Optimizing Maternal Health: Addressing Hemolysis in Pregnant Women with Sickle Cell Anemia

Article · January 2024

DOI: 10.58538/IJIAR/2072

3 authors:

Emmanuel Ifeanyi Obeagu
Kampala International University (KIU)
1,290 PUBLICATIONS **7,594** CITATIONS
SEE PROFILE

Getrude Uzoma Obeagu
Kampala International University (KIU)
299 PUBLICATIONS **2,034** CITATIONS
SEE PROFILE

Buhari Ali Hauwa
Usmanu Danfodiyo University Sokoto
69 PUBLICATIONS **152** CITATIONS
SEE PROFILE

ISSN 2348-0319 International Journal of Innovative and Applied Research [2024]
(Volume 12, Issue 01)
50-61

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

INTERNATIONAL JOURNAL
OF INNOVATIVE AND APPLIED RESEARCH

RESEARCH ARTICLE

Article DOI:10.58538/IJIAR/2072
DOI URL: *http://dx.doi.org/10.58538/IJIAR/2072*

Optimizing Maternal Health: Addressing Hemolysis in Pregnant Women with Sickle Cell Anemia

*Emmanuel Ifeanyi Obeagu[1] and Getrude Uzoma Obeagu[2] and Hauwa Ali Buhari[3]

[1]Department of Medical Laboratory Science, Kampala International University, Uganda.
[2]School of Nursing Science, Kampala International University, Uganda.
[3]Department of Haematology, School of Medical Laboratory Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria.

Manuscript Info

Manuscript History
Received: 29 November 2023
Final Accepted: 12 January 2024
Published: January 2024

Keywords:
Sickle Cell Anemia, Pregnancy, Hemolysis, Maternal Health, Complications, Management, Fetal Health, Red Blood Cell Disorders, Hemoglobinopathies

Abstract

Pregnancy in women with sickle cell anemia presents a unique clinical scenario, entailing intricate management strategies due to the inherent challenges posed by hemolysis and vaso-occlusive events. The convergence of the pathophysiological complexities of sickle cell anemia and the physiological changes during gestation underscores the significance of addressing hemolysis in pregnant individuals with this hemoglobinopathy. This paper synthesizes current understanding and clinical perspectives on the impact of hemolysis in pregnant women with sickle cell anemia, exploring its implications on maternal health, fetal well-being, and strategies for optimized care. Emphasis is placed on elucidating the underlying mechanisms, delineating maternal and fetal complications, and outlining current management approaches. Furthermore, this review highlights emerging interventions and future directions aimed at improving maternal and fetal outcomes in this challenging clinical scenario. By comprehensively addressing the intricacies of hemolysis in pregnant women with sickle cell anemia, this review aims to provide insights that guide clinicians and researchers toward enhancing care and ensuring better maternal-fetal health in this vulnerable population.

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

Introduction

Sickle cell anemia (SCA) represents a prevalent hemoglobinopathy characterized by the presence of abnormal hemoglobin, leading to chronic hemolysis and vaso-occlusive events. The coalescence of SCA with the physiological demands of pregnancy creates a complex clinical landscape, presenting formidable challenges for both expectant mothers and healthcare providers. The intricate interplay between the underlying hemolytic disorder and the hemodynamic changes of gestation accentuates the risk of maternal complications and adverse fetal outcomes [1-22].

Pregnancy induces profound alterations in the circulatory, hematological, and immunological systems to meet the metabolic demands of the developing fetus. However, in women with SCA, these adaptations are intricately intertwined with the inherent hemolytic process, elevating the risk of complications such as vaso-occlusive crises, anemia, thrombotic events, and end-organ damage. Moreover, the placental microenvironment in SCA is predisposed to impaired oxygen delivery, fostering a milieu conducive to adverse fetal outcomes [23-42]. Understanding the nuanced pathophysiology of hemolysis in pregnant women with SCA is pivotal for tailored management strategies aimed at optimizing maternal health while safeguarding fetal well-being. This comprehensive review aims to delineate the intricacies of managing hemolysis during pregnancy in the context of SCA. By exploring the impact of hemolysis on maternal health, the implications for fetal development, and the current clinical approaches, this review seeks to provide insights into optimizing care for this vulnerable population [43-52].

The paper delves into the pathophysiological mechanisms, maternal complications associated with hemolysis, considerations for fetal health, current clinical management strategies, and the potential for novel interventions. Additionally, it explores emerging research directions and innovative approaches aimed at enhancing the care continuum for pregnant women grappling with the challenges of hemolysis in the backdrop of SCA. Ultimately, this paper aims to consolidate existing knowledge, highlight clinical nuances, and identify avenues for future research to improve the management and outcomes of pregnant women navigating the complexities of hemolysis in the context of SCA.

Pathophysiology of Hemolysis in Sickle Cell Anemia During Pregnancy

Pregnancy induces a myriad of physiological changes that profoundly impact women with sickle cell anemia (SCA), adding complexity to the underlying hemolytic condition. Understanding the interplay between pregnancy-induced adaptations and the pathophysiology of SCA is crucial in elucidating the mechanisms exacerbating hemolysis during gestation [53-63]. The hypercoagulable state of pregnancy, characterized by increased plasma volume, hormonal alterations, and enhanced coagulation factors, accentuates the risk of vaso-occlusive crises and

thrombotic events in women with SCA. These changes heighten the potential for microvascular occlusion, exacerbating tissue ischemia and precipitating hemolysis by causing red blood cell (RBC) fragmentation [64-74].

