Elite Journal of Medical Sciences. Volume 2 issue 5(2023), Pp.1-9
https://epjournals.com/journals/EJMS

Antioxidants and Neurodevelopmental Outcomes in Offspring: A Review of Maternal Interventions

*Emmanuel Ifeanyi Obeagu[1], Kesaobaka Batisani[2] and Getrude Uzoma Obeagu[3]

[1]Department of Medical Laboratory Science, Kampala International University, Uganda

[2]School of Medicine and Health Sciences, University of Lusaka, Zambia

[3]School of Nursing Science, Kampala International University, Uganda

*Corresponding authour: Emmanuel Ifeanyi Obeagu, Department of Medical Laboratory Science, Kampala International University, Uganda, emmanuelobeagu@yahoo.com, ORCID: 0000-0002-4538-0161

Abstract

Neurodevelopmental outcomes in offspring are influenced by a myriad of factors, with maternal nutrition during pregnancy emerging as a critical determinant. Antioxidants, including vitamins C and E, selenium, zinc, and polyphenols, possess neuroprotective properties by counteracting oxidative stress and modulating key pathways involved in brain development. Through a thorough examination of both animal studies and observational data from human populations, this review elucidates the potential mechanisms and clinical implications of maternal antioxidant supplementation for offspring neurodevelopment. Evidence from animal studies underscores the neuroprotective effects of maternal antioxidant supplementation, with improvements observed in cognitive function, synaptic plasticity, and behavioral outcomes in offspring. These findings suggest a crucial role for antioxidants in mitigating the adverse effects of oxidative stress on neurodevelopment during critical periods of fetal brain development. Moreover, observational studies in human populations have provided valuable insights into the associations between maternal antioxidant intake during pregnancy and offspring neurodevelopmental outcomes, highlighting the potential benefits of antioxidant-rich diets and supplementation regimens for optimizing cognitive function and behavioral outcomes in children. The clinical implications of maternal antioxidant interventions for offspring neurodevelopment are significant, with implications for both preventive strategies and therapeutic interventions. Integrating antioxidant-rich diets and supplementation regimens into prenatal care regimens may offer a promising approach for optimizing neurodevelopmental outcomes in offspring.

Citation: Obeagu EI, Batisani K, Obeagu GU. Antioxidants and Neurodevelopmental Outcomes in Offspring: A Review of Maternal Interventions. Elite Journal of Health Science, 2023; 2(5):1-9

Keywords: *Antioxidants, Neurodevelopment, Offspring, Pregnancy, Maternal Interventions, Cognitive Development, Behavioral Outcomes*

Introduction

Neurodevelopmental outcomes in offspring are paramount for their lifelong health and well-being, encompassing cognitive abilities, social skills, emotional regulation, and adaptive functioning. The prenatal period represents a critical window of vulnerability and opportunity, during which maternal factors exert profound influences on fetal brain development and subsequent neurobehavioral outcomes in offspring. Maternal nutrition, in particular, has emerged as a key determinant of neurodevelopment, with deficiencies or imbalances in essential nutrients posing risks for neurodevelopmental disorders such as autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), and intellectual disabilities. Amidst the complex interplay of maternal factors, oxidative stress has garnered increasing attention as a mechanistic link between maternal nutrition and neurodevelopmental outcomes in offspring.[1-25] Oxidative stress arises from an imbalance between reactive oxygen species (ROS) production and the body's antioxidant defense mechanisms, leading to cellular damage and dysfunction. During pregnancy, maternal oxidative stress levels are heightened due to increased metabolic demands, hormonal fluctuations, and placental oxidative metabolism. This oxidative burden can have detrimental effects on fetal brain development, disrupting key processes such as neurogenesis, synaptogenesis, and myelination, and predisposing offspring to neurodevelopmental abnormalities. Consequently, interventions aimed at mitigating oxidative stress during pregnancy hold promise for optimizing neurodevelopmental outcomes in offspring.[6-8]

