
PREVALENCE, KNOWLEDGE, AND RISK FACTORS OF HEPATITIS B AND HEPATITIS C INFECTIONS AMONG VOLUNTARY BLOOD DONORS: A COMPREHENSIVE REVIEW

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ABSTRACT

Hepatitis B virus (HBV) and hepatitis C virus (HCV) remain major global public health concerns, accounting for significant morbidity and mortality due to chronic liver disease, cirrhosis, and hepatocellular carcinoma. Blood transfusion is an indispensable component of modern healthcare; however, it continues to pose a potential risk for the transmission of blood-borne pathogens despite substantial improvements in donor screening and laboratory testing. Voluntary blood donors represent the safest source of blood, yet asymptomatic infections, window-period donations, and inadequate awareness regarding hepatitis transmission continue to challenge blood safety programs, particularly in developing countries such as India. This review synthesizes current evidence on the prevalence, epidemiology, knowledge, and risk factors associated with HBV and HCV infections among voluntary blood donors. The review also examines advances in diagnostic technologies, including enzyme-linked immunosorbent assay (ELISA), chemiluminescent microparticle immunoassay (CMIA), nucleic acid testing (NAT), and polymerase chain reaction (PCR), which have substantially improved the detection of transfusion-transmitted infections. Furthermore, the review discusses donor education, vaccination strategies, risk assessment, and public health interventions aimed at minimizing hepatitis transmission through blood transfusion. Strengthening surveillance systems, expanding voluntary non-remunerated blood donation, implementing highly sensitive screening methods, and improving public awareness are essential to achieving the World Health Organization's target of eliminating viral hepatitis as a public health threat by 2030.

Continuous research and evidence-based policy development remain crucial for enhancing blood safety and reducing the burden of hepatitis infections among blood donors and recipients.

KEYWORDS: Hepatitis B, Hepatitis C, Blood Donors, Blood Transfusion, Blood Safety, Risk Factors, Knowledge, India

INTRODUCTION

Viral hepatitis remains one of the leading causes of chronic liver disease worldwide and continues to pose a major challenge to healthcare systems. Among the different hepatitis viruses, hepatitis B virus (HBV) and hepatitis C virus (HCV) are responsible for the majority of chronic infections and are significant contributors to liver cirrhosis, hepatic failure, and hepatocellular carcinoma. According to the World Health Organization (WHO), hundreds of millions of people worldwide are living with chronic HBV or HCV infection, while more than one million individuals die annually due to hepatitis-related complications. Despite remarkable advances in vaccination, antiviral therapy, and diagnostic technologies, viral hepatitis continues to represent a substantial public health burden, particularly in low- and middle-income countries where access to screening and treatment remains limited.

Blood transfusion is an essential therapeutic intervention used for trauma management, surgical procedures, obstetric emergencies, hematological disorders, and cancer treatment. The safety of transfused blood directly depends on the accurate identification and exclusion of infectious donations. Hepatitis B and hepatitis C viruses are among the most important transfusion-transmitted infections because infected individuals often remain asymptomatic for prolonged periods while carrying infectious viral particles in their bloodstream. Consequently, infected donors who are unaware of their infection status may unintentionally contribute to disease transmission despite routine donor selection procedures.

The introduction of mandatory screening protocols has significantly reduced the risk of hepatitis transmission through blood transfusion. Modern blood banks utilize highly sensitive serological assays such as enzyme-linked immunosorbent assay (ELISA) and chemiluminescent microparticle immunoassay (CMIA), together with molecular techniques including nucleic acid testing (NAT) and polymerase chain reaction (PCR), to detect viral markers during both chronic infection and the early window period. These technological advances have substantially improved transfusion safety; however, residual risks persist due to occult infections, laboratory limitations, and inconsistent implementation of quality assurance measures.

Voluntary non-remunerated blood donors constitute the safest donor population because they generally exhibit lower prevalence of transfusion-transmissible infections compared with replacement or paid donors. Nevertheless, variations in hepatitis prevalence continue to exist across geographical regions owing to differences in socioeconomic status, healthcare infrastructure, vaccination coverage, cultural practices, and donor awareness. Understanding these variations is essential for developing evidence-based blood safety policies and targeted preventive strategies.

Knowledge regarding HBV and HCV transmission plays a fundamental role in preventing infection. Individuals who understand the routes of transmission, recognize associated risk factors, and appreciate the importance of vaccination and regular screening are more likely to adopt safer behaviors. Unfortunately, studies conducted in developing countries have consistently reported inadequate awareness among blood donors regarding viral hepatitis, particularly concerning asymptomatic infection, occupational exposure, unsafe injection practices, tattooing, body piercing, and unprotected sexual contact. Such deficiencies in knowledge may increase the likelihood of high-risk behaviors and consequently compromise blood safety.