Furthermore, the hemodynamic alterations in pregnancy, including increased cardiac output and peripheral vasodilation, may contribute to hemolysis by inducing sheer stress on fragile sickled RBCs as they traverse through narrowed vessels. The resultant mechanical stress on RBCs promotes their rupture and accelerates the release of free hemoglobin, perpetuating the cycle of hemolysis [75-82]. Vaso-occlusive crises, hallmark events in SCA, exert profound implications on placental perfusion and oxygenation [83]. These events compromise the placental microcirculation, leading to ischemia-reperfusion injury and impairing oxygen exchange, thereby predisposing the fetus to chronic hypoxia. The chronicity of hypoxia in the placenta fosters an unfavorable intrauterine environment, contributing to fetal growth restriction and adverse pregnancy outcomes [84-89].

Maternal Complications Associated with Hemolysis in Pregnancy

Hemolysis in pregnant women with sickle cell anemia (SCA) precipitates a spectrum of maternal complications, significantly impacting maternal health and posing considerable challenges for obstetric care [90-93]. Chronic hemolysis exacerbates anemia in women with SCA during pregnancy, intensifying the physiological burden. The increased demand for oxygen delivery to the fetus strains the already-compromised oxygen-carrying capacity of the blood, culminating in maternal fatigue, dyspnea, and susceptibility to cardiac decompensation. Severe anemia may necessitate transfusion therapy to mitigate hemolytic stress and optimize oxygen delivery [93]. Moreover, the chronic anemic state in SCA exacerbates the risk of cardiovascular complications, including heart failure and pulmonary hypertension, further amplifying the challenges in managing maternal hemodynamics during gestation.

The prothrombotic state of pregnancy, coupled with the underlying hemolytic disorder in SCA, accentuates the risk of thrombotic complications such as deep vein thrombosis and pulmonary embolism. Endothelial dysfunction, secondary to hemolysis and vaso-occlusive crises, predisposes pregnant women with SCA to venous thromboembolism, necessitating vigilant monitoring and thromboprophylaxis strategies. Hemolysis-mediated vaso-occlusive events contribute to renal microcirculatory impairment, exacerbating renal dysfunction and increasing the risk of acute kidney injury in pregnant women with SCA [94]. Additionally, the propensity for hypertension-related complications, including preeclampsia and eclampsia, is heightened in SCA due to endothelial dysfunction, exacerbating the maternal-fetal risks. These maternal complications underscore the multifaceted impact of hemolysis in pregnant women with SCA, necessitating meticulous monitoring, multidisciplinary management, and tailored interventions to mitigate the risks and optimize maternal outcomes during gestation.

Fetal and Neonatal Considerations in Maternal Sickle Cell Anemia

Maternal sickle cell anemia (SCA) significantly impacts fetal and neonatal health, posing a myriad of challenges throughout gestation and during the perinatal period. Chronic hemolysis and vaso-occlusive events in maternal SCA contribute to an adverse intrauterine environment,

predisposing the fetus to growth restriction and impaired development [95]. The compromised placental perfusion resulting from vaso-occlusive crises limits oxygen and nutrient delivery to the fetus, potentially leading to intrauterine growth restriction (IUGR) and associated developmental complications. Additionally, the increased risk of maternal complications, such as preeclampsia and placental insufficiency, further exacerbates the risk of adverse fetal outcomes, including preterm birth and low birth weight.

Neonates born to mothers with SCA are at heightened risk for complications, including preterm delivery, intrauterine asphyxia, and neonatal intensive care unit (NICU) admissions [96]. Moreover, the risk of neonatal complications such as respiratory distress syndrome and neonatal anemia is amplified in this population, warranting close monitoring and supportive care postnatally. Early identification of neonates affected by sickle cell disease (SCD) or carrying the sickle cell trait is crucial. Neonatal screening for hemoglobinopathies enables timely initiation of interventions and comprehensive follow-up care for affected infants, offering opportunities for early disease management and preventive measures.