Antioxidants represent a diverse array of compounds found abundantly in fruits, vegetables, nuts, seeds, and herbs, with potent neuroprotective properties. These compounds scavenge ROS, inhibit lipid peroxidation, modulate inflammatory pathways, enhance mitochondrial function, and regulate gene expression, thereby safeguarding against oxidative damage and supporting neurodevelopment. Maternal antioxidant status during pregnancy is increasingly recognized as a critical determinant of fetal brain health, with implications for cognitive function, behavioral outcomes, and mental health in offspring. Consequently, interventions aimed at enhancing maternal antioxidant intake during pregnancy have emerged as potential strategies for optimizing neurodevelopmental trajectories in offspring.[9-13] Animal studies have provided compelling evidence supporting the neuroprotective effects of maternal antioxidant supplementation, demonstrating improvements in cognitive function, synaptic plasticity, and behavioral outcomes in offspring. These findings underscore the importance of maternal nutrition in shaping neurodevelopmental outcomes and highlight the potential therapeutic benefits of antioxidant interventions. Moreover, observational studies in human populations have yielded valuable insights into the associations between maternal antioxidant intake during pregnancy and offspring neurodevelopmental outcomes, further supporting the notion that maternal nutrition plays a critical role in fetal brain development.[14-15] However, translating these findings into clinical practice requires a nuanced understanding of the optimal timing, dosage, and formulation of antioxidant interventions, as well as consideration of individual maternal and fetal characteristics.

Additionally, elucidating the underlying mechanisms of antioxidant protection in neurodevelopmental disorders is essential for developing targeted therapeutic strategies and identifying novel therapeutic targets. Collaborative efforts between researchers, healthcare providers, and policymakers are needed to advance our understanding of the role of antioxidants in neurodevelopment and translate this knowledge into effective clinical strategies for optimizing neurodevelopmental outcomes in offspring.[16-20]

Antioxidants and Neurodevelopment

Antioxidants play a crucial role in neurodevelopment by counteracting oxidative stress, a process implicated in various neurodevelopmental disorders. The developing fetal brain is particularly vulnerable to oxidative damage due to its high metabolic activity, abundance of polyunsaturated fatty acids, and limited antioxidant defense mechanisms. Oxidative stress disrupts essential processes such as neurogenesis, synaptogenesis, and myelination, contributing to neuronal dysfunction and aberrant circuit formation. Antioxidants, including vitamins C and E, selenium, zinc, and polyphenols, exert neuroprotective effects by scavenging ROS, inhibiting lipid peroxidation, and modulating inflammatory pathways, thereby promoting optimal neurodevelopmental trajectories.[21-25] Animal studies have provided compelling evidence supporting the neuroprotective effects of maternal antioxidant supplementation on offspring neurodevelopment. Prenatal exposure to antioxidants has been associated with improvements in cognitive function, memory retention, and motor coordination in animal models. These benefits are attributed to the ability of antioxidants to mitigate oxidative damage to neurons, preserve synaptic integrity, and enhance neuroplasticity. Furthermore, antioxidant supplementation during critical periods of fetal brain development has been shown to mitigate the adverse effects of oxidative stress on neurodevelopmental outcomes, underscoring the potential therapeutic implications of maternal antioxidant interventions.[26-27]

Observational studies in human populations have also suggested associations between maternal antioxidant intake during pregnancy and offspring neurodevelopmental outcomes. Higher maternal intake of antioxidants, such as vitamins C and E, has been associated with improved cognitive function, language development, and social behavior in children. Additionally, epidemiological evidence suggests that antioxidant-rich diets, characterized by high consumption of fruits, vegetables, nuts, and seeds, are associated with reduced risk of neurodevelopmental disorders such as ASD and ADHD. These findings highlight the importance of maternal nutrition in shaping neurodevelopmental outcomes and support the potential role of antioxidants as modulators of neurodevelopment in humans.[28-32] Despite promising evidence from animal and observational studies, further research is needed to elucidate the optimal strategies for antioxidant interventions in neurodevelopmental disorders. Well-designed clinical trials are warranted to evaluate the efficacy, safety, and long-term effects of maternal antioxidant supplementation on offspring neurodevelopment. Additionally, mechanistic studies are needed to elucidate the underlying pathways through which antioxidants exert their neuroprotective effects and identify biomarkers for assessing antioxidant status and neurodevelopmental outcomes. By addressing these knowledge gaps, researchers can advance our understanding of the role of antioxidants in

neurodevelopment and develop targeted interventions to promote optimal neurodevelopmental outcomes in offspring.[33-42]

