



Research Article

Comparative Profile of HS-CRP, ESR, and Serum Protein Electrophoresis in Pelvic Inflammatory Disease, Rheumatoid Arthritis, and Pulmonary Tuberculosis

*David Jarafu¹, Sikiru Adetona Lawal², Lukman Olayinka Olatunbosun³, and Seidat Omolabake Hassan⁴

¹Cantonment Medical Center Sobi Barrack, Ilorin, Kwara State, Nigeria

²Department of Medical Laboratory Science, Faculty of Allied Health Sciences, Kwara State University, Malete, Kwara State, Nigeria

³Department of Hematology and Blood Transfusion, University of Ilorin Teaching Hospital, Ilorin, Kwara State, Nigeria

⁴Department of Histopathology, University of Ilorin Teaching Hospital, Ilorin, Kwara State, Nigeria

*Corresponding Author's email: jarafudavid@gmail.com; Phone: +2347038765493

ABSTRACT

High-sensitivity C-reactive protein (hs-CRP), erythrocyte sedimentation rate (ESR), and serum protein electrophoresis (SPEP) are widely available, low-cost inflammatory markers whose comparative behaviour across distinct inflammatory conditions is not well characterized in Nigeria. This cross-sectional study compared hs-CRP, ESR, and five SPEP fractions (albumin, α 1-, α 2-, β -, and γ -globulins) among 126 confirmed patients in Ilorin, Nigeria (42 each with pelvic inflammatory disease [PID], rheumatoid arthritis [RA], and pulmonary tuberculosis [PTB]), examining correlations among markers and with age, disease duration, and sex. All seven parameters differed significantly across groups (all $p < 0.0001$); hs-CRP was highest in PID and lowest in RA, whereas ESR was highest in PTB and lowest in RA. PTB patients had the lowest albumin and highest α 1- and α 2-globulins (an acute-phase pattern), while RA patients had the most pronounced γ -globulin elevation despite modest hs-CRP and ESR. hs-CRP and ESR correlated strongly within each group ($r = 0.77$ – 0.997 , all $p < 0.0001$) but only moderately when pooled ($r = 0.562$), because the groups occupied distinct regions of the marker plane; the same pooled-versus-within-group divergence occurred for age and disease duration. At conventional cut-offs, hs-CRP and ESR were concordant (both elevated) in all 126 patients, with no discordant results. hs-CRP, ESR, and SPEP fractions show distinct, disease-specific profiles across PID, RA, and PTB, reflecting each condition's inflammatory kinetics, and inter-marker and demographic correlations depend heavily on whether disease group is accounted for. These findings support interpreting inflammatory-marker relationships within groups, rather than pooling them, in comparative studies of this kind.

Keywords: Erythrocyte sedimentation rate; High-sensitivity C-reactive protein; Pelvic inflammatory disease; Pulmonary tuberculosis; Rheumatoid arthritis; Serum protein electrophoresis

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INTRODUCTION

Inflammation is the shared physiological response that underlies clinically disparate conditions ranging from acute bacterial infection to chronic autoimmune and granulomatous diseases, and a small set of acute-

phase measures, chiefly C-reactive protein (CRP) and the erythrocyte sedimentation rate (ESR), remain the most widely used laboratory windows onto that response in routine practice (Medzhitov, 2021). Hepatocytes synthesize CRP under interleukin-6-driven transcriptional control, which rises and falls

over hours to a few days, closely tracking the acute-phase stimulus (Sproston & Ashworth, 2018). The high-sensitivity assay (hs-CRP) extends the lower end of this measurement range and is now routinely available on automated chemistry platforms (Singh *et al.*, 2026). ESR, in contrast, is an indirect measure that depends on plasma concentrations of fibrinogen and immunoglobulins promoting erythrocyte rouleaux formation, changes more slowly than CRP, and is additionally influenced by red-cell number and morphology, age, and sex (Tishkowski & Zubair, 2026). Because the two markers respond on different time courses and to different upstream drivers, their concordance is imperfect even though both are conventionally treated as interchangeable acute-phase indices in clinical practice (Lapić *et al.*, 2020). Serum protein electrophoresis (SPEP) offers a complementary, pattern-based view of the same underlying process: albumin characteristically falls as a negative acute-phase reactant while α_1 , α_2 , and, in more chronic or immunologically active states, γ -globulin fractions rise, so the overall SPEP pattern can distinguish an acute inflammatory response from a more indolent, chronic, or immunoglobulin-driven one (O'Connell *et al.*, 2005).