Clinical Management Strategies for Optimizing Maternal Health

The management of pregnant women with sickle cell anemia (SCA) necessitates a comprehensive and multidisciplinary approach to mitigate complications, optimize maternal health, and improve pregnancy outcomes. Preconception counseling plays a pivotal role in managing pregnancies in women with SCA. Comprehensive counseling sessions should focus on genetic counseling, optimizing maternal health before conception, and discussing potential risks and management strategies during pregnancy. Multidisciplinary care involving hematologists, obstetricians, genetic counselors, and other specialists facilitates individualized care plans, ensuring close monitoring and timely interventions throughout gestation. Regular monitoring of hemolytic parameters, including hemoglobin levels, reticulocyte count, bilirubin levels, and lactate dehydrogenase (LDH), is imperative in assessing the severity of hemolysis and guiding therapeutic interventions. Timely transfusion therapy or hydroxyurea administration may be considered to mitigate hemolytic stress and optimize hemoglobin levels, aiming to prevent complications associated with chronic anemia. Pharmacological interventions, such as hydroxyurea, may be employed in selected cases to minimize vaso-occlusive events and reduce the frequency of painful crises. Transfusion therapy, particularly in cases of severe anemia or acute complications, serves to augment oxygen delivery, ameliorate symptoms, and prevent maternal and fetal complications [96]. Additionally, prophylactic measures, including anticoagulation for thromboprophylaxis and early initiation of folic acid supplementation, are essential components of the management plan to mitigate the risks of thrombotic events and prevent neural tube defects in the fetus. Comprehensive management strategies in maternal SCA during pregnancy necessitate a personalized approach, integrating close monitoring, timely interventions, and proactive management of complications. Moreover, patient education and support systems play a pivotal role in ensuring adherence to treatment regimens, optimizing maternal health, and fostering positive pregnancy outcomes.

Novel Approaches and Future Directions

Advancements in medical research and technological innovations offer promising avenues for improving the care and outcomes of pregnant women grappling with sickle cell anemia (SCA). The advent of genetic therapies, including gene editing techniques like CRISPR/Cas9, holds promise for correcting the genetic defects underlying SCA. Although primarily investigational, ongoing research in this field may offer potential curative options for affected individuals, potentially mitigating the risk of SCA-related complications in future pregnancies. In fetal medicine, advancements in non-invasive prenatal testing (NIPT) and in-utero interventions present opportunities for early identification of fetal hemoglobinopathies and potential interventions aimed at improving intrauterine outcomes in affected pregnancies. Invasive procedures, such as fetal blood sampling or intrauterine transfusions, may be considered in select cases to manage severe fetal anemia or complications arising from SCA.

Telemedicine and remote monitoring platforms present an innovative approach to healthcare delivery, especially in the context of managing chronic conditions like SCA during pregnancy. These modalities facilitate regular follow-ups, enable real-time monitoring of vital parameters, and provide timely consultations with healthcare providers, thereby improving access to specialized care and optimizing pregnancy management in geographically remote or underserved areas. Emphasizing patient-centered care and establishing robust support systems are integral components of managing SCA during pregnancy. Patient education, peer support groups, and access to resources aimed at enhancing self-management skills empower individuals to actively engage in their care, leading to better adherence to treatment regimens and improved health outcomes. Continued research efforts, coupled with technological innovations and patient-centric care models, hold the potential to revolutionize the landscape of managing SCA during pregnancy. Collaborative endeavors between clinicians, researchers, and patient advocacy groups are essential in translating these advancements into clinical practice, ultimately paving the way for improved outcomes and better quality of life for pregnant women with SCA.

Conclusion

The management of pregnancy in women with sickle cell anemia (SCA) represents a complex clinical scenario, necessitating a multifaceted approach to mitigate the complications associated with hemolysis and vaso-occlusive events. Moreover, the impact of hemolysis in SCA extends beyond maternal complications, significantly influencing fetal growth, intrauterine complications, and neonatal outcomes. The increased risk of intrauterine growth restriction, preterm birth, and neonatal complications emphasizes the importance of proactive monitoring and early interventions to safeguard fetal and neonatal well-being.

As advancements in genetic therapies, fetal medicine, and telemedicine continue to evolve, collaborative efforts between healthcare providers, researchers, and patient advocacy groups are pivotal in translating these innovations into clinical practice. Empowering individuals with SCA through education, support systems, and enhanced access to care is fundamental in improving adherence to treatment regimens and fostering positive pregnancy outcomes. While managing pregnancy in women with SCA poses multifaceted challenges, a holistic and patient-centric approach, integrating advancements in medical research and innovative care models, holds promise for optimizing maternal health, improving fetal outcomes, and enhancing the overall quality of care in this vulnerable population.

