

1. Professional donor.
2. Current history of taking any antibiotic, antiviral or anti-malarial or antiretroviral therapy.
3. History of major surgery.
4. Blood transfusion within 1 years.
5. Radiotherapy or Chemotherapy (recent or past).

Investigations

1. Anti-HIV 1 & 2 antibody ELISA (ERBA Lisa HIV Gen. 3)
2. HBsAg by ELISA (ERBA Lisa SEN HBsAg)
3. HCV Antibody ELISA (ERBA Lisa HCV Gen 3)
4. Syphilis RPR card test (Transasia).

Malaria card test (SD bio line) and positive samples were confirmed by peripheral smear method (Giemsa stain). All reactive samples for HIV, HBsAg, HCV were sent to PCR lab for confirmation. Syphilis was confirmed by TPHA test and malaria was confirmed by Peripheral smear study. All seropositive blood donors were sent to appropriate departments for treatment and they were rejected for blood donation.

Data Analysis

Data analysis was done by SPSS software version 21.

RESULTS

12241 samples were processed over 8 years period. Voluntary and Replacement blood donor's distribution was showed in Fig 1. Male and female distribution in different types of donors was showed in Fig 2. Prevalence of different TTI over 8 years was showed in Fig 3. Trends of different TTI over 8 years with annual prevalence was showed in Fig 4. Positivity of Different TTI according to age group was showed in Table 1.

