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Research paper



Investigation of parental socioeconomic status as a determinant of dietary habits and disease severity of sickle cell disease children

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Abstract

Background: Socioeconomic status (SES) impacts dietary choices and poor dietary pattern has been reported to play a role in the etiopathogenic mechanisms that give rise to various diseases. Objective: The study is designed to explore the relationship between parental SES and both the dietary habits and disease severity markers among sickle cell disease (SCD) pediatric patients. Methods: Participants' hemoglobin genotypes and hematocrit levels were determined using standard methods. Questionnaire was administered to the participants to obtain information on qualitative parameters. Descriptive and inferential statistics were used for data analysis. Significant level was set with $P < .05$. Results: A high percentage of parents of SCD participants were of medium to high SES [73.33%- HbSC; 64.29%-HbSS]. While the rates of hospitalization of HbSS (92.85%) and HbSC (66.67%) were dissimilar, the rates of patients that had suffered vaso-occlusive crisis (VOC) in the last three months prior to the study were comparable [46.67%-HbSC; 53.57%-HbSS]. The daily fruit/vegetable consumption habits of 3 genotypes were poor ranging from 15-25%. The hematocrit levels of the 3 groups were significantly different. Conclusion: The study suggests that high percentage of patients belong to medium-high SES, signifying that educational background of parents did not impact prevalence of the disease.

Keywords: *Disease Severity; Fruit/Vegetable Intake; Sickle Cell Disease; Socioeconomic Status.*

1. Introduction

Sickle cell anemia (SCA) is an autosomal recessive genetic disorder that occurs from abnormality in the hemoglobin β gene which encodes hemoglobin ß chain [1-3]. Hemoglobin molecule is a heterotetramer composed of four hemoglobin chains (two α and two β). The severe form of sickle cell disease (SCD) results from the inheritance of two sickle β hemoglobin gene. Defective hemoglobin chains within the red blood cell cause rigidity and alteration of its shape [4,5]. The disease has high prevalence among people of sub-Saharan African, Indian, Saudi Arabian, or Mediterranean ancestry. Annually, on global scale as many as 300,000 infants are born with major hemoglobin disorders [6]; Africa has the highest burden of the disease with over 200,000 cases of sickle-cell anemia newly recorded among infants yearly.

The term sickle cell disease (SCD) is used to include a group of related β-hemoglobinopathies characterized by the predominance of sickle hemoglobin (HbS) within erythrocytes. HbS tend to polymerize upon deoxygenation [7], and this peculiar feature brings about all the pathophysiology of SCD. Repeated polymerization of red blood cell (RBC) that occurs from cycles of oxygenation and deoxygenation in circulation destroys erythrocyte membrane [8,9]. This eventually results in dehydration and inflexibility of RBC as well as a greatly shortened lifespan of erythrocytes. The ultimate consequence is a chronic hemolytic anemia, and a tendency for microvascular obstruction or vaso-occlusion (VOC). The chronic inflammatory response and endothelial dysfunction that were identified as important features of SCD have been linked with ischemia, infarction, and ischemia-reperfusion injury of multiple organs and tissues [10],[11].

Improved survival rate has transformed SCD which was once considered a fatal disease of children into a chronic disease through early detection, preventive measures, and disease-modifying therapies [10]. The increased survival rate therefore suggests that many SCD affected children may attain to adulthood. Nigeria, the most populous nation in the continent has a large number of individuals that are carriers of the disease (HBAS), which has been estimated to be as high as 24% of the population. Meanwhile the prevalence of sickle-cell anemia (HbSS) is about 3% according to a report of survey (newborn screening program) carried out in a region in Nigeria [12].

