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Infectıon of Hepatıtıs B Vırus and Hepatıtıs C Vırus in Thalassemıa

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Abstract: Thalassemia disease remains incurable and causes many complications. People with thalassemia major require routine lifelong blood transfusions. A main risk of transfusion is infection with diseases transmitted through blood, which is among the most frequent causes of death in thalassemia patients. Transfusion-transmitted infections (TTIs) include hepatitis B and hepatitis C. This study aimed to determine the prevalence of hepatitis B and C in thalassemia patients in Ciamis Regency and examine the relationship between transfusion frequency and these infections. The method was a cross-sectional study on thalassemia patients who received blood transfusions. The study included 191 thalassemia patients at Ciamis Hospital from January to June 2023. Purposive sampling selected 89 patients as the sample. Hepatitis B and C tests used immunochromatography. The prevalence of Hepatitis C Virus and Hepatitis B Virus infections in thalassemia patients in Ciamis Regency was 2.2% and 3.4%, respectively. The chi-square test showed a significant relationship ($p < 0.05$) between transfusion frequency and hepatitis B and C infection in thalassemia patients. This result suggests a risk of hepatitis B and C infection. Thalassemia patients are potentially susceptible to blood-borne Hepatitis C Virus and Hepatitis B Virus. These infections increase morbidity due to transfusion therapy. Routine inspection for Hepatitis B Virus and Hepatitis C Virus is essential for thalassemia patients. These results emphasize the need for strict screening protocols in blood transfusion processing.
Keywords: Antibodies to Hepatitis C Virus; Blood transfusion; Hepatitis B Surface Antigen; Hepatitis B Virus; Hepatitis C Virus.

INTRODUCTION

Thalassemia is a congenital recessive disorder caused by the lack or absence of the synthesis of the haemoglobin beta-globin chain (Ahmed et al., 2018). The disease is characterised by the reduction or absence of alpha chains or beta globins, two protein subunits of the Hb molecule (Dutta et al., 2023). Thalassemia is the most common genetic disease worldwide. This disease is caused by the bone marrow's inability to make protein to produce Hb (Kandi et al., 2021a). According to data from *the* World Health Organization (WHO), the prevalence of thalassemia (also called thalassemia minor) in Indonesia is 6-10%, meaning that 6-10 people out of every 100 are carriers of the thalassemia gene. According to data from the Indonesian Thalassemia Foundation, the number of people with thalassemia in Indonesia increased from 4,896 in 2012 to 9,028 in 2018. The prevalence of thalassemia reaches 2.5 to 15% in 11 countries in the Southeast Asian region (WHO, 2021b)

Blood-borne infections are the second most common cause of death in thalassemia patients. Thalassemia patients who receive routine blood transfusions are

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at higher risk of contracting Hepatitis (Naz et al., 2023), especially if the blood is not thoroughly screened for the virus. (Maffei et al., 2020). The risk of infection in thalassemia patients is a marker of the risk of transfusion-transmitted infections due to high exposure to blood transfusions. Hepatitis C infection is one of the most common infections transmitted through blood (Akhtar et al., 2020). According to WHO estimates, in lower-middle-income and low-income countries, only 83% and 76% of blood donors, respectively, are screened using basic quality procedures. This implies that up to 24% of donors in low-income settings may not undergo appropriate screening, increasing the risk of transfusion-transmitted infections (WHO, 2025). So, HCV infection remains the most common disease in thalassemia patients (Origa, 2023).

Hepatitis is a systemic infection that often attacks the liver. The five most common hepatitis viruses are hepatitis A virus (HAV), hepatitis B virus (HBV), hepatitis C virus (HCV), hepatitis D virus (HDV), and hepatitis E virus (HEV) (Li et al., 2023). All these viruses are RNA viruses, except HBV, which is a DNA virus. Each virus has different molecular and antigenic characteristics. However, the clinical symptoms shown by all types of these viruses are similar. Hepatitis has many clinical forms, ranging from those that show no symptoms at all to very severe ones, such as fulminant hepatitis that can lead to death. Other symptoms can range from cirrhosis hepatitis, which is very common, to chronic liver disease infections that are getting worse (Moghimbeygi & Alavian, 2020). Spread of hepatitis viruses through the blood, including HBV and HCV (Yousuf et al., 2022). Given the magnitude of the threat posed by the hepatitis virus, the WHO proposes an initiative to reduce hepatitis infections by 90% by 2030 (WHO, 2021).