In India, hepatitis B remains moderately endemic, while hepatitis C prevalence varies considerably across different regions and population groups. Although the National Blood Transfusion Council (NBTC) has implemented standardized screening guidelines, regional disparities in laboratory infrastructure, availability of advanced diagnostic technologies, and donor education continue to influence the effectiveness of hepatitis prevention strategies. Continuous epidemiological surveillance is therefore necessary to monitor disease trends, evaluate the impact of vaccination programs, and identify populations requiring targeted interventions.

This review aims to summarize current evidence regarding the epidemiology, prevalence, knowledge, risk factors, diagnostic approaches, and preventive strategies related to HBV and HCV infections among voluntary blood donors. By integrating findings from published literature, the review highlights existing challenges in blood safety while emphasizing evidence-based approaches that can strengthen donor screening, improve public awareness, and support national and international efforts toward hepatitis elimination.

Global and Indian Burden of Hepatitis B and Hepatitis C

Hepatitis B and hepatitis C continue to impose a substantial burden on global health. The World Health Organization estimates that approximately 254 million individuals are living with

chronic hepatitis B infection, while nearly 50 million people are chronically infected with hepatitis C. Together, these infections account for more than one million deaths annually, primarily resulting from cirrhosis and hepatocellular carcinoma. Despite the availability of an effective vaccine against HBV and highly effective direct-acting antiviral therapies for HCV, disease burden remains disproportionately high in resource-constrained countries where screening, diagnosis, and treatment services are inadequate.

The epidemiology of HBV varies considerably across geographical regions. High-endemic areas, including sub-Saharan Africa and parts of East Asia, report hepatitis B surface antigen prevalence exceeding 8%, whereas intermediate-endemic regions such as India demonstrate prevalence ranging between 2% and 4%. Low-endemic countries including North America and Western Europe generally report prevalence below 2%, largely due to universal vaccination, effective healthcare infrastructure, and comprehensive blood screening programs.

Similarly, hepatitis C prevalence differs among populations. Although India's overall HCV prevalence is estimated to remain below 1%, certain high-risk groups—including intravenous drug users, hemodialysis patients, multi-transfused individuals, and healthcare workers—experience substantially higher infection rates. These variations emphasize the importance of targeted surveillance and risk-based interventions.

Blood donors represent a critical population for monitoring hepatitis epidemiology because donor screening provides valuable information regarding infection trends within apparently healthy individuals. Numerous Indian studies have reported declining HBV and HCV prevalence among voluntary blood donors following implementation of mandatory serological screening, donor education initiatives, and improved laboratory quality assurance systems. Nevertheless, occasional detection of infected donations highlights the continuing need for highly sensitive diagnostic technologies, including nucleic acid testing, to identify infections during the serological window period.

Furthermore, demographic factors such as age, gender, educational level, socioeconomic status, and urban-rural residence significantly influence hepatitis prevalence and awareness among blood donors. Younger individuals generally demonstrate better knowledge due to increased educational exposure, whereas rural populations often experience limited access to vaccination services and health education programs. These disparities underscore the need for region-specific public health interventions tailored to local epidemiological characteristics.

Blood Donors as a High-Priority Population

Blood transfusion is an indispensable component of modern healthcare, providing life-saving

support for patients undergoing major surgical procedures, trauma management, cancer therapy, obstetric emergencies, hematological disorders, and organ transplantation. The effectiveness of blood transfusion services, however, depends on the availability of safe blood free from transfusion-transmitted infections (TTIs). Hepatitis B virus (HBV) and hepatitis C virus (HCV) remain among the most clinically significant TTIs because both viruses can establish chronic infections and remain asymptomatic for prolonged periods. Consequently, infected individuals may unknowingly donate blood, thereby posing a potential risk to recipients despite routine donor screening procedures. Voluntary non-remunerated blood donors are widely recognized as the safest donor population because they generally demonstrate lower prevalence rates of infectious diseases and are more likely to donate blood voluntarily without financial motivation. Nevertheless, epidemiological studies continue to report varying prevalence of HBV and HCV among voluntary donors, indicating that donor selection alone cannot completely eliminate transfusion-related risks.

The prevalence of hepatitis infections among blood donors reflects not only the burden of disease within the general population but also the effectiveness of national blood safety policies. In many developing countries, improvements in donor recruitment, standardized screening protocols, quality assurance systems, and public awareness campaigns have contributed to a gradual decline in hepatitis prevalence among blood donors. However, residual risks remain due to occult infections, donations collected during the serological window period, and variations in laboratory capacity across different healthcare settings. Therefore, continuous surveillance of blood donors provides valuable epidemiological information that supports policy formulation, evaluation of screening strategies, and implementation of targeted public health interventions.