In Nigeria, some of the methods adopted to address or prevent the unfortunate occurrence of this genetic disease in the offspring are diverse, although for majority of the people, information about disease prevention is received in informal settings (e.g. during religious services, in motor parks, and in market places), mostly provided by non-governmental organizations. Additionally, those with the benefit of high school education seem to have an advantage of being further furnished concerning information relating to metabolic alteration associated with the disease, its pattern of inheritance, and means of preventing its various complications as well as its overall management, since a couple of these important steps have been incorporated into educational curricula of elementary to higher levels of education. There is the need therefore to investigate socio-economic status/educational status of parents of SCD patients. Additionally, it be-

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comes imperative to study the role parental SES plays in frequency of VOC, rates of hospitalization and dietary habits of SCD children. Especially, as it has been documented that dietary pattern is determined by SES and can play a role in modulating severity of many diseases. Moreover, it is not surprising that SES is linked to disease severity, both have been associated with various distressing pathological and physiological alterations [13], [14].

2. Materials and methods

2.1. Ethical issues

Ethical approval for the study was given by the Osun State Ministry of Health, Osogbo. Additional ethical issues were resolved by obtaining informed consent (written) from the parents, guardians or caregivers as well as getting the assent of children who were 7 years and above. Adequate discretion was upheld about all data derived from the study; strict confidentiality of all information supplied by all study participants was maintained.

2.2. Study participants, sampling technique, study design, and PCV estimation

While the study design was cross-sectional comparative in form, sampling for enrollment of all participants was carried out using multistage random selection technique. At the Haematology and Outpatient clinics of Obafemi Awolowo University Teaching Hospital Complex (OAUTHC) Ile-Ife; Wesley Guild Hospital, Ilesha; and Osun State University Teaching Hospital Osogbo (UTH), Nigeria, pediatric SCD [HbSS, HbSC] patients were enrolled for the study as test participants whereas the non-SCD served as control group. The participants in the control group were enrolled at the Outpatient Department (OPD) where each of them came in for minor medical complaints such as minor aches and pains, medical certificate of fitness for school enrollment, etc. A detailed medical history of all participants was taken. The hemoglobin genotype of each participant was determined using the cellulose acetate hemoglobin electrophoresis. A total of 63 children below the age of 18 years were recruited. Three mL of the blood was collected for hematocrit estimation and Hb electrophoresis. The blood was collected into an anticoagulant bottle containing dipotassium ethylenediamine tetra-acetic acid. Hematocrit estimation was done using standard technique, i.e. the microhaematocrit method (Haematospin 1400, Hawksley & Sons, Sussex, England).
Individually, questionnaire was administered to the participants to obtain information on age, gender, parental socioeconomic status, dietary habits [specifically fruit/vegetable consumption habit] or disease severity markers [packed cell volume, absence or presence of vaso-occlusive crisis, rate of hospitalization] and clinic attendance in the preceding 3 months before the participants were enrolled for the study. Parents' socioeconomic status was determined by the method of Oyedeji [15]. Socioeconomic level was categorized into 3, namely low, medium and high. With respect to absence or presence of vaso-occlusive crisis; patients were categorized into 3- steady [without VOC], VOC [undergoing VOC], and post-VOC [recovered from VOC].

2.3. Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 26. (Armonk, NY: IBM Corp). Qualitative data was expressed as relative frequency. The results of packed cell volume [PCV] were summarized as mean ± standard deviation. Comparison of means of quantitative data was determined using analysis of variance (ANOVA). LSD post hoc tests were carried out for paired comparison. For categorical variables, the Chi-squared test (Fisher's exact test, if indicated) was used for the test the degree of association. Significant levels were set with $P < 0.05$.

