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Socio-Economic Status and Traditional Risk Factors for Chronic Kidney Disease among Hypertensive and Diabetic Patients in Ekiti-State, Nigeria

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Abstract

Background: Chronic kidney disease (CKD) is a growing public health burden in many low and middle-income countries including Nigeria. This study evaluated demographic, socio-economic, and anthropometric data, as well as results of traditional clinical diagnostic tests among chronic kidney disease patients living with hypertension and diabetes in Ekiti-State, Nigeria.

Methods: A cross-sectional study was conducted among 270 adult participants. Participants were grouped based on their eGFR values into CKD stage 1 (n=29), CKD stage 2 (n=41), CKD stage 3 (n=35), CKD stage 4 (n=15), CKD stage 5 (n=50), and Control (n=100). Demographic, socio-economic, and anthropometric data, as well as serum urea and creatinine values were analyzed.

Results: Participants in CKD stage 5 (73.50 ± 5.64) were significantly older compared to those in CKD stage 1 (50.10 ± 6.20) (F=31.42, p<0.001). Low-income earners (<₦30,000/month) comprised 64.0% of participants in CKD stage 5 compared to 22.0% of controls (χ^2=38.12, p<0.001). Participants with combined hypertension and diabetes had the most severe clinical profiles, with mean systolic blood pressure of 162.40 ± 18.50mmHg, serum urea of 14.60 ± 6.80 mmol/L, serum creatinine of 284.60 ± 112.40 µmol/L, and eGFR of 28.60 ± 16.40 mL/min/1.73m² (p<0.001). Socio-economic indices correlated positively with eGFR (r=+0.458, p<0.001) and negatively with serum creatinine (r=-0.436, p<0.001).

Conclusion: Low socio-economic status, advancing age, and dual burden of hypertension and diabetes drive progression of renal impairment among CKD patients in Ekiti-State. Standard creatinine estimation misses early-stage decline, highlighting the urgent need for routine eGFR reporting and subsidized medical testing.

Keywords: *Chronic kidney disease, Socio-economic status, Risk factors, Hypertension, Diabetes, Nigeria.*

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I. INTRODUCTION

Chronic kidney disease (CKD) is a disease condition defined by the progressive loss of function and structure of the kidneys over a three month period or longer. [1] It is an important non-communicable disease due to its rapidly rising mortality rate and financial healthcare implications. [1] CKD is typically marked by an estimated glomerular filtration rate (eGFR) under 60 mL/min/1.73m² or the presence of kidney damage with an eGFR under 90 mL/min/1.73m² for over 3 months. [1] CKD often progresses from these stages silently towards total loss of renal function in end-stage renal disease (ESRD) with eGFR dropping under 15 mL/min/1.73m². [1]

Globally, non-communicable diseases (NCDs) account for 60% of deaths each year, with a vast majority happening in low and middle-income countries (LMICs). [2] Amidst these, chronic kidney disease (CKD) has jumped from the 17th global leading cause of death in 1990 to the 9th global leading cause of death in 2024. [3] The clinical and socio-economic reality for CKD and CKD care in Nigeria is particularly severe due to delayed presentation and immense out-of-pocket health expenditure (OOP). [4] Access to maintenance renal replacement therapy (RRT) such as hemodialysis and kidney transplantation is also restricted or often financially out of reach. [5]

Long-standing systemic hypertension and chronic hyperglycemia in diabetic nephropathy induce hyaline arteriolosclerosis, intraglomerular hyperfiltration, and basement membrane thickening, ultimately advancing glomerulosclerosis and tubular injury. [6] When hypertension and diabetes co-occur, they exert a synergistic effect on renal hemodynamics that accelerates the rate of eGFR decline. [7] Factors such as obesity act as an independent driver of renal damage by inducing hyperfiltration and as a metabolic precursor to both hypertension and dysglycemia. [8] Other demographic factors such as age, physical inactivity, tobacco smoking, and alcohol consumption also significantly impact metabolic risk. [8]

Socio-economic status including educational attainment, occupational status, and household income fundamentally dictates healthcare seeking behavior, medication adherence, dietary habits, and baseline health literacy. [9] Many of these individuals in lower socio-economic brackets often face systemic barriers such as delayed medical consultation, inability to afford continuous antihypertensive or antidiabetic drugs, reliance on unstandardized nephrotoxic herbal remedies, and chronic exposure to high dietary sodium and poor nutritional choices. [9]

