Innovations in Blood Screening: Advancing Safety and Quality in Transfusion Medicine

Article *in* International Journal of Innovative and Applied Research · March 2024

DOI: 10.58538/IJIAR/2082

1 author:

Emmanuel Ifeanyi Obeagu
Kampala International University (KIU)
1,422 PUBLICATIONS **11,224** CITATIONS

SEE PROFILE

ISSN 2348-0319 International Journal of Innovative and Applied Research [2024]
(Volume 12, Issue 02)
64-71

Journal home page: http://www.journalijiar.com

INTERNATIONAL JOURNAL
OF INNOVATIVE AND APPLIED RESEARCH

REVIEW ARTICLE

Article DOI:10.58538/IJIAR/2082
DOI URL: *http://dx.doi.org/10.58538/IJIAR/2082*

Innovations in Blood Screening: Advancing Safety and Quality in Transfusion Medicine

Emmanuel Ifeanyi Obeagu

Department of Medical Laboratory Science, Kampala International University, Ishaka, Uganda.

Manuscript Info

Manuscript History
Received: 20 January 2024
Final Accepted: 24 February 2024
Published: February 2024

Keywords:
innovations, blood screening, safety, transfusion medicine

Abstract

This review explores the latest innovations in blood screening, focusing on advancements that have significantly contributed to advancing safety and quality in transfusion medicine. Blood screening plays a pivotal role in ensuring the safety of blood products and minimizing the risk of transfusion-transmissible infections. Over the years, transformative technologies and methodologies have emerged, revolutionizing traditional screening practices. Key innovations discussed in this review include Nucleic Acid Testing (NAT), multiplex testing, pathogen reduction technologies, Next-Generation Sequencing (NGS), enhanced serological assays, Point-of-Care Testing (POCT), and the integration of Artificial Intelligence (AI) and Machine Learning (ML). Each innovation is examined for its unique contributions to enhancing the precision, efficiency, and safety of blood screening processes.

Corresponding Author:-Emmanuel Ifeanyi Obeagu, *Department of Medical Laboratory Science, Kampala International University, Uganda.*

Introduction:-

Blood transfusion, a cornerstone of modern medicine, has been integral to patient care, surgeries, and emergency interventions. Ensuring the safety and quality of transfused blood is paramount to prevent the transmission of infectious agents and adverse reactions. The landscape of blood screening, designed to detect and eliminate potential risks in donated blood, has undergone

remarkable innovations, propelling transfusion medicine into an era marked by enhanced precision and efficiency. Over the years, the implementation of Nucleic Acid Testing (NAT) has revolutionized blood screening by enabling the direct detection of viral nucleic acids, significantly reducing the window period for infectious disease detection. This technology has become a cornerstone in transfusion safety, enhancing our ability to identify and mitigate the risk of transfusion-transmissible infections such as HIV, hepatitis B and C, and emerging pathogens. Multiplex testing, another frontier in blood screening, allows for the simultaneous detection of multiple pathogens in a single assay, providing a comprehensive overview of potential infectious threats and streamlining the screening process.[1-23]

In the quest for a safer blood supply, pathogen reduction technologies have emerged as powerful tools, capable of inactivating or removing a broad spectrum of pathogens present in blood components. These technologies, including ultraviolet (UV) light and chemical treatments, contribute to minimizing the risk of transfusion-transmitted infections, thus bolstering the safety profile of blood products. Next-Generation Sequencing (NGS), a revolutionary approach in genomics, offers high-throughput sequencing that enhances the accuracy and resolution of pathogen detection. By providing insights into the genetic makeup of potential threats, NGS plays a crucial role in identifying both known and emerging infectious agents. The integration of enhanced serological assays further refines the accuracy and sensitivity of blood screening, ensuring the reliable detection of antibodies and antigens associated with various infections. This complementarity with molecular techniques creates a robust screening framework that addresses a wide spectrum of potential risks. Additionally, the advent of Point-of-Care Testing (POCT) brings diagnostic capabilities closer to the patient, offering rapid and on-site screening opportunities that are particularly valuable in emergency situations and resource-limited settings. Furthermore, the infusion of Artificial Intelligence (AI) and Machine Learning (ML) into blood screening processes represents a paradigm shift. These technologies analyze vast datasets, identify patterns, and enhance the accuracy of screening results, contributing to the continuous improvement of transfusion safety.[24-43]