3. Results

Table 1 is the summary of data on SES, disease severity markers and fruit/vegetable consumption habits of study participants. Only 5% HbAA patients had parents in low SES rather than higher percentages of 26.67% and 35 .71% for HbSC and HbSS respectively. Moreover, only 7.14% of HbSS as against 33.33% of HbSC had not been hospitalized in relation to complications arising from SCD. Meanwhile, the daily fruit/vegetable consumption habits of study participants were only 15% (HbAA); 26.67% (HbSC); and 25% (HbSS). On the other hand, 46.67% (HbSC) and 53.57% (HbSS) had suffered VOC in the three months prior to the study participant recruitment. In Fig. 1, the hematocrit levels of the study participants are expressed with the HbSS and HbSC showing statistically lower level compared with HbAA; HbSS was also significantly lower than HbSC.
Chi square results revealed that there was no difference in the distribution of parental SES (X2= .849; p= .654), rate of hospitalization (X2=5.826; p= .054), fruit/vegetable consumption (X2= .014; p= .590), clinic attendance (X2=1.149; p= .226), and VOC (X2= .386; p= .824) with respect to the 2 genotypes. Also, when SES of SCD patients was related to rate of hospitalization (X2= 12.09; p= .017), fruit/vegetable consumption (X2= 7.715; p=.021), clinic attendance (X2= 76.10; p= .022), and VOC (X2= 8.966; p= .062); only VOC did not show association with SES. Meanwhile, disease severity marker of hemoglobinopathies (i.e. VOC) showed relationship with hospitalization (X2= 19.21; p= .001), and fruit/vegetable consumption (X2= 10.71; p=.005) but not clinic attendance (X2= 2.770; p= .250). For HbSS and HbSC patients, there was association of hospitalization with fruit/vegetable consumption (X2= 11.17; p=.004), but not clinic attendance (X2= 5.327.10; p= .070); even though statistical analysis showed that the relationship between fruit/vegetable consumption and clinic attendance (X2= 6.435; p= .016) was significant

Table 1: Relative Frequency of Qualitative Data of 3 Types of Hemoglobin Genotype

Variables	HbAA- relative frequency (%)	HbSC- relative frequency (%)	HbSS- relative frequency (%)
SES			
low	5.00	26.67	35.71
middle	75.00	53.33	53.57
high	20.00	20.00	10.71
Information relating to occurrence of VOC			
steady	-	53.33	46.43
VOC	-	26.67	25.00
Post-VOC	-	20.00	28.57
Rate of hospitalization [relating to SCD]			

Never	-	33.33	7.14
< 1 year	-	40.00	71.40
>1 year	-	26.66	21.43
SCD clinic attendance			
No	-	40.00	57.14
Yes	-	60.00	42.86
Fruit/vegetable consumption habit			
0- not daily	85.00	73.33	75.00
1-daily	15.00	26.67	25.00

Abbreviations: HbAA- non-sickle cell disease (control); HbSC- heterozygous sickle cell disease; HbSS- homozygous sickle cell disease; SES- socioeconomic status; VOC- vaso-occlusive crisis; SCD- sickle cell disease

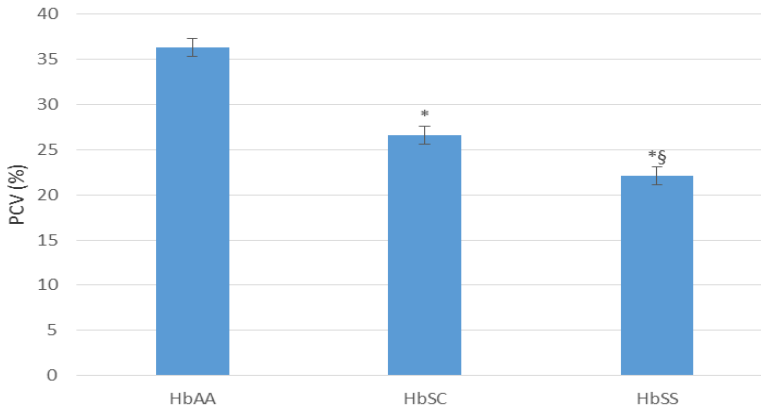


Fig. 1: The Concentration of Packed Cell Volume of Hbaa, Hbsc, and Hbss Study Participants. Abbreviations: Hbaa- Non-Sickle Cell Disease (Control); Hbsc- Heterozygous Sickle Cell Disease; Hbss- Homozygous Sickle Cell Disease.
*- Significant Different from Hbaa, §- Significant Different from Hbsc.