Standard laboratory evaluation of renal function relies on serum urea and creatinine estimation. [10] Serum creatinine has however suffered from well-documented limitations including its tendency to significantly rise above reference limits after about 50% of renal function has been lost. [10] Also, its varying effects of muscle mass, age, sex, and dietary protein intake have also been well documented. [10] Likewise, serum urea levels also fluctuate due to many non-renal factors, including dietary habits, and metabolic states. [10]

Hence, establishing the precise baseline distribution of these traditional clinical metrics across demographic and socio-economic status is an essential prerequisite for earlier detection of renal damage and advancement in designing targeted public health interventions. This study aims to evaluate demographic, socioeconomic, and lifestyle data, as well as results of traditional clinical diagnostic tests in order to draw predictive insights and define risk factors for chronic kidney disease among hypertensive and diabetic patients in Ekiti-State, Nigeria.

II. METHODOLOGY

Study Design and Setting

This study adopted a hospital-based, cross-sectional study design and was conducted in Federal Teaching Hospital Ido, Ekiti-State, Nigeria. Federal Teaching Hospital Ido is a centre for kidney dialysis referral, diagnosis, and treatment for patients with Chronic kidney disease in Ekiti-State. Participants were grouped into six groups including control and CKD stages 1 to 5.

Ethical Clearance

The ethical clearance for this research was obtained from the Human Research and Ethics Committee of Federal Teaching Hospital Ido, Ekiti-State, Nigeria with Reference number ERC/2021/05/06/543A. Before the collection of the sample, information regarding the study was explained to the subjects. Oral and written consent for participation in the study were obtained.

Population, Eligibility, and Sample Size

The study comprised 270 adult participants including 100 healthy participants and 170 patients attending the Endocrinology and Cardiac Clinic of Federal Teaching Hospital Ido, Ekiti-State.

Inclusion criteria were participants aged 18 to 92. Also, patients with an established clinical diagnosis of essential hypertension, type 2 diabetes mellitus, or both, were recruited and grouped based on their stage of renal function. Healthy control participants

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were recruited from hospital staff, clinic attendees, and voluntary donors with no clinical history of hypertension, diabetes, or renal disease. Exclusion criteria included patients under 18 years or above 92 years of age, pregnant women, patients with acute kidney injury (AKI), sepsis, cardiac failure, cancers, hepatic cirrhosis, or those unable to provide informed voluntary consent.

Based on an expected prevalence of 14.2% of chronic kidney disease (CKD) reported for the study area by a related study [11], a minimum sample size of 187 participants was required. Accounting for a 10% non-response rate, the target sample size was increased to 206. To allow for subgroup analysis across the 6 study groups, a total of 270 participants were recruited.

Participant Groups
Participants were recruited and primarily grouped based on their eGFR values and state of kidney function into CKD stage 1 (n=29), CKD stage 2 (n=41), CKD stage 3 (n=35), CKD stage 4 (n=15), CKD stage 5 (n=50), and control (n=100).

Controls included normotensive, non-diabetic adults with eGFR ≥ 90 mL/min/1.73 m². [12] CKD stage 1 included patients with any level of kidney damage with normal or increased eGFR (≥ 90 mL/min/1.73 m²). [12] CKD stage 2 included patients with kidney damage with mild eGFR reduction (60-89 mL/min/1.73 m²). [12] CKD stage 3 included patients with moderate eGFR reduction (30-59 mL/min/1.73 m²). [12] CKD stage 4 included patients with severe eGFR reduction (15-29 mL/min/1.73 m²). [12] CKD stage 5 included patients with end-stage renal disease (eGFR < 15 mL/min/1.73 m²). [12]

For some comparisons, participants were grouped into 4 main groups including early CKD stage (which includes CKD stage 1 and 2, where n=70), mid CKD stage (which includes CKD stage 3 and 4, where n=50), late CKD stage (which includes CKD stage 5, where n=50), and control (n=100).

Likewise, for some comparisons, participants were grouped into 4 main groups including participants with hypertension alone (n=65), participants with diabetes alone (n=45), participants with hypertension and diabetes (n=60), and control (n=100).

Demographic, Socio-economic, and Anthropometric Assessment
A structured questionnaire was used to capture demographic data (age, sex), lifestyle/behavioral parameters (physical exercise participation, tobacco smoking status, and alcohol consumption), and socio-economic status of participants (monthly household income level, educational attainment, and occupational class).