Anti-HCV screening can be used to identify hepatitis C disease. However, anti-HCV IgM often persists when the infection becomes more chronic, indicating active virus replication (Lee et al., 2014). The HBsAg test, part of the HBV antigen, can be used to check for chronic hepatitis B. This examination is also used for screening for hepatitis B disease (Moonsamy et al., 2022). Results from previous studies conducted in India showed that HCV infection among beta-thalassemia patients was much higher than among other patients (Kandi et al., 2021b). Other studies show that in rural areas with a high incidence of thalassemia, the limited quality of pre-transfusion testing in blood banks leads to a high incidence of TTI, particularly HCV infection (Mandal et al., 2024). Other studies show that the most significant risk factors for Hepatitis B infection in thalassemia major patients are repeated blood transfusions and lack of HBV vaccination (Naz et al., 2023).

Patients who receive frequent blood transfusions, especially those with intervals of 30 days or less between transfusions, demonstrate a significantly higher prevalence of HCV infection, and to a lesser extent, HBV. In a cohort of transfusion-dependent β-thalassemia patients in Dhaka, individuals receiving transfusions every ≤30 days had markedly higher rates of HCV and HBV seropositivity compared to those with less frequent transfusions ($p < 0.0005$) (Bhuyan et al., 2021). Similarly, a study of Egyptian thalassemia patients found that a greater number of transfusion units was significantly associated with a higher prevalence of HCV (40.5%) and HBV (29.0%) (Mansour et al., 2012). These findings suggest that cumulative exposure through repeated transfusions substantially raises the risk of transfusion-transmitted infections.

Based on observations at the Regional General Hospital and POPTI of Ciamis Regency, in 2023, 191 patients with thalassemia underwent routine blood transfusion therapy, including 146 pediatric patients and 45 adult patients at risk of HBV and HCV

infection. Previous studies only investigated hepatitis B or hepatitis C infection and did not look at how transfusion frequency factors into the incidence of hepatitis B and hepatitis C infection. This research was conducted to evaluate the prevalence of hepatitis B and C infections among thalassemia patients in Ciamis Regency and to explore how the frequency of blood transfusions may be associated with the occurrence of these infections.

MATERIALS AND METHODS

The cross-sectional research method was used to determine the prevalence of hepatitis B and hepatitis C in thalassemia patients who routinely undergo blood transfusion therapy at Ciamis Hospital. The study population comprised 191 thalassemia patients at Ciamis Hospital from January to June 2023. The sampling technique was purposive sampling. The sample size in this study was 89 thalassemia patients at the hospital. The inclusion criteria for this study were as follows: patients with a confirmed diagnosis of β-thalassemia major or intermedia, who had received regular blood transfusions for at least the past six months, who resided within the Ciamis Regency, and participants were required to be at least two years of age to minimize the risk of maternal antibody interference. Conversely, the exclusion criteria included patients with known hepatitis B or C infections acquired through non-transfusion routes, such as vertical transmission or intravenous drug use. Individuals with a history of organ transplantation or chronic liver disease unrelated to viral hepatitis were also excluded, as were patients with incomplete medical records, particularly regarding transfusion history and laboratory results. Additionally, those who declined to participate or were in critical condition at the time of data collection were excluded from the study. The characteristics of the sample in the study are shown in Table 1. Female respondents indicated more than men. In addition, the frequency of transfusions is the highest, more than twice in one month, with each transfusion requiring one blood bag.

Table 1. Characteristics of Research Subjects

Characteristic	Frequency (N)	Percentage (%)
Gender		
Man	45	49.9
Woman	46	50.1
Transfusion Frequency		
≥2x per month	56	62
1x per month	35	38
Number of 1x blood transfusion		
1 blood bag	89	78
2 blood bags	2	22
Samples included	89	

The tools and materials used are one package of anti-HCV examination materials and one package of HBsAg. A 3 mL sample of whole blood was collected via venipuncture (BD Vacutainer® non-containing the anticoagulant). Specimen serum was examined in the laboratory. The data collection technique uses primary data obtained from HBsAg and anti-HCV (Answer HBsAg and anti-HCV Cassette) test results in patients with thalassemia, using the Immunochromatography method, as per

the procedure outlined in the insert kit. Statistically, the SPSS program was used to examine relationships among variables, which were then presented in tabular form, narrated, and concluded. Data processing used a Chi-square test to determine the significance of the relationship between transfusion frequency and the incidence of hepatitis B and hepatitis C infection in thalassemia patients. This research has received an ethical permit from the Ethics Commission of STIKes Muhammadiyah Ciamis with letter number 004/KEPK-STIKESMUCIS/VIII/2023.