4. Discussion

The severity of the disease on rate of hemoglobin degradation is evident by the significant lower PCV level among the SCD patients compared with control and support earlier observations by various authors [5], [16], [17]. Generally it has been established that increased oxidized lipids and a greater tendency for lipid peroxidation is associated with SCD compared with HbAA containing erythrocytes [18, 19]. This no doubt encourages hemolysis, release of free Hb, leading to low PCV. The cause of reactive oxygen species (ROS) generation in SCD is multi-factorial. First tissue ischemia plays a significant role and when the occlusion is relieved, the increased blood levels of oxygen and oxygen free radicals may lead to oxidative damage, membrane lipid peroxidation from free radical damage, cell damage and nuclear factor kappa B (NF-KB) activation [20], [21]. NF-KB activation causes elevated endothelial cell adhesion molecule expression, which combines with integrins on leukocytes and young erythrocytes [22], [23], resulting in cell adherence which induces more vaso-occlusion, further triggering increased cycle of ischemia and reperfusion as well as profound hemoglobin degradation. Only 53% and 46% of HbSC and HbSS patients respectively were in the steady state, meaning they had not experienced VOC in the preceding 3 months. This suggests that 47% [HbSC] and 54% [HbSS] were either experiencing VOC or just recovered from it,

The dense nature of RBC co-existing with abnormal membrane morphology results in rigidity of red blood cells and encourages their easy entrapment within organs with slow microcirculation. This occurs from their interaction with the inflammatory activated vascular endothelial cells and neutrophils. These events seem to be the perquisite for acute vaso-occlusion, which leads to ischemic-reperfusion damage of target organs such as lung, kidney or brain [24-27].

The results of the study revealed that 73% [HbSC] & 63% [HbSS] of parents of SCD children are in the middle and higher SES, with at least one parent having a minimum of high school/secondary school certificate. This leaves much to be desired about the current efforts in eradication of SCD. Bearing in mind that sickle cell disease is a genetic disorder, inherited in an autosomal recessive fashion in which the genetic abnormality is transmitted from parents to offspring. This basic understanding about SCD has been recognized for several decades. That a disorder that has been copiously researched, and its pattern of transmission by parents and mode of inheritance in progeny can be reasonably predicted can still be found among people in high SES suggest that current efforts of the government in preventing this disease are not yielding desired outcomes. There is no doubt it has become inescapable that the curricula of health related courses at primary and secondary schools should be overhauled. Interestingly and yet unfortunately the frequency of SCD among children of parents with high SES [20%] was only slightly lower compared with those of low SES [26%], which leaves the question, are educational materials about SCD presented in the curriculum in a way that can be assimilated and its knowledge translated to everyday use?

Yet it is important to note that this study was not conducted among neonates but those in age range of 3-17 years. SCD is a disorder in which 'under 5' mortality rate is high. The role of SES in rate of 'under 5' mortality rate among SCD pediatric patients is not clearly defined and whether it plays a role in lower frequency of SCD among those in low SES needs to be verified. According to Adigwe et al. [28] and Adigwe [29] the prevalence of SCD is 2-3% with adult prevalence of 0.05% in Nigeria. SCD is a significant contributor to Nigeria's 'under five' mortality figures. Yet there is no evidence that the survival rates of children of high SES are higher than those in low SES. Sickle cell disease is known to have a significant public health implication for Africa, as it is responsible for about 5% of under-five deaths in the continent and up to 16% in West Africa. It can also be inferred that there are more children in the high SES because the parents can afford the cost of treatment, leading to increase survival rate and the cause of high frequency among those outside low SES.

