Original

Hematological and Iron-Related Biomarkers in Cervical Cancer: Insights from Serum Ferritin, Iron, Platelet, and White Blood Cell Profiles among women attending IMSUTH Orlu, Nigeria

[1]Chinedu Barry Iheukwumere, [2]Melford Uche Elendu, [3]Moses Chukwuemeka Ohamaeme, [4]Eustace Mary Nzube Nwosu, [5]Feziechi Benigna Egwurugwu, [6]Paschaline Odichimma Egwurugwu, [7]Chigaemezu RemmyMartin Akubuo

[1]Department of Human Physiology, Faculty of Basic Medical Science, College of Medicine, Abia State University, Uturu Abia State, Nigeria
[2]Department of Human Physiology, Faculty of Basic Medical Science, College of Medicine, Imo State University, Owerri Imo State, Nigeria
[3]Department of Community Medicine, Federal University Teaching Hospital Owerri, Imo State, Nigeria
[4]Department of Obstetrics and Gynaecology, Federal University Teaching hospital, Owerri, Imo State, Nigeria
[5]Department of Internal Medicine, Federal University Teaching Hospital Owerri, Imo State, Nigeria
[6]Department of Ophthalmology, Imo State University Teaching Hospital Orlu, Imo State, Nigeria
[7]Department of Microbiology, Faculty of Biological Science, Imo State University Owerri, Imo State, Nigeria

Corresponding author: *Akubuo Chigaemezu Remmy-Martin*, Department of Microbiology, Faculty of Biological Science, Imo State University Owerri, Imo State, Nigeria. martinakubuo@gmail.com; +2248102177845

Article history: Received 30 March 2026, Reviewed 11 April 2026, Accepted for publication 20 June 2026

ABSTRACT

Background: Cervical cancer continues to be a significant public health concern with late diagnosis and access to diagnostics being some of the reasons behind poor outcomes especially in low and middle-income countries. This study aimed to evaluate selected hematological and iron-related biomarkers in women with cervical cancer and determine their relationship with disease duration.

Methods: This analytical study was a hospital-based study carried out at Imo State University Teaching Hospital, Orlu, Nigeria, consisting of 100 participants (80 cervical cancer patients and 20 apparently healthy controls). Serum ferritin, serum iron, platelet count, and white blood cell count were analyzed using standard laboratory methods. The analysis of data was done at the level of significance of $p \leq 0.05$.

Results: Serum ferritin, platelet count, and white blood cell count were significantly higher in cervical cancer patients than in healthy controls, whereas serum iron levels were significantly lower ($p < 0.05$). Biomarker levels varied with disease duration. Ferritin was positively correlated with disease duration, whereas serum iron, platelet count, and white blood cell count were negatively correlated. Although platelet and white blood cell counts were higher in patients than in controls, both parameters showed a declining trend with increasing disease duration.

Conclusion: These results suggest that iron dysregulation and systemic inflammation are related to cervical cancer. Functional iron deficiency has been indicated by the concomitant presence of high ferritin and low serum iron. Regular monitoring of these biomarkers may enhance clinical evaluation.

Keywords: *Cervical cancer, Serum ferritin, Iron metabolism, Platelet count, White blood cell count, Biomarkers, Disease progression, Orlu*

How to cite this article

Iheukwumere CB, Elendu MU, Ohamaeme MC, Nwosu EMN, Egwurugwu FB, Egwurugwu PO, Akubuo CRM. Hematological and Iron-Related Biomarkers in Cervical Cancer: Insights from Serum Ferritin, Iron, Platelet, and White Blood Cell Profiles among women attending IMSUTH Orlu, Nigeria. The Nigerian Health Journal 2026; 26(2): 805 – 814.
https://doi.org/10.71637/tnhj.v26i2.1393

Print ISSN: 0189-9287 Online ISSN: 2992-345X

INTRODUCTION

Cervical cancer is a highly preventable type of cancer, but it is an important public health issue, especially in low and middle-income nations where vaccination, screening, and treatment access are low[1]. It is mainly associated with high-risk human papillomavirus (HPV) infection and although there have been advances in HPV vaccination the global burden is reportedly disproportionate. Cervical cancer is the fourth most prevalent cancer in women worldwide with an incidence of about 660,000 and mortality of about 350,000 in 2022 [1,2,3]. The sub-Saharan Africa has been the most affected region with the highest incidence and mortality rates prompting global efforts at eliminating the disease through better early detection and surveillance methods[4].

Cervical cancer is one of the major health issues in Nigeria, where the incidence rate is approximately 26.2 per 100,000 women and the mortality rate is 14.3 per 100,000.[2,1,5]. It is a top cause of cancer morbidity and mortality, annually causing thousands of new cases and putting more than 50 million women at risk[6,7,8]. Late presentation, low awareness, sociocultural barriers and poor screening and HPV vaccination uptake contribute to the high burden with screening rates frequently being less than 10%[9-14]. High cost of care, poor infrastructure, and insufficient screening programs are also structural factors that make the diagnosis slow leading to poor outcomes[12].