References

1. Obeagu EI, Ochei KC, Nwachukwu BN, Nchuma BO. Sickle cell anaemia: a review. Scholars Journal of Applied Medical Sciences. 2015;3(6B):2244-52.
2. Obeagu EI. Erythropoeitin in Sickle Cell Anaemia: A Review. International Journal of Research Studies in Medical and Health Sciences. 2020;5(2):22-8.
3. Obeagu EI. Sickle Cell Anaemia: Haemolysis and Anemia. Int. J. Curr. Res. Chem. Pharm. Sci. 2018;5(10):20-1.
4. Obeagu EI, Muhimbura E, Kagenderezo BP, Uwakwe OS, Nakyeyune S, Obeagu GU. An Update on Interferon Gamma and C Reactive Proteins in Sickle Cell Anaemia Crisis. J Biomed Sci. 2022;11(10):84.
5. Obeagu EI, Bunu UO, Obeagu GU, Habimana JB. Antioxidants in the management of sickle cell anaemia: an area to be exploited for the wellbeing of the patients. International Research in Medical and Health Sciences. 2023 Sep 11;6(4):12-7.
6. Obeagu EI, Ogunnaya FU, Obeagu GU, Ndidi AC. Sickle cell anaemia: a gestational enigma. European Journal of Biomedical and Pharmaceutical Sciences. 2023;10((9): 72-75
7. Obeagu EI. An update on micro RNA in sickle cell disease. Int J Adv Res Biol Sci. 2018;5:157-8.
8. Obeagu EI, Babar Q. Covid-19 and Sickle Cell Anemia: Susceptibility and Severity. J. Clinical and Laboratory Research. 2021;3(5):2768-0487.
9. Obeagu EI, Obeagu GU, Igwe MC, Alum EU, Ugwu OP. Men's Essential roles in the Management of Sickle Cell Anemia. **NEWPORT INTERNATIONAL JOURNAL OF SCIENTIFIC AND EXPERIMENTAL SCIENCES 4(2):20-29**.https://doi.org/10.59298/NIJSES/2023/10.3.1111
10. Obeagu EI. Depression in Sickle Cell Anemia: An Overlooked Battle. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(10):41-.
11. Obeagu EI, Obeagu GU. Evaluation of Hematological Parameters of Sickle Cell Anemia Patients with Osteomyelitis in A Tertiary Hospital in Enugu, Nigeria. Journal of Clinical and Laboratory Research.2023;6(1):2768-0487.
12. Obeagu EI, Dahir FS, Francisca U, Vandu C, Obeagu GU. Hyperthyroidism in sickle cell anaemia. Int. J. Adv. Res. Biol. Sci. 2023;10(3):81-9.
13. Obeagu EI, Obeagu GU, Akinleye CA, Igwe MC. Nosocomial infections in sickle cell anemia patients: Prevention through multi-disciplinary approach: A review. Medicine. 2023 Dec 1;102(48):e36462.
14. Njar VE, Ogunnaya FU, Obeagu EI. Knowledge And Prevalence of The Sickle Cell Trait Among Undergraduate Students Of The University Of Calabar. Prevalence.;5(100):0-5.
15. Swem CA, Ukaejiofo EO, Obeagu EI, Eluke B. Expression of micro RNA 144 in sickle cell disease. Int. J. Curr. Res. Med. Sci. 2018;4(3):26-32.
16. Obeagu EI, Nimo OM, Bunu UO, Ugwu OP, Alum EU. Anaemia in children under five years: African perspectives. Int. J. Curr. Res. Biol. Med. 2023;1:1-7.
17. Obeagu EI. Sickle cell anaemia: Historical perspective, Pathophysiology and Clinical manifestations. Int. J. Curr. Res. Chem. Pharm. Sci. 2018;5(11):13-5.
18. Obeagu EI, Obeagu GU. Sickle Cell Anaemia in Pregnancy: A Review. International Research in Medical and Health Sciences. 2023 Jun 10;6(2):10-3.

19. Obeagu EI, Mohamod AH. An update on Iron deficiency anaemia among children with congenital heart disease. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(4):45-8.
20. Edward U, Osuorji VC, Nnodim J, Obeagu EI. Evaluationof Trace Elements in Sickle Cell Anaemia Patients Attending Imo State Specialist Hospital, Owerri. Madonna University journal of Medicine and Health Sciences ISSN: 2814-3035. 2022 Mar 4;2(1):218-34.
21. Umar MI, Aliyu F, Abdullahi MI, Aliyu MN, Isyaku I, Aisha BB, Sadiq RU, Shariff MI, Obeagu EI. Assessment Of Factors Precipitating Sickle Cell Crises Among Under 5-Years Children Attending Sickle Cell Clinic Of Murtala Muhammad Specialist Hospital, Kano. blood.;11:16.
22. Obeagu EI. Vaso-occlusion and adhesion molecules in sickle cells disease. Int J Curr Res Med Sci. 2018;4(11):33-5.
23. Obeagu EI, Agreen FC. Anaemia among pregnant women: A review of African pregnant teenagers. J Pub Health Nutri. 2023; 6 (1). 2023;138.links/63da799664fc860638054562/Anaemia-among-pregnant-women-A-review-of-African-pregnant-teenagers.pdf.
24. Obeagu EI, Ezimah AC, Obeagu GU. Erythropoietin in the anaemias of pregnancy: a review. Int J Curr Res Chem Pharm Sci. 2016;3(3):10-8.links/5710fae108ae846f4ef05afb/ERYTHROPOIETIN-IN-THE-ANAEMIAS-OF-PREGNANCY-A-REVIEW.pdf.
25. Obeagu EI, Adepoju OJ, Okafor CJ, Obeagu GU, Ibekwe AM, Okpala PU, Agu CC. Assessment of Haematological Changes in Pregnant Women of Ido, Ondo State, Nigeria. J Res Med Dent Sci. 2021 Apr;9(4):145-8.links/608a6728a6fdccaebdf52d94/Assessment-of-Haematological-Changes-in-Pregnant-Women-of-Ido-Ondo.pdf.
26. Obeagu EI, Obeagu GU. Sickle Cell Anaemia in Pregnancy: A Review. International Research in Medical and Health Sciences. 2023 Jun 10;6(2):10-3.http://irmhs.com/index.php/irmhs/article/view/111.
27. Jakheng SP, Obeagu EI. Seroprevalence of human immunodeficiency virus based on demographic and risk factors among pregnant women attending clinics in Zaria Metropolis, Nigeria. J Pub Health Nutri. 2022; 5 (8). 2022;137.links/6317a6b1acd814437f0ad268/Seroprevalence-of-human-immunodeficiency-virus-based-on-demographic-and-risk-factors-among-pregnant-women-attending-clinics-in-Zaria-Metropolis-Nigeria.pdf.
28. Obeagu EI, Obeagu GU, Chukwueze CM, Ikpenwa JN, Ramos GF. Evaluation of Protein C, Protein S and Fibrinogen of Pregnant Women with Malaria in Owerri Metropolis. Madonna University journal of Medicine and Health Sciences ISSN: 2814-3035. 2022 Apr 19;2(2):1-9.
29. Obeagu EI, Ikpenwa JN, Chukwueze CM, Obeagu GU. Evaluation of protein C, protein S and fibrinogen of pregnant women in Owerri Metropolis. Madonna University Journal of Medicine and Health Sciences ISSN: 2814-3035. 2022 Apr 18;2(1):292-8.https://madonnauniversity.edu.ng/journals/index.php/medicine/article/view/57.
30. Obeagu EI, Obeagu GU, Adepoju OJ. Evaluation of haematological parameters of pregnant women based on age groups in Olorunsogo road area of Ido, Ondo state. J. Bio. Innov11 (3). 2022:936-41.