Giving credence on the possible impact of SES on survival rate is that there was a relationship between SES of SCD patients and rate of hospitalization, clinic attendance and fruit/vegetable consumption. The importance of fruits and vegetable in prevention of disease or related complications are well described in literature. VOC that was not related with SES was related with hospitalization rate and fruit/vegetable consumption but not clinic attendance. Meanwhile, statistical analysis of the data revealed that for HbSS and HbSC, there were similarities (i.e. no significant difference) in the distribution of parental SES (p= .654), rate of hospitalization (p= .054), fruit/vegetable consumption (p= .590), and clinic attendance (p= .226). The result of the study showed that SES influenced rate of hospi-

talization. SCD children in high SES had higher frequency of daily fruit/vegetable consumption rate, higher clinic attendance rate but lower rate of hospitalization compared with other levels of socioeconomic. This was supported by the fact that those with daily good dietary habit had low frequency of VOC, and low frequency of hospitalization. It is unfortunate, that a continent in which adults and children alike are already encumbered with a wide range of challenges from inadequate nutrition [30-32], child labour [33], child abuse, environmental contamination [34], infectious diseases [35], etc should have to put up with the menace of a preventable disease like SCA in the twenty-first century.

5. Conclusion

From the results of the study, one can only assume that many of the measures being adopted for the prevention of the disease mostly provided in the formal or informal settings have not been found adequate i.e. not yielding expected outcomes in preventing the occurrence of the disease among non-adult population. Aside the fact that the results revealed that the disease preventive measures are not adequate; they further supports the fact that large percentage of SCD children have been recently hospitalized and with equally high percentage presenting with one or more other markers of disease severity.

References

[1] Inusa BPD, Hsu LL, Kohli N, Patel A, Ominu-Evbota K, et al. Sickle Cell Disease-Genetics, Pathophysiology, Clinical Presentation and Treatment. Int J Neonatal Screen. 2019 May 7;5(2):20. https://doi.org/10.3390/ijns5020020.

[2] Elendu C, Amaechi DC, Alakwe-Ojimba CE, Elendu TC, Elendu RC, et al. Understanding Sickle cell disease: Causes, symptoms, and treatment options. Medicine (Baltimore). 2023 Sep 22;102(38):e35237. https://doi.org/10.1097/MD.0000000000035237.

[3] Nkya S, Mwita L, Mgaya J, Kumburu H., Zwetselaar M, et al. Identifying genetic variants and pathways associated with extreme levels of fetal hemoglobin in sickle cell disease in Tanzania. BMC Med Genet 202; 21, 125. https://doi.org/10.1186/s12881-020-01059-1.

[4] Alaka AA, Alaka OO, Iyanda AA. Zinc and Anthropometry in Sickle Cell Disease: Comparison between Two Genotypes (SS and SC Hemoglobinopathies). J Integrated Health Sci 2022;10(2): 60-66. | https://doi.org/10.4103/jihs.jihs_6_22.

[5] Alaka AA, Alaka OO, Iyanda AA. Nitric oxide and zinc levels in sickle cell hemoglobinopathies: a relationship with the markers of disease severity. Pomeranian J Life Sci [S.l.], v. 69, n. 1, mar. 2023. ISSN 2450-4637. Available at: <https://ojs.pum.edu.pl/pomjlifesci/article/view/887>. Date accessed: 29 June 2023.

[6] Iragbogie IA, Maimuna YO, Hayatu A, Dalhat AS, Musa IK. Clinical profile of paediatric sickle cell disease at a reference hospital in North– eastern Nigeria. Niger J Paediatr 2021; 48 (2):74 – 81. https://doi.org/10.4314/njp.v48i2.3.

[7] Rab MAE, van Oirschot BA, Bos J, Merkx TH, van Wesel ACW, et al. Rapid and reproducible characterization of sickling during automated deoxygenation in sickle cell disease patients. Am J Hematol. 2019 May;94(5):575-584. https://doi.org/10.1002/ajh.25443.

[8] Eaton WA. Hemoglobin S polymerization and sickle cell disease: A retrospective on the occasion of the 70th anniversary of Pauling's Science paper. Am J Hematol. 2020 Feb;95(2):205-211. https://doi.org/10.1002/ajh.25687.