Clinical Implications and Future Directions

The potential implications of antioxidants in neurodevelopment extend beyond theoretical frameworks to tangible clinical applications, with profound implications for preventive strategies and therapeutic interventions. Integrating antioxidant-rich diets and supplementation regimens into prenatal care regimens may offer a promising approach for optimizing neurodevelopmental outcomes in offspring. By targeting oxidative stress-mediated mechanisms underlying neurodevelopmental disorders, antioxidants may offer a novel therapeutic avenue for mitigating the burden of neurodevelopmental disabilities. However, several challenges and knowledge gaps must be addressed to fully realize the clinical potential of antioxidants in neurodevelopment.[43-48] One of the key challenges in translating antioxidant research into clinical practice is determining the optimal timing, dosage, and formulation of antioxidant interventions. Prenatal exposure to antioxidants during critical periods of fetal brain development may be particularly beneficial for mitigating the adverse effects of oxidative stress and optimizing neurodevelopmental outcomes in offspring. However, the safety and efficacy of antioxidant supplementation during pregnancy require further investigation, as excessive antioxidant intake may disrupt redox homeostasis and have unintended consequences for maternal-fetal health. Well-designed clinical trials are needed to evaluate the efficacy, safety, and long-term effects of maternal antioxidant supplementation on offspring neurodevelopment.[49-52] Furthermore, personalized approaches to antioxidant therapy are warranted to account for individual variability in antioxidant metabolism, responsiveness, and genetic predisposition. Biomarker-guided strategies, such as assessing maternal antioxidant status and oxidative stress markers, may help identify high-risk populations who stand to benefit most from antioxidant interventions. Additionally, elucidating the underlying mechanisms of antioxidant protection in neurodevelopmental disorders is essential for developing targeted therapeutic strategies and identifying novel therapeutic targets. Collaborative efforts between researchers, healthcare providers, and policymakers are needed to advance our understanding of the role of antioxidants in neurodevelopment and translate this knowledge into effective clinical strategies for optimizing neurodevelopmental outcomes in offspring. By addressing these knowledge gaps, we can pave the way for a future where neurodevelopmental disorders are prevented, and every child has the opportunity to thrive.[53-36]

Conclusion

In conclusion, antioxidants represent promising therapeutic agents for optimizing neurodevelopmental outcomes in offspring, offering potential avenues for improving cognitive function, behavioral outcomes, and lifelong health trajectories. Through their ability to counteract oxidative stress and modulate key pathways involved in brain development, antioxidants have emerged as potential modulators of neurodevelopmental trajectories in offspring. Animal studies have provided compelling evidence supporting the neuroprotective effects of maternal antioxidant supplementation, demonstrating improvements in cognitive function, synaptic plasticity, and

behavioral outcomes in offspring. Observational studies in human populations have further supported these findings, suggesting associations between maternal antioxidant intake during pregnancy and improved neurodevelopmental outcomes in children.

References

1. Coad J, Pedley K, Dunstall M. Anatomy and Physiology for Midwives E-Book: Anatomy and Physiology for Midwives E-Book. Elsevier Health Sciences; 2019.
2. Moog NK, Entringer S, Heim C, Wadhwa PD, Kathmann N, Buss C. Influence of maternal thyroid hormones during gestation on fetal brain development. Neuroscience. 2017; 342:68-100.
3. 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;6(4):12-7.
4. Obeagu EI, Ubosi NI, Uzoma G. Antioxidant Supplementation in Pregnancy: Effects on Maternal and Infant Health. Int. J. Adv. Multidiscip. Res. 2023;10(11):60-70.
5. 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.
6. 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.
7. Agarwal A, Aponte-Mellado A, Premkumar BJ, Shaman A, Gupta S. The effects of oxidative stress on female reproduction: a review. Reproductive biology and endocrinology. 2012; 10:1-31.
8. Lappas M, Hiden U, Desoye G, Froehlich J, Mouzon SH, Jawerbaum A. The role of oxidative stress in the pathophysiology of gestational diabetes mellitus. Antioxidants & redox signaling. 2011;15(12):3061-3100.
9. Obeagu EI, Obeagu GU. Utilization of Antioxidants in the management of diabetes mellitus patients. J Diabetes Clin Prac. 2018;1(102):2.
10. 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.
11. 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;9(4):145-8. links/608a6728a6fdccaebdf52d94/Assessment-of-Haematological-Changes-in-Pregnant-Women-of-Ido-Ondo.pdf.