RESULTS AND DISCUSSION

The results of HBV infection with HBsAg showed a positive result of 3.4% and HCV infection with anti-HCV as much as 2.2%, where the risk of hepatitis B infection was higher than that of hepatitis C. The results showed the risk of HBV and HCV infection in patients with thalassemia with transfusion therapy.

Table 2. HBsAg and Anti-HCV Examination Results

Characteristic	Frequency (N)	Percentage (%)
HBsAg		
Positive	3	3,4
Negative	86	96,6
Total	89	100
Anti-HCV		
Positive	2	2,2
Negative	87	97,8
Total	89	100

The study's results showed that the overall HCV in thalassemia patients in the Ciamis Regency was positive at 2.2% and negative at 97.8%. The HBsAg test result was 3.4% positive. The increased immunity of patients to the hepatitis B virus led to a positive HBsAg result. HBsAg-negative 96.6% of patients vaccinated with the virus may be due to repeated blood transfusions, thus reducing the vaccine's effectiveness in those patients (Mohammed Hasan et al., 2020).

Blood transfusions are one intervention effort to save lives, such as in patients with thalassemia. However, this intervention is not risk-free. Infections that can be transmitted through blood transfusions include hepatitis B and hepatitis C. Many cases of hepatitis B and hepatitis C infection occur in adult populations associated with the use of blood transfusions. This happens because hepatitis B and hepatitis C are transmitted through blood and body fluids, so it is a vertical transmission (Astuti & Kusumawati, 2014).

Although blood donors are examined using immunochromatographic methods, it is still essential to examine the source of hepatitis virus infection in multi-transfusion thalassemia. There may be drawbacks in donor screening using this method. Nucleic acid amplification technology (NAT) testing can be done using PCR. Immunochromatographic tests are affordable and easy to use, but have lower sensitivity compared to nucleic acid testing (NAT), often missing early or occult HBV and HCV infections (Shenge & Osiowy, 2021).NAT offers higher diagnostic accuracy by detecting viral nucleic acids during the window period, but its application is limited in low-resource settings due to cost, infrastructure, and technical demands(Candotti & Allain, 2013; Naidu et al., 2016). While NAT is the gold standard, ICTs remain the practical choice in many regions despite their diagnostic limitations. This can be done in combined testing and can save costs if performed in large-scale testing and blood

storage facilities. Based on the results of research from developing countries, it was concluded that the prevalence of transfusion-transmitted infections (TTIs) such as HCV, HBV, and HIV is very high in transfusion-dependent thalassemia patients; this emphasises the high prevalence of HCV or a combination with HBV. Fragmented blood transfusion systems and inadequate safety measures can cause these TTIs. This reduction in prevalence can be lowered by implementing policies regarding safe blood transfusion practices, and screening donors based on quality-assured procedures can help reduce the risk of TTIs in the future (Riaz et al., 2022)

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Table 3. Relationship Between Status of Infection Hepatitis B and Hepatitis C with Transfusion Frequency

Characteristic	Transfusion Frequency (%)		Chi-square *(p-value)*
	≥2x per month	1x per month	
HBsAg			
Positive	2(2)	1(1)	
Negative	70(79)	16(18)	0.020*
Total	89	100	
Anti-HCV			
Positive	2(2)	0(0)	
Negative	70(79)	17(19)	0.007*
Total	89	100	

*significant if p-value <0.05

There is a lack of robust policies regarding transfusion safety and the proper, strict monitoring of blood banks to ensure adherence to policies and reduce the risk of transfusion-transmitted hepatitis (20). National and regional health programs must mandate and monitor screening procedures to reduce the risk of transfusion-transmitted infections, such as HCV, among the general population of thalassemia patients (Dutta et al., 2023). Table 3 shows that transfusion frequency is a significant factor (p-value<0.05) for the occurrence of hepatitis B and hepatitis C infections. Patients with multi-transfusion thalassemia have a high risk of developing HCV infection (Gupta et al., 2022), so more accurate blood test screening techniques (Al-Sharifi et al., 2019) are recommended to reduce the occurrence of TTIs (Mirzaei et al., 2021).