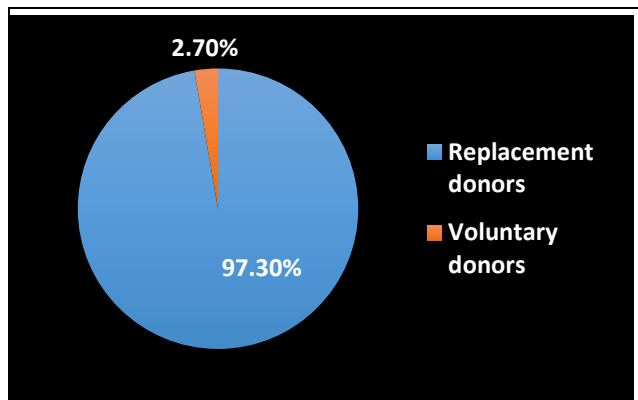


Figure 1. Replacement vs Voluntary Donors

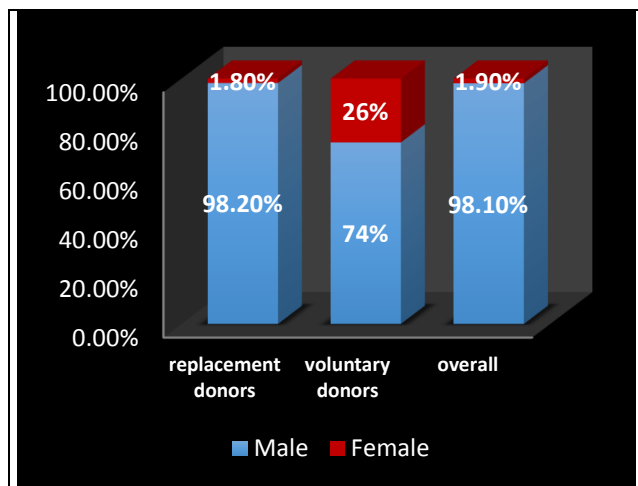


Figure 2. Sex Distribution among Different Types of Donors

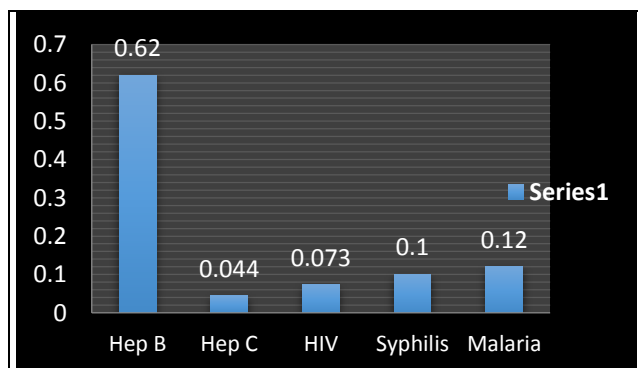


Figure 3. Prevalence of TTI Over 8 Years

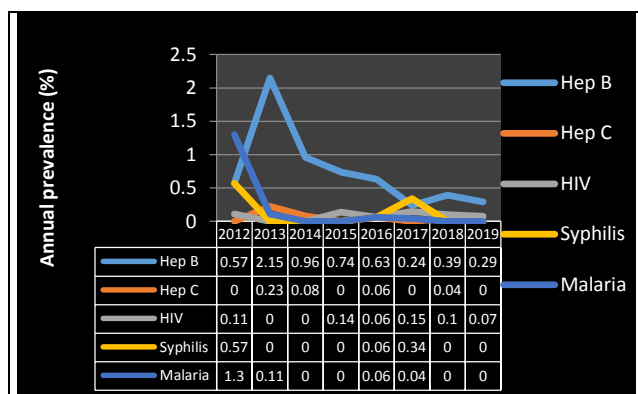


Figure 4. Trends of Annual Prevalence of TTI over 8 Years

Age Group	No. of Donor n (%)	HBsAg Positive	HCV Positive	HIV Positive	Syphilis Positive	malaria Positive	Total Positive
<20	1236 (10%)	5 (6.1%)	0 (0%)	0 (0%)	0 (0%)	1 (7%)	6 (5.02%)
21-30	5256 (43%)	28 (37%)	4 (80%)	6 (67%)	9 (69%)	8 (53%)	55 (46.6%)
31-40	4112 (34%)	40 (53%)	1 (20%)	3 (33%)	4 (31%)	5 (33%)	53 (45%)
41-50	1637 (13%)	3 (3.9%)	0 (0%)	0 (0%)	0 (0%)	1 (7%)	4 (3.38%)
51-60	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	12241 (100%)	76 (100%)	5 (100%)	9 (100%)	13 (100%)	15 (100%)	118 (100%)

Table 1. Positivity of Different TTI According to Age Group

DISCUSSION

Every blood transfusion poses risk for transmissible disease; thereby it is important to check every unit of blood before transfusion. Most common TTI in India are HBV, HCV, HIV, Syphilis and malaria. Chagas disease, HTLV and Cytomegalovirus can be transmitted through blood, but these are not common in India¹³. We had excluded donors below 18 years and above 60 years and most of the donors were male, still our study reflected the disease burden in community of Western Odisha.

In our study most of the samples were from replacement donors (97.3%) only 2.7% were from voluntary donors. Voluntary blood donation (%) in our study was very much smaller than study done by Bhaumik et al¹ (91.8%), Bhawani et al¹⁵ (41.64%), Fernandes H et al¹⁶ (61.2%), Kaur et al¹⁷ (45%). This area needed more no of blood donation campaign to increase voluntary blood donation. In our study 98.12% were male donors and 1.87% were female donors. This finding was comparable with study done by Qureshi et al¹⁸ (2.2% female), Gopi et al¹⁹ (2.84% female), Biswal et al²⁰ (0.92% female) Ray et al²¹ (0.22% female) but not consistent with the study done by Karmakar et al²² (15% female) and Panda et al⁹ (8.3% female). However, in voluntary blood donation female participation was more (26%) compared to replacement blood donation (1.80%). This finding was consistent with the study done by Biswal et al²⁰. In our study most of the donors were in age group of 21-30 (43%) followed by age group of 31-40 (34%) like another study by Gopi et al,¹⁹ Qureshi et al,¹⁸ Panda et al,⁹ Ray et al,²¹ Karmakar et al.²² Seroprevalence of TTI in our study was 0.96% which was higher than Agarwal et al²³ (0.87%) but lower than Ray et al²¹ (3.22%), Karmakar et al²² (2.73%), Gopi et al¹⁹ (1.34%), Leena et al²⁴ (1.35%), Amrutha et al²⁵ (2.81%). Kotwal et al²⁶ (3.02%) and Kumar et al²⁷ (4.57%).

HBV seroprevalence was highest in our study compared to another TTI and it was consistent with most of the study worldwide. hepatitis B virus (HBV) is a member of the hepadnavirus group and is an enveloped DNA virus. HBV is transmitted through parenteral route and may be found in blood and other body fluids like semen and vaginal fluid. From the blood stream the virus travels to the liver as site of replication is hepatocytes. HBV is endemic globally and hyper-endemic in many parts of the world. While HBV is present in the bloodstream, the levels of the virus itself are variable. In recently infected individuals, viral DNA is normally present, although not always at high levels. Chronically infected individuals may either be infectious (DNA present) or non-infectious (viral DNA absent) and viraemia would generally be expected to be very low or absent entirely.¹³