Pelvic inflammatory disease (PID), rheumatoid arthritis (RA), and pulmonary tuberculosis (PTB) were selected for comparison here because they represent three pathophysiologically distinct causes of a systemic inflammatory response: PID is an acute-to-subacute polymicrobial infection of the female upper genital tract, typically diagnosed on a combination of pelvic examination findings and supportive laboratory and imaging criteria (Workowski *et al.*, 2021), and carries a substantial and, in recent global burden-of-disease modelling, rising burden that is disproportionately concentrated in low-resource, high-fertility settings including western sub-Saharan Africa (Chen *et al.*, 2026). The RA is a chronic, immune-mediated symmetric polyarthritis diagnosed by internationally standardized classification criteria (Aletaha *et al.*, 2010); community-based surveys in Nigeria have found its population prevalence to be very low relative to hospital-clinic caseloads, a discrepancy plausibly explained by under-recognition in primary care and the limited rheumatology workforce available across the region to confirm and refer suspected cases (Mody, 2017; Adelowo *et al.*, 2022). The PTB, meanwhile, remains a major infectious cause of chronic systemic inflammation in Nigeria with several new cases estimated annually and continued gaps between estimated and notified

cases despite recent programmatic gains (World Health Organization [WHO], 2025).

Since PID, RA, and PTB differ so markedly in tempo mechanism, and typical patient demography comparing hs-CRP, ESR, and SPEP fraction profiles across all three within a single population and laboratory context offers a way to characterize how these widely used, low-cost markers behave differently depending on the type of inflammatory process driving them, information that is directly relevant to how clinicians in a resource-limited setting should interpret any one of these tests in isolation. This study therefore compared hs-CRP, ESR, and SPEP fractions across confirmed PID, RA, and PTB patients on referral care in Ilorin, Nigeria, and examined the correlation structure linking these markers to one another and to patient age, disease duration, and sex, both overall and within each disease group.

MATERIALS AND METHODS

Study Design and Area

This was a hospital-based, cross-sectional, comparative study (Setia, 2016), conducted using biochemical and haematological data collected from patients with confirmed pelvic inflammatory disease (PID), rheumatoid arthritis (RA), or pulmonary tuberculosis (PTB) attending three referral facilities in Ilorin, Kwara State, Nigeria: Sobi Barracks Medical Centre, Sobi Special Hospital, and Kwara State University Teaching Hospital (KWASUTH).

Study Population

A total of 126 participants were included, 42 each with PID, RA, and PTB. Participants were recruited from patients with an established diagnosis of one of the three index conditions attending outpatient care during the study period; participants with overlapping diagnoses or with another active systemic inflammatory, infective, or malignant condition that could independently alter hs-CRP, ESR, or the SPEP pattern were excluded. Age, sex, and duration of the index illness (months since diagnosis) were recorded for each participant at the time of blood sampling.

Ethical Considerations

Ethical approval was sought from Kwara State Ministry of Health Ethical Review Committee, Ilorin (ERC/MOH/2026/06/761) and the study conducted was guided by the Nigerian National Code of Health Research Ethics and the Helsinki Declaration. Written informed consent was obtained from each participant prior to participation in the study.

Collection of Samples and Laboratory Analysis

Venous blood (5ml) was collected from each participant at enrolment. High-sensitivity C-reactive

protein was measured by immunoturbidimetric assay on an automated chemistry analyzer. Erythrocyte sedimentation rate was measured by the Westergren method. Serum protein electrophoresis was performed by agarose gel electrophoresis, with densitometric scanning used to quantify the albumin, α_1 -globulin, α_2 -globulin, β -globulin, and γ -globulin fractions as a proportion of total protein, expressed in g/dL.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 27.0. Spearman's rank correlation was used to assess associations between continuous variables in the pooled sample and within each disease group. Sex differences in hs-CRP and ESR were evaluated using Mann-Whitney U test overall and within each group, with statistical significance set at $p < 0.05$.