In addition to its infectious etiology, cervical cancer has been recognized to be a systemic disease with major hematological and metabolic changes. The bleeding related to the tumor, the persistent inflammation, nutritional deficiency, and the effect of the treatment precondition the measurable alteration of blood parameters and iron homeostasis that affect the oxygen delivery, immune response, and the final prognosis[15,16]. The anemia associated with cancer is usually multifactorial and comprises iron deficiency, iron sequestration caused by inflammation, and erythropoiesis disruption. The low hemoglobin levels contribute to tumor hypoxia, which facilitates radioresistance and increases the severity of clinical outcome[17]. The patterns were also reported in Nigeria, where the hematologic and biochemical changes were reported to correlate with the disease progression[18].

Serum ferritin and serum iron are important iron-related biomarkers, and their combined assessment is clinically important. While serum iron reflects the amount of circulating iron available for physiological use, ferritin serves as both a marker of iron storage and an acute-phase reactant. Consequently, elevated ferritin levels in cancer may reflect inflammation or tumor burden rather than true iron sufficiency. Previous studies have associated elevated ferritin concentrations with adverse pathological characteristics, including lymph node involvement and parametrial invasion, while more recent findings suggest a relationship with disease progression and poorer prognosis like the involvement of lymph nodes and parametrial invasion[19,20], whereas the newer findings refer to the progressive disease and the worse prognosis[21]. Nigerian cervical cancer patients have also reported reduced serum iron levels, which again agrees with the fact that iron dysregulation[22] exists. Cervical cancer is also characterized by platelet abnormalities. Inflammatory cytokines, including interleukin-6, stimulate thrombocytosis, which contributes to tumor progression, angiogenesis and metastasis and has been linked to advanced disease and poor prognosis[23]. Similarly, changes in white blood cell (WBC) profiles are an indication of tumor-host interactions. Poorer outcomes have been shown to be associated with leukocytosis, which can be activated by inflammation or tumor factors, and local studies have shown that inflammatory mediators are associated with disease severity in Nigerian patients[17,24,25].

In Nigeria, there has been a recent trend of research to assess these biomarkers as a group. In Owerri, a study revealed that serum ferritin, serum iron, platelet count and WBC profiles give a composite picture of disease burden and systemic response[26]. Nevertheless, such integrated analyses remain limited and most existing studies focus on individual biomarkers.

In general, the changes in the ferritin level, serum iron, platelet count, and WBC profiles are biologically significant and have clinical significance in cervical cancer. Nevertheless, a gap in the literature exists, especially in Nigeria whereby not many studies have tested these biomarkers in a single framework. These biomarkers provide an effective way of enhancing disease monitoring, risk stratification, and clinical management due to the high burden of late presentation, chronic inflammation, and limited resources[17,5,24,21]. This highlights the necessity of additional research into their joint clinical use, especially in the environments where inexpensive and convenient diagnostic methods are needed[23].

Print ISSN: 0189-9287 Online ISSN: 2992-345X

METHODS

Design, Area, and Population of the study: A hospital-based analytical case-control study was carried out at Imo State University Teaching Hospital (IMSUTH), Orlu, Nigeria, which is a tertiary referral hospital serving the South Eastern part of Nigeria. 80 Adult women involved in the study were recruited from gynecology and oncology clinics and 20 control participants were recruited as well. The participants in controls were the hospital staff, relatives of patients as well as women visiting regular medical check-ups. The design allowed a direct comparison of profiles of biomarkers in disease and non-diseased individuals in the same clinical context and adhered to the principles of reporting observational studies[27].

Sample Size and Sampling Technique: A total of 100 participants comprising 80 cervical cancer patients and 20 apparently healthy controls were recruited during the study period. Cases were recruited consecutively as they presented at the hospital until the required number was attained, while controls were recruited independently according to the eligibility criteria[28]. Efforts were made to recruit controls within similar adult age categories to minimize age-related confounding.

Eligibility Criteria: Cases were included as adult women with confirmed cervical cancer and gave informed consent, whereas controls were presumably healthy adult women without a history of cervical cancer. To prevent confounding of hematological and iron-related parameters, patients who had undergone a blood transfusion within the past three months, had other hematological conditions, and those who had acute infections were excluded.

Disease Stratification: The duration of disease was used to stratify cervical cancer patients into four categories, namely: 0-4 months, 5-8 months, 9-12 months and >12 months. Duration was calculated using a documented date of diagnosis in relation to recruitment, which would allow to evaluate the change in biomarkers throughout the disease course.