HBV seroprevalence was 0.62% in our study which was almost similar to study done by Singh et al²⁸ (0.62%), Gupta et al¹⁸ (0.66%) and Leena MS et al²⁴ (0.71%). It was higher than Biswal et al²⁰ (0.394) Qureshi et al¹⁸ (0.48%), Gopi et al¹⁹ (0.098%), Shrestha et al²⁹ (0.12%) but lower than study done by Amrutha Kumari²⁵ (1.77%) Kumar R et al²⁷ (1.03%), Panda et al⁹ (1.13%) Srikrishna et al³⁰ (1.86%) Sastry et al³¹ (1.23%) Bhattacharya et al³² (1.66%), Bhaumik et al¹ (1.2%) Karmakar et al²² (1.41%), Garg et al¹¹ (3.44%), Pahuja et al¹⁰ (2.23%), Chandra et al³³ (1.96%), Arora et al³⁴ (1.7%), Buseri FI et al³⁵ (8.1%) Terenpuntsag B et al³⁶ (8.1%), Ray et al²¹ (1.36%) Giri et al³⁷ (1.09%).

Hepatitis C virus (HCV) is a member of the flavivirus group and is an enveloped RNA virus. It is transmitted through parenteral route and may be found in blood and other body fluids like vaginal fluid or semen. From the bloodstream, the virus travels to the liver where it replicates in hepatocytes, resulting in a similar picture to that seen with HBV infection. In our study hepatitis C prevalence was 0.044% which was lower than study done by Leena et al²⁴ (0.14%), Amrutha et al²⁵ (0.13%), Kumar et al²⁷ (1.53%), Panda et al⁹ (1.98%), Srikrishna et al³⁰ (1.02%), Sastry et al³¹ (0.41%) Gopi et al¹⁹ (0.081%), Pallavi et al³⁸ (0.23%), Gupta et al⁸ (1.09%), Pahuja et al⁹ (0.66%), Chandra T et al³³ (0.85%), Arora et al³⁴ (1%), Bhattacharya et al³² (0.31%) Karmakar et al²² (0.59%), Shrestha et al²⁹ (0.64%), Buseri Fletal³⁵ (6%), Terenpuntsag B et al³⁶ (8.7%).

In our study HIV prevalence was 0.073% which was almost similar to Giri et al³⁷ (0.07%) and Gupta et al⁸ (0.084%). But it was lower than study done by Leena MS et al²⁴ (0.27%), Ray et al²¹ (0.56%), Kumar et al²⁷ (0.26%), Panda et al⁹ (0.35%), Srikrishna et al³⁰ (0.44%), Sastry et al³¹ (0.28%), Gopi et al¹⁹ (0.16%), Pallavi et al³⁸ (0.44%), Pahuja et al¹⁰ (0.56%), Chandra T et al³³ (0.23%), Arora et al³⁴ (0.3%), Bhattacharya et al³² (0.28%), Karmakar et al²² (0.6%), Biswal et al²⁰ (0.128%), Shrestha et al²⁹ (0.12%), Buseri FI et al³⁵ (3.1%) and Amrutha Kumari²⁵ (0.63%). In our study Syphilis prevalence was 0.1% which was similar to Leena MS et al²⁴ (0.129%) It was lower than Fernades H et al¹⁶ (2%), Kumar et al²⁷ (1.74%), Srikrishna et al³⁰ (1.6%), Gupta et al⁸ (0.85%), Arora et al³⁴ (0.9%), Bhattacharya et al³² (0.72%), Karmakar et al²² (0.23%), Biswal et al²⁰ (0.706%), Buseri FI et al³⁵ (1.1%), Amrutha Kumari²⁵ (0.28%) It was higher than Sastry et al³¹ (0.008%), Gopi et al¹⁹ (0.024%) and Chandra T et al³³ (0.01%). In our study malaria prevalence was 0.12% which was higher than Kumar et al²⁷ (0.006%), Sastry et al³¹ (0.0%), Fernades H et al¹⁶ (0.01%) but it was lower than Leena MS et al²⁴ (0.129%), Biswal et al²⁰ (0.113%), Buseri et al³⁵ (30.2%), Ali MSM et al³⁹ (16.5%).

About trend analysis gradual fall of annual prevalence was noted in case of hepatitis B but not in another TTI like Hepatitis C and HIV. This gradual decrease in prevalence of HBV was also showed by Bhaumik et al¹, Ray et al²¹ and Karmakar et al²² Gopi et al¹⁹ had reported no significant changes of prevalence of HBV over years. Qureshi et al¹⁸ had reported decrease of both HBV and HCV prevalence over years. Karmakar et al²² had reported decrease of HCV prevalence only but not of HBV. Gradual decrease of HBV prevalence over recent years in our study might be due to increase in HBV vaccination in that area and increase awareness among general population about risky behaviour like blood transfusion, needle sharing, unsafe sex etc.