This review delves into the transformative innovations in blood screening, collectively shaping a new era in transfusion medicine. Each technological leap discussed here plays a pivotal role in advancing the precision, efficiency, and safety of blood screening practices.

Nucleic Acid Testing (NAT)

One of the most significant innovations in blood screening is the widespread adoption of Nucleic Acid Testing (NAT).[44] NAT allows for the direct detection of viral nucleic acids, such as RNA or DNA, offering unparalleled sensitivity in identifying infections even during the window period when conventional tests may yield false negatives. This technology has been instrumental in enhancing the safety of blood transfusions by reducing the risk of transmitting blood-borne pathogens, including HIV, hepatitis B and C, and emerging viruses.

Multiplex Testing

Multiplex testing represents a paradigm shift in blood screening by enabling the simultaneous detection of multiple pathogens in a single assay.[45] This innovation streamlines the screening

process, providing a comprehensive overview of potential infectious threats in a more efficient and cost-effective manner. Multiplex testing not only enhances the detection of known pathogens but also allows for the identification of emerging infectious agents, addressing the dynamic nature of infectious disease landscapes.

Pathogen Reduction Technologies

Pathogen reduction technologies are designed to inactivate or remove pathogens present in blood components, further bolstering transfusion safety. These technologies, including ultraviolet (UV) light and chemical treatments, target a broad spectrum of pathogens, including bacteria, viruses, and parasites. By mitigating the risk of transfusion-transmitted infections, pathogen reduction technologies contribute to the ongoing efforts to enhance the safety of the blood supply[46-50].

Next-Generation Sequencing (NGS)

Next-Generation Sequencing (NGS) has emerged as a powerful tool in blood screening, offering high-throughput sequencing of genetic material. NGS enables the identification of a wide range of pathogens with unprecedented accuracy and resolution. This technology is particularly valuable in detecting new or emerging infectious agents, providing a more comprehensive understanding of the transfusion-transmissible disease landscape.[51]

Serological Enhancements

In addition to molecular techniques, innovations in serological testing have refined the accuracy and efficiency of blood screening.[52] Enhanced serological assays with improved specificity and sensitivity contribute to the detection of antibodies and antigens associated with various infections. These advancements not only ensure the reliability of traditional blood screening methods but also complement molecular techniques for a more comprehensive screening approach.

Point-of-Care Testing (POCT)

The integration of Point-of-Care Testing (POCT) in blood screening represents a shift towards decentralized and rapid diagnostics.[53] POCT allows for on-site testing, facilitating timely decision-making in diverse healthcare settings, including remote or resource-limited environments. This innovation addresses the need for immediate results, especially in emergency situations, and contributes to the overall efficiency of blood screening processes.

Artificial Intelligence (AI) and Machine Learning (ML)

The application of Artificial Intelligence (AI) and Machine Learning (ML) in blood screening is a transformative development.[54] These technologies analyze vast datasets to identify patterns, predict outcomes, and enhance the accuracy of screening results. By learning from historical data, AI and ML algorithms contribute to the continuous improvement of blood screening processes, adapting to evolving infectious disease landscapes and ensuring proactive responses to potential threats.

Conclusion

Innovations in blood screening represent a dynamic field within transfusion medicine, continually advancing to meet the evolving challenges of ensuring the safety and quality of the blood supply. From the precision of Nucleic Acid Testing to the comprehensive insights provided by Next-Generation Sequencing, each innovation contributes to a more robust and proactive approach to transfusion-transmissible infection detection. As technology continues to progress, the integration of these innovations into routine blood screening practices will be essential for maintaining the highest standards of patient care and safeguarding the well-being of individuals receiving blood transfusions worldwide.