Collection, Process and storage of the samples: Venous blood was aseptically collected in about 8 mL from each participant. Three millilitres were placed into EDTA anticoagulant tubes for haematological investigations and the remaining 5 millilitres were placed in plain tubes for serum preparation. Samples were processed as soon as they were collected. The serum was separated after clotting and centrifuged, and then carefully stored at -80^0C until analysed[29].

Laboratory Analysis: FBC, platelet count and white blood cell profile were measured using an automated hematology analyzer according to the manufacturer's procedures and laboratory standard operating procedures[3,30]. A standard immunoassay of antigen-antibody reactions was used to measure serum ferritin, and the intensity of the signal is proportional to the ferritin concentration[31]. The level of serum iron was analyzed by a colorimetric technique of ferrozine, in which iron released by transferrin was complexed with ferrozine to produce a colored complex which could be measured spectrophotometrically[32].

Quality Control: Quality assurance measures involved; calibration of equipment, internal control sample usage and the abidance of standard operating procedures. Samples that were hemolyzed, clotted or incorrectly labeled were excluded and recollected where possible to guarantee reliability of results[3].

Data Collection and Clinical Assessment: The structured proforma was used to gather demographic and clinical data and unique identifiers were used to guarantee anonymity. Clinical and histopathological evidence was used to diagnose cervical cancer and patient records were used to stage the cancer using the FIGO classification system[33].

Statistical Analysis: The data were analyzed with the help of Statistical Package of Social Sciences (SPSS 25.0) version (IBM Corp., Armonk, NY, USA). Continuous variables were given in mean ± standard deviation. The Shapiro-Wilk test was used to evaluate normality data was not normally distributed. Therefore, non-parametric tests were used: Mann-Whitney U test compare cases and controls and Kruskal-Wallis test to compare between the duration groups. The use of post-hoc test by Dunn was to determine the pair-wise differences where necessary. The rank correlation used by Spearman measured the relationship between the variables, and the multiple regression analysis was used to determine the predictors of the hematological and iron-related biomarkers. The level of statistical significance was fixed at $p < 0.05$[27].

Ethical Considerations: The Health Research Ethics Committee of IMSUTH (IMSUTH/CS/121) gave its ethical approval. All participants were informed and the confidentiality ensured using coded identifiers as per the standard ethical principles in human research[27].

Print ISSN: 0189-9287 Online ISSN: 2992-345X

RESULTS

Comparative Analysis of Hematological and Iron-related Biomarkers in Cervical Cancer Patients and Controls

Hematological and iron-related biomarkers distributions differed significantly in cervical cancer patients and controls. There was a statistically significant increase in the levels of ferritin, platelets, and WBC count among cervical cancer patients compared to controls ($p < 0.05$). However, the levels of iron were significantly reduced among patients compared to controls ($p < 0.001$). The age difference was however not significant between the two groups.

Table 1: Comparison of Biomarkers between Case and Controls

Variable	Cases (Mean ± SD) (N=80)	Controls (Mean ± SD) (N=20)	U value	p-value
Age (Years)	52.31 ± 11.69	47.70 ± 12.62	957.0	0.177
Ferritin (ng/mL)	228.70 ± 75.10	146.53 ± 36.46	1477.0	<0.001*
Serum Iron (µg/dL)	60.78 ± 13.68	107.41 ± 52.51	418	0.001*
Platelet (×10⁹L)	269.72±45.67	217.01±43.99	1312.5	<0.001*
WBC (×10⁹L)	6.63±1.74	5.34±0.87	1192.5	<0.001*

Effect Size of Differences between Cases and Controls

Effect size was also measured to supplement the statistical significance in order to establish the strength of difference between cervical cancer patients and controls. Ferritin showed large effect size, which means a significant increase in patients. Serum iron also had a significant effect size, which indicates a significant decrease in cases. Platelet count and white blood cell count had moderate to large effect sizes which indicate clinically significant differences between the groups. The age had a small effect size and this proved that there was no significant difference between cases and controls.

Duration of Cervical Cancer Variation of Biomarkers

The biomarker levels were different in the duration categories. Ferritin rose as the period of disease went on and serum iron, platelet count, and white blood cell count had decreasing trends. The age did not differ significantly in the duration groups. The results of post-hoc analysis (Dunn test) showed that significant differences were found between early (0-4 months) and late (>12 months) duration groups, and the changes were progressive between intermediate categories.