31. Obeagu EI. An update on utilization of antenatal care among pregnant Women in Nigeria. Int. J. Curr. Res. Chem. Pharm. Sci. 2022;9(9):21-6.DOI: 10.22192/ijcrcps.2022.09.09.003
32. Okoroiwu IL, Obeagu EI, Obeagu GU. Determination of clot retraction in preganant women attending antenatal clinic in federal medical centre Owerri, Nigeria. Madonna University Journal of Medicine and Health Sciences ISSN: 2814-3035. 2022 Jul 22;2(2):91-7.https://madonnauniversity.edu.ng/journals/index.php/medicine/article/view/67.
33. Obeagu EI, Hassan AO, Adepoju OJ, Obeagu GU, Okafor CJ. Evaluation of Changes in Haematological Parameters of Pregnant Women Based on Gestational Age at Olorunsogo Road Area of Ido, Ondo State. Nigeria. Journal of Research in Medical and Dental Science. 2021;9(12):462-.links/61b1e32f0c4bfb675178bfa7/Evaluation-of-Changes-in-Haematological-Parameters-of-Pregnant-Women-Based-on-Gestational-Age-at-Olorunsogo-Road-Area-of-Ido-Ondo-State-Nigeria.pdf.
34. Anyiam AF, Obeagu EI, Obi E, Omosigho PO, Irondi EA, Arinze-Anyiam OC, Asiyah MK. ABO blood groups and gestational diabetes among pregnant women attending University of Ilorin Teaching Hospital, Kwara State, Nigeria. International Journal of Research and Reports in Hematology. 2022 Jun 21;5(2):113-21.
35. Obeagu EI. Gestational Thrombocytopaenia. J Gynecol Women's Health. 2023;25(3):556163.links/64b01aa88de7ed28ba95fccb/Gestational-Thrombocytopaenia.pdf.
36. Jakheng SP, Obeagu EI, Abdullahi IO, Jakheng EW, Chukwueze CM, Eze GC, Essien UC, Madekwe CC, Madekwe CC, Vidya S, Kumar S. Distribution Rate of Chlamydial Infection According to Demographic Factors among Pregnant Women Attending Clinics in Zaria Metropolis, Kaduna State, Nigeria. South Asian Journal of Research in Microbiology. 2022 Aug 9;13(2):26-31.
37. 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 Feb 23;33(4):10-9.
38. Ifeanyi OE, Stella EI, Favour AA. Antioxidants In The Management of Sickle Cell Anaemia. Int J Hematol Blood Disord (Internet) 2018 (cited 2021 Mar 4); 3. Available from: https://symbiosisonlinepublishing. com/hematology/hema tology25. php. 2018 Sep.
39. Buhari HA, Ahmad AS, Obeagu EI. Current Advances in the Diagnosis and Treatment of Sickle Cell Anaemia. APPLIED SCIENCES (NIJBAS). 2023;4(1).
40. Nnodim J, Uche U, Ifeoma U, Chidozie N, Ifeanyi O, Oluchi AA. Hepcidin and erythropoietin level in sickle cell disease. British Journal of Medicine and Medical Research. 2015;8(3):261-5.
41. Obeagu EI. BURDEN OF CHRONIC OSTEOMYLITIS: REVIEW OF ASSOCIATIED FACTORS. Madonna University journal of Medicine and Health Sciences ISSN: 2814-3035. 2023;3(1):1-6.
42. Aloh GS, Obeagu EI, Okoroiwu IL, Odo CE, Chibunna OM, Kanu SN, Elemchukwu Q, Okpara KE, Ugwu GU. Antioxidant-Mediated Heinz Bodies Levels of Sickle Erythrocytes under Drug-Induced Oxidative Stress. European Journal of Biomedical and Pharmaceutical sciences. 2015;2(1):502-7.