References

1. Barro L, Drew VJ, Poda GG, Tagny CT, El-Ekiaby M, Owusu-Ofori S, Burnouf T. Blood transfusion in sub-Saharan Africa: understanding the missing gap and responding to present and future challenges. Vox Sanguinis. 2018;113(8):726-736.
2. Goforth CW, Tranberg JW, Boyer P, Silvestri PJ. Fresh whole blood transfusion: military and civilian implications. Critical care nurse. 2016;36(3):50-57.
3. Basavarajegowda A, Pai DR, Nalini YC. Simulation in the field of transfusion medicine: Scope and utility. Asian Journal of Transfusion Science. 2023.
4. Obeagu EI, Obeagu GU, Obiezu J, Ezeonwumelu C, Ogunnaya FU, Ngwoke AO, Emeka-Obi OR, Ugwu OP. Hematologic Support in HIV Patients: Blood Transfusion Strategies and Immunological Considerations. Applied Sciences (NIJBAS). 2023;3(3).
5. Obeagu EI, Obeagu GU. Hematological Changes Following Blood Transfusion in Young Children with Severe Malaria and HIV: A Critical Review. Elite Journal of Laboratory Medicine. 2024;2(1):33-45.
6. Obeagu EI, Obeagu GU. Hematological Changes Following Blood Transfusion in Young Children with Severe Malaria and HIV: A Critical Review. Elite Journal of Laboratory Medicine. 2024;2(1):33-45.
7. Obeagu EI, Obeagu GU. The Role of Blood Transfusion Strategies in HIV Management: Current Insights and Future Directions. Elite Journal of Medicine. 2024;2(1):10-22.
8. Obeagu EI, Obeagu GU. Advances in Understanding the Impact of Blood Transfusion on Anemia Resolution in HIV-Positive Children with Severe Malaria: A Comprehensive Review. Elite Journal of Haematology. 2024;2(1):26-41.
9. Obeagu EI, Babar Q, Obeagu GU. Allergic blood Transfusion reaction: A Review. Int. J. Curr. Res. Med. Sci. 2021;7(5):25-33.
10. Obeagu EI, Ubosi NI, Uzoma G. Maternal Hemorrhage and Blood Transfusions: Safeguarding Pregnancy Health. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(11):26-35.
11. Obeagu EI, Obeagu GU. Transfusion-Related Complications in Children Under 5 with Coexisting HIV and Severe Malaria: A Review. Int. J. Curr. Res. Chem. Pharm. Sci. 2024;11(2):9-19.
12. Obeagu EI, Okwuanaso CB, Edoho SH, Obeagu GU. Under-nutrition among HIV-exposed Uninfected Children: A Review of African Perspective. Madonna University journal of Medicine and Health Sciences. 2022;2(3):120-127.
13. Obeagu EI, Alum EU, Obeagu GU. Factors associated with prevalence of HIV among youths: A review of Africa perspective. Madonna University journal of Medicine and

