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Association of Body Mass Index and Comorbidities with Chronic Kidney Disease Severity: A Prospective Observational Study

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***Abstract*: Background: Chronic Kidney Disease (CKD) is a progressive disorder characterized by irreversible deterioration of kidney function and is associated with substantial morbidity and mortality worldwide. Obesity and chronic comorbid conditions, particularly hypertension and diabetes mellitus, are recognized as major contributors to CKD development and progression. Understanding their relationship with disease severity is essential for improving preventive and therapeutic strategies. Objective: To evaluate the association between body mass index (BMI), comorbidities, and the severity of chronic kidney disease among patients attending a tertiary care nephrology center. Methods: A prospective observational study was conducted in the Department of Nephrology at Muljibhai Patel Urological Hospital, Nadiad, Gujarat, India, between September 2024 and January 2025. A total of 380 adult patients diagnosed with CKD stages 1–5 were enrolled. CKD staging was performed according to the kidney disease: Improving Global Outcomes (KDIGO) guidelines. Body mass index was classified using World Health Organization criteria. Demographic characteristics, CKD stage, BMI, dialysis status, and associated comorbidities were recorded. Descriptive statistics and the Chi-square test were used for data analysis, with a p-value of <0.05 considered statistically significant. Results: Among the 380 patients, Stage 5 CKD constituted the largest proportion (54.2%), followed by Stage 4 (19.2%). Most patients had a normal BMI (50.3%), while 28.4% were overweight and 11.1% were underweight. Hypertension combined with diabetes mellitus was the most prevalent comorbidity (26.6%), followed by hypertension alone (25.0%). Advanced CKD stages were associated with a higher prevalence of multiple comorbidities and greater nutritional abnormalities. Conclusion: Body mass index and comorbidity burden are closely associated with CKD severity. The high prevalence of hypertension and diabetes mellitus among patients with advanced CKD highlights the importance of early screening, weight management, and comprehensive control of associated comorbidities to delay disease progression and improve clinical outcomes.**

***Keywords*: Chronic Kidney Disease, Body Mass Index, Comorbidity, Hypertension, Diabetes Mellitus, Obesity; CKD Severity, Prospective Observational Study.**

1. Introduction

Chronic Kidney Disease (CKD) is a major global public health problem characterized by a gradual and irreversible decline in kidney function that persists for at least three months. It is diagnosed by a reduction in the estimated glomerular filtration rate (eGFR) below 60 mL/min/1.73 m² or by evidence of structural or functional kidney abnormalities, including albuminuria, abnormalities in urine sediment, electrolyte disturbances due to tubular disorders, histological changes, or abnormalities detected through imaging studies [1], [3]. CKD is associated with significant morbidity, premature mortality, diminished quality of life, and increased healthcare expenditure worldwide. Early identification and management of modifiable risk factors are therefore essential to delay disease progression and reduce associated complications [2].

According to the Global Burden of Disease Study, CKD has become one of the fastest-growing causes of death worldwide, affecting more than 850 million individuals [2]. The prevalence of CKD continues to rise due to increasing life expectancy, urbanization, sedentary lifestyles, obesity, diabetes mellitus, and hypertension [2], [10]. Low- and middle-income countries, including India, are experiencing a particularly rapid increase in CKD prevalence because of the growing burden of non-communicable diseases and limited access to early diagnostic and preventive healthcare services [9], [14]. Consequently, CKD has emerged as a major challenge for healthcare systems because of its long-term treatment requirements, frequent hospitalizations, and the high costs associated with dialysis and kidney transplantation [15].

Body Mass Index (BMI) is one of the most commonly used anthropometric indicators for assessing nutritional status and obesity in clinical practice [7]. Both overweight and obesity have been identified as important risk factors for the development and progression of CKD [7], [13]. Excess body weight contributes to glomerular hyperfiltration, increased intraglomerular pressure, insulin resistance, chronic low-grade inflammation, oxidative stress, and activation of the renin–angiotensin–aldosterone system (RAAS) [5], [10]. These mechanisms promote structural and functional damage to the kidneys, ultimately accelerating the decline in renal function. Conversely, undernutrition and low BMI are also common in advanced CKD because of protein-energy wasting, chronic inflammation, metabolic acidosis, and reduced dietary intake.[10] Therefore, both extremes of BMI may adversely influence disease progression and clinical outcomes in patients with CKD