Anthropometric measurements were performed according to standardized protocols. Body weight was measured to the nearest 0.1 kg using a calibrated digital scale with participants wearing light clothing and no shoes. Height was measured to the nearest 0.1 cm using a stadiometer. Body Mass Index (BMI) was computed as weight in kilograms divided by height in meters squared (kg/m²).

Evaluation for Hypertension and Diabetes
Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured in the left arm after participants had been seated for at least five minutes. An electronic blood pressure monitor (Omron M X2 Basic) with appropriate cuff size was used. Hypertension was defined as SBP ≥ 140 mmHg and/or DBP ≥ 90mmHg or those who had normal blood pressure but were pharmacologically treated for hypertension were categorized as hypertensive subjects.

Type 2 diabetes mellitus (T2DM) was determined by measurement of fasting plasma glucose ≥ 7.0 mmol/L, or glycated hemoglobin (HbA1c) ≥ 6.5%, and/or participants established diabetes diagnosis and use of hypoglycemic agents. [13]

Sample Collection and Laboratory Investigations
A 5 mL venous blood sample was collected from each fasting participant via venipuncture under aseptic conditions into plain non-vacutainer bottles. Samples were allowed to clot at room temperature for 30 minutes and then centrifuged at 3,000 rpm for 10 minutes to obtain serum. Serum samples were immediately separated and analyzed for serum urea and creatinine estimation.

Serum urea and creatinine were measured using the urease-Berthelot method and modified Jaffe kinetic method respectively from commercially prepared reagent packs on a full Chemistry Auto-analyzer (Chemray Rayto 240). Estimated Glomerular Filtration Rate (eGFR) was calculated for each participant using the 2021 Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) creatinine equation expressed in mL/min/1.73 m².

Data Presentation and Statistical Analysis
Participant responses to the study questionnaire were summarized in frequencies and percentages (n, %) and presented in tabular form. Clinical data were analyzed using Statistical Package for Social Sciences (SPSS) v23 and expressed as Mean ± Standard Deviation (SD). The One-Way Analysis of variance (ANOVA) was used to calculate the significance of means, while the Chi-Square analysis was used to test for relationships. Statistical significance was defined as a two-tailed $p < 0.05$.

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III. RESULTS

Demographic, Socioeconomic, and Lifestyle Characteristics

Across the groups of participants recruited, individuals aged ≥ 45 years constituted 96.0% (n=48) of late CKD stage patients compared to 34.0% (n=34) in the control group (χ^2=92.74, p<0.001). Female participants were the majority across all groups with 63.0% of the population in the control group and percentages ranging from 58% to 60% for the early to late CKD stages (χ^2=11.99, p=0.001) **(Table 1).**

An inverse relationship was observed between socio-economic status and stage of renal disease. Low-income earners (<₦30,000/month) constituted 22.0% (n=22) of participants in the control group, but comprised 44.3% (n=31) of patients in early CKD stages, 56.0% (n=28) of patients in mid CKD stages, and 64.0% (n=32) of patients in late CKD stage (χ^2=38.12, p<0.001). Similarly, individuals with primary or informal education made up 54.0% (n=27) in the late CKD stage compared to 14.0% (n=14) in the control group (χ^2=32.84, p<0.001). Also, informal employment or unemployment represented 68.0% (n=34) in the late CKD stage compared to 28.0% (n = 28) in the control group (χ^2=24.10, p<0.001) **(Table 1).**

Furthermore, physical exercise participation declined significantly with progressive renal function loss, dropping from 76.0% (n=76) in controls to 46.0% (n=23) in late CKD stage (χ^2=19.21, p<0.001). Alcohol consumption also showed significant group differences (χ^2=7.18, p=0.007), however, routine or occasional tobacco smoking rates across the groups (33.0% to 40.0%) showed no statistically significant variation (χ^2=0.59, p=0.442) **(Table 1).**