Health Sciences. 2023;3(1):13-18.https://madonnauniversity.edu.ng/journals/index.php/medicine/article/view/93.
14. Obeagu EI. A Review of Challenges and Coping Strategies Faced by HIV/AIDS Discordant Couples. Madonna University journal of Medicine and Health Sciences. 2023 ;3(1):7-12.https://madonnauniversity.edu.ng/journals/index.php/medicine/article/view/91.
15. Obeagu EI, Obeagu GU. An update on premalignant cervical lesions and cervical cancer screening services among HIV positive women. J Pub Health Nutri. 2023; 6 (2). 2023; 141:1-2.links/63e538ed64252375639dd0df/An-update-on-premalignant-cervical-lesions-and-cervical-cancer-screening-services-among-HIV-positive-women.pdf.
16. Ezeoru VC, Enweani IB, Ochiabuto O, Nwachukwu AC, Ogbonna US, Obeagu EI. Prevalence of Malaria with Anaemia and HIV status in women of reproductive age in Onitsha, Nigeria. Journal of Pharmaceutical Research International. 2021;33(4):10-19.
17. Omo-Emmanuel UK, Chinedum OK, Obeagu EI. Evaluation of laboratory logistics management information system in HIV/AIDS comprehensive health facilities in Bayelsa State, Nigeria. Int J Curr Res Med Sci. 2017;3(1): 21-38.DOI: 10.22192/ijcrms.2017.03.01.004
18. Obeagu EI, Obeagu GU, Musiimenta E, Bot YS, Hassan AO. Factors contributing to low utilization of HIV counseling and testing services. Int. J. Curr. Res. Med. Sci. 2023;9(2): 1-5.DOI: 10.22192/ijcrms.2023.09.02.001
19. Obeagu EI, Obeagu GU. An update on survival of people living with HIV in Nigeria. J Pub Health Nutri. 2022; 5 (6). 2022;129.links/645b4bfcf3512f1cc5885784/An-update-on-survival-of-people-living-with-HIV-in-Nigeria.pdf.
20. Offie DC, Obeagu EI, Akueshi C, Njab JE, Ekanem EE, Dike PN, Oguh DN. Facilitators and barriers to retention in HIV care among HIV infected MSM attending Community Health Center Yaba, Lagos Nigeria. Journal of Pharmaceutical Research International. 2021;33(52B):10-19.
21. Obeagu EI, Ogbonna US, Nwachukwu AC, Ochiabuto O, Enweani IB, Ezeoru VC. Prevalence of Malaria with Anaemia and HIV status in women of reproductive age in Onitsha, Nigeria. Journal of Pharmaceutical Research International. 2021;33(4):10-19.
22. Odo M, Ochei KC, Obeagu EI, Barinaadaa A, Eteng UE, Ikpeme M, Bassey JO, Paul AO. TB Infection Control in TB/HIV Settings in Cross River State, Nigeria: Policy Vs Practice. Journal of Pharmaceutical Research International. 2020;32(22):101-119.
23. Obeagu EI, Eze VU, Alaeboh EA, Ochei KC. Determination of haematocrit level and iron profile study among persons living with HIV in Umuahia, Abia State, Nigeria. J BioInnovation. 2016; 5:464-471.links/592bb4990f7e9b9979a975cf/DETERMINATION-OF-HAEMATOCRIT-LEVEL-AND-IRON-PROFILE-STUDY-AMONG-PERSONS-LIVING-WITH-HIV-IN-UMUAHIA-ABIA-STATE-NIGERIA.pdf.
24. ObeaguEI AA, Obeagu GU. Synergistic Effects of Blood Transfusion and HIV in Children Under 5 Years with Severe Malaria: A Review. Elite Journal of HIV. 2024;2(1):31-50.
25. Obeagu EI, Anyiam AF, Obeagu GU. Managing Anemia in HIV through Blood Transfusions: Clinical Considerations and Innovations. Elite Journal of HIV. 2024;2(1):16-30.
26. Obeagu EI, Obeagu GU. Transfusion Therapy in HIV: Risk Mitigation and Benefits for Improved Patient Outcomes. Sciences. 2024;4(1):32-37.