43. Obeagu EI, Malot S, Obeagu GU, Ugwu OP. HIV resistance in patients with Sickle Cell Anaemia. Newport International Journal of Scientific and Experimental Sciences (NIJSES). 2023;3(2):56-9.
44. Obeagu EI, Bot YS, Opoku D, Obeagu GU, Hassan AO. Sickle Cell Anaemia: Current Burden in Africa. International Journal of Innovative and Applied Research. 2023;11(2):12-4.
45. Obeagu EI, Obeagu GU. Sickle Cell Anaemia in Pregnancy: A Review. International Research in Medical and Health Sciences. 2023 Jun 10; 6 (2): 10-3.
46. Obeagu EI, Ogbuabor BN, Ikechukwu OA, Chude CN. Haematological parameters among sickle cell anemia patients' state and haemoglobin genotype AA individuals at Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. International Journal of Current Microbiology and Applied Sciences. 2014;3(3):1000-5.
47. Ifeanyi OE, Nwakaego OB, Angela IO, Nwakaego CC. Haematological parameters among sickle cell anaemia... Emmanuel Ifeanyi1, et al. pdf• Obeagu. Int. J. Curr. Microbiol. App. Sci. 2014;3(3):1000-5.
48. Obeagu EI, Abdirahman BF, Bunu UO, Obeagu GU. Obsterics characteristics that effect the newborn outcomes. Int. J. Adv. Res. Biol. Sci. 2023;10(3):134-43.
49. Obeagu EI, Opoku D, Obeagu GU. Burden of nutritional anaemia in Africa: A Review. Int. J. Adv. Res. Biol. Sci. 2023;10(2):160-3.
50. Ifeanyi E. Erythropoietin (Epo) Level in Sickle Cell Anaemia (HbSS) With Falciparum Malaria Infection in University Health Services, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. PARIPEX - INDIAN JOURNAL OF RESEARCH, 2015; 4(6): 258-259
51. Ifeanyi OE, Nwakaego OB, Angela IO, Nwakaego CC. Haematological parameters among sickle cell anaemia patients in steady state and haemoglobin genotype AA individuals at Michael Okpara, University of Agriculture, Umudike, Abia State, Nigeria. Int. J. Curr. Microbiol. App. Sci. 2014;3(3):1000-5.
52. Ifeanyi OE, Stanley MC, Nwakaego OB. Comparative analysis of some haematological parameters in sickle cell patients in steady and crisis state at michaelokpara University of agriculture, Umudike, Abia state, Nigeria. Int. J. Curr. Microbiol. App. Sci. 2014;3(3):1046-50.
53. Obeagu EI, Abdirahman BF, Bunu UO, Obeagu GU. Obsterics characteristics that effect the newborn outcomes. Int. J. Adv. Res. Biol. Sci. 2023;10(3):134-43.DOI: 10.22192/ijarbs.2023.10.03.016
54. Obeagu EI, Ogunnaya FU. PREGNANCYINDUCED HAEMATOLOGICAL CHANGES: A KEY TO MARTERNAL AND CHILD HEALTH. European Journal of Biomedical. 2023;10(8):42-3.links/64c890bddb38b20d6dad2c5c/PREGNANCY-INDUCED-HAEMATOLOGICAL-CHANGES-A-KEY-TO-MARTERNAL-AND-CHILD-HEALTH.pdf.
55. 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):10-9.
56. Okamgba OC, Nwosu DC, Nwobodo EI, Agu GC, Ozims SJ, Obeagu EI, Ibanga IE, Obioma-Elemba IE, Ihekaire DE, Obasi CC, Amah HC. Iron Status of Pregnant and Post-Partum Women with Malaria Parasitaemia in Aba Abia State, Nigeria. Annals of Clinical and Laboratory Research. 2017;5(4):206.links/5ea97df145851592d6a8acf2/Iron-Status-

