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Patterns and statistical associations in routine urinalysis: A retrospective analysis of 1000 first-morning midstream samples from Owerri southeast, Nigeria

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Abstract
Background: Urinalysis is a routine laboratory investigation that provides valuable information on urinary tract health and systemic conditions. Despite its clinical importance, there is limited evidence from private diagnostic facilities in Southeast Nigeria on the prevalence patterns and associations of urinalysis parameters.
Objective: To determine the prevalence of physical, chemical, and microscopic urinalysis findings and assess associations between selected urinary parameters in clients attending a private diagnostic laboratory in Owerri, Imo State, Nigeria.
Method: A retrospective descriptive study was conducted using 1000 first-morning midstream urine samples collected between July 2023 and June 2025. Data were retrieved from laboratory records and analyzed using Jamovi (v2.4) and Microsoft Excel. Urinalysis included physical (colour, appearance), chemical (pH, protein, glucose, ketones, bilirubin, urobilinogen, blood, nitrite), and microscopic (RBCs, WBCs, epithelial cells, casts, crystals, bacteria/yeast) examinations. Descriptive statistics summarized findings, Chi-square tested associations between categorical variables, Spearman's correlation assessed continuous relationships, and multiple linear regression identified predictors of WBC count. Significance was set at $p<0.05$.
Results: The age range of participants was from 1 to 88 years (mean = 37.05 ± 17.17 years) and there was equal gender distribution. Pale yellow urine (68.3%) and clear urine (80.9%) were the most predominant characteristics. Glucose (13.1%) and blood (12.6%) were the most prevalent chemical abnormalities, while crystals (14.5%) and bacteria/yeast (13.2%) were the most common microscopy abnormalities. Cloudy urine showed a strong association with higher presence of bacteria/yeast (30.89%) and clear urine (9.0%; $p<0.001$). Proteinuria was seen more often in females ($p<0.001$). Presence of nitrite had a strong association with the presence of bacteria/yeast ($p<0.001$). Spearman's correlation showed that age was positively correlated with urine pH ($\rho = 0.099$, $p = 0.002$) and RBC count ($\rho = 0.146$, $p<0.001$), but negatively correlated with WBC count ($\rho = –0.208$, $p<0.001$). Regression analysis showed that nitrite, protein, blood, RBCs, age, and casts were statistically significant predictors of WBC count ($R^2 = 0.254$, $p<0.001$).
Conclusion: The findings from this showed a very high magnitude of glucosuria, haematuria, proteinuria, and crystalluria, and positive associations with urine appearance, nitrite positivity, and microbial presence. This highlights the importance of routine urinalysis for detection of subclinical abnormalities sustained by data values and intervention in community diagnostic settings.

Keywords: Epithelial cells, glucosuria, haematuria, proteinuria, urinalysis

Introduction
Urinalysis continues to remain among the most widely ordered laboratory tests in clinical practice because of its speed, low cost, and versatility across both primary care and hospital settings. According to the 2023 EFLM European Urinalysis Guideline, released 2024, current guidelines endorse urinalysis as a first-line test in suspected cases of urinary tract infection (UTI), screening for kidney disease, and as a general assessment in clinical care, if pre-analytical management of specimens, reagent strip test quality, and microscopy are standardized and quality assured (Kouri *et al.*, 2025) [13].

Chemistry (dipstick) testing and microscopy provide additional information. More recent comparative studies suggest dipstick parameters (especially leukocyte esterase and nitrite) can rule out UTI in many situations while microscopic urinalysis is often more useful to confirm presence of the disease and characterize abnormalities (i.e., haemtauria, casts, crystals) that occur beyond infection and suggest intrinsic renal pathology. Altogether – when interpreted in the clinical context – both tests will provide better diagnostic certainty over either alone (Almuhanna *et al*., 2024) [1]. Simultaneously new methodologic guidance describes how specimen collection (i.e., first morning, midstream) and rigorous particle assessment improve accuracy and minimize both contamination and reporting discrepancies between laboratories (Kouri *et al*., 2025) [13].

On a population level, UTIs continue to be an important global health burden. Recent analyses of the global burden of disease indicate a high, sustained incidence of UTIs in all age groups and regions of the world continue to stress the role of effective front-line diagnostics, such as urinalysis, to determine care options and guide future testing (Wang *et al*., 2024) [25]. The situation is also complicated by the known continuing effects of antimicrobial resistance (AMR), which is leading to the ongoing erosion of the efficacy of commonly used agents for community-acquired UTI and further calls for improved stewardship around diagnostics, AMR surveillance, and context specific data to inform empiric treatment (WHO 2023) [28].

In Nigeria, as is reflected within these global conversations, some of the same problems of UTI remain, while better understanding the local realities with respect to service-delivery. Facility based analysis from Southeast Nigeria, has highlighted a meaningful burden of presentations of pediatric UTI, and identified ongoing dependence on urinalysis (the dipstick and microscopy) to bolster decisions in a low resource clinical environment. Such data sets are useful when attempting to map trends by age or sex between common pathogens, as well as identify potential action for routine testing quality improvement (Osuji *et al*., 2024) [19].

In this context, the present retrospective descriptive study examined 1000 first-morning midstream urinalysis reports processed by a private diagnostic laboratory in Owerri, Imo State, Nigeria (July 2023–June 2025). This research collated and described, in aggregate physical, chemical (Combi-9 dipstick), and microscopic results for ages 1 to 88 years, to (i) describe urinalysis practices (based on urinalysis result patterns) in a southeastern Nigerian urban and aspects of an urban catchment, and (ii) provide local evidence relevant to the health decision making process to assist in clinical decision making, strengthen internal quality practices, and inform future research into UTI and renal-disease screening pathways.

Methodology

Study Design and Setting

This research utilized a retrospective descriptive design which took place at Everight Diagnostic and Laboratory, a private diagnostic center in Owerri, Imo State, Southeast Nigeria, which provides routine and specialized laboratory services to clients from Owerri and neighboring communities. The study period was from July 2024 to June 2025 and examined urinalysis trends in individuals who utilized the diagnostic facility.

Study Population - Inclusion and Exclusion criteria

The study population included all people between the ages of 1 - 90 years who had submitted a first-morning midstream urine test within the study period. Inclusion criteria included:

1. Complete demographic information
2. All evaluated patients had valid urinalysis results.

Individuals who had repeat tests done within the study period, incomplete records, or urine samples that failed to meet the collection protocol were excluded (Alves *et al*., 2023) [3].

Sample size - Sampling technique

A total of 1000 urinalysis reports that met the inclusion criteria were selected using a simple random sampling technique to demonstrate the representativeness of the study population (Li *et al*., 2021) [14].

Urinalysis Methodology

Urinalysis involved three examinations: physical, chemical, and microscopic

- Physical examination: Colour of urine (pale yellow, straw, yellow, amber, bloody) and appearance (clear, cloudy, turbid).
- Chemical examination: Each urine sample was tested with Combi-10 Medi-Test® strips, which assessed pH, protein, glucose, ketones, bilirubin, urobilinogen, blood, and nitrite.
- Microscopic examination: Each urine specimen was centrifuged at 1,500 rpm for 5 minutes before performing a microscopic examination to identify and count the following: red blood cells (RBCs), white blood cells (WBCs), epithelial cells, casts, crystals, bacteria, and yeast cells.

Data Management and Analysis

Data were retrieved from laboratory records, entered into Microsoft Excel where it was cleaned and coded, and exported to Jamovi (version 2.4) for analysis.

Descriptive statistics (mean, standard deviation, frequencies and percentages) were calculated to summarize demographic and laboratory findings. The inferential statistics included;

- Chi-square tests for associations between categorical variables.
- Spearman's correlation for relationships between continuous variables.
- Multiple linear regression to assess predictors of WBC count in urine sediment.
- Statistical significance was set at $p < 0.05$ (Kaur *et al*., 2022) [11].

Ethical Considerations

Ethical approval was obtained from the Everight Diagnostic and Laboratory Management Board. As the study used de-identified retrospective laboratory data, individual informed consent was waived in accordance with international ethical principles for secondary data analysis (World Medical Association, 2023) [29].

Results and Discussion

3.1: Demographic Distribution of Patients

Age Distribution of Study Participants

The participants' ages ranged from 1 to 88 years, with an average age of 37.05 years (SD = 17.17), indicating a broad age spread across the sample.

Table 1: Age Distribution of Study Participants (N = 1000)

Statistic	Value
Minimum (years)	1
Maximum (years)	88
Mean (years)	37.05
Standard Deviation (SD)	17.17

Gender Distribution of Participants

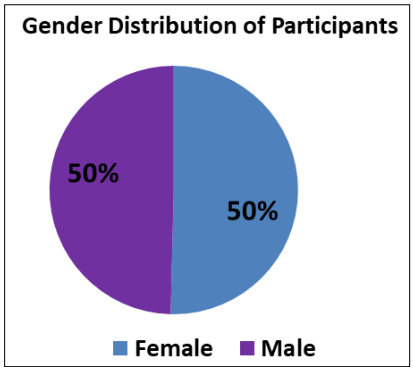

Fig 1: Gender Distribution of Patients

As shown in Figure 1, the study population (1000 patients), consisted of 50% male and 50% female.

3.2: Physical Characteristics of Urine Sample

Table 2 presents the distribution of urine colour among the 1,000 participants. The majority of samples were pale yellow (68.3%), followed by straw-coloured urine (15.2%) and yellow urine (10.4%). Amber-coloured urine was observed in 5.7% of participants, while bloody urine was rare, occurring in only 0.4% of cases.

Table 2: Summary of Participants Urine Colour

Colour	Frequency	%
Pale yellow	683	68.3
Straw	152	15.2
Yellow	104	10.4
Amber	57	5.7
Bloody	4	0.4

Urine Appearance of Study Participants

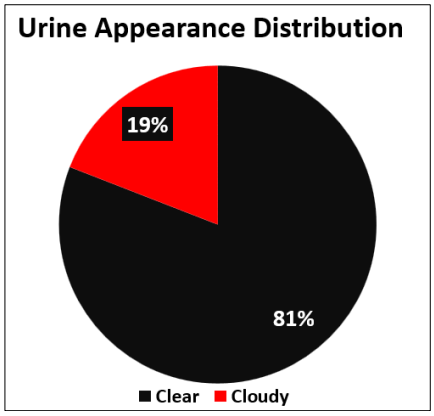

Fig 2: Urine Appearance Distribution

Most urine samples were clear (80.9%), while cloudy urine was observed in 19.1% of participants (Figure 2).

Bacterial/Yeast Presence by Urine Appearance among Study Participants

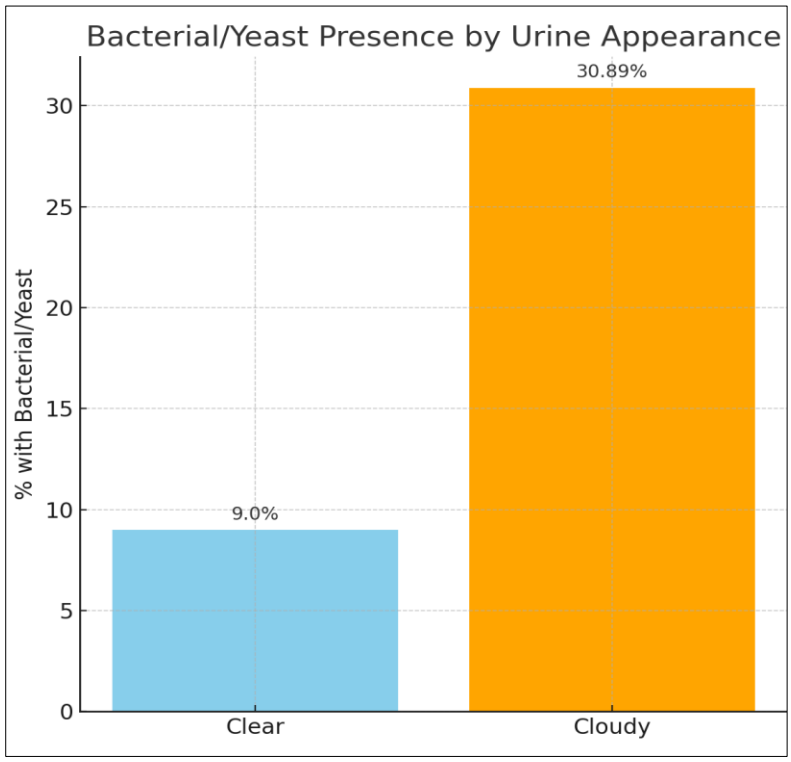

Fig 3: Percentage Prevalence of Bacteria/Yeast by Urine Appearance

The presence of bacterial or yeast elements was markedly higher in cloudy urine samples (30.89%) compared to clear urine samples (9.0%) (Figure 3).

3.3: Chemical Composition
pH Distribution Across Gender

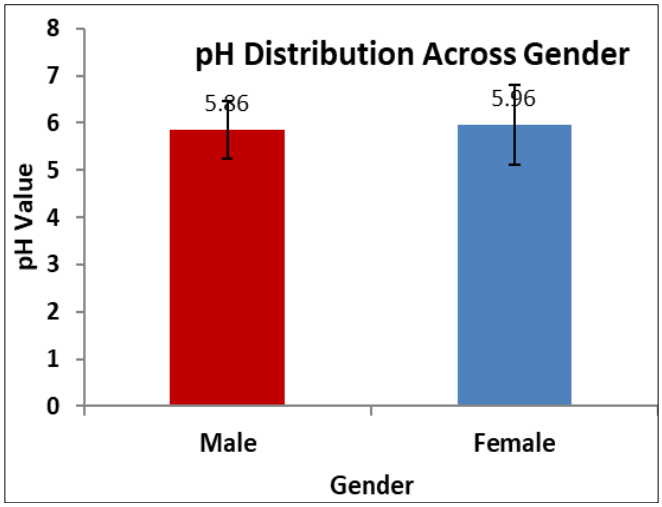

Fig 4: pH Distribution Across Gender

Figure 4 shows the distribution of pH across gender with male (5.86) and female (5.96).

Prevalence of Biochemical Parameters

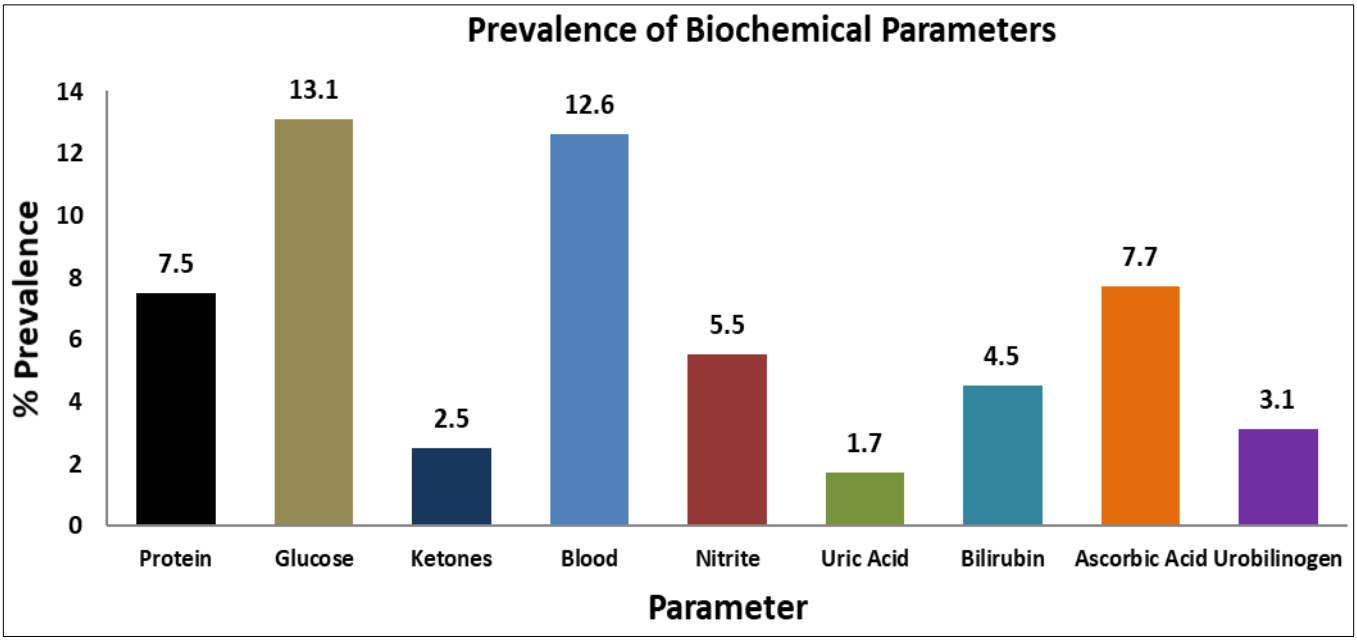

Fig 5: Prevalence of Biochemical Parameters

Urinalysis of the sampled population revealed varying prevalence rates for different biochemical parameters. Among the 1,000 urine samples analyzed, glucose showed the highest positivity rate (13.10%), followed by blood (12.60%), ascorbic acid (7.70%), and protein (7.50%). The least prevalent was uric acid at 1.70%. Figure 5 summarized the Prevalence of Biochemical Parameters.

3.4: Microscopic Findings:

The most frequent microscopic abnormality was the presence of crystals (14.5%), followed by bacteria/yeast (13.2%). Elevated white blood cell counts (>5/HPF) were observed in 8.3% of participants, while elevated red blood cells (>5/HPF) were less common (2.4%).

Table 3: Percentage Prevalence of Microscopic findings

Element	Prevalence (%)
WBCs >5/HPF	8.3
RBCs >5/HPF	2.4
Epithelial cells>2+	3
Crystals	14.5
Casts	3.3
Bacteria/yeast	13.2

3.5 Chi-square Analysis
Association between Sex and Protein Presence in Urinalysis

A chi-square test of independence was conducted (Table 4) to examine the association between sex and proteinuria among the study participants. The result showed a statistically significant relationship between sex and the

presence of urinary protein, χ^2 (df=1, N = 1000) = 31.77, $p<$ 0.001) at 0.05 confidence interval indicating that proteinuria was more prevalent among females than males in the study population.

Table 4: Chi-square Test Result for Association between Gender and Protein

Variable Pair	χ^2	df	p-value
Sex vs. Protein	31.77	1	< 0.001

Association between Nitrite and Bacteria/Yeast Presence in Urinalysis

The Chi-square test results (χ2=535.963, df = 15, $p<$ 0.001) as shown in Table 5 indicated a statistically significant association between nitrite levels and bacteria/yeast findings in urine samples from the study population.

Table 5: Chi-square Test Result for Association between Nitrite and Bacteria/Yeast Presence

Variable Pair	χ^2	Df	p-value
Nitrite vs. Bacteria/Yeast	555.92	15	< 0.001

Association between Urine Appearance and Bacteria/Yeast Presence in Urinalysis

A Chi-square test of independence was conducted to examine the relationship between urine appearance (Clear, Cloudy) and bacteria/yeast presence of bacteria/Yeast Seen) in 1,000 urinalysis samples. The Chi-square test result (χ^2 = 173.633, df = 5, $p<$ 0.001) as shown in Table 6 below indicate a statistically significant association between urine appearance and bacteria/yeast presence.

Table 6: Chi-square Test Result for Association between Urine Appearance and Bacteria/Yeast Presence

Variable Pair	χ^2	df	p-value
Urine Appearance vs. Bacteria/Yeast	173.63	5	< 0.001

3.6: Correlation Analysis

A Spearman's rank correlation analysis (Table 7) was performed to examine associations among age, urine pH, white blood cell count (WBCs per high-power field), and red blood cell count (RBCs per high-power field) in the study population. Age had a weak, but statistically significant positive correlation with pH (ρ = 0.099, p = 0.002), meaning older participants had a slightly higher urinary pH. Age also had a significant positive correlation with RBCs (ρ = 0.146, $p<$ 0.001), meaning that there was a slight increase in incidental microscopic haematuria with age.

WBCs had a significant negative correlation with age (ρ = −0.208, $p<$ 0.001), meaning there was greater incidence of pyuria in younger individuals. There was no statistical significant correlation between pH and WBCs (ρ = 0.007, p = 0.818).

RBCs showed significant positive correlations with pH (ρ = 0.170, $p<$ 0.001) and WBCs (ρ = 0.196, $p<$ 0.001), meaning samples with higher pH values or greater pyuria were also more likely to have higher levels of haematuria. It should be noted that while the strength of the correlations was mainly weak in magnitude, most were statistically significant and suggest subtle trends in the urinary parameter as a function of age and urinary conditions in the sampled population.

Table 7: Spearman's Rank Correlation Coefficients Among Age, pH, White Blood Cells, and Red Blood Cells in Urine Samples from 1,000 Patients

Correlation Matrix					
		Age	**pH**	**WBCs (per HPF)**	**RBCs (per HPF)**
Age	Spearman's rho	—			
	df	—			
	p-value	—			
pH	Spearman's rho	0.099**	—		
	df	998	—		
	p-value	0.002	—		
WBCs (per HPF)	Spearman's rho	-0.208***	0.007	—	
	df	998	998	—	
	p-value	<.001	0.818	—	
RBCs (per HPF)	Spearman's rho	0.146***	0.170***	0.196***	—
	df	998	998	998	—
	p-value	<.001	<.001	<.001	—

Note: * $p<$ .05, ** $p<$ .01, *** $p<$ .001

3.7: Regression Analysis

A multiple linear regression was conducted using WBC count (per HPF) as the dependent variable and selected predictors from the urinalysis (pH, age, RBC count, blood, nitrite, protein, epithelial cells, and casts). The regression model moderately well fitted the data (R = 0.504, R^2 = 0.254), indicating approximately 25.4% of the variance in WBCs per high power field was accounted for by the predictors (Table 8). The overall model was statistically significant, F(15, 984) = 22.40, $p<$ .001), from a sample size of 1,000.

The omnibus ANOVA (Table 9) showed that RBCs (F(1, 984) = 7.37, p = .007), age (F(1, 984) = 16.40, $p<$ .001), blood (F(4, 984) = 16.24, $p<$ .001), nitrite (F(2, 984) = 72.60, $p<$ .001), protein (F(1, 984) = 29.68, $p<$ .001) and casts (F(2, 984) = 5.66, p = .004) were statistically significant predictors. In contrast, pH (p = .317) and epithelial cells (p = .688) were not statistically significant predictors.

The regression coefficients (Table 10) provide additional insight into the direction and amount of effect. Keeping all other variables in the model constant, RBCs (per HPF) (B = –0.633, p = .007), and age (B = –0.024, $p<$ .001) were negatively and significantly associated with WBC counts. Conversely, blood (Levels 1-4; $p<$ .001 for all), nitrite (Levels 1-2; p ≤ .010, for both), and protein (Level 1; $p<$ .001) predicted higher WBC counts. Among those tests, nitrite Level 1 had the greatest positive effect (B = 6.302, 95% CI [5.276, 7.329]), while casts Level 2 had the greatest negative effect (B = –4.304, 95% CI [–7.483, –1.126]). pH (p = .317) and all epithelial cell levels ($p \geq$ .347) were not statistically significant predictors.

Figure 6 demonstrates the strength and direction of these associations in a bar chart of each coefficient and its respective 95% confidence interval, where we identify significant positive and negative predictors of WBC counts.

Table 8: Model Fit Measures for Predicting WBCs (per HPF)

Model Fit Measures						
			Overall Model Test			
Model	R	R^2	F	df1	df2	P
1	0.504	0.254	22.4	15	984	<.001

Note: Models estimated using sample size of N=1000

Table 9: Omnibus ANOVA Test

	Sum of Squares	df	Mean Square	F	P
RBCs (per HPF)	69.00	1	69.00	7.371	0.007
Age	153.52	1	153.52	16.401	<.001
pH	9.39	1	9.39	1.003	0.317
Blood	608.09	4	152.02	16.240	<.001
Nitrite	1359.11	2	679.56	72.595	<.001
Protein	277.81	1	277.81	29.678	<.001
Epithelial Cells	13.80	3	4.60	0.491	0.688
Casts	105.97	2	52.99	5.660	0.004
Residuals	9211.12	984	9.36	-	-

Note: Type 3 sum of squares

Table 10: Model Coefficients - WBCs (per HPF)

			95% Confidence Interval			
Predictor	**Estimate**	**SE**	**Lower**	**Upper**	**t**	**P**
Intercept[a]	6.4127	1.38852	3.6879	9.1375	4.6183	<.001
RBCs (per HPF)	-0.6333	0.23325	-1.0910	-0.1755	-2.7150	0.007
Age	-0.0242	0.00597	-0.0359	-0.0125	-4.0498	<.001
pH	-0.1213	0.12108	-0.3589	0.1163	-1.0017	0.317
Blood:						
1+	1.6712	0.45354	0.7812	2.5612	3.6848	<.001
2+	3.4778	0.58491	2.3300	4.6256	5.9459	<.001
3+	4.7379	0.86992	3.0308	6.4451	5.4464	<.001
4+	5.9976	1.23197	3.5800	8.4152	4.8683	<.001
Nitrite:						
1+	6.3021	0.52304	5.2757	7.3285	12.0490	<.001
2+	3.0608	1.18241	0.7405	5.3811	2.5886	0.010
Protein:						
1+	2.1433	0.39342	1.3712	2.9153	5.4477	<.001
Epithelial Cells:						
1+	0.6396	1.15794	-1.6327	2.9119	0.5524	0.581
2+	0.0960	1.22618	-2.3103	2.5022	0.0783	0.938
3+	1.7823	1.89398	-1.9344	5.4990	0.9410	0.347
Casts:						
1+	-2.0221	0.77055	-3.5342	-0.5100	-2.6242	0.009
2+	-4.3042	1.61964	-7.4825	-1.1258	-2.6575	0.008

[a] Represents reference level

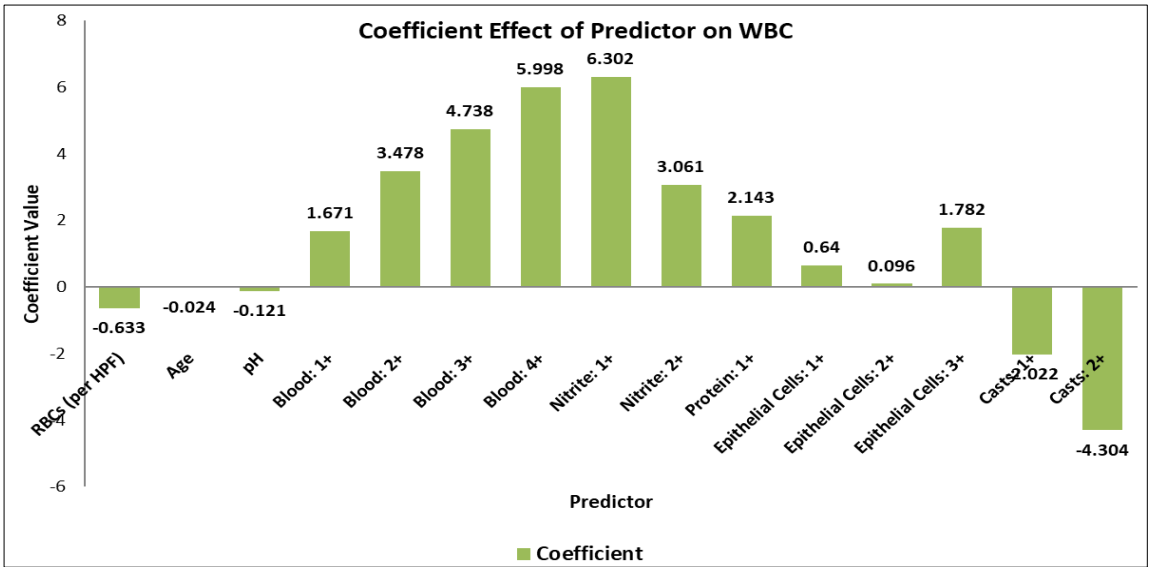

Fig 6: Coefficient Effect of Predictor on WBC

Discussion

This urban Southeast Nigerian cohort of 1,000 patients (50% female; mean age 37.05) provided examples of expected normal patterns and also clinically significant abnormalities in urinalysis. The demographic profile, encompassing a broad age range, aligns with recent epidemiological surveys highlighting age- and sex-specific variations in renal parameters, facilitating robust comparative insights into urinary tract dynamics (Yamamoto & Yamamoto, 2025) [30]. That variability suggests superior detection of age-modulated urinary change, and further demonstrated the need for age-appropriate screening in heterogeneous populations to enhance renal vulnerability. The assumptions we have drawn also align with current research in patients in haemodialysis cohorts in general, but the relative age distributions are often different and even variable, especially with respect to sex (Hecking *et al*., 2014) [9].

The majority of the specimens were pale yellow (68.3%), followed by straw (15.2%), yellow (10.4%), amber (5.7%), and a rare percentage of bloody specimens (0.4%). As Devkota & Devaraj (2025) discussed in their review, these colour changes can be attributed to differences in hydration levels, which influences the urochrome concentrations or concentrations of other pigmentation in the urine, rather than pathology. The majority of the specimens were clear (80.9%) with a smaller percentage cloudy (19.1%). The number of microbial elements (bacteria, yeast) was consistently higher in cloudy specimens than clear specimens (30.89% cloudy versus 9% clear) in the 19.1% cloudy specimens. The finding of turbidity to be associated with infection or inflammation has been established, and cloudy urine is associated with greater risk of developing early pyelonephritis, which leads to a potentially serious systemic infection, and is considered normal to begin treatment as soon as an infection is found (Dias, 2020) [7].

The overall mean pH was 5.86 in males and 5.96 in females. Though it is possible that the small elevation in female mean pH could be ascribed to hormonal changes, some reports indicate no difference between the two genders. This finding also implies that females may be more susceptible to infections, potentially requiring a different strategy for prevention based on gender (Riehl-Tonn *et al*., 2024) [21].

Biochemical dipstick findings were positive for glucose in 13.1%, protein in 7.5%, and blood in 12.6%. The finding of glucouria at this rate may indicate unrecognized hyperglycemia. In all cases, glucouria should be followed with blood glucose measurements to determine additional testing as urine glucose is not diagnostic for diabetes (American Academy of Family Physicians [AAFP], 2022) [4]. Proteinuria was significantly higher in females in this cohort, which is in contrast to many epidemiological studies that suggest persistent higher rates of proteinuria reported in men (Kasiakogias *et al*, 2024; Wolfs *et al*., 2025) [10, 27]. The literature suggests that low-grade persistent proteinuria in women still may be due to clinically significant albuminuria, which would require a confirmatory test measuring albumin-to-creatinine ratios (ACR) in both sexes (Shin *et al*, 2023; KDIGO, 2024) [22, 12]. For haemturia, the prevalence (12.6% by dipstick; 2.4% microscopic >5 RBC/HPF) is consistent with the global expectation that microhaemturia, regardless of symptoms, requires a structured risk-stratified evaluation especially among older adults (AUA/SUFU, 2025; O'Grady *et al*, 2024) [5, 18].

Microscopic abnormalities focused on crystals (14.5%), bacteria/yeast (13.2%), elevated WBC (>5/HPF, 8.3%), and RBC (>5/HPF, 2.4%). The frequency of crystalluria was well within those reported in outpatient settings (8-22%), indicative of metabolic derangements and a risk of stone formation, warranting interventions aimed at hydration and dietary changes (Sutron *et al*., 2025; Tasian & Ferraro, 2023) [23, 24]. The presence of microbes systemically suggests the potential for infection, which provides support for prophylactic measures in susceptible populations (Dias, 2020) [7].

Associations included urine appearance with bacteria/yeast (χ^2=173.633, p<0.001), with cloudiness being an indicator of infection, although the sophistication of indicator varies such that caution is advised against being relied upon solely and it would be prudent to include microscopy (Zaw *et al*., 2025; Woc-Colburn *et al*., 2025) [31]. Nitrite was strongly associated with microbial (bacteria and yeast) findings overall (χ^2=535.963, p<0.001) as a result of nitrate reduction. It has good specificity for the presence of bacteriuria especially in an infectious context of investigation which can aid in targeted management (Mambatta *et al*., 2024; Farashi & Momtaz, 2025) [15].

Spearman correlations revealed weak positive associations between age and pH (ρ = 0.099, p = 0.002) and age and RBC (ρ = 0.146, p< 0.001), but a weak negative association with WBC (ρ = -0.208, p< 0.001) and also weak positive correlations between RBC, pH, and WBC, all of which were consistent with age and pH increases in the elderly but opposed to non-significant locomotive findings among youth, implying adaptation in urinary homeostasis with geriatric care impact (Yamamoto & Yamamoto, 2025; Park *et al*., 2023) [30]. Haemturia, indicated an understated positive age correlation (ρ = 0.146, p<0.001), aligned with existing literature regarding microscopic blood and age dependent disease resulting in contemporaneous assessment and potential risk stratification protocols to minimize evolution of disease processes (O'Grady *et al*., 2024) [18].

Multivariable regression noted nitrite positivity, the presence of haemturia, and proteinuria were all independent predictors of pyuria, while RBC count, casts, and age were factors of inverse association. These reflect similar inflammatory and infectious pathways discussed extensively in urinary tract pathology (StatPearls, 2025; Nassar *et al*., 2024) [31, 17]. Clinically, any patient with nitrite, protein, and haemturia while symptomatic, should elicit prompt culture and follow guideline principles for empirically based therapeutics and templated management (EAU, 2024) [8].

Overall, the findings from this study reinforce that routine urinalysis remains a cost-effective screen for subclinical metabolic and renal abnormalities in resource-limited settings. Integrating dipstick and microscopy results strengthens diagnostic stewardship in urinary tract infection evaluation (Woc-Colburn *et al*., 2025) [26], while reporting crystal type and providing preventive counseling can reduce stone disease burden (Tasian & Ferraro, 2023) [24].

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