Table 1: Demographic, Socioeconomic, and Lifestyle Characteristics

Parameter (n, %)	Controls (n=100)	Early CKD: Stages 1-2 (n=70)	Mid CKD: Stages 3-4 (n=50)	Late CKD: Stage 5 (n=50)	Test Stat (χ^2 or F)	p-value
Age Category						
< 45 Years	66 (66.0%)	11 (15.7%)	4 (8.0%)	2 (4.0%)	χ^2=92.74	<0.001
≥ 45 Years	34 (34.0%)	59 (84.3%)	46 (92.0%)	48 (96.0%)		
Sex						
Male	37 (37.0%)	28 (40.0%)	20 (40.0%)	21 (42.0%)	χ^2=11.99	0.001
Female	63 (63.0%)	42 (60.0%)	30 (60.0%)	29 (58.0%)		
Socio-economic Status						
Low Income (<₦30,000/month)	22 (22.0%)	31 (44.3%)	28 (56.0%)	32 (64.0%)	χ^2=38.12	<0.001
Middle Income (₦30,000-₦100,000/month)	58 (58.0%)	29 (41.4%)	17 (34.0%)	14 (28.0%)	χ^2=18.24	0.004
High Income (>₦100,000/month)	20 (20.0%)	10 (14.3%)	5 (10.0%)	4 (8.0%)	χ^2=6.62	0.085
Educational Attainment						
Primary/Informal Education	14 (14.0%)	27 (38.6%)	24 (48.0%)	27 (54.0%)	χ^2=32.84	<0.001
Secondary Education	36 (36.0%)	26 (37.1%)	17 (34.0%)	15 (30.0%)	χ^2=1.51	0.682
Tertiary Education	50 (50.0%)	17 (24.3%)	9 (18.0%)	8 (16.0%)	χ^2=29.41	<0.001
Employment / Occupation						
Informal/Unemployed	28 (28.0%)	37 (52.9%)	31 (62.0%)	34 (68.0%)	χ^2=24.10	<0.001
Formal/Civil Servant	52 (52.0%)	23 (32.9%)	13 (26.0%)	11 (22.0%)	χ^2=12.80	0.001
Retired/Dependent	20 (20.0%)	10 (14.3%)	6 (12.0%)	5 (10.0%)	χ^2 = 3.08	0.215
Lifestyle & Behavioral Factors						
Routinely Exercises	76 (76.0%)	36 (51.4%)	24 (48.0%)	23 (46.0%)	χ^2=19.21	<0.001
Does Not Exercise	24 (24.0%)	34 (48.6%)	26 (52.0%)	27 (54.0%)		
Smokes Tobacco	33 (33.0%)	25 (35.7%)	19 (38.0%)	20 (40.0%)	χ^2=0.59	0.442
Does Not Smoke	67 (67.0%)	45 (64.3%)	31 (62.0%)	30 (60.0%)		
Consumes Alcohol	63 (63.0%)	42 (60.0%)	31 (62.0%)	31 (62.0%)	χ^2=7.18	0.007
Does Not Drink	37 (37.0%)	28 (40.0%)	19 (38.0%)	19 (38.0%)		

Statistical significance was set at p < 0.05; χ^2: Pearson Chi-square; F: F-Test CKD: Chronic Kidney Disease

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Medical History, Clinical Symptoms, and Traditional Risk Factors

A positive family history of renal disease was reported by over half of all disease groups, ranging from 55.4% to 60.0%, compared with only 11.0% (n=11) in the control group (χ^2=56.91, p<0.001). Patients with both hypertension and diabetes had a higher prevalence of disease lasting > 2 years with 36.7% for diabetes and 31.7% for hypertension **(Table 2).**

Pharmacotherapy analysis revealed significant variation, with 53.3%-58.5% of disease groups on antihypertensives compared to 26.7% of the diabetic group on antidiabetic medications. Clinical symptom reports showed significant differences across groups (χ^2=68.89, p<0.001) as weakness and fatigue were the predominant symptoms ranging from 33.3% to 36.7% in disease groups compared to 17.0% in the control group. Also, 51.0% (n=51) of participants in the control group were generally asymptomatic **(Table 2).**

Body Mass Index (BMI) was significantly higher in all disease groups compared to controls (23.98 ± 4.79 kg/m²), with the highest recorded in patients with combined hypertension and diabetes (29.90 ± 5.10 kg/m²) (F=8.45, p<0.001). Patients with combined hypertension and diabetes had the most severe blood pressure profile, with mean systolic blood pressure reaching 162.40 ± 18.50 mmHg (F=34.20, p<0.001) and mean diastolic blood pressure reaching 101.20 ± 12.00 mmHg (F=28.60, p<0.001). Renal function loss was higher in patients with combined hypertension and diabetes with serum urea of 14.60 ± 6.80 mmol/L (F=84.30, p<0.001), serum creatinine of 284.60 ± 112.40 µmol/L (F=142.60, p<0.001), and eGFR of 28.60 ± 16.40 mL/min/1.73 m² (F=95.10, p<0.001) **(Table 2).**