The process of repeated transfusion of blood and blood products is one of the ways of transmission of HBV, HCV, and HIV to patients who need blood, especially thalassemia patients (Riaz et al., 2022). The prevalence rate of HBV and HCV in developing countries is higher than in developed countries due to inadequate blood screening and blood products to be transfused, improper blood collection safety practices, high-risk sexual behaviour, socio-cultural practices such as tattoos and circumcision, as well as practices through the use of non-sterile instruments. In addition, differences in prevalence are likely due to variations in geographic location, differences in diagnostic tools used in detecting HBV and HCV, and population selection (Pius et al., 2022). Another strategy to prevent hepatitis transmission, especially hepatitis B, is vaccination. Vaccination will provide immunity by the formation of anti-HB antibodies (Rakhmina et al., 2021).

Based on the findings that frequent transfusions are associated with increased risk of HBV and HCV infections, several preventive strategies should be prioritised.

The integration of nucleic acid testing (NAT) alongside conventional serological screening can significantly reduce window-period infections, especially in high-risk populations such as thalassemia patients (Bhuyan et al., 2021b). Strengthening voluntary, non-remunerated blood donor systems with strict pre-donation screening and excluding high-risk individuals is also essential to improve blood safety (Sara Trompeter & Aurelio Maggio, 2021). This study has several limitations. The use of immunochromatography may underestimate the true prevalence due to lower sensitivity compared to NAT or ELISA, and purposive sampling at a single hospital may limit generalizability to the broader thalassemia population.

CONCLUSION

Transfusion therapy can increase the risk of infection with hepatitis B and C. Thalassemia patients are potentially susceptible to blood-borne HCV and HBV infections. HBV and HCV infections are essential for thalassemia patients. HBV and HCV infections can increase the morbidity of thalassemia patients due to blood transfusion therapy. To enhance patient safety, national health policies should mandate the use of highly sensitive screening methods such as NAT alongside serology in blood banks, especially for transfusion-dependent populations. Clinically, regular HBV and HCV monitoring and vaccination for thalassemia patients should be integrated into routine care protocols.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Ahmed, I., Iqbal, S., & Waheed, A. (2018). Prevalence of Hepatitis B and Hepatitis C in transfusion dependent thalassemia patients. *Medical Forum Monthly*, *29*(9), 76–79.

Akhtar, S., Nasir, J. A., Usman, M., Sarwar, A., Majeed, R., & Billah, B. (2020). The prevalence of hepatitis C virus in hemodialysis patients in Pakistan: A systematic review and meta-analysis. In *PLoS.* 15(5), 1–13. Public Library of Science. https://doi.org/10.1371/journal.pone.0232931

Al-Sharifi, L. M., Murtadha, J., Shahad, A., Mohammed, Y., Sura, J., Waleed, Z., Raheeq, M., Sura, A., Ehab, H., Shahad, M., & Abbas, Q. (2019). Prevalence of hepatitis B and C in thalassemic patients and its relation with type of thalassemia, frequency of blood transfusion, and spleen status. *Medical Journal of Babylon*, *16*(2), 108–111. https://doi.org/10.4103/MJBL.MJBL_6_19

Astuti, H. P., & Kusumawati, E. (2014). Kajian Efektivitas Pemberian Vaksinasi Hepatitis B Terhadap Pembentukan Antibodi Anti Hbs. *Jurnal Kesehatan Kusuma Husada*, *4*(2), 29–34.