27. Obeagu EI, Obeagu GU, Obiezu J, Ezeonwumelu C, Ogunnaya FU, Ngwoke AO, Ugwu OP. Immunomodulatory Effects of Transfusions on Maternal Immunity in Pregnancy. Applied Sciences (NIJBAS). 2023;3(3).
28. Obeagu EI, Babar Q, Uduchi IO, Ibekwe AM, Chijioke UO, Okafor CJ, Vincent CC. An Update on Transfusion Related Immunomodulation (TRIM) in a Time of COVID-19 Pandemic. Journal of Pharmaceutical Research International. 2021 Aug 27;33(42A):135-146.
29. Okoroiwu IL, Obeagu EI, Elemchukwu Q, Ochei KC, Christian GS. Frequency of Transfusion Reactions Following Compatible Cross Matching of Blood: A Study in Owerri Metropolis. International Journal of Current Research and Academic Review. 2015;3(1):155-160.
30. Obeagu EI, Oshim IO, Ochei KC, Obeagu GU. Iron and blood donation: A Review. Int. J. Curr. Res. Med. Sci. 2016;2(10):16-48.
31. Ogar CO, Okoroiwu HU, Obeagu EI, Etura JE, Abunimye DA. Assessment of blood supply and usage pre-and during COVID-19 pandemic: a lesson from non-voluntary donation. Transfusion Clinique et Biologique. 2021;28(1):68-72.
32. Anyiam AF, Arinze-Anyiam OC, Irondi EA, Obeagu EI. Distribution of ABO and rhesus blood grouping with HIV infection among blood donors in Ekiti State Nigeria. Medicine. 2023;102(47): e36342.
33. Obeagu EI. Blood Transfusion: A Powerful Process of Saving Anaemic Patients. EC Emergency Medicine and Critical Care. 2020;4(7):33-40.
34. Obeagu EI, Buhari HA. Implications of Blood Transfusion in Renal Disease Patients. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(10):45-49.
35. Anyiam AF, Arinze-Anyiam OC, Omosigho PO, Ibrahim M, Irondi EA, Obeagu EI, Obi E. Blood Group, Genotype, Malaria, Blood Pressure and Blood Glucose Screening Among Selected Adults of a Community in Kwara State: Implications to Public Health. Asian Hematology Research Journal. 2022;6(3):9-17.
36. Obeagu EI, Obeagu GU, Ukibe NR, Oyebadejo SA. Anemia, iron, and HIV: decoding the interconnected pathways: A review. Medicine. 2024;103(2): e36937.
37. Obeagu EI. An update on susceptibility of individuals to diseases based on ABO blood groups. Int. J. Curr. Res. Med. Sci. 2019;5(3):1-8.
38. Eze R, Obeagu EI, Nwakulite A, Vincent CC, Ogbodo SO, Ibekwe AM, Okafor CJ, Chukwurah EF. Frequency of Haemoglobin Genotype Variants, ABO and Rh 'D'Antigen among Madonna Undergraduates of South East Origin, Nigeria. Journal of Pharmaceutical Research International. 2021 May 26;33(29B):149-57.
39. Ifeanyi OE, Obeagu GU. The values of prothrombin time among HIV positive patients in FMC owerri. International Journal of Current Microbiology and Applied Sciences. 2015;4(4):911-916.https://www.academia.edu/download/38320140/Obeagu_Emmanuel_Ifeanyi_and_Obeagu__Getrude_Uzoma2.EMMA1.pdf.
40. Izuchukwu IF, Ozims SJ, Agu GC, Obeagu EI, Onu I, Amah H, Nwosu DC, Nwanjo HU, Edward A, Arunsi MO. Knowledge of preventive measures and management of HIV/AIDS victims among parents in Umuna Orlu community of Imo state Nigeria. Int. J. Adv. Res. Biol. Sci. 2016;3(10): 55-65.DOI; 10.22192/ijarbs.2016.03.10.009
41. Chinedu K, Takim AE, Obeagu EI, Chinazor UD, Eloghosa O, Ojong OE, Odunze U. HIV and TB co-infection among patients who used Directly Observed Treatment Short-

course centres in Yenagoa, Nigeria. IOSR J Pharm Biol Sci. 2017;12(4):70-75.links/5988ab6d0f7e9b6c8539f73d/HIV-and-TB-co-infection-among-patients-who-used-Directly-Observed-Treatment-Short-course-centres-in-Yenagoa-Nigeria.pdf