of-Pregnant-and-Post-Partum-Women-with-Malaria-Parasitaemia-in-Aba-Abia-State-Nigeria.pdf.
57. Eze RI, Obeagu EI, Edet FN. Frequency of Rh Antigen C And c among pregnant women in Sub-Urban area in Eastern Nigeria. Madonna Uni J Med Health Sci. 2021;1(1):19-30.
58. Obeagu EI, Ofodile AC, Okwuanaso CB. A review of urinary tract infections in pregnant women: Risks factors. J Pub Health Nutri. 2023; 6 (1). 2023;137:26-35.links/63c3a9116fe15d6a571e8bba/A-review-of-urinary-tract-infections-in-pregnant-women-Risks-factors.pdf.
59. Obeagu EI, Obeagu GU, Musiimenta E. Post partum haemorrhage among pregnant women: Update on risks factors. Int. J. Curr. Res. Med. Sci. 2023;9(2):14-7.DOI: 10.22192/ijcrms.2023.09.02.003
60. Ifeanyi EO, Uzoma GO. Malaria and The Sickle Cell Trait: Conferring Selective Protective Advantage to Malaria. J Clin Med Res. 2020; 2:1-4.
61. Obeagu EI, Obeagu GU, Ogunnaya FU. Deep vein thrombosis in pregnancy: A review of prevalence and risk factors. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(8):14-21.DOI: 10.22192/ijcrcps.2023.10.08.002
62. Jakheng SP, Obeagu EI, Jakheng EW, Uwakwe OS, Eze GC, Obeagu GU, Vidya S, Kumar S. Occurrence of Chlamydial Infection Based on Clinical Symptoms and Clinical History among Pregnant Women Attending Clinics in Zaria Metropolis, Kaduna State, Nigeria. International Journal of Research and Reports in Gynaecology. 2022 Aug 11;5(3):98-105.
63. Okorie HM, Obeagu EI, Eze EN, Jeremiah ZA. Assessment of some haematological parameters in malaria infected pregnant women in Imo state Nigeria. Int. J. Curr. Res. Biol. Med. 2018;3(9):1-4.DOI: 10.22192/ijcrbm.2018.03.09.001
64. Onyenweaku FC, Amah HC, Obeagu EI, Nwandikor UU, Onwuasoanya UF. Prevalence of asymptomatic bacteriuria and its antibiotic susceptibility pattern in pregnant women attending private ante natal clinics in Umuahia Metropolitan. Int J Curr Res Biol Med. 2017;2(2):13-23.DOI: 10.22192/ijcrbm.2017.02.02.003
65. Okoroiwu IL, Chinedu-Madu JU, Obeagu EI, Vincent CC, Ochiabuto OM, Ibekwe AM, Amaechi CO, Agu CC, Anoh NV, Amadi NM. Evaluation of Iron Status, Haemoglobin and Protein Levels of Pregnant Women in Owerri Metropolis. Journal of Pharmaceutical Research International. 2021 Apr 29;33(27A):36-43.
66. Obeagu EI, Njar VE, Obeagu GU. Infertility: Prevalence and Consequences. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(7):43-50.
67. Emeka-Obi OR, Ibeh NC, Obeagu EI, Okorie HM. Evaluation of levels of some inflammatory cytokines in preeclamptic women in owerri. Journal of Pharmaceutical Research International. 2021 Aug 25;33(42A):53-65.
68. Obeagu EI, Faduma MH, Uzoma G. Ectopic Pregnancy: A Review. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(4):40-4.DOI: 10.22192/ijcrcps.2023.10.04.004
69. Obeagu EI, Gamade SM, Obeagu GU. The roles of Neutrophils in pregnancy. Int. J. Curr. Res. Med. Sci. 2023;9(5):31-5.DOI: 10.22192/ijcrms.2023.09.05.005
70. Eze R, Obeagu EI, Nwakulite A, Okoroiwu IL, Vincent CC, Okafor CJ, Chukwurah EF, Chijioke UO, Amaechi CO. Evaluation of Copper Status and Some Red Cell Parameters of Pregnant Women in Enugu State, South Eastern Nigeria. Journal of Pharmaceutical Research International. 2021 May 29;33(30A):67-71.

71. Obeagu EI, Obeagu GU. Molar Pregnancy: Update of prevalence and risk factors. Int. J. Curr. Res. Med. Sci. 2023;9(7):25-8.DOI: 10.22192/ijcrms.2023.09.07.005
72. Obeagu EI, Bunu UO. Factors that influence unmet need for family planning. International Journal of Current Research in Biology and Medicine. 2023;8(1):23-7.
73. Ibebuike JE, Ojie CA, Nwokike GI, Obeagu EI, Nwosu DC, Nwanjo HU, Agu GC, Ezenwuba CO, Nwagu SA, Akujuobi AU. Barriers to utilization of maternal health services in southern senatorial district of Cross Rivers state, Nigeria. International Journal of Advanced Multidisciplinary Research. 2017;4(8):1-9.DOI: 10.22192/ijamr.2017.04.08.001
74. Emannuel G, Martin O, Peter OS, Obeagu EI, Daniel K. Factors Influencing Early Neonatal Adverse Outcomes among Women with HIV with Post Dated Pregnancies Delivering at Kampala International University Teaching Hospital, Uganda. Asian Journal of Pregnancy and Childbirth. 2023 Jul 29;6(1):203-11.http://research.sdpublishers.net/id/eprint/2819/.
75. Okorie HM, Obeagu EI, Eze EN, Jeremiah ZA. Assessment of coagulation parameters in malaria infected pregnant women in Imo state, Nigeria. International Journal of Current Research in Medical Sciences. 2018;4(9):41-9.DOI: 10.22192/ijcrms.2018.04.09.006
76. Obeagu EI, Obeagu GU. Postpartum haemorrhage among women delivering through spontaneous vaginal delivery: Prevalence and risk factors. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(8):22-6.DOI: 10.22192/ijcrcps.2023.10.08.003
77. Obeagu E, Eze RI, Obeagu EI, Nnatuanya IN, Dara EC. ZINC LEVEL IN APPARENTLY PREGNANT WOMEN IN URBAN AREA. Madonna University journal of Medicine and Health Sciences ISSN: 2814-3035. 2022 Mar 2;2(1):134-48.https://www.journal.madonnauniversity.edu.ng/index.php/medicine/article/view/40.
78. Ogomaka IA, Obeagu EI. Malaria in Pregnancy Amidst Possession of Insecticide Treated Bed Nets (ITNs) in Orlu LGA of Imo State, Nigeria. Journal of Pharmaceutical Research International. 2021 Aug 25;33(41B):380-6.
79. Obeagu EI, Ogunnaya FU, Obeagu GU, Ndidi AC. SICKLE CELL ANAEMIA: A GESTATIONAL ENIGMA. migration. 2023;17:18.
80. Ifeanyi OE, Uzoma OG. A review on erythropietin in pregnancy. J. Gynecol. Womens Health. 2018;8(3):1-4.https://www.academia.edu/download/56538560/A_Review_on_Erythropietin_in_Pregnancy.pdf.
81. Ifeanyi OE. A review on pregnancy and haematology. Int. J. Curr. Res. Biol. Med. 2018;3(5):26-8.DOI: 10.22192/ijcrbm.2018.03.05.006
82. Nwosu DC, Nwanjo HU, Obeagu EI, Ibebuike JE, Ezeama MC. Ihekireh. Changes in liver enzymes and lipid profile of pregnant women with malaria in Owerri, Nigeria. International Journal of Current Research and Academic Review. 2015;3(5):376-83.
83. Dong M, Ware RE, Dallmann A, Vinks AA. Hydroxyurea treatment for sickle cell anemia during pregnancy and lactation: current evidence and knowledge gaps. Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy. 2023;43(5):419-29.
84. Ibebuike JE, Ojie CA, Nwokike GI, Obeagu EI, Nwosu DC, Nwanjo HU, Agu GC, Ezenwuba CO, Nwagu SA, Akujuobi AU. Factors that influence women's utilization of primary health care services in Calabar Cros river state, Nigeria. Int. J. Curr. Res. Chem. Pharm. Sci. 2017;4(7):28-33.