Although male donors and donors of age group of 20 to 40 were more affected with TTI in our study but it was not significant as no of male donors and donors of this age group was also larger compared to female donors and donors of another age group respectively?

CONCLUSIONS

Prevalence of TTI in our study (0.96%) was lower compared to other studies of India. It might be due to good health status of blood donors as compared to general population, better lifestyle and effective impact of government program (like NACO for HIV). HBV was the most prevalent TTI in our study. So, there is need for initiating efforts for health programmes for HBV in addition to boosting universal immunization programs with HBV which was started in 2007 with more focus on youth population who are not vaccinated yet. Also, there is a need for organizing more number of blood donation camps to increase voluntary blood donation and female participation in blood donation should be encouraged.

REFERENCES

- [1] Bhaumik P, Debnath K. Prevalence of blood-borne viral infections among blood donors of Tripura. *Euroasian J Hepatogastroenterol* 2014;4 (2):79-82.
- [2] Widman FK. Technical manual. American Association of Blood Bank, Arington, 1985: p. 325-44.
- [3] History of Blood Transfusions. <http://www.redcrossblood.org/learn-about-blood/blood-transfusions/history-blood-transfusion> accessed on 18/5/2016.
- [4] Narayan S. Microbes and blood transfusion. *Indian J Med Microbiol* 2001;19 (3):119-26.
- [5] Makroo RN, Chowdhry M, Bhatia A, et al. Prevalence of HIV among blood donors in a tertiary care center of north India. *The Indian Journal of Medical Research* 2011;134 (6):950-3.
- [6] Schreiber GB, Busch MP, Kleinman SH, et al. The risk of transfusion-transmitted viral infections. *The Retrovirus Epidemiology Donor Study*. *N Engl J Med* 1996;334 (26):1685-90.
- [7] Datta S. An overview of molecular epidemiology of hepatitis B virus (HBV) in India. *Virol J* 2008;5:156.
- [8] Gupta N, Kumar V, Kaur A. Seroprevalence of HIV, HBV, HCV and syphilis in voluntary blood donors. *Indian J Med Sci* 2004;58 (6):255-7.
- [9] Panda M, Kar K. HIV, hepatitis B and C infection status of the blood donors in a blood bank of a tertiary health care centre of Orissa. *Indian J Public Health* 2008;52 (1):43-4.
- [10] Pahuja S, Sharma M, Baitha B, et al. Prevalence and trends of markers of hepatitis C virus, hepatitis B virus and human immunodeficiency virus in Delhi blood donors: a hospital based study. *Jpn J Infect Dis* 2007;60 (6):389-91.
- [11] Garg S, Mathur DR, Garg DK. Comparison of seropositivity of HIV, HBV, HCV and syphilis in replacement and voluntary blood donors in western India. *Indian J Pathol Microbiol* 2001;44 (4):409-12.