[9] Suhail M. Biophysical chemistry behind sickle cell anemia and the mechanism of voxelotor action. Sci Rep 14, 1861 (2024). https://doi.org/10.1038/s41598-024-52476-8.

[10] Quinn CT. Clinical severity in sickle cell disease: the challenges of definition and prognostication. Experimental Biology and Medicine 2016; 241: 679–688. https://doi.org/10.1177/1535370216640385.

[11] Jang T, Poplawska M, Cimpeanu E, Mo G, Dutta D, et al. Vaso-occlusive crisis in sickle cell disease: a vicious cycle of secondary events. J Transl Med 19, 397 (2021). https://doi.org/10.1186/s12967-021-03074-z.

[12] Odunvbun ME, Okolo AA, Rahimy CM. Newborn screening for sickle cell disease in a Nigerian hospital. Public Health 2008; 122:1111. https://doi.org/10.1016/j.puhe.2008.01.008.

[13] Anetor JI, Igharo OG, Anetor GO, Nwobi L, Iyanda AA. The Zamfara lead poisoning episode in Nigeria: an indication for children's environmental toxicology and micronutrient centre. Toxicology Digest. 2016;1: 23-33.

[14] Iyanda AA. Serum heavy metal levels in teenagers currently or formerly employed as gas station attendants. Bangladesh J Med Sci. 2018;17(2): 224-229. https://doi.org/10.3329/bjms.v17i2.35875.

[15] Oyedeji GA. Socio-economic and cultural background of hospitalized children in llesha. Nigeria J Paed 1985;12:111–117.

[16] Snyder AB, Lakshmanan S, Hulihan MM, Hulihan MM, Paulukonis ST et al. Surveillance for Sickle Cell Disease — Sickle Cell Data Collection Program, Two States, 2004–2018. MMWR Surveill Summ 2022;71(No. SS-9):1–18. https://doi.org/10.15585/mmwr.ss7109a1.

[17] Ajeigbe KA, Adejumo O, OwojuyigbeT, Ayinbuomwan E, Okesina B, Disease severity and renal function among sickle cell anaemia patients in a tertiary hospital, South-south, Nigeria: a cross sectional study . Malawi Med J. 2023; 35 (1); 9-14 March 2023 https://doi.org/10.4314/mmj.v35i1.3.

[18] Antwi-Boasiako C, Dankwah GB, Aryee R, Hayfron-Benjamin C, Aboagye G, et al. Correlation of lipid peroxidation and nitric oxide metabolites, trace elements, and antioxidant enzymes in patients with sickle cell disease. J Clin Lab Anal. 2020 Jul;34(7):e23294. https://doi.org/10.1002/jcla.23294.

[19] Vona R, Sposi NM, Lorenza Mattia L, Gambardella L, Straface E, et al. Sickle Cell Disease: Role of Oxidative Stress and Antioxidant Therapy. Antioxidants, 2021; 10, 2: 296. https://doi.org/10.3390/antiox10020296.

[20] Lin G, Field JJ, Yu JC, Ken R, Neuberg D, et al. NF-κB is activated in CD4+ iNKT cells by sickle cell disease and mediates rapid induction of adenosine A2A receptors. PLoS One. 2013 Oct 4;8(10):e74664. https://doi.org/10.1371/journal.pone.0074664.

[21] Das I, Mishra H, Khodiar PK, Patra PK. Identification of therapeutic targets for inflammation in sickle cell disease (SCD) among Indian patients using gene expression data analysis. Bioinformation. 2018 Jul 31;14(7):408-413. https://doi.org/10.6026/97320630014408.

[22] Mussbacher M, Salzmann M, Brostjan C, Hoesel B, Schoergenhofer C, et al. Cell Type-Specific Roles of NF-κB Linking Inflammation and Thrombosis. Front Immunol. 2019 Feb 4;10:85. https://doi.org/10.3389/fimmu.2019.00085.