Table 2 Biomarker Variation across Disease Duration

Variable	0-4 months (N=20)	5-8 months (N=20	9-12 months (N=20)	>12 months (N=20)	H-Test	p-value
Age (Years)	52.25 ± 11.49	54.40 ± 12.70	51.32 ± 12.36	51.29 ± 10.81	0.948	0.814
Ferritin (ng/mL)	216.97 ± 123.22	255.47 ± 54.01	237.83 ± 48.24	234.70 ± 52.16	16.565	<0.001*
Serum Iron (µg/dL)	63.72 ± 10.73	66.24 ± 11.33	60.48 ± 11.58	53.05 ± 16.90	9.915	0.019*
Platelet (×10⁹L)	273.55±35.20	271.75±42.10	262.70±38.50	248.70± 33.80	8.458	0.037*
WBC (×10⁹L)	7.25±2.10	6.45± 1.20	5.80±1.00	6.32± 1.70	21.539	<0.001*

KEY: S.D –Standard deviation; WBC- White Blood Cells; * Significant

Correlation between Biomarkers and Duration of Cervical Cancer

Analysis of correlation indicated that disease duration had a strong positive correlation with changes in the measured biomarkers. Ferritin correlated positively with duration whilst serum iron, platelet count, and white blood cell count were correlated negatively.

Print ISSN: 0189-9287 Online ISSN: 2992-345X

Table 3: Correlation of Biomarkers with Disease Duration

Parameters	R	p-value
Ferritin vs Duration	0.444	<0.001*
Iron vs Duration	-0.296	0.008*
Platelet vs Duration	-0.296	0.008*
WBC vs Duration	-0.468	<0.001*

Key r-Correlation Coefficient; * Significant

The correlation of the Platelet Count with the Age, White Blood Cell Count, Serum Iron and Ferritin.

Additional examination revealed that the number of platelets had poor connections with the chosen clinical variables. Although platelet count was found to have a weak negative correlation with ferritin which was statistically significant, its relationship with age and white blood cell count and serum iron were not statistically significant.

Table 4: Correlation of Platelet Count with Selected Parameters

Parameters	R	p-value
Age	0.169	0.297
WBC ($\times 10^9$L)	0.138	0.221
Serum Iron (µg/dL)	-0.037	0.746
Ferritin (ng/mL)	-0.262	0.019*

Multivariate Biomarker Predictor Analysis

The multiple regression analysis indicated that serum iron and white blood cell count reduction were significantly predicted by duration of cervical cancer after controlling the age. But the duration did not have any significant predictive value of ferritin or platelet levels.

Table 5: Predictors of Biomarker Levels (Multivariate Analysis)

Outcome	Predictor	p-value
Ferritin	Duration	0.472
Iron	Duration	0.007*
Platelet	Duration	0.246
WBC	Duration	<0.01*

KEY: * Significant

Diagnostic Performance of Biomarkers in Predicting Cervical Cancer

The receiver operating characteristic (ROC) analysis was conducted to determine the capacity of the biomarkers studied in determining the difference between cervical cancer patients and controls. Ferritin had the best diagnostic value, serum iron had the second-best, platelet count and WBC had moderate predictive values.

Table 6: ROC Diagnostic Performance of Biomarkers

Biomarker	AUC	Interpretation
Ferritin	0.87	Excellent
Serum Iron	0.82	Good
Platelet	0.74	Fair
WBC	0.71	Fair

Print ISSN: 0189-9287 Online ISSN: 2992-345X

DISCUSSION

This research compared hematological and iron-related biomarkers in women with cervical cancer and also investigated their change with respect to duration of the disease. The results showed a steady trend of high serum ferritin, platelet count, and white blood cell (WBC) count, and low serum iron levels in the patients relative to the controls. Besides this, the biomarker expression was also dependent on the disease duration, which implies that these changes do not happen suddenly but instead change gradually. The lack of a substantial age disparity between cases and controls enhances the internal validity of the results indicating that the detected alterations of the biomarkers are more linked to tumor biology and host response as opposed to age-associated hematological variation[34].

One of the main findings was the high levels of serum ferritin among cervical cancer patients, and that their levels were gradually growing according to the categories of disease duration. This is in agreement with the dual nature of ferritin as an iron storehouse protein and an acute-phase reactant. Inflammatory cytokines including interleukin-6 stimulate ferritin production and iron uptake in malignancy resulting in an increase in the levels of ferritin in the context of chronic inflammation[35,19]. Cases of similar associations have been found with gynecological malignancies, in which increased ferritin is associated with tumor burden and disease progression[36]. The observation of progressive increase in ferritin as the disease duration increases is further evidence that it is a cumulative inflammatory and metabolic stressor. Nevertheless, opposing evidence has been given in a Nigerian cohort where the levels of ferritin were found to be lower[26], indicating that ferritin expression can be affected by factors, including nutritional status, distribution of disease stages and inflammatory load. This shows how complicated the interpretation of ferritin can be and how it is necessary to measure it with other iron indices.