Blood donor selection is a critical component of transfusion safety. Potential donors undergo detailed medical history assessment, physical examination, and behavioral risk evaluation before blood collection. Individuals with recent high-risk sexual behavior, history of intravenous drug use, previous hepatitis infection, recent blood transfusion, tattooing, body piercing, or occupational exposure to infected blood are generally deferred from donation according to national guidelines. Although these measures substantially reduce the likelihood of collecting infected blood, they depend heavily on accurate self-reporting by donors. Social stigma, inadequate knowledge, or intentional nondisclosure of risk behaviors may compromise donor selection, emphasizing the need for highly sensitive laboratory screening methods alongside comprehensive donor education.

Risk Factors Associated with Hepatitis B and Hepatitis C Infection

The transmission of HBV and HCV occurs primarily through exposure to infected blood and body fluids. Several behavioral, occupational, medical, and socioeconomic factors increase an individual's susceptibility to infection. Understanding these determinants is essential for developing effective prevention strategies and strengthening blood safety programs.

Unsafe blood transfusion historically represented one of the major routes of hepatitis transmission. Although mandatory screening has dramatically reduced transfusion-associated infections, transmission remains possible when infected donations occur during the diagnostic window period or when laboratory errors compromise screening accuracy. The adoption of nucleic acid testing has significantly shortened the window period, thereby reducing residual transmission risk.

Injection drug use is considered one of the strongest risk factors for both HBV and HCV infection. Sharing contaminated needles and syringes facilitates direct blood-to-blood transmission, resulting in exceptionally high infection rates among intravenous drug users. Numerous epidemiological investigations have consistently identified injection drug use as a principal driver of hepatitis C transmission worldwide.

Healthcare-related exposure also contributes substantially to hepatitis transmission. Healthcare professionals, laboratory personnel, nurses, physicians, dentists, and emergency medical workers frequently encounter blood and body fluids during routine clinical practice. Needle-stick injuries, accidental exposure to contaminated sharp instruments, and inadequate infection control practices increase occupational risk. Strict adherence to universal precautions, proper disposal of biomedical waste, vaccination against hepatitis B, and routine occupational health surveillance remain essential preventive measures.

Cultural and cosmetic practices including tattooing, body piercing, traditional scarification, acupuncture, and community circumcision ceremonies may also facilitate hepatitis transmission when performed using inadequately sterilized instruments. Similarly, unsafe medical injections, reuse of syringes, and poorly sterilized surgical equipment continue to contribute to disease transmission in resource-limited settings.

Sexual transmission represents another important risk factor, particularly for hepatitis B virus. Individuals with multiple sexual partners, men who have sex with men, commercial sex workers, and persons with sexually transmitted infections exhibit significantly increased susceptibility. Mother-to-child transmission during childbirth remains an important cause of chronic HBV infection in highly endemic regions, highlighting the importance of antenatal screening and timely neonatal vaccination.

Socioeconomic determinants also influence hepatitis epidemiology. Limited educational attainment, poor sanitation, inadequate healthcare access, poverty, and insufficient health literacy reduce awareness regarding disease transmission and preventive measures. Rural populations often experience lower vaccination coverage and delayed diagnosis due to limited healthcare infrastructure, thereby sustaining community transmission. Addressing these social determinants through public health education and equitable healthcare access remains fundamental for hepatitis control.

Knowledge and Awareness Among Blood Donors

Knowledge regarding hepatitis viruses plays a pivotal role in reducing infection rates and ensuring blood safety. Blood donors who understand the modes of transmission, recognize high-risk behaviors, appreciate the benefits of vaccination, and seek regular health screening are less likely to engage in practices that increase infection risk. Consequently, donor education constitutes an essential component of comprehensive blood safety programs.

Despite considerable improvements in public health communication, several studies have reported inadequate knowledge regarding HBV and HCV among blood donors, particularly in developing countries. Many individuals remain unaware that hepatitis infections frequently remain asymptomatic for years before clinical manifestations develop. Misconceptions regarding transmission through casual social contact, sharing utensils, or mosquito bites continue to exist, while awareness regarding genuine transmission routes—including contaminated needles, unsafe blood transfusion, unprotected sexual contact, and occupational exposure—remains insufficient among certain populations.