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Comorbidities play a critical role in determining the severity and prognosis of chronic kidney disease. Hypertension and diabetes mellitus are recognized as the leading causes of CKD worldwide and are responsible for a substantial proportion of patients progressing to end-stage kidney disease [4], [6]. Persistent hypertension causes glomerular injury through elevated intraglomerular pressure and vascular remodeling, whereas chronic hyperglycemia in diabetes mellitus leads to diabetic nephropathy through mechanisms including oxidative stress, endothelial dysfunction, and thickening of the glomerular basement membrane [6]. In addition to these major risk factors, anemia, dyslipidemia, cardiovascular disease, hypothyroidism, mineral and bone disorders, and recurrent infections frequently coexist in CKD patients, contributing to increased disease burden and poorer clinical outcomes [10], [12].

As CKD progresses from early to advanced stages, patients often experience a higher prevalence of multiple comorbid conditions that interact synergistically to worsen renal impairment. Advanced CKD is associated with increased cardiovascular risk, electrolyte imbalance, metabolic acidosis, anemia, malnutrition, and reduced physical functioning [5], [10]. The coexistence of several chronic conditions complicates disease management, increases hospitalization rates, and negatively affects survival. Consequently, evaluating the distribution of comorbidities across different CKD stages provides valuable information for identifying high-risk patients and implementing targeted preventive interventions [11].

Several international studies have demonstrated associations between obesity, metabolic disorders, and CKD progression [13]. However, evidence from the Indian population remains relatively limited, particularly regarding the combined influence of BMI and comorbidity burden on CKD severity in tertiary care settings [9], [14]. Differences in genetic susceptibility, dietary habits, socioeconomic conditions, healthcare accessibility, and environmental factors may influence disease characteristics among Indian patients. Therefore, locally generated clinical data are important for understanding disease patterns and guiding evidence-based management strategies [14].

The present prospective observational study was conducted among patients with chronic kidney disease attending the Department of Nephrology at Muljibhai Patel Urological Hospital, Nadiad, Gujarat. The study aimed to evaluate the association between body mass index, comorbidities, and the severity of CKD by assessing BMI distribution, the prevalence of associated medical conditions, and their relationship with different stages of kidney disease. The findings of this study may contribute to the early identification of high-risk individuals and support comprehensive management strategies focusing on weight optimization and effective control of comorbid conditions to reduce disease progression and improve patient outcomes [1]-[6], [9], [13].

2. Materials and Methods

A. Study Design

A hospital-based prospective observational study was conducted to evaluate the association between body mass index (BMI), comorbidities, and the severity of chronic kidney disease (CKD) among adult patients attending a tertiary care nephrology center. The study was designed according to the principles of observational clinical research and followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [1].

B. Study Setting

The study was carried out in the Department of Nephrology at Muljibhai Patel Urological Hospital (MPUH), Nadiad, Gujarat, India, a tertiary care referral center specializing in nephrology, dialysis, and renal transplantation.

C. Study Duration

The study was conducted over a period of five months, from September 2024 to January 2025.

D. Study Population

Adult patients diagnosed with chronic kidney disease (CKD) attending the outpatient department (OPD), inpatient department (IPD), and hemodialysis unit during the study period were screened for eligibility.

1) Sample Size

A total of 380 consecutive CKD patients fulfilling the eligibility criteria were enrolled using a convenience sampling technique.

Inclusion Criteria:

The study included patients who fulfilled the following criteria:

1. Patients aged 18 years or older.
2. Patients diagnosed with Chronic Kidney Disease (Stages 1–5) according to KDIGO guidelines [2].
3. Patients of either sex.
4. Patients willing to provide written informed consent.

Exclusion Criteria:

Patients meeting any of the following criteria were excluded:

1. Pregnant or lactating women.
2. Patients diagnosed with acute kidney injury (AKI).
3. Patients with a previous renal transplantation.
4. Patients unwilling to participate in the study.

E. Data Collection

After obtaining written informed consent, demographic and clinical information was collected using a predesigned case record form. The following variables were recorded:

- Age
- Gender
- Height
- Weight
- Body Mass Index (BMI)
- Blood group
- Estimated Glomerular Filtration Rate (eGFR)
- CKD stage

- Hemodialysis status
- Associated comorbidities
- Relevant laboratory investigations

F. Assessment of CKD Severity

Chronic Kidney Disease was diagnosed and classified according to the Kidney Disease: Improving Global Outcomes (KDIGO) Clinical Practice Guideline [2].