Citation: Obeagu EI, Batisani K, Obeagu GU. Antioxidants and Neurodevelopmental Outcomes in Offspring: A Review of Maternal Interventions. Elite Journal of Health Science, 2023; 2(5):1-9

12. Obeagu EI, Obeagu GU. Sickle Cell Anaemia in Pregnancy: A Review. International Research in Medical and Health Sciences. 2023 ;6(2):10-3. http://irmhs.com/index.php/irmhs/article/view/111.
13. Adwas AA, Elsayed A, Azab AE, Quwaydir FA. Oxidative stress and antioxidant mechanisms in human body. J. Appl. Biotechnol. Bioeng. 2019;6(1):43-47.
14. He L, He T, Farrar S, Ji L, Liu T, Ma X. Antioxidants maintain cellular redox homeostasis by elimination of reactive oxygen species. Cellular Physiology and Biochemistry. 2017;44(2):532-553.
15. Nwosu DC, Obeagu EI, Ezenwuba C, Agu GC, Amah H, Ozims SJ, Nwanjo HU, Edward A, Izuchukwu IF, Amadike JN, Nwagwu AJ. Antioxidant status of children with Plasmodium falciparum malaria in Owerri municipal council of Imo state. Int. J. Curr. Res. Chem. Pharm. Sci. 2016;3(8):40-6.
16. Ezimah UA, Obeagu EI, Ezimah CO, Ezimah A, Nto NJ. Diarrhoeal diseases of acquired immunodeficiency syndrome stimulate more depletion of total antioxidant status. Int. J. Adv. Multidiscip. Res. 2016;3(4):23-25.
17. 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):502-507.
18. Prins JR, Schoots MH, Wessels JI, Campmans-Kuijpers MJ, Navis GJ, van Goor H, Robertson SA, van der Beek EM, Sobrevia L, Gordijn SJ. The influence of the dietary exposome on oxidative stress in pregnancy complications. Molecular Aspects of Medicine. 2022; 87:101098.
19. Nwakuilite A, Nwanjo HU, Nwosu DC, Obeagu EI. EVALUATION OF ENZYME ANTIOXIDANTS IN STREPTOZOCIN INDUCED DIABETIC RATS TREATED WITH MORINGA OLEIFERA LEAF POWDER. European Journal of Biomedical. 2020;7(11):285-8.
20. Ifeanyi OE. A review on free radicals and antioxidants. Int. J. Curr. Res. Med. Sci. 2018;4(2):123-133.
21. Akinpelu M, Gamade SM, Akinbo F, Adeniyi TD, Elizebeth AF, Obeagu EI. Histopathological and Biochemical Effect of Vitamin C and D on Phosphine-Induced Hepatotoxicity in Wistar Rats. Asian Journal of Dental and Health Sciences. 2023;3(2):18-22.
22. Nwakulite A, Obeagu EI, Eze R, Ugochi VE, Vincent CC, Okafor CJ, Chukwurah EF, Unaeze BC, Amaechi CO, Okwuanaso CB, Chukwuani U. Estimation of Serum Glutathione Peroxidase in Streptozotocin Induced Diabetic Rat Treated with Bitter Leaf Extract. Journal of Pharmaceutical Research International. 2021;33(30B):200-6.
23. Ortega Ávila JG, Echeverri I, de Plata CA, Castillo A. Impact of oxidative stress during pregnancy on fetal epigenetic patterns and early origin of vascular diseases. Nutrition reviews. 2015;73(1):12-21.
24. Ozougwu JC. The role of reactive oxygen species and antioxidants in oxidative stress. International Journal of Research. 2016;1(8):1-8.

Citation: Obeagu EI, Batisani K, Obeagu GU. Antioxidants and Neurodevelopmental Outcomes in Offspring: A Review of Maternal Interventions. Elite Journal of Health Science, 2023; 2(5):1-9