Educational status consistently demonstrates a positive association with hepatitis awareness. Individuals with higher educational attainment generally exhibit greater understanding of preventive measures, diagnostic testing, and vaccine availability. Younger donors, urban residents, and repeat voluntary donors also tend to possess better knowledge compared with first-time or replacement donors. These findings emphasize the importance of integrating structured educational interventions into blood donation campaigns.

Vaccination awareness represents another important aspect of donor education. Although an effective vaccine against hepatitis B has been available for decades, vaccination coverage among adults remains suboptimal in many countries. Many prospective donors are unaware of their vaccination status or the long-term protective benefits of immunization. In contrast, the absence of a vaccine against hepatitis C underscores the importance of preventive behaviors,

early diagnosis, and treatment to interrupt transmission.

Public awareness campaigns organized through hospitals, educational institutions, community organizations, social media platforms, and government health programs have demonstrated significant effectiveness in improving hepatitis-related knowledge. Regular educational activities conducted before blood donation not only improve donor understanding but also encourage honest disclosure of risk behaviors during donor screening interviews. Consequently, strengthening health education initiatives should remain a priority for blood transfusion services and national hepatitis control programs.

Diagnostic Approaches and Blood Screening

Early and accurate diagnosis of hepatitis B virus (HBV) and hepatitis C virus (HCV) infections is fundamental to ensuring blood safety and preventing transfusion-transmitted infections (TTIs). Since many infected individuals remain asymptomatic for years, laboratory screening serves as the primary strategy for identifying infected blood donors before transfusion. Over the past three decades, remarkable advancements in immunological and molecular diagnostic technologies have substantially improved the sensitivity and specificity of hepatitis screening, thereby reducing the residual risk of viral transmission through blood transfusion.

Serological testing remains the cornerstone of hepatitis screening in blood banks worldwide. For HBV, the detection of hepatitis B surface antigen (HBsAg) is the primary marker used to identify active infection. Additional serological markers, including antibodies against hepatitis B core antigen (anti-HBc), hepatitis B e antigen (HBeAg), and antibodies against hepatitis B surface antigen (anti-HBs), provide valuable information regarding disease stage, infectivity, immunity, and vaccination status. In HCV infection, screening primarily involves the detection of anti-HCV antibodies, which indicate previous or current exposure to the virus. Although antibody detection is highly effective for routine screening, it cannot distinguish between resolved and active infection, necessitating confirmatory molecular testing.

Enzyme-linked immunosorbent assay (ELISA) has historically been one of the most widely used screening methods because of its excellent sensitivity, affordability, and ability to process large numbers of samples simultaneously. However, many modern blood transfusion centers have increasingly adopted Chemiluminescent Microparticle Immunoassay (CMIA), which provides superior analytical performance, automation, and faster turnaround time. CMIA utilizes antigen–antibody interactions coupled with chemiluminescent detection, allowing for highly accurate identification of HBsAg and anti-HCV antibodies even at low concentrations. The automation of CMIA also minimizes operator-dependent errors and improves laboratory

efficiency, making it particularly suitable for high-volume blood banks.

Despite the high sensitivity of serological assays, one important limitation is the diagnostic window period—the interval between initial infection and the development of detectable antibodies or antigens. During this period, infected individuals may donate blood despite testing negative by conventional serological methods. To overcome this limitation, molecular diagnostic techniques have become increasingly important.

Nucleic Acid Testing (NAT) directly detects viral DNA or RNA and significantly shortens the diagnostic window period for both HBV and HCV. By identifying viral nucleic acids before serological markers become detectable, NAT substantially reduces the risk of transfusion-transmitted hepatitis. Several countries have incorporated NAT into routine blood donor screening, resulting in remarkable improvements in blood safety. Although the implementation of NAT requires specialized laboratory infrastructure and increases screening costs, numerous cost-effectiveness studies have demonstrated that preventing even a small number of hepatitis infections justifies its routine use in regions with moderate or high disease prevalence.

Polymerase Chain Reaction (PCR) serves as another highly sensitive molecular technique used primarily for confirmatory diagnosis and viral load quantification. PCR amplifies specific viral genetic sequences, enabling detection of extremely low concentrations of viral DNA or RNA. For HBV, quantitative PCR assists clinicians in evaluating viral replication, monitoring antiviral therapy, and assessing disease progression. Similarly, HCV RNA PCR confirms active infection and guides treatment decisions using direct-acting antiviral agents. Real-time PCR has further improved diagnostic accuracy by providing rapid quantitative measurements while minimizing contamination risks.

Quality assurance remains an essential component of blood screening programs. Laboratories must adhere to standardized operating procedures, participate in internal and external quality assessment programs, regularly calibrate diagnostic equipment, and ensure continuous training of laboratory personnel. These measures reduce analytical errors, improve reproducibility, and enhance confidence in screening results. Continuous technological innovation, combined with stringent quality management systems, remains fundamental for achieving optimal blood safety.