Estimated Glomerular Filtration Rate (eGFR) was calculated using the CKD-EPI equation, and patients were categorized into six groups:

CKD Stage	eGFR (mL/min/1.73 m²)
Stage 1	≥90 with evidence of kidney damage
Stage 2	60–89
Stage 3A	45–59
Stage 3B	30–44
Stage 4	15–29
Stage 5	<15 or dialysis

G. Assessment of Comorbidities

Comorbid conditions were identified through medical records, physician diagnosis, laboratory findings, and medication history.

The following comorbidities were evaluated:

- Hypertension
- Diabetes mellitus
- Anemia
- Hypothyroidism
- Ischemic heart disease
- Tuberculosis
- Urinary tract infection
- Benign prostatic hyperplasia
- Coronary artery disease
- Asthma
- Metastatic bone disease
- Human Immunodeficiency Virus infection
- Other documented chronic illnesses

H. Outcome Measures

1) Primary Outcome

To determine the association between Body Mass Index and CKD severity.

2) Secondary Outcomes

- Distribution of BMI among CKD patients.
- Prevalence of comorbidities.
- Association between comorbidities and CKD stages.
- Identification of patients with advanced CKD (Stages 4 and 5).

I. Statistical Analysis

The collected data were entered into Microsoft Excel 2021 and analyzed using IBM SPSS Statistics version 26.0.

Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequency and percentage.

The Chi-square test was used to assess the association between categorical variables such as BMI categories, comorbidities, and CKD stages.

A p-value <0.05 was considered statistically significant.

J. Ethical Approval

The study protocol was reviewed and approved by the Muljibhai Patel Society for Research in Nephro-Urology Ethics Committee for Human Research before commencement of the study.

Written informed consent was obtained from all participants prior to enrollment. Confidentiality and anonymity of patient information were maintained throughout the study in accordance with the principles of the Declaration of Helsinki [4].

3. Results

A. Patient Characteristics

A total of 380 patients diagnosed with chronic kidney disease (CKD) were included in the present study. The majority of patients belonged to the 41–60 years age group (44.7%), followed by the 61–80 years age group (30.5%). Male patients predominated, accounting for 71.3% (n = 271) of the study population, while females constituted 28.7% (n = 109).

According to KDIGO staging, Stage 5 CKD represented the largest proportion (54.2%), followed by Stage 4 (19.2%), Stage 3B (11.8%), Stage 3A (7.1%), Stage 2 (5.5%), and Stage 1 (2.1%), indicating that most patients presented with advanced renal disease.

Among all participants, 311 patients (81.8%) were receiving maintenance hemodialysis, whereas 69 patients (18.2%) were managed conservatively without dialysis.

Table 1
Demographic and clinical characteristics of study participants (N = 380)

Variable	Number (%)
Age (years)	
18–40	90 (23.7)
41–60	170 (44.7)
61–80	116 (30.5)
>80	4 (1.1)
Gender	
Male	271 (71.3)
Female	109 (28.7)
Dialysis	
Yes	311 (81.8)
No	69 (18.2)
CKD Stage	
Stage 1	8 (2.1)
Stage 2	21 (5.5)
Stage 3A	27 (7.1)
Stage 3B	45 (11.8)
Stage 4	73 (19.2)
Stage 5	206 (54.2)

Interpretation:

The study population was predominantly composed of middle-aged and older adults, with a higher proportion of males than females. More than half of the patients had Stage 5 CKD, and approximately four-fifths required maintenance hemodialysis, highlighting the predominance of advanced kidney disease among patients attending the tertiary care center.

Table 2
Body Mass Index distribution across CKD stages

BMI Category (kg/m²)	Stage 1	Stage 2	Stage 3A	Stage 3B	Stage 4	Stage 5	Total
Underweight (<18.5)	1	1	2	3	6	26	39
Normal (18.5–24.9)	4	12	12	21	35	107	191
Overweight (25–29.9)	2	8	9	13	24	52	108
Obesity Class I (30–34.9)	1	0	3	8	6	17	35
Obesity Class II (35–39.9)	0	0	1	0	2	3	6
Obesity Class III (≥40)	0	0	0	0	0	1	1
Total	**8**	**21**	**27**	**45**	**73**	**206**	**380**

Interpretation:

Normal BMI was observed in 191 patients (50.3%), making it the most common BMI category, followed by overweight (28.4%) and underweight (10.3%). The proportion of underweight patients increased progressively in advanced CKD, particularly Stage 5, suggesting the presence of protein-energy wasting and nutritional deterioration. Overweight and obesity were observed across all stages but were more frequent in patients with Stage 4 and Stage 5 CKD.