85. Eze R, Ezeah GA, Obeagu EI, Omeje C, Nwakulite A. Evaluation of iron status and some haematological parameters of pregnant women in Enugu, South Eastern Nigeria. World Journal of Pharmaceutical and Medical Research. 2021;7(5):251-4.
86. Elemchukwu Q, Obeagu EI, Ochei KC. Prevalence of Anaemia among Pregnant Women in Braithwaite Memorial Specialist Hospital (BMSH) Port Harcourt. IOSR Journal of Pharmacy and Biological Sciences. 2014;9(5):59-64.
87. Akandinda M, Obeagu EI, Katonera MT. Non Governmental Organizations and Women's Health Empowerment in Uganda: A Review. Asian Research Journal of Gynaecology and Obstetrics. 2022 Dec 14;8(3):12-6.
88. Vidya S. Sunil Kumar Shango Patience Emmanuel Jakheng, Emmanuel Ifeanyi Obeagu, Emmanuel William Jakheng, Onyekachi Splendid Uwakwe, Gloria Chizoba Eze, and Getrude Uzoma Obeagu (2022). Occurrence of Chlamydial Infection Based on Clinical Symptoms and Clinical History among Pregnant Women Attending Clinics in Zaria Metropolis, Kaduna State, Nigeria. International Journal of Research and Reports in Gynaecology.;5(3):98-105.
89. Gamde MS, Obeagu EI. IRON DEFICIENCY ANAEMIA: ENEMICAL TO PREGNANCY. European Journal of Biomedical. 2023;10(9):272-5.links/64f63358827074313ffaae7b/IRON-DEFICIENCY-ANAEMIA-ENEMICAL-TO-PREGNANCY.pdf.
90. Emeka-Obi OR, Ibeh NC, Obeagu EI, Okorie HM. Evaluation of levels of some inflammatory cytokines in preeclamptic women in owerri. Journal of Pharmaceutical Research International. 2021 Aug 25;33(42A):53-65.
91. Emeka-Obi OR, Ibeh NC, Obeagu EI, Okorie HM. Studies of Some Haemostatic Variables in Preeclamptic Women in Owerri, Imo State, Nigeria. Journal of Pharmaceutical Research International. 2021 Aug 30;33(42B):39-48.
92. Obeagu EI, Obeagu GU. Postpartum haemorrhage among women delivering through spontaneous vaginal delivery: Prevalence and risk factors. Int. J. Curr. Res. Chem. Pharm. Sci. 2023;10(8):22-6.
93. Obeagu EI, Obeagu GU. Sickle Cell Anaemia in Pregnancy: A Review. International Research in Medical and Health Sciences. 2023 Jun 10;6(2):10-3.
94. Sarode R, Ballas SK, Garcia A, Kim HC, King K, Sachais B, Williams III LA. Red blood cell exchange: 2015 American Society for Apheresis consensus conference on the management of patients with sickle cell disease. Journal of Clinical Apheresis. 2017;32(5):342-67.
95. Parrish MR, Morrison JC. Sickle cell disease. InClinical Maternal-Fetal Medicine 2021:19-1. CRC Press.
96. Ling EW, Sosuan LC, Hall JC. Congenital anomalies: an increasingly important cause of mortality and workload in a neonatal intensive care unit. American journal of perinatology. 1991;8(03):164-9.