RESULTS

All seven parameters differed significantly across RA, PID, and PTB ($p < 0.0001$). hs-CRP ranked highest in PID (60.0 [45.3–73.5] mg/L) and lowest in RA (27.5 [19.3–39.8] mg/L; $H=44.32$), whereas ESR ranked highest in PTB (88.0 [72.8–105.8] mm/hr) and lowest in RA (40.5 [35.0–46.8] mm/hr; $H=91.24$). Albumin was lowest in PTB (3.15 [2.90–3.30] g/dL) and highest in RA ($F=76.19$); α_1 and α_2 were highest in PTB and lowest in RA ($H=76.5$ and 77.6), while β was highest in PID and lowest in RA ($H=66.7$). Interestingly, γ -globulin was lowest in PID (1.59 g/dL) but highest in PTB (2.77 g/dL), with RA (2.46 g/dL) closer to PTB than to PID ($H=88.62$), confirming that RA retains the most

prominent polyclonal hypergammaglobulinaemia despite having the lowest acute-phase markers.

The hs-CRP and ESR correlated strongly and significantly within every disease group examined individually (PID: $r=0.862$; RA: $r=0.766$; PTB: $r=0.997$; all $p < 0.0001$), but only moderately when all 126 patients were pooled irrespective of group ($r=0.562$, $p < 0.0001$) (Table 2, Figure 1). This pooled-versus-within-group divergence arises because the three disease groups occupy substantially different, only partly overlapping regions of the hs-CRP/ESR plane (Figure 1).

Across the pooled sample, albumin correlated negatively with both hs-CRP ($r=-0.63$, $p < 0.0001$) and ESR ($r=-0.95$, $p < 0.0001$), a typical negative acute-phase pattern; α_1 -, α_2 -, and β -globulin all correlated positively with both markers ($r=0.53$ to 0.95 , all $p < 0.0001$); gamma-globulin correlated with ESR ($r=0.47$, $p < 0.0001$) but not significantly with hs-CRP ($r=0.04$, $p=0.6205$) (Table 3).

Age and disease duration showed only weak, and for age non-significant, correlation with hs-CRP and ESR when all 126 patients were pooled (age: $r=0.01$ – 0.06 , both $p > 0.4$; duration: $r=-0.19$ to -0.21 , both $p < 0.05$ but weak), yet very strong correlation with both markers within every individual disease group ($r=0.81$ – 1.00 , all $p < 0.0001$) (Table 4). As with the hs-CRP/ESR relationship above, this reflects the fact that age and duration both differ systematically between the three disease groups, so pooling mixes between-group and within-group variation and substantially understates the within-group relationship.

Table 1: hs-CRP, ESR, and SPEP Fractions across the Three Disease Groups

Parameter	PID (n=42)	RA (n=42)	PTB (n=42)	P
hs-CRP (mg/L)	60.00 (45.25–73.50) ^a	27.50 (19.25–39.75) ^b	40.50 (29.25–54.75) ^c	< 0.0001
ESR (mm/hr)	60.00 (50.00–65.75) ^a	40.50 (35.00–46.75) ^b	88.00 (72.75–105.75) ^c	< 0.0001
Albumin (g/dL)	3.50 (3.40–3.70) ^a	3.80 (3.60–3.90) ^b	3.15 (2.90–3.30) ^c	< 0.0001
α_1 -globulin (g/dL)	0.36 (0.33–0.40) ^a	0.29 (0.26–0.31) ^b	0.41 (0.37–0.46) ^c	< 0.0001
α_2 -globulin (g/dL)	1.05 (0.98–1.15) ^a	0.88 (0.82–0.92) ^b	1.14 (1.03–1.23) ^c	< 0.0001
β -globulin (g/dL)	1.14 (1.05–1.23) ^a	0.92 (0.88–0.96) ^b	0.97 (0.93–1.04) ^c	< 0.0001
γ -globulin (g/dL)	1.59 (1.40–1.71) ^a	2.46 (2.12–2.69) ^b	2.77 (2.53–3.09) ^c	< 0.0001