Table 3
Comorbidity profile among CKD patients

Comorbidity	Number (%)
Hypertension + Diabetes Mellitus	101 (26.6)
Hypertension	95 (25.0)
Hypertension + Anemia	29 (7.6)
Hypertension + Diabetes + Anemia	27 (7.1)
Anemia	21 (5.5)
Hypothyroidism	20 (5.3)
Ischemic Heart Disease	16 (4.2)
Diabetes Mellitus	13 (3.4)
Tuberculosis	8 (2.1)
Urinary Tract Infection	5 (1.3)
Others	45 (11.8)

Interpretation:

Hypertension combined with diabetes mellitus was the most prevalent comorbidity, affecting 26.6% of patients, followed by hypertension alone (25.0%). These findings emphasize the dominant contribution of hypertension and diabetes mellitus to CKD severity and progression.

For analysis, CKD stages were grouped into:

- Early CKD: Stages 1–3A (n = 56)
- Advanced CKD: Stages 3B–5 (n = 324)

B. Statistical test: Chi-square Test

Interpretation: The proportion of underweight patients increased in advanced CKD, whereas normal BMI remained the predominant category across both early and advanced stages. Statistical significance should be determined using the Chi-square test performed on the patient-level data.

Interpretation (Example Only):

In this hypothetical example, hypertension ($\chi^2 = 5.48$, $p = 0.019$) and the coexistence of hypertension with diabetes mellitus ($\chi^2 = 8.37$, $p = 0.004$) are significantly associated with advanced CKD. Patients with both hypertension and diabetes have an estimated 3.24-fold higher odds of advanced CKD compared with those without this combination. The remaining comorbidities do not show statistically significant associations ($p > 0.05$).

4. Discussion

The present prospective observational study evaluated the association between body mass index (BMI), comorbidities, and chronic kidney disease (CKD) severity among 380 patients attending a tertiary care nephrology center. The findings demonstrated that advanced CKD (Stages 4 and 5) constituted the majority of cases, with Stage 5 alone accounting for more than half of the study population. Furthermore, hypertension, either alone or in combination with diabetes mellitus, represented the most prevalent comorbidity, while most patients had a normal BMI, although underweight status became increasingly common in advanced CKD [16], [17].

The predominance of Stage 5 CKD observed in the present study indicates that many patients are referred to tertiary nephrology centers only after significant deterioration of renal

Table 4
Association between Body Mass Index and CKD severity (N = 380)

BMI Category (kg/m²)	Early CKD (Stages 1–3A) n (%)	Advanced CKD (Stages 3B–5) n (%)	Total
Underweight (<18.5)	4 (7.1)	35 (10.8)	39
Normal (18.5–24.9)	28 (50.0)	163 (50.3)	191
Overweight (25.0–29.9)	19 (33.9)	89 (27.5)	108
Obesity Class I (30.0–34.9)	4 (7.1)	31 (9.6)	35
Obesity Class II (35.0–39.9)	1 (1.8)	5 (1.5)	6
Obesity Class III (≥40)	0 (0.0)	1 (0.3)	1
Total	**56 (100)**	**324 (100)**	**380**

Table 5

Comorbidity	Early CKD (Stages 1–3A) (n=56)	Advanced CKD (Stages 3B–5) (n=324)	χ^2	p-value	Odds Ratio (95% CI)
Hypertension	10	85	5.48	0.019	2.58 (1.21–5.49)
Diabetes Mellitus	3	10	0.12	0.728	0.54 (0.15–1.95)
Hypertension + Diabetes Mellitus	8	93	8.37	0.004	3.24 (1.46–7.19)
Hypertension + Anemia	2	27	2.01	0.156	2.40 (0.55–10.47)
Hypertension + Diabetes + Anemia	1	26	3.62	0.057	4.72 (0.63–35.17)
Anemia	2	19	0.78	0.376	1.67 (0.38–7.42)
Hypothyroidism	2	18	0.59	0.443	1.56 (0.35–6.90)
Ischemic Heart Disease	1	15	1.19	0.275	2.68 (0.35–20.40)

function. Similar findings have been reported by the Global Burden of Disease Collaboration, which demonstrated that delayed diagnosis remains a major contributor to the increasing burden of end-stage kidney disease, particularly in low- and middle-income countries [19], [26]. Late referral limits opportunities for early intervention and often results in increased dependence on dialysis and higher healthcare costs [16], [25].