Bhuyan, G. S., Zaman Noor, A. U., Sultana, R., Noor, F. A., Sultana, N., Sarker, S. K., Islam, M. T., Abu Sayeed, M., Ul Khabir, M. I., Ekramul Hossain, A. K. M., Zeba, Z., Qadri, S. K., Furkan Siddique, M. R., Qadri, S. S., Qadri, F., & Mannoor, K. (2021). Frequency of Hepatitis B, C and HIV infections among transfusion-dependent beta thalassemia patients in Dhaka. *Infectious Disease Reports*, *13*(1), 89–95. https://doi.org/10.3390/IDR13010011

Candotti, D., & Allain, J. P. (2013). Molecular virology in transfusion medicine laboratory. In *Blood Transfusion*.11(2), 203–216. https://doi.org/10.2450/2012.0219-12

Dutta, S., Biswas, A., Bakshi, S., Choudhury, P., Das, R., Nath, S., Chowdhury, P., Bhattacharyya, M., Chakraborty, S., Dutta, S., & Sadhukhan, P. C. (2023). Molecular Epidemiology of HCV Infection among Multi-Transfused β-Thalassemia Patients in Eastern India: A Six-Year Observation. *Thalassemia Reports*, *13*(3), 165–178. https://doi.org/10.3390/thalassrep13030016

Gupta, P., Barnwal, R. K., Sundi, A., & Irfan, S. (2022). burden estimation of hepatitis B & C in thalassemia patients in MGM Medical College and Hospital, Jamshedpur. *International Journal of Health Sciences*, *6*(April), 7360–7366. https://doi.org/10.53730/ijhs.v6ns5.10713

Kandi, V., Vinjamuri, S. R., & Tanikella, B. P. (2021a). Hepatitis C Viral Infection Among Beta-Thalassemia Patients: A Study From the Centre for Excellence in Thalassemia and Other Blood Disorders. *Cureus*, *13*(7), 7–11. https://doi.org/10.7759/cureus.16207

Lee, M. H., Yang, H. I., Yuan, Y., L'Italien, G., & Chen, C. J. (2014). Epidemiology and natural history of hepatitis C virus infection. *World Journal of Gastroenterology*, *20*(28), 9270–9280. https://doi.org/10.3748/wjg.v20.i28.9270

Li, S., Li, J., Xu, Y., Xiang, Z., & Wu, J. (2023). Editorial: Pathogen-host interaction in the development of viral hepatitis. *Frontiers in Cellular and Infection Microbiology*, *13*(November), 1–3. https://doi.org/10.3389/fcimb.2023.1333470

Maffei, L., Sorrentino, F., Caprari, P., Taliani, G., Massimi, S., Risoluti, R., & Materazzi, S. (2020). HCV Infection in Thalassemia Syndromes and Hemoglobinopathies: New Perspectives. *Frontiers in Molecular Biosciences*, *7*(January), 1–6. https://doi.org/10.3389/fmolb.2020.00007

Mandal, T. Kr., Sarkar, S., Haldar, P., Mondal, S., Chatterjee, S. S., Paul, P., Ray, R., Ghosh, R. R., Saha, S., & Dan, U. (2024). Prevalence of HIV, hepatitis B and hepatitis C infections among patients with thalassemia attending a tertiary care (rural) hospital. *Journal of Family Medicine and Primary Care*, *13*(5), 1780–1786. https://doi.org/10.4103/jfmpc.jfmpc_1751_23

Mansour, A. K., Aly, R. M., Abdelrazek, S. Y., Elghannam, D. M., Abdelaziz, S. M., Shahine, D. A., Elmenshawy, N. M., & Darwish, A. M. (2012). Prevalence of HBV and HCV infection among multi-transfused Egyptian thalassemic patients. *Hematology/ Oncology and Stem Cell Therapy*, *5*(1), 54–59. https://doi.org/10.5144/1658-3876.2012.54

Mirzaei, G., Shamsasenjan, K., Jafari, B., Bagherizadeh, Y., Sadafzadeh, A., Bannazadeh-Baghi, H., Sadeghi-Deylamdeh, Z., & Jafari-Sales, A. (2021). Prevalence of HBV and HCV infection in beta-thalassemia major patients of Tabriz city, Iran. *New Microbes and New Infections*, *43*, 100912. https://doi.org/10.1016/j.nmni.2021.100912

Moghimbeygi, M., & Alavian, S. M. (2020). Eradication of hepatitis C virus infection in thalassemia patients in Iran using various treatment strategies. *Journal of Virus Eradication*, *6*(3), 1–6. https://doi.org/10.1016/J.JVE.2020.100006