Table 2: Medical History, Clinical Symptoms, and Traditional Risk Factors

Parameter (n, %)	Controls (n=100)	Hypertension Alone (n=65)	Diabetes Alone (n=45)	Combined HTN + DM (n=60)	Test Stat (χ^2 or F)	p-value
Family History of Renal Disease						
Yes	11 (11.0%)	36 (55.4%)	26 (57.8%)	36 (60.0%)	χ^2=56.91	<0.001
No	89 (89.0%)	29 (44.6%)	19 (42.2%)	24 (40.0%)		
Duration of Diabetes Mellitus						
≤1 Year	5 (5.0%)	0 (0.0%)	18 (40.0%)	22 (36.7%)	χ^2=58.69	0.002
2 Years	5 (5.0%)	0 (0.0%)	10 (22.2%)	11 (18.3%)		
>2 Years	0 (0.0%)	0 (0.0%)	17 (37.8%)	22 (36.7%)		
None	90 (90.0%)	65 (100.0%)	0 (0.0%)	0 (0.0%)		
Duration of Hypertension						
≤1 Year	20 (20.0%)	14 (21.5%)	0 (0.0%)	13 (21.7%)	χ^2=58.61	<0.001
2Years	0 (0.0%)	18 (27.7%)	0 (0.0%)	16 (26.7%)		
>2 Years	1 (1.0%)	21 (32.3%)	0 (0.0%)	19 (31.7%)		
None	79 (79.0%)	0 (0.0%)	45 (100.0%)	0 (0.0%)		
Pharmacotherapy						
Antihypertensive	20 (20.0%)	38 (58.5%)	0 (0.0%)	32 (53.3%)	χ^2=18.84	<0.001
Antidiabetic	13 (13.0%)	0 (0.0%)	12 (26.7%)	16 (26.7%)		
Antimalarial	67 (67.0%)	25 (38.5%)	18 (40.0%)	26 (43.3%)		
None	37 (37.0%)	2 (3.1%)	1 (2.2%)	0 (0.0%)	χ^2=0.24	0.625
Clinical Symptoms						
Weakness & Fatigue	17 (17.0%)	22 (33.8%)	15 (33.3%)	22 (36.7%)	χ^2=68.89	<0.001
Weight Loss	15 (15.0%)	13 (20.0%)	9 (20.0%)	13 (21.7%)		
Fever	12 (12.0%)	11 (16.9%)	7 (15.6%)	10 (16.7%)		
Rashes	1 (1.0%)	9 (13.8%)	6 (13.3%)	9 (15.0%)		
Itching	4 (4.0%)	4 (6.2%)	3 (6.7%)	3 (5.0%)		
Asymptomatic/None	51 (51.0%)	6 (9.2%)	5 (11.1%)	3 (5.0%)		
Anthropometric & Clinical Evaluation						
Body Mass Index (kg/m²)	23.98 ± 4.79	27.80 ± 4.20	28.50 ± 4.60	29.90 ± 5.10	F=8.45	<0.001
Systolic Blood Pressure (mmHg)	118.20 ± 9.50	154.60 ± 16.80	136.20 ± 14.10	162.40 ± 18.50	F=34.20	<0.001
Diastolic Blood Pressure (mmHg)	76.40 ± 6.80	96.80 ± 10.40	84.50 ± 9.20	101.20 ± 12.00	F=28.60	<0.001
Serum Urea (mmol/L)	3.82 ± 1.23	7.80 ± 3.40	8.20 ± 3.90	14.60 ± 6.80	F=84.30	<0.001

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Serum Creatinine (µmol/L)	79.23 ± 15.82	128.50 ± 45.20	134.10 ± 51.00	284.60 ± 112.40	F=142.60	<0.001
eGFR (mL/min/1.73 m²)	104.50 ± 12.80	58.40 ± 18.20	55.10 ± 19.60	28.60 ± 16.40	F=95.10	<0.001

Statistical significance was set at $p < 0.05$; χ^2: Pearson Chi-square; F: F-Test HTN: Hypertension; DM: Diabetes Mellitus; eGFR: Estimated Glomerular Filtration Rate