42. Oloro OH, Oke TO, Obeagu EI. Evaluation of Coagulation Profile Patients with Pulmonary Tuberculosis and Human Immunodeficiency Virus in Owo, Ondo State, Nigeria. Madonna University journal of Medicine and Health Sciences. 2022;2(3):110-119.
43. Nwosu DC, Obeagu EI, Nkwocha BC, Nwanna CA, Nwanjo HU, Amadike JN, Elendu HN, Ofoedeme CN, Ozims SJ, Nwankpa P. Change in Lipid Peroxidation Marker (MDA) and Non enzymatic Antioxidants (VIT C & E) in HIV Seropositive Children in an Urban Community of Abia State. Nigeria. J. Bio. Innov. 2016;5(1):24-30.links/5ae735e9a6fdcc5b33eb8d6a/CHANGE-IN-LIPID-PEROXIDATION-MARKER-MDAAND-NON-ENZYMATIC-ANTIOXIDANTS-VIT-C-E-IN-HIV-SEROPOSITIVE-CHILDREN-IN-AN-URBAN-COMMUNITY-OF-ABIA-STATE-NIGERIA.pdf.
44. Li Z, Bai Y, You M, Hu J, Yao C, Cao L, Xu F. Fully integrated microfluidic devices for qualitative, quantitative and digital nucleic acids testing at point of care. Biosensors and Bioelectronics. 2021; 177:112952.
45. Kim H, Chung DR, Kang M. A new point-of-care test for the diagnosis of infectious diseases based on multiplex lateral flow immunoassays. Analyst. 2019;144(8):2460-2466.
46. Cardoso M, Ragan I, Hartson L, Goodrich RP. Emerging Pathogen Threats in Transfusion Medicine: Improving Safety and Confidence with Pathogen Reduction Technologies. Pathogens. 2023;12(7):911.
47. Okoroiwu IL, Obeagu EI, Christian SG, Elemchukwu Q, Ochei KC. Determination of the haemoglobin, genotype and ABO blood group pattern of some students of Imo State University, Owerri, Nigeria. International Journal of Current Research and Academic Review. 2015;3(1):20-27.
48. Oloro OH, Obeagu EI, Puche RO, Lawal OA. Blood Products in Blood Banking: Preparation and Clinical Importance. Madonna University journal of Medicine and Health Sciences ISSN: 2814-3035. 2022;2(3):102-109.
49. Asemota EA, Njar VE, Aguanah IT, Obeagu EI. Distribution of ABO, Rhesus Blood Group and Helicobacter Pylori Infection among Secondary School Students in Calabar South Local Government, Cross River State, Nigeria. Madonna University journal of Medicine and Health Sciences. 2023;3(1):32-45.
50. Obeagu EI, Katya MC. A Systematic Review on Physiological Jaundice: Diagnosis and Management of the Affected Neonates. Madonna University journal of Medicine and Health Sciences. 2022;2(3):25-41.
51. Kumar KR, Cowley MJ, Davis RL. Next-generation sequencing and emerging technologies. InSeminars in thrombosis and hemostasis 2019; 45(07): 661-673.
52. Teles FS. Biosensors and rapid diagnostic tests on the frontier between analytical and clinical chemistry for biomolecular diagnosis of dengue disease: A review. Analytica chimica acta. 2011;687(1):28-42.
53. Heidt B, Siqueira WF, Eersels K, Diliën H, van Grinsven B, Fujiwara RT, Cleij TJ. Point of care diagnostics in resource-limited settings: A review of the present and future of PoC in its most needed environment. Biosensors. 2020;10(10):133.

54. Zhang Z, Bowes B. The future of artificial intelligence (AI) and machine learning (ML) in landscape design: A case study in Coastal Virginia, USA. arXiv preprint arXiv:2305.02327. 2023.