Mohammed Hasan, K., Ahmad Rashid, J., & Khasraw Ghafoor, I. (2020). Prevalence of Hepatitis C Virus Infection Among Children With Beta Thalassemia Major in Sulaimani. *Journal of Sulaimani Medical College*, *10*(1), 89–96. https://doi.org/10.17656/jsmc.10244

Moonsamy, S., Suchard, M., Pillay, P., & Prabdial-Sing, N. (2022). Prevalence and incidence rates of laboratory-confirmed hepatitis B infection in South Africa, 2015 to 2019. *BMC Public Health*, *22*(1), 1–13. https://doi.org/10.1186/s12889-021-12391-3

Naidu, N. K., Bharucha, Z. S., Sonawane, V., & Ahmed, I. (2016). Nucleic acid testing: Is it the only answer for safe Blood in India. *Asian Journal of Transfusion Science*, *10*(1), 79–83. https://doi.org/10.4103/0973-6247.175423

Naz, R., Ullah, F., Muhammad, T., Khan, O., Shah, F., Rehman, A. u, & Basir, N. U. (2023). Incidence of Hepatitis B Due to Multiple Transfusions in Patients of β-Thalassemia Major. *Pakistan Journal of Health Sciences*, 4(2 February 2023), 86–90. https://doi.org/10.54393/pjhs.v4i02.558

Origa, R. (2023). Hepatitis C and Thalassemia: A Story with (Almost) a Happy Ending. *Pathogens*, *12*(5), 1–15. https://doi.org/10.3390/pathogens12050683

Pius, O., Ekundayo, O., & Abiodun, S. (2022). Sero-Prevalence of Transfusion Transmissible Hepatitis Viruses Among Blood Donors in Ilorin, Kwara State. *International Journal of Applied Biology*, 6(2),14–35.

Rakhmina, D., Norsiah, W., Herlina, T. E., Sari, N. M., Pertiwi, R., Ariani, R., & Rahman, S. (2021). Immune Response to anti-HBs Antibodies in Health Workers Following Hepatitis B Vaccination. *Medical Laboratory Technology Journal*, *7*(2), 182–193. https://doi.org/10.31964/mltj.v7i2.418

Riaz, M., Abbas, M., Rasool, G., Baig, I. S., Mahmood, Z., Munir, N., Mahmood Tahir, I., Ali Shah, S. M., & Akram, M. (2022). Prevalence of transfusion-transmitted infections in multiple blood transfusion-dependent thalassemic patients in Asia: A systemic review. *International Journal of Immunopathology and Pharmacology*, *36*, 1–9. https://doi.org/10.1177/03946320221096909

Trompeter, S. , and M. A. (2021). Blood transfusion. In F. D. P. J. Cappellini MD (Ed.), *Guidelines: For the Management of Transfusion Dependent Thalassaemia (TDT)* (4th ed.). Thalassaemia International Federation.

Shenge, J. A., & Osiowy, C. (2021). Rapid Diagnostics for Hepatitis B and C Viruses in Low- and Middle-Income Countries. In *Frontiers in Virology* (Vol. 1, Issue October, pp. 1–12). Frontiers Media SA. https://doi.org/10.3389/fviro.2021.742722

Waheed, U., Saba, N., Wazeer, A., & Ahmed, S. (2021). A Systematic Review and Meta-Analysis on the Epidemiology of Hepatitis B and Hepatitis C Virus among Beta-Thalassemia Major Patients in Pakistan. *Journal of Laboratory Physicians*, *13*(03), 270–276. https://doi.org/10.1055/s-0041-1731110

WHO. (2021b, September 7). *Regional desk review of haemoglobinopathies with an emphasis on thalassaemia and accessibility and availability of safe blood and blood products as per these patients' requirement in South-East Asia under universal health coverage*. Https://Www.Who.Int/Publications/i/Item/9789290228516.

WHO. (2025, May 30). *Blood safety and availability*. Https://Www.Who.Int/News-Room/Fact-Sheets/Detail/Blood-Safety-and-Availability?

Yousuf, R., Akter, S., Wasek, S. M., Sinha, S., Ahmad, R., & Haque, M. (2022). Thalassemia: A Review of the Challenges to the Families and Caregivers. *Cureus*, *14*(12), 8–15. https://doi.org/10.7759/cureus.32491