Prevention and Public Health Strategies

Preventing HBV and HCV transmission requires an integrated public health approach involving vaccination, safe blood transfusion practices, infection prevention, community education, and effective surveillance systems. Although significant progress has been achieved

globally, hepatitis continues to impose considerable health and economic burdens, particularly in low- and middle-income countries where access to healthcare services remains limited.

Universal hepatitis B vaccination represents one of the most successful preventive interventions in modern medicine. The World Health Organization recommends administration of the first vaccine dose within 24 hours of birth, followed by completion of the full vaccination schedule during infancy. Universal immunization has substantially reduced childhood HBV infection and chronic carrier rates in many countries. Vaccination is also strongly recommended for healthcare workers, laboratory personnel, dialysis patients, household contacts of infected individuals, and other high-risk populations.

Ensuring safe blood transfusion remains another critical preventive strategy. Blood donation should rely primarily on voluntary non-remunerated donors who demonstrate lower prevalence of transfusion-transmissible infections than replacement or paid donors. Comprehensive donor selection, standardized health questionnaires, confidential self-exclusion procedures, and advanced laboratory screening collectively reduce the likelihood of collecting infected blood. Incorporating highly sensitive screening technologies such as CMIA and NAT further enhances transfusion safety by identifying infections during early stages.

Infection prevention and control measures within healthcare facilities also play a vital role in limiting hepatitis transmission. Strict adherence to universal precautions, proper hand hygiene, safe injection practices, sterilization of reusable medical equipment, appropriate disposal of sharps, and use of personal protective equipment significantly reduce occupational exposure among healthcare workers. Continuous training programs reinforce adherence to infection control guidelines and promote patient safety.

Public education remains indispensable for reducing hepatitis transmission within communities. Educational campaigns should emphasize disease transmission routes, benefits of hepatitis B vaccination, importance of voluntary testing, avoidance of needle sharing, safe sexual practices, and early medical consultation. Schools, universities, workplaces, healthcare institutions, and mass media provide valuable platforms for disseminating accurate information. Improved health literacy empowers individuals to adopt healthier behaviors and encourages voluntary participation in hepatitis screening programs.

National hepatitis control programs should strengthen surveillance systems to monitor disease trends, evaluate intervention effectiveness, and identify high-risk populations requiring targeted preventive measures. Integration of hepatitis screening into primary healthcare services, antenatal care, HIV programs, and community outreach initiatives facilitates early diagnosis and timely treatment. Collaboration among governments, healthcare professionals,

academic institutions, and international organizations remains essential for achieving the World Health Organization's goal of eliminating viral hepatitis as a public health threat by 2030.

Future Perspectives

Future efforts to eliminate HBV and HCV should focus on expanding access to molecular diagnostic technologies, improving adult hepatitis B vaccination coverage, strengthening donor education programs, and promoting universal access to antiviral therapy. Artificial intelligence and digital health technologies may further enhance donor selection, laboratory quality management, epidemiological surveillance, and prediction of disease outbreaks. Continued research into therapeutic vaccines for HBV and preventive vaccines for HCV also represents a promising avenue for reducing the global burden of viral hepatitis. Investment in healthcare infrastructure, workforce development, and public health research will remain essential for sustaining progress toward hepatitis elimination.

CONCLUSION

Hepatitis B and hepatitis C continue to represent significant challenges for blood transfusion services and global public health despite considerable advances in diagnostic technology, vaccination, and antiviral treatment. Voluntary blood donors constitute the safest source of blood; however, asymptomatic infections, diagnostic window periods, and inadequate awareness continue to present residual risks for transfusion-transmitted infections. Modern screening technologies, including CMIA, NAT, and PCR, have substantially improved the detection of infected donations and strengthened blood safety. Nevertheless, laboratory screening alone cannot eliminate hepatitis transmission without complementary public health interventions.

Comprehensive prevention strategies incorporating universal hepatitis B vaccination, voluntary blood donation, effective donor education, stringent infection control practices, community awareness, and continuous epidemiological surveillance are essential for reducing hepatitis prevalence and protecting blood recipients. Strengthening healthcare infrastructure and ensuring equitable access to advanced diagnostic technologies will further support national hepatitis control programs. Achieving the World Health Organization's 2030 hepatitis elimination targets will require sustained collaboration among governments, healthcare providers, researchers, and communities. Continued investment in research, surveillance, and public health policy will be critical for minimizing the burden of HBV and HCV and ensuring

a safer blood supply worldwide.

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