Values with no shared letter differed significantly ($p < 0.05$)

Table 2: Correlation between hs-CRP and ESR, Overall and by Disease Group

Group	N	R	P
PID	42	0.862	< 0.0001
RA	42	0.766	< 0.0001
PTB	42	0.997	< 0.0001
Aggregate	126	0.562	< 0.0001

r = Spearman rank correlation coefficient between hs-CRP and ESR, ($p < 0.05$)

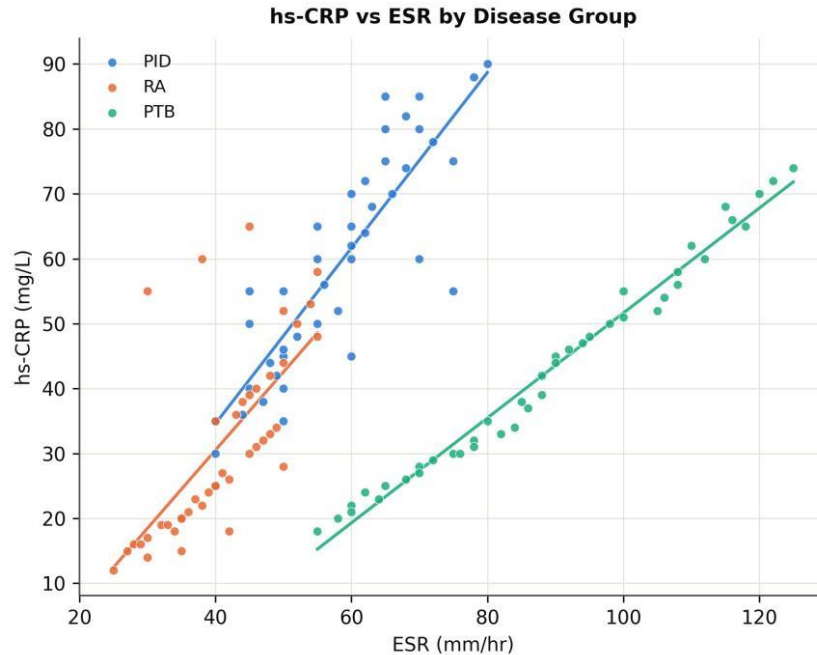


Figure 1: hs-CRP versus ESR by Disease Group

Table 3: Correlation of Each SPEP Fraction with hs-CRP and ESR (n = 126)

SPEP fraction	hs-CRP	ESR
Albumin (g/dL)	$r=-0.63, p<0.0001$	$r=-0.95, p<0.0001$
α_1 -globulin (g/dL)	$r=0.73, p<0.0001$	$r=0.95, p<0.0001$
α_2 -globulin (g/dL)	$r=0.77, p<0.0001$	$r=0.93, p<0.0001$
β -globulin (g/dL)	$r=0.95, p<0.0001$	$r=0.53, p<0.0001$
γ -globulin (g/dL)	$r=0.04, p=0.6205$	$r=0.47, p<0.0001$

Table 4: Spearman Correlation of Age and Disease Duration with hs-CRP and ESR

Group	Age vs hs-CRP	Age vs ESR	Duration vs hs-CRP	Duration vs ESR
Overall	$r=0.01, p=0.9023$	$r=0.06, p=0.4780$	$r=-0.19, p=0.0363$	$r=-0.21, p=0.0176$
PID	$r=0.93, p<0.0001$	$r=0.87, p<0.0001$	$r=0.95, p<0.0001$	$r=0.94, p<0.0001$
RA	$r=0.94, p<0.0001$	$r=0.81, p<0.0001$	$r=0.94, p<0.0001$	$r=0.83, p<0.0001$
PTB	$r=0.99, p<0.0001$	$r=1.00, p<0.0001$	$r=0.99, p<0.0001$	$r=0.99, p<0.0001$

r = Spearman rank correlation coefficient.