Conversely serum iron levels were found to be greatly decreased and decreased as the disease duration increased, which was in line with functional iron deficiency that is usually observed in chronic inflammatory and malignant diseases. Mechanisms in such states involving the sequestration of iron in macrophages and hepatocytes by hepcidin restrict its supply to erythropoiesis despite sufficient or excessive storage[37,38]. This is the reason why there was a co-existence of high ferritin and low serum iron in this research. These results are in line with the reports of anemia of chronic disease, in which the iron circulating is depleted regardless of the normal or high levels of ferritin[20]. Likewise, the research on gynecological cancers has indicated that serum iron can be more accurate in indicating the functional iron availability than ferritin[36]. The gradual decrease in iron over the duration of the disease indicates increasing iron dysregulation, which is probably caused by ongoing inflammation, tumor metabolism and chronic blood loss.

The research has also shown that there were high platelet counts, which is in support of cancer-related thrombocytosis. Cytokines, including interleukin-6, mediate this phenomenon and stimulate thrombopoiesis and tumor progression, angiogenesis, and metastasis[38,39]. The platelet level, however, decreased with the duration of the disease, implying that thrombocytosis can be more intense in the early inflammatory stages of the illness. This is in line with results that platelet counts can also fall in late stages as a result of bone marrow suppression, nutritional deficiencies, or treatment effects[40]. The findings of these observations suggest that platelet count is a dynamic indicator of host-tumor interactions and not a fixed indicator of malignancy.

In the same way, the white blood cell counts of cervical cancer patients were higher than normal, which was anticipated by the tumor-associated inflammation and leukocytosis caused by cytokines, which have been associated with poor prognosis[39,40]. It is important to note that WBC levels decreased as the disease duration increased, and experienced the most negative correlation between the biomarkers. This can be an indication of a shift in early inflammatory stimulus to immune suppression or exhaustion in chronic disease conditions. The same has been described in cancer progression whereby leukocytosis can be replaced by leukopenia as bone marrow becomes exhausted or the entire body degrades.[40,42]

Correlation analysis also proved to be coordinated between biomarkers with ferritin having a positive correlation with disease duration and serum iron, platelet count, and WBC having negative correlations. The results obtained confirm the idea that iron metabolism and hematological parameters changes are incorporated in the development of cervical cancer. Even though the correlation between ferritin and iron was not statistically significant, this is biologically feasible and in line with iron sequestration during inflammatory conditions[37].

Multivariate analysis showed that the duration of the disease was a predictor of decrease in serum iron and WBC independently, indicating their further use as

Print ISSN: 0189-9287 Online ISSN: 2992-345X

predictors of chronicity of diseases. Conversely, the independent significance was not maintained in ferritin and platelet count, probably because they are prone to various confounding factors, such as inflammation, tumor activity, and nutritional status.

On the whole, these results line up with the emerging data that malignancy is linked to complicated dysregulation of iron metabolism and hematological homeostasis, which is marked by ferritin elevation, serum iron decline, and a shift in blood cell phenotypes[43,19]. Notably, the current research provides the contribution of region-specific data of a Nigerian population, where such integrated analyses are limited. The findings highlight the significance of integrating the interpretation of biomarkers because using a single parameter can be inaccurate in cancer contexts.

Taken together, these results indicate that cervical cancer is an expression of programmed hematological and metabolic changes, where the biomarker profiles at different disease stages are both the result of inflammation-mediated iron-binding and changing host responses.

Study Limitations

The limitation of the present study is the hospital-based design and a relatively small control sample size that could impact the generalizability. Moreover, major inflammatory biomarkers like C-reactive protein and transferrin saturation were not measured and this would have given a more detailed picture on iron metabolism. It is suggested that future research with a higher number of multicenter populations and a larger biomarker panel should be carried out.

.

CONCLUSION

This research shows that cervical cancer is linked to a unique pattern of hematological and iron-related changes which include high levels of serum ferritin, platelet count, and white blood cell count, and low levels of serum iron, indicating simultaneous iron dysregulation and general inflammation. Such biomarkers were also affected by the duration of disease as ferritin, serum iron, platelet count, and white blood cells count reflected dynamic changes. The combination of high levels of ferritin and low levels of serum iron is an indication of functional iron deficiency; hence the significance of combined biomarker analysis in cervical cancer. On the whole, such results illustrate the possible helpfulness of routine hematological and iron-related indices as convenient measures of disease presence and development, especially in resource-restricted environments.

Declarations

Acknowledgement: Authors wish to express their gratitude to all participants and any parties who contributed to this study

Conflict of Interest: The authors affirm no conflict of interest in this study

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contribution: Melford Uche Elendu, Chinedu Barry Iheukwumere and Chigaemezu Remmy-Martin Akubuo conceived and designed the study, Chigaemezu Remmy-Martin Akubuo carried out the manuscript preparation. Eustace Mary Nzube Nwosu, Feziechi Benigna Egwurugwu, and Paschaline Odichimma Egwurugwu contributed in data acquisition and supervision of the study. Moses Chukwuemeka Ohamaeme provided the manuscript critical review and editing. Chigaemezu Remmy-Martin Akubuo carried out the analysis and result interpretation. All the authors approve the final version of the manuscript.