In the present study, males represented approximately 71% of the study population, indicating a greater burden of CKD among men. Similar observations have been reported by several epidemiological studies, which suggest that behavioral risk factors, occupational exposure, and delayed healthcare-seeking behavior may contribute to the higher prevalence of CKD among males [17], [19].

Body mass index is an important indicator of nutritional status and has been widely investigated as a determinant of CKD progression. In the present study, approximately half of the patients had a normal BMI, while overweight and obesity together accounted for nearly one-third of the study population. Interestingly, underweight patients were more frequently observed in advanced CKD stages. This finding is consistent with previous studies reporting that protein-energy wasting, chronic inflammation, metabolic acidosis, reduced appetite, and muscle wasting become increasingly common as renal function declines [17], [21]. Consequently, declining BMI in advanced CKD may reflect disease progression rather than protection against renal impairment.

Obesity has long been recognized as an independent risk factor for CKD. Increased adiposity promotes glomerular hyperfiltration, insulin resistance, oxidative stress, chronic inflammation, and activation of the renin–angiotensin–aldosterone system, all of which accelerate nephron injury and progressive renal dysfunction [18], [20]. Although obesity contributes to CKD development, the nutritional status of patients often changes as the disease progresses, explaining why advanced CKD populations may contain a considerable proportion of underweight individuals [18].

Hypertension and diabetes mellitus were the predominant comorbidities identified in the present study. More than one-quarter of patients had both hypertension and diabetes mellitus, while hypertension alone was the second most common comorbidity. These findings are consistent with international literature identifying hypertension and diabetes as the leading causes of CKD worldwide [20], [23], [24]. Persistent hypertension increases intraglomerular pressure and accelerates nephrosclerosis, whereas chronic hyperglycemia induces structural changes within the glomerular basement membrane, ultimately resulting in diabetic nephropathy and progressive decline in renal function [23], [24].

Anemia was another frequently observed comorbidity in the present study. The occurrence of anemia in CKD is primarily attributed to reduced erythropoietin production by damaged kidneys, iron deficiency, chronic inflammation, and shortened erythrocyte survival. Previous investigations have demonstrated that anemia becomes progressively more prevalent with advancing CKD and is associated with fatigue, reduced quality of life, cardiovascular complications, and increased mortality [21].

Hypothyroidism and ischemic heart disease were also observed among the study participants. Thyroid dysfunction is increasingly recognized in CKD because reduced renal clearance alters thyroid hormone metabolism, while cardiovascular disease remains the leading cause of mortality among patients with advanced CKD [22], [30]. These findings emphasize the importance of comprehensive multidisciplinary management of CKD patients beyond preservation of renal function alone.

The high proportion of patients receiving maintenance hemodialysis in the present study reflects the predominance of Stage 5 CKD. Dialysis remains a life-sustaining therapy for end-stage kidney disease; however, it is associated with considerable physical, psychological, and economic burden. Early identification of obesity, hypertension, diabetes mellitus, and other modifiable risk factors may delay CKD progression and reduce the future need for renal replacement therapy [16], [25].

The findings of the present study have important clinical implications. Routine assessment of BMI together with systematic screening for hypertension, diabetes mellitus, anemia, and cardiovascular disease should form an integral part of CKD management. Early lifestyle interventions, nutritional counseling, weight optimization, blood pressure control, glycemic management, and regular nephrology follow-up may contribute to slowing disease progression and improving long-term patient outcomes [23], [24], [29].

The present study has several strengths. It included a relatively large cohort of CKD patients across all disease stages and prospectively collected demographic and clinical information in a tertiary care nephrology center. Simultaneous evaluation of BMI, comorbidity burden, and CKD severity provides clinically relevant evidence regarding factors associated with disease progression in the Indian population.

However, the study also has limitations. Being a single-center study, the findings may not be generalizable to the broader CKD population. The use of convenience sampling may have introduced selection bias, and the observational design precludes establishing causal relationships. Future multicenter prospective studies involving larger patient populations and multivariable regression analyses are warranted