DISCUSSION

This study compared hs-CRP, ESR, and SPEP fraction profiles across confirmed PID, RA, and PTB patients in Ilorin, Nigeria, and found that although all the parameters measured differed significantly by disease group, hs-CRP and ESR did not rank the three conditions in the same order. hs-CRP, which responds within hours to a few days of an acute inflammatory stimulus (Pepys & Hirschfield, 2003; Sproston & Ashworth, 2018), was highest in PID, the most acute of the three conditions studied here, and lowest in RA. ESR, which depends on the slower-changing plasma fibrinogen and immunoglobulin pool rather than directly on the acute-phase cytokine response (Tishkowski & Zubair, 2026), was instead highest in

PTB, the most chronic of the three conditions, and likewise lowest in RA. This divergence is consistent with the broader literature describing imperfect concordance between the two markers despite their common clinical treatment as interchangeable acute-phase indices (Lapić *et al.*, 2020), and illustrates concretely why the specific inflammatory tempo and mechanism of the underlying condition, not only the presence of inflammation *per se*, shapes which of the two markers is more informative.

The SPEP findings reinforce this picture. PTB showed the lowest albumin and highest α_1 - and α_2 -globulin among the three groups, the classic negative- and positive acute-phase SPEP pattern (O'Connell *et al.*, 2005), consistent with active granulomatous-

infective disease. RA, by contrast, showed the most pronounced gamma-globulin elevation of the three groups despite having the lowest hs-CRP and ESR, a pattern consistent with chronic polyclonal immunoglobulin production in established autoimmune disease proceeding somewhat independently of the acute-phase reactant response captured by hs-CRP and ESR. That RA patients in this hospital-based sample showed clearly abnormal inflammatory-marker and SPEP profiles, despite Nigerian community-based surveys finding rheumatoid arthritis to be rare in the general population (Adelowo *et al.*, 2022), is consistent with a limited rheumatology workforce and diagnostic capacity concentrating confirmed cases in referral centres rather than reflecting a discrepancy in disease biology (Mody, 2017).

The pooled-versus-within-group divergence seen for both the hs-CRP/ESR correlation and the age/duration correlations is, statistically, the most important feature of this dataset for interpretation. Both markers correlated strongly within every disease group individually, most strikingly in PTB ($r=0.997$ for hs-CRP versus ESR; $r \geq 0.99$ for both markers versus age and duration), yet these relationships were substantially attenuated, and for age not even statistically significant, once all three groups were pooled together. This is not a contradiction but an illustration of how between-group heterogeneity, here driven by systematic differences in age and duration between the PID, RA, and PTB groups, can mask a strong underlying relationship if group membership is not accounted for in the analysis.

CONCLUSION

In this cross-sectional comparison of confirmed PID, RA, and PTB patients in Ilorin, Nigeria, hs-CRP, ESR, and SPEP fractions each showed distinct, statistically significant, disease-specific profiles, and hs-CRP and ESR ranked the three conditions differently, consistent with their different underlying kinetics. Correlations among these markers, and with age and disease duration, were strong within each disease group but substantially weaker when groups were pooled together, underscoring the importance of within-group analysis in comparative inflammatory-marker studies of this kind. At conventional cut-offs, hs-CRP and ESR were fully concordant. These findings characterize how three widely available, low-cost inflammatory markers behave differently across three pathophysiologically distinct causes of systemic inflammation in a Nigerian clinical population, and provide a basis for future studies, incorporating a

comparison group and longitudinal follow-up, to evaluate the diagnostic and monitoring values.

Author Contributions: DJ conceptualised the study, supervised participant recruitment and sample collection, and analysis. SAL and LOO supervised the study and reviewed the manuscript. S.O.H did the statistical analysis and contributed to manuscript drafting and writing. All authors read and approved the final manuscripts

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Data Availability: The dataset analyzed during the current study is available from the corresponding author on reasonable request.

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