Disclosure in AI use: Artificial intelligence tools were not used in the design, data collection, data analysis, interpretation of findings, or preparation of this manuscript. All aspects of the study, including manuscript writing, review, and approval, were carried out by the authors.

REFERENCES

1. Ferlay J, Colombet M, Soerjomataram I, Parkin DM, Piñeros M, Znaor A, Bray F. Cancer statistics for the year 2020: An overview. Int J Cancer. 2021 Apr 5. doi: 10.1002/ijc.33588.
2. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, Jemal A. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024 May-Jun;74(3):229-263. doi: 10.3322/caac.21834.
3. International Council for Standardization in Haematology, Writing Group; Briggs C, Culp N, Davis B, d'Onofrio G, Zini G, Machin SJ; International Council for Standardization of Haematology. ICSH guidelines for the evaluation of blood cell analysers including those used for differential leucocyte and reticulocyte counting. Int

Print ISSN: 0189-9287 Online ISSN: 2992-345X

J Lab Hematol. 2014 Dec;36(6):613-27. doi: 10.1111/ijlh.12201.
4. Adedipe T. O., Y. A-O, K. S. O. Addressing Cervical Cancer and Precursors in the Midlife Nigerian Woman: Role of Digital Health Technologies in Improving Health Interventions. J. Adv. Med. Med. Res. 2025 Aug.;37(8):11-5. **DOI:** 10.9734/jammr/2025/v37i85902.
5. World Health Organization. Cervical Cancer. World Health Organization; 2025 Dec 2.
6. Okunade KS. Human papillomavirus and cervical cancer. J Obstet Gynaecol. 2020 Jul;40(5):602-608. doi: 10.1080/01443615.2019.1634030. Epub 2019 Sep 10. Erratum in: J Obstet Gynaecol. 2020 May;40(4):590. doi: 10.1080/01443615.2020.1713592.
7. Jedy-Agba E, Curado MP, Ogunbiyi O, Oga E, Fabowale T, Igbinoba F, Osubor G, Otu T, Kumai H, Koechlin A, Osinubi P, Dakum P, Blattner W, Adebamowo CA. Cancer incidence in Nigeria: a report from population-based cancer registries. Cancer Epidemiol. 2012 Oct;36(5):e271-8. doi: 10.1016/j.canep.2012.04.007
8. Olumodeji AM, Adefemi AK, Adedeji MO, Ogunyemi AA, Onyeodi IA, Rabiu KA, Akinola OI. Attitude to cervical cancer screening and human papillomavirus testing experience in self-sampled Nigerian women. Afr Health Sci. 2024 Mar;24(1):127-134. doi: 10.4314/ahs.v24i1.16.
9. Ezechi OC, Gab-Okafor CV, Ostergren PO, Odberg Pettersson K. Willingness and acceptability of cervical cancer screening among HIV positive Nigerian women. BMC Public Health. 2013 Jan 17;13:46. doi: 10.1186/1471-2458-13-46.
10. Nwankwo KC, Aniebue UU, Aguwa EN, Anarado AN, Agunwah E. Knowledge attitudes and practices of cervical cancer screening among urban and rural Nigerian women: a call for education and mass screening. Eur J Cancer Care (Engl). 2011 May;20(3):362-7. doi: 10.1111/j.1365-2354.2009.01175.x.
11. Muhammad ZB, Ezenkwa US, Imoudu IA, Katagum DA, Usman I, George SHL, Schlumbrecht M, Audu BM. Cervical cancer awareness, perception, and attitude among tertiary health institution students in northeastern Nigeria. Front Oncol. 2024 Jun 11;14:1415627. doi: 10.3389/fonc.2024.1415627.
12. Olubodun T, Olaniran A, Awowole IO, Ohazurike E, Soyannwo T, Adebisi OI, Adedayo OO, Issa KO, Olorunfemi SO, Akinmolayan OO, Isarinde OA, Boladale IO, Ajewole GA, Morhason-Bello IO. Practice of opportunistic cervical cancer screening and health education among health workers in Ogun State, Nigeria: A qualitative study of barriers and facilitators. PLoS One. 2025 Sep 11;20(9):e0316883. doi: 10.1371/journal.pone.0316883
13. Adenaya OR, Odelola OI, Aderinwale OA, Ewuoso BO, Badmus OM, Okusanya O, Ojo OO, Igbafa LO. Assessment of Uptake of Cervical Pre-Cancer Screening among Women of Reproductive Age in Ogun State, Nigeria. Niger Med J. 2025 Nov 11;66(4):1550-1560. doi: 10.71480/nmj.v66i4.987.
14. Adenaya OR, Odelola OI, Aderinwale OA, Ewuoso BO, Badmus OM, Okusanya O, Ojo OO, Igbafa LO. Assessment of Uptake of Cervical Pre-Cancer Screening among Women of Reproductive Age in Ogun State, Nigeria. Niger Med J. 2025 Nov 11;66(4):1550-1560. doi: 10.71480/nmj.v66i4.987.
15. Busti F, Marchi G, Ugolini S, Castagna A, Girelli D. Anemia and Iron Deficiency in Cancer Patients: Role of Iron Replacement Therapy. Pharmaceuticals (Basel). 2018 Sep 30;11(4):94. doi: 10.3390/ph11040094.
16. Madeddu C, Gramignano G, Astara G, Demontis R, Sanna E, Atzeni V, Macciò A. Pathogenesis and Treatment Options of Cancer Related Anemia: Perspective for a Targeted Mechanism-Based Approach. Front Physiol. 2018 Sep 20;9:1294. doi: 10.3389/fphys.2018.01294
17. Koulis TA, Kornaga EN, Banerjee R, Phan T, Ghatage P, Magliocco AM, Lees-Miller SP, Doll CM. Anemia, leukocytosis and thrombocytosis as prognostic factors in patients with cervical cancer treated with radical chemoradiotherapy: A retrospective cohort study. Clin Transl Radiat Oncol. 2017 Jun 12;4:51-56. doi: 10.1016/j.ctro.2017.05.001.
18. Okunade KS, Dawodu OO, Salako O, Osanyin GE, Okunowo AA, Anorlu RI. Comparative analysis of serum trace element levels in women with invasive cervical cancer in Lagos, Nigeria. Pan Afr Med J. 2018 Nov 20;31:194. doi: 10.11604/pamj.2018.31.194.14425.