Clinical Metrics and Biomarkers Across Individual CKD Stages

Systolic blood pressure increased from 118.20 ± 9.50 mmHg in controls to 138.50 ± 14.20 mmHg in CKD stage 1, 145.30 ± 15.80 mmHg in CKD stage 2, 154.20 ± 17.50 mmHg in CKD stage 3, 162.80 ± 19.40 mmHg in CKD stage 4, and 168.40 ± 21.00 mmHg in CKD stage 5, with overall CKD stages mean of 154.20 ± 18.50 mmHg (p<0.001). Diastolic blood pressure similarly increased steadily from 76.40 ± 6.80 mmHg in the control group to 102.50 ± 13.40 mmHg in CKD stage 5 (p<0.001). Body mass index initially increased in the early stage of disease with a score of 28.40 ± 4.20 kg/m² in CKD stage 1 followed by a steady reduction from that point down to CKD stage 5 with a score of 24.46 ± 3.80 kg/m² (p<0.001) **(Table 3).**

Serum creatinine and urea levels increased exponentially across CKD stages. Serum creatinine was 79.23 ± 15.82 µmol/L in the control group and rose to 88.50 ± 18.20 µmol/L for CKD stage 1 and through to 530.40 ± 112.30 µmol/L in CKD stage 5 (p<0.001). Serum urea followed a similar pattern, increasing from 3.82 ± 1.23 mmol/L in the control group to 5.10 ± 1.40 mmol/L in CKD stage 1 and through to 16.29 ± 5.80 mmol/L in CKD stage 5 (ptrend<0.001). eGFR decreased from 104.50 ± 12.80 mL/min/1.73 m² in the control group down to 8.40 ± 3.20 mL/min/1.73 m² in CKD stage 5 (p<0.001) **(Table 3).**

Table 3: Clinical Metrics and Biomarkers Across Individual CKD Stages

Parameter	Control (n=100)	CKD Stage 1 (n=29)	CKD Stage 2 (n=41)	CKD Stage 3 (n=35)	CKD Stage 4 (n=15)	CKD Stage 5 (n=50)	All CKD Stages (n=170)	p-trend
Age (Years)	39.53 ± 22.11	50.10 ± 6.20	58.12 ± 5.10	62.40 ± 6.10	68.07 ± 6.50	73.50 ± 5.64	64.24 ± 14.90	<0.001
BMI (kg/m²)	23.98 ± 4.79	28.40 ± 4.20	27.89 ± 4.10	27.60 ± 4.00	26.93 ± 3.90	24.46 ± 3.80	26.48 ± 4.77	<0.001
Systolic BP (mmHg)	118.20 ± 9.50	138.50 ± 14.20	145.30 ± 15.80	154.20 ± 17.50	162.80 ± 19.40	168.40 ± 21.00	154.20 ± 18.50	<0.001
Diastolic BP (mmHg)	76.40 ± 6.80	85.20 ± 8.90	91.00 ± 10.20	94.80 ± 10.80	100.20 ± 12.10	102.50 ± 13.40	94.80 ± 11.60	<0.001
Serum Urea (mmol/L)	3.82 ± 1.23	5.10 ± 1.40	6.98 ± 1.80	11.20 ± 3.20	16.53 ± 4.10	16.29 ± 5.80	10.70 ± 9.09	<0.001
Serum Creatinine (µmol/L)	79.23 ± 15.82	88.50 ± 18.20	105.74 ± 21.10	192.40 ± 42.00	370.40 ± 78.50	530.40 ± 112.30	285.95 ± 30.60	<0.001
eGFR (mL/min/1.73 m²)	104.50 ± 12.80	98.40 ± 8.20	72.10 ± 6.50	42.50 ± 7.80	21.40 ± 3.50	8.40 ± 3.20	44.80 ± 28.50	<0.001

Statistical significance was set at $p < 0.05$ CKD: Chronic Kidney Disease; BMI: Body Mass Index; BP: Blood Pressure; eGFR: Estimated Glomerular Filtration Rate

Bivariate Correlation Analysis

A higher Socio-economic index showed significant negative correlations with systolic blood pressure (r=-0.385, p<0.001), diastolic blood pressure (r=-0.352, p<0.001), serum urea (r=-0.412, p< 0.001), and serum creatinine (r=-0.436, p<0.001), while displaying a strong positive correlation with eGFR (r=+0.458, p<0.001) **(Table 4).**

Systolic blood pressure correlated positively with serum creatinine (r=+0.582, p<0.001) and inversely with eGFR (r=-0.641, p<0.001). Serum urea and creatinine displayed a strong mutual positive correlation (r=+0.814, p<0.001), confirming nitrogenous waste accumulation as kidney function decreases **(Table 4).**