25. 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. 2022;2(2):1-9.
26. 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. 2022;2(1):292-8. https://madonnauniversity.edu.ng/journals/index.php/medicine/article/view/57.
27. 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 S.
28. Al-Gubory KH, Fowler PA, Garrel C. The roles of cellular reactive oxygen species, oxidative stress and antioxidants in pregnancy outcomes. The international journal of biochemistry & cell biology. 2010;42(10):1634-1650.
29. Silvestro S, Calcaterra V, Pelizzo G, Bramanti P, Mazzon E. Prenatal hypoxia and placental oxidative stress: Insights from animal models to clinical evidences. Antioxidants. 2020;9(5):414.
30. Hussain T, Murtaza G, Metwally E, Kalhoro DH, Kalhoro MS, Rahu BA, Sahito RG, Yin Y, Yang H, Chughtai MI, Tan B. The role of oxidative stress and antioxidant balance in pregnancy. Mediators of Inflammation. 2021; 2021:1-1.
31. 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). 2022:936-941.
32. 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
33. 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. 2022;2(2):91-97. https://madonnauniversity.edu.ng/journals/index.php/medicine/article/view/67.
34. 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.
35. Pisoschi AM, Pop A, Iordache F, Stanca L, Predoi G, Serban AI. Oxidative stress mitigation by antioxidants-an overview on their chemistry and influences on health status. European Journal of Medicinal Chemistry. 2021; 209:112891.
36. Ahmad S. Oxidative stress and antioxidant defenses in biology. Springer Science & Business Media; 2012.
37. Matés JM, Segura JA, Alonso FJ, Márquez J. Intracellular redox status and oxidative stress: implications for cell proliferation, apoptosis, and carcinogenesis. Archives of toxicology. 2008; 82:273-299.

Citation: Obeagu EI, Batisani K, Obeagu GU. Antioxidants and Neurodevelopmental Outcomes in Offspring: A Review of Maternal Interventions. Elite Journal of Health Science, 2023; 2(5):1-9

38. Singh P, Kesharwani RK, Keservani RK. Antioxidants and vitamins: Roles in cellular function and metabolism. InSustained energy for enhanced human functions and activity 2017: 385-407. Academic Press.
39. Cömert ED, Mogol BA, Gökmen V. Relationship between color and antioxidant capacity of fruits and vegetables. Current Research in Food Science. 2020; 2:1-0.
40. Jideani AI, Silungwe H, Takalani T, Anyasi TA, Udeh H, Omolola A. Antioxidant-rich natural grain products and human health. Antioxidant-Antidiabetic Agents and Human Health. Oguntibeju O ed., InTech Publisher. Rijeka, Croatia. 2014:167-187.
41. Gush L, Shah S, Gilani F. Macronutrients and micronutrients. InA prescription for healthy living 2021: 255-273. Academic Press.
42. Gao Y, Sheng C, Xie RH, Sun W, Asztalos E, Moddemann D, Zwaigenbaum L, Walker M, Wen SW. New perspective on impact of folic acid supplementation during pregnancy on neurodevelopment/autism in the offspring children–a systematic review. PloS one. 2016;11(11):e0165626.
43. Kar S, Wong M, Rogozinska E, Thangaratinam S. Effects of omega-3 fatty acids in prevention of early preterm delivery: a systematic review and meta-analysis of randomized studies. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2016; 198:40-46.
44. 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):113-121.
45. Obeagu EI. Gestational Thrombocytopaenia. J Gynecol Women's Health. 2023;25(3):556163. links/64b01aa88de7ed28ba95fccb/Gestational-Thrombocytopaenia.pdf.
46. 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.
47. 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.
48. Obeagu EI, Ogunnaya FU. PREGNANCYINDUCED HAEMATOLOGICAL CHANGES: A KEY TO MARTERNAL AND CHILD HEALTH. European Journal of Biomedical. 2023;10(8):42-43. links/64c890bddb38b20d6dad2c5c/PREGNANCY-INDUCED-HAEMATOLOGICAL-CHANGES-A-KEY-TO-MARTERNAL-AND-CHILD-HEALTH.pdf.
49. 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.
50. 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.

51. Swain N, Moharana AK, Jena SR, Samanta L. Impact of oxidative stress on embryogenesis and fetal development. InOxidative Stress and Toxicity in Reproductive Biology and Medicine: A Comprehensive Update on Male Infertility Volume II 2022: 221-241. Cham: Springer International Publishing.
52. 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): 14-17.DOI: 10.22192/ijcrms.2023.09.02.003
53. 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
54. 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;5(3):98-105.
55. Sebastiani G, Navarro-Tapia E, Almeida-Toledano L, Serra-Delgado M, Paltrinieri AL, García-Algar Ó, Andreu-Fernández V. Effects of antioxidant intake on fetal development and maternal/neonatal health during pregnancy. Antioxidants. 2022;11(4):648.
56. Xia Y, Hong L, Zheng J, Lu Z, Zhang Q, Chen S, Pang Z, Li L, Qiao S, Wang Q, Zhou Y. Ulcerative colitis alleviation of colon-specific delivered rhamnolipid/fullerene nanocomposites via dual modulation in oxidative stress and intestinal microbiome. Journal of Materials Chemistry B. 2023;11(25):5882-5897.