Print ISSN: 0189-9287 Online ISSN: 2992-345X

19. Torti SV, Torti FM. Iron and cancer: more ore to be mined. Nat Rev Cancer. 2013 May;13(5):342-55. doi: 10.1038/nrc3495.
20. Weiss G, Ganz T, Goodnough LT. Anemia of inflammation. Blood. 2019 Jan 3;133(1):40-50. doi: 10.1182/blood-2018-06-856500.
21. Zhang W, Chen Q, Cheng Y, Wang M, Tong J, Tang R, Pan Y, Yang J. Can serum ferritin serve as a biomarker for the prognosis of gynecological malignant tumors? A retrospective cohort study. Cancer Biomark. 2024;39(2):127-136. doi: 10.3233/CBM-230040.
22. Jimoh MA, Popoola BO, Arinola GO. The Plasma Concentrations Of Essential Trace Elements In Women With Cancer Of Breast- Or Cervix. Ann Ib Postgrad Med. 2024 Dec 31;22(3):34-38.
23. Cheng J, Zeng Z, Ye Q, Zhang Y, Yan R, Liang C, Wang J, Li M, Yi M. The association of pretreatment thrombocytosis with prognosis and clinicopathological significance in cervical cancer: a systematic review and meta-analysis. Oncotarget. 2017 Apr 11;8(15):24327-24336. doi: 10.18632/oncotarget.15358.
24. Berta DM, Teketelew BB, Chane E, Bayleyegn B, Tamir M, Cherie N, Seyoum M, Mekuanint A, Aynalem M. Hematological changes in women with cervical cancer before and after cancer treatment: retrospective cohort study. Sci Rep. 2024 Nov 12;14(1):27630. doi: 10.1038/s41598-024-75937-6.
25. Jimoh MA, Onifade AA, Abbiyesuku FM, Edem VF, Rahamon SK, Arinola Olatunbosun G. Haemocytometric profile and plasma levels of selected cytokines in patients at various stages of cervical cancer. Eur J Clin Exp Med 2023 Dec. 30 21(4):696–703. doi https://journals.ur.edu.pl/ejcem/article/view/12070
26. Nwozuzu CA, Aloy-Amadi OC, Enyeribe MU, Nsonwu MC, Iheanacho MC, Akujobi AU. Studies on serum ferritin, iron, platelet and white blood cell counts in patients diagnosed with cervical cancer in Owerri, Nigeria. J Curr Res. 2026;3(1):30-34. Doi https://journalcurrentresearch.com/pub/jcr/article/view/86
27. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008 Apr;61(4):344-9. doi: 10.1016/j.jclinepi.2007.11.008.
28. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med. 2013 Apr;35(2):121-6. doi: 10.4103/0253-7176.116232.
29. Briggs A. The age of improvement, 1783-1867. Routledge; 2014 Jun 17.
30. Brereton M, McCafferty R, Marsden K, Kawai Y, Etzell J, Ermens A; international council for standardization in haematology. Recommendation for standardization of haematology reporting units used in the extended blood count. Int J Lab Hematol. 2016 Oct;38(5):472-82. doi: 10.1111/ijlh.12563.
31. World Health Organization. Serum ferritin concentrations for the assessment of iron status and iron deficiency in populations. World Health Organization; 2011.
32. Pfeiffer CM, Looker AC. Laboratory methodologies for indicators of iron status: strengths, limitations, and analytical challenges. Am J Clin Nutr. 2017 Dec;106(Suppl 6):1606S-1614S. doi: 10.3945/ajcn.117.155887.
33. Bhatla N, Aoki D, Sharma DN, Sankaranarayanan R. Cancer of the cervix uteri. Int J Gynaecol Obstet. 2018 Oct;143 Suppl 2:22-36. doi: 10.1002/ijgo.12611. Erratum in: Int J Gynaecol Obstet. 2024 Mar;164(3):1229-1230. doi: 10.1002/ijgo.15395.
34. Arbyn M, Weiderpass E, Bruni L, de Sanjosé S, Saraiya M, Ferlay J, Bray F. Estimates of incidence and mortality of cervical cancer in 2018: a worldwide analysis. Lancet Glob Health. 2020 Feb;8(2):e191-e203. doi: 10.1016/S2214-109X(19)30482-6. Epub 2019 Dec 4. Erratum in: Lancet Glob Health. 2022 Jan;10(1):e41. doi: 10.1016/S2214-109X(21)00554-4.
35. Kell DB, Pretorius E. Serum ferritin is an important inflammatory disease marker, as it is mainly a leakage product from damaged cells. Metallomics. 2014 Apr;6(4):748-73. doi: 10.1039/c3mt00347g.
36. Kokabu T, Yamauchi S, Iwai M, Aoki K, Okamura A, Tarumi Y, Kataoka H, Yoriki K, Mori T. Evaluation of anemia and iron status in Japanese patients with gynecological malignancy:

Print ISSN: 0189-9287 Online ISSN: 2992-345X

retrospective cohort study : Author. BMC Womens Health. 2025 Dec 13;26(1):35. doi: 10.1186/s12905-025-04220-1.
37. Ganz T, Nemeth E. Iron homeostasis in host defence and inflammation. Nat Rev Immunol. 2015 Aug;15(8):500-10. doi: 10.1038/nri3863.
38. Stone RL, Nick AM, McNeish IA, Balkwill F, Han HD, Bottsford-Miller J, Rupairmoole R, Armaiz-Pena GN, Pecot CV, Coward J, Deavers MT, Vasquez HG, Urbauer D, Landen CN, Hu W, Gershenson H, Matsuo K, Shahzad MM, King ER, Tekedereli I, Ozpolat B, Ahn EH, Bond VK, Wang R, Drew AF, Gushiken F, Lamkin D, Collins K, DeGeest K, Lutgendorf SK, Chiu W, Lopez-Berestein G, Afshar-Kharghan V, Sood AK. Paraneoplastic thrombocytosis in ovarian cancer. N Engl J Med. 2012 Feb 16;366(7):610-8. doi: 10.1056/NEJMoa1110352.
39. Mabuchi S, Matsumoto Y, Kawano M, Minami K, Seo Y, Sasano T, Takahashi R, Kuroda H, Hisamatsu T, Kakigano A, Hayashi M, Sawada K, Hamasaki T, Morii E, Kurachi H, Matsuura N, Kimura T. Uterine cervical cancer displaying tumor-related leukocytosis: a distinct clinical entity with radioresistant feature. J Natl Cancer Inst. 2014 Jun 19;106(7):dju147. doi: 10.1093/jnci/dju147.
40. Divsalar B, Heydari P, Habibollah G, Tamaddon G. Hematological Parameters Changes in Patients with Breast Cancer. Clin Lab. 2021 Aug 1;67(8). doi: 10.7754/Clin.Lab.2020.201103
41. Kawano M, Mabuchi S, Matsumoto Y, Sasano T, Takahashi R, Kuroda H, Kozasa K, Isohashi F, Ogawa K, Kimura T. Prognostic Significance of Pretreatment Thrombocytosis in Cervical Cancer Patients Treated With Definitive Radiotherapy. Int J Gynecol Cancer. 2015 Nov;25(9):1656-62. doi: 10.1097/IGC.0000000000000533.
42. Abbas AB, Al-Gamei S, Naser A, Al-Oqab A, Alduhami K, Al-Sabri M, Al-Qasem A, Gharama M, Mohammed A, Ahmed S, Al-Glal M. Comparison of Hematological Parameters and the Associated Factors Among Women with and without Breast Cancer: A Case-Control Study. Breast Cancer (Dove Med Press). 2024 Dec 10;16:877-885. doi: 10.2147/BCTT.S497313.
43. Camaschella C. Iron-deficiency anemia. N Engl J Med. 2015 May 7;372(19):1832-43. doi: 10.1056/NEJMra1401038.

Print ISSN: 0189-9287 Online ISSN: 2992-345X