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Table 4: Pearson Correlation of Risk Factors, Socio-economic Index, and Renal Indices

Variable	Socioeconomic Index	BMI (kg/m²)	Systolic BP	Diastolic BP	Serum Urea	Serum Creatinine	eGFR
Socioeconomic Index	1.000	-0.248	-0.385*	-0.352*	-0.412*	-0.436*	+0.458*
BMI (kg/m²)	-0.248	1.000	+0.312*	+0.294*	+0.285	+0.264	-0.305*
Systolic BP (mmHg)	-0.385*	+0.312*	1.000	+0.842*	+0.524*	+0.582*	-0.641*
Diastolic BP (mmHg)	-0.352*	+0.294*	+0.842*	1.000	+0.486*	+0.518*	-0.594*
Serum Urea (mmol/L)	-0.412*	+0.285	+0.524*	+0.486*	1.000	+0.814*	-0.785*
Serum Creatinine	-0.436*	+0.264	+0.582*	+0.518*	+0.814*	1.000	-0.673*
eGFR (mL/min/1.73 m²)	+0.458*	-0.305*	-0.641*	-0.594*	-0.785*	-0.673*	1.000

Statistical significance was set at $p < 0.05$. *Statistically significant at $p < 0.001$ BMI: Body Mass Index; BP: Blood Pressure; eGFR: Estimated Glomerular Filtration Rate

IV. DISCUSSION

Discussion of Study

This study provides a comprehensive analysis of how demography, socio-economic status, anthropometric data, and other risk factors intersect with conventional renal function parameters across individual disease stages in Ekiti-State, Nigeria. By expanding our analysis to evaluate CKD stages 1 to 5 individually, these findings offer a refined perspective on the pathophysiology of renal function decline and underscore the roles of the factors defined in this study in driving CKD progression.

A central finding of this investigation is the inverse association between socio-economic status and the stage of renal function loss. Patients in low-income brackets (<₦30,000/month) and those with limited educational attainment accounted for a disproportionately high percentage of advanced CKD cases of about 56.0% in the mid CKD stage group (CKD stage 3 and 4) and 64.0% in the late CKD stage group. This social gradient in kidney disease aligns with global observations in developing nations, where low socio-economic status acts as a major driver of health disparities. [14] In resource-constrained settings like Ekiti-State, low socio-economic status restricts access to proper diagnosis, compliance and continuity of care, affordability of prescribed antihypertensive and hypoglycemic medications, and reduces health literacy regarding lifestyle choices and dietary sodium intake. [14,15] Hence, patients often are compelled to seek cheaper alternative therapies, such as unstandardized herbal concoctions, which may exacerbate further renal function loss as many contain nephrotoxic heavy metals or phytochemicals that accelerate renal tubular injury. [16]

The physical activity trends observed amongst the study groups further confirm this. Participants who routinely engage in physical exercises declined sharply across study groups. While this decline partly reflects functional impairment and uremic fatigue in advanced disease stages, physical inactivity also serves as an upstream risk factor that exacerbates hypertension, insulin resistance, and obesity. [17]

The compounding impact of hypertension and diabetes mellitus on renal function deterioration has been very evident in our study. Patients presenting with both hypertension and diabetes exhibited significantly higher blood pressure levels (systolic blood pressure of 162.40 ± 18.50 mmHg and diastolic blood pressure of 101.20 ± 12.00 mmHg) and the severely depressed renal clearance (eGFR of 28.60 ± 16.40 mL/min/1.73 m² and serum creatinine of 284.60 ± 112.40 µmol/L) compared to patients with either condition alone. The pathophysiology of this disease combination produces a double negative impact on the renal microvasculature. [6] Systemic hypertension induces intraglomerular hyperfiltration and arterial hyalinosis, while diabetic hyperglycemia accelerates advanced glycation end-product accumulation, mesangial expansion, and basement membrane thickening. [6]

The trajectory of the body mass index (BMI) data across the CKD stages is also noteworthy. While BMI was elevated in the CKD stage 1 group relative to the control group, it demonstrated a steady decline across subsequent stages. This trajectory illustrates the obesity paradox in chronic renal failure, where in early disease stages, obesity drives renal impairment via metabolic syndrome, insulin resistance, and hyperfiltration-induced glomerulopathy. [18] However, as renal function deteriorates toward end-stage failure, chronic uremic toxicity, systemic inflammation, protein-energy wasting, and severe anorexia precipitate progressive loss of muscle mass and adipose tissue, resulting in lower BMI values in CKD stage 5 patients. [19]