- [12] WHO. Global surveillance and control of hepatitis C. Report of a WHO consultation organized in collaboration with the Viral hepatitis Prevention Board, Antwerp, Belgium. *J Viral Hepat* 1999;6 (1):35-47.
- [13] WHO. Screening donated blood for transfusion transmissible infections, Who.int.2019. [Cited 22 December 2019]. <https://www.who.int/bloodsafety/ScreeningDonatedBloodforTransfusion.pdf>
- [14] Ministry of Health & Family Welfare Government of India. HIV Estimations 2015. Technical report. National AIDS Control Organisation and National Institute of Medical Statistics, ICMR. 2015.
- [15] Bhawani Y, Rao PR, Sudhakar V. The seroprevalence of transfusion transmissible infection among the blood donors in a tertiary care hospital of Andhra Pradesh. *Biology and Medicine* 2010;2 (4):45-8.
- [16] FernadesH, D'Souza PF, D'Souza PM. Prevalence of transfusion transmitted infection in voluntary and replacement donors. *Ind J Hematol Blood Transfus* 2010;26 (3):89-91.
- [17] Kaur H, Manjari M, Thaman RG, et al. Prevalence of markers of hepatitis C virus among the blood donors. *J Clin Diag Res* 2012;6 (6):959-62.
- [18] Qureshi MZ, Bashir H, Maroof P, et al. Seropositivity of hepatitis B Virus and hepatitis C Virus among blood donors at a tertiary care hospital in Kashmir: a ten-year study. *Int J Cur Res Rev* 2016;8 (19):17-20.
- [19] Dobariya GH, Raja KA, Unagar CA, et al. Prevalence and trends of transfusion transmitted infections among blood donors of blood bank attached to government hospital of South Gujarat, India. *Int J Res Med Sci* 2016;4 (9):4123-7.
- [20] Biswal M, Mohanty P, Panda P, et al. Prevalence of transfusion transmitted infections (ttis) amongst blood donors of North Odisha – a 8 years study. *Int J Rec Sci Res* 2018;9 (5) (5):26598-600. <http://www.recentscientific.com>.
- [21] Ray K, Roy H, Das M. Trends of transfusion transmissible infections among blood donors in a rural medical college of West Bengal, India. *Al Ameen J Med Sci* 2018;11 (2):93-100.
- [22] Karmakar PR, Shrivastava P, Ray TG. Seroprevalence of transfusion transmissible infections among blood donors at the blood bank of a Medical College of Kolkata. *Indian J Public Health* 2014;58 (1):61-4.
- [23] Agarwal N. Response rate of blood donors in the Uttarakhand region of India after notification of reactive test results on their blood samples. *Blood Transfus* 2014;12 (Suppl 1):S51-3.
- [24] Leena MS, Mohd. Shafee. Trend and prevalence of transfusion transmitted infections among blood donors in rural teaching institute, south India. *Journal of Pathology of Nepal* 2012;2 (3):203-6.
- [25] Amrutha KB, Deepa S, Venkatesha D. Blood transfusions: are they life-saving or transfusing infections? *Online J Health & Allied Sci* 2011;10 (2):7.
- [26] Kotwal U, Doda V, Arora S, et al. Blood donor notification and counselling: our experience from a tertiary care hospital in India. *Asian J Transfus Sci* 2015;9 (1):18-22.
- [27] Kumar R, Gupta S, Kaur A, et al. Sero-prevalence and changing trends of transfusion transmitted infections among blood donors in a tertiary care hospital. *Indian J Comm Health* 2015;27 (1):25-9.
- [28] Singh K, Bhat S, Shastry S. Trend in seroprevalence of hepatitis B Virus infection among blood donors of Coastal Karnataka, India. *J Infect Dev Ctries* 2009;3 (5):376-9.
- [29] Shrestha AC, Ghimire P, Tiwari BR, et al. Transfusion transmissible infections among blood donors in Kathmandu, Nepal. *J Infect Dev Ctries* 2009;3 (10):794-7.
- [30] Srikrishna A, Sitalakshmi S, Damodar P. How safe are our safe donors? *Indian J Pathol Microbiol* 1999;42 (4):411-6.
- [31] Sastry JM, Agawane SU, Harke VA. Retrospective study of the five-year prevalence and trends of Transfusion Transmitted Infections (TTIs) among blood donors at a charitable hospital blood bank in Pune, India. *International J of Healthcare and Biomedical Research* 2014;2 (3):193-200.
- [32] Bhattacharya P, Chandra PK, Datta S, et al. Significant increase in HBV, HCV, HIV and syphilis infections among blood donors in West Bengal, Eastern India 2004-2005: Exploratory screening reveals high frequency of occult HBV infection. *World J Gastroenterol* 2007;13 (27):3730-3.
- [33] Chandra T, Kumar A, Gupta A. Prevalence of transfusion transmitted infection in blood donors: an Indian experience. *Trop Doct* 2009;39 (3):152-4.
- [34] Arora D, Arora B, Khetarpal A. Seroprevalence of HIV,HBV, HCV and syphilis in blood donors in southern Haryana. *Ind J Pathol Micro* 2010;53 (2):308-9.
- [35] Buseri FI, Muhibi MA, Jeremiale ZA. Seroepidemiology of transfusion transmissible infectious diseases among blood donors in Osoglor, southwest Nigeria. *Blood Transfus* 2009;7:293-9.
- [36] Terenpuntsag B, Oupbileg L, Nelson K, et al. Prevalence of infectious diseases among Mangolian blood donors. *J Infect Dev Ctries* 2008;2 (1):73-5.
- [37] Giri PA, Deshpande JD, Phalke DB, et al. Seroprevalence of transfusion transmissible infections among voluntary blood donors at a teaching Hospital in a rural area of India. *J Fam Med Prim Care* 2012;1 (1):48-51.
- [38] Pallavi P, Ganesh CK, Jayashree K, et al. Seroprevalence and trends in transfusion transmitted infections among blood donors in a university hospital blood bank: a 5-year study. *Ind J Hematol Blood Transfus* 2011;27 (1):1-6. Published online: 14 December 2010.
- [39] Ali MSM, Kadaru AAGMY, Mustafa MS. Screening blood donors for malaria parasite in Sudan. *Ethiop J Health Dev* 2004;18 (2):70-4.