[23] Belcher JD, Chen C, Nguyen J. The fucosylation inhibitor, 2-fluorofucose, inhibits vaso-occlusion, leukocyteendothelium interactions and NF-kB activation in transgenic sickle mice. PLoS One. 2015; 10(2):e0117772. https://doi.org/10.1371/journal.pone.0117772.

[24] Matte A, Zorzi F, Mazzi F, Federti E, Olivieri O, et al. New Therapeutic Options for the Treatment of Sickle Cell Disease. Mediterr J Hematol Infect Dis. 2019 Jan 1;11(1):e2019002. https://doi.org/10.4084/mjhid.2019.002.

[25] Matte A, Recchiuti A, Federti E, Koehl B, Mintz T, et al. Resolution of sickle cell disease-associated inflammation and tissue damage with 17R-resolvin D1. Blood. 2019 Jan 17;133(3):252-265. https://doi.org/10.1182/blood-2018-07-865378.

[26] Matte A, Cappellini MD, Iolascon, A, Enrica F, Franceschi LD. Emerging drugs in randomized controlled trials for sickle cell disease: are we on the brink of a new era in research and treatment?, Expert Opinion on Investigational Drugs. 2020;29:1, 23-31, https://doi.org/10.1080/13543784.2020.1703947.

[27] Ansari J, Gavins FNE. Ischemia-Reperfusion Injury in Sickle Cell Disease: From Basics to Therapeutics. Am J Pathol. 2019 Apr;189(4):706-718. https://doi.org/10.1016/j.ajpath.2018.12.012.

[28] Adigwe OP, Onavbavba G, Onoja SO. Impact of Sickle Cell Disease on Affected Individuals in Nigeria: A Critical Review. Int J Gen Med. 2023;16:3503-3515 https://doi.org/10.2147/IJGM.S410015.

[29] Adigwe OP. Knowledge and awareness of sickle cell disease: a cross sectional study amongst unmarried adults in Nigeria's capital city. J Community Genet. 2022; 13:579–585. https://doi.org/10.1007/s12687-022-00607-x.
[30] John C, Poh BK, Jalaludin MY, Michael G, Adedeji I, et al. Exploring disparities in malnutrition among under-five children in Nigeria and potential solutions: a scoping review. Front Nutr. 2024 Jan 5;10:1279130. https://doi.org/10.3389/fnut.2023.1279130.
[31] Abdullahi SU, Gambo S, Murtala HA, Kabir H, Shamsu KA, et al. Feasibility trial for the management of severe acute malnutrition in older children with sickle cell anemia in Nigeria. Blood Adv. 2023 Oct 24;7(20):6024-6034. https://doi.org/10.1182/bloodadvances.2023010789.
[32] Iyanda AA. Serum elements status of androgenetic alopecia subjects exposed to cigarette smoke or alcohol. Journal of Emerging Trends in Engineering and Applied Sciences. 2012; 3(4): 702-707. United Kingdom. http://www.jeteas.scholarlinkresearch.com
[33] Iyanda AA. Serum vitamin levels in different categories of androgenetic alopecia subjects. Scientificreports 2012; 1: 137. https://doi.org/10.4172/scientificreports.137.
[34] Anetor JI, Iyanda AA, Akinseye I, Anetor GO. Strengthening analytical capability in micronutrients: A prophylactic approach to DNA repair defects, genome instability and carcinogenesis in developing countries. 5th FESTEM, Congress, Avignon, France; 2013; May 22nd -24th, 2013.
[35] He Z, Bishwajit G, Zou D, Yaya S, Cheng Z, et al. Burden of Common Childhood Diseases in Relation to Improved Water, Sanitation, and Hygiene (WASH) among Nigerian Children. Int J Environ Res Public Health 2018, 15, 1241. https://doi.org/10.3390/ijerph15061241.