The detailed stage-by-stage analysis of standard renal biomarkers adopted by this study also provides crucial insights into the non-linear dynamics of serum creatinine and urea retention. In the CKD stages 1 and 2 groups, serum creatinine rises only modestly (88.50 ± 18.20 µmol/L and 105.74 ± 21.10 µmol/L respectively) above the control group levels of 79.23 ± 15.82 µmol/L, despite

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an underlying loss of over 30% to 40% of functional eGFR. This highlights the classic clinical creatinine blind spot, where substantial early loss of nephron mass occurs while serum creatinine remains largely within normal clinical reference ranges. [10] As renal failure progresses into Stage 3 and Stage 4, creatinine clearance becomes severely compromised, ultimately surging exponentially in Stage 5 (530.40 ± 112.30 µmol/L). Similarly, serum urea increases from Stage 1 to 5, reflecting severe uremic retention. [10]

Study Limitations

The cross-sectional design has allowed the authors to present statistical correlations and prevents the study from establishing cause-and-effect relationships between socio-economic factors, lifestyle behaviors, risk profiles, and CKD progression. Also, specific antihypertensive drug classes that patients took and the dietary sodium intake levels were not fully quantified, which could influence blood pressure levels and urea clearance. Despite these limitations, the study offers robust empirical data from an under-researched West African population, providing a crucial baseline for clinical decision-making and health policy.

V. CONCLUSION AND RECOMMENDATIONS

Conclusion

This study establishes that low socio-economic status, advanced age, physically inactive lifestyles, uncontrolled hypertension, and co-existing diabetes mellitus are primary drivers of chronic kidney disease burden in Ekiti-State, Nigeria. Patients in lower socioeconomic brackets experience a disproportionately higher prevalence of advanced renal failure, driven by delayed presentation, financial barriers to pharmacotherapy, and poor health literacy. [9,20] Furthermore, standard renal function markers (serum urea and serum creatinine) remain insensitive in early-stage disease, reinforcing the mandatory adoption of routine eGFR reporting in clinical practice. [10,21,22]

Recommendation

Based on these conclusions, it is important that subsidized community and clinic-based routine screening for hypertension, diabetes, and early renal impairment is key, especially in high-risk and low socio-economic status populations. Also, policies must be put in place to allow expansion of state and national health insurance schemes to cover basic antihypertensive, hypoglycemic, and renal protective medications, reducing out-of-pocket expenditure for low-income patients. Lastly, the government should launch or revive state-funded health literacy campaigns focusing on physical exercise promotion, dietary salt reduction, blood pressure control, and the severe hazards of nephrotoxic herbal remedies.

ABBREVIATIONS

CKD: Chronic kidney disease
eGFR: Estimated glomerular filtration rate
ESRD: End-stage renal disease
NCDs: Non-communicable diseases
LMICs: Low and middle-income countries
OOP: Out-of-pocket
RRT: Renal replacement therapy
AKI: Acute kidney injury
BMI: Body mass index
SBP: Systolic blood pressure
DBP: Diastolic blood pressure
T2DM: Type 2 diabetes mellitus
CKD-EPI: Chronic kidney disease epidemiology collaboration
SPSS: Statistical package for social sciences
SD: Standard deviation
ANOVA: One-way analysis of variance

AUTHORS CONTRIBUTIONS

Babajide Adewoyin Adeleke: conceptualization, research execution, project administration, visualization, writing of the original draft, writing and review of the final draft. **Olaoluwa Akindele Adesanoye:** research execution, visualization, writing of the original and final draft. **Boluwatife Samuel Fatokun:** visualization, writing of the original draft, writing and review of the final draft. **Muyiwa Adeleye Moronkeji:** data curation, writing of the original draft. **Bunmi Feyisayo Olowolagba:** data curation, writing of the original draft. **Kazeem Damilola Suleman:** data curation, writing of the original draft.

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DECLARATION

Ethics Approval and Consent to Participate: The ethical clearance for this research was obtained from the Human Research and Ethics Committee of Federal Teaching Hospital Ido, Ekiti-State, Nigeria with Reference number ERC/2021/05/06/543A.
Consent for Publication: Informed consent was obtained from all participants of this research.

Availability of Data and Materials: The data used to support the findings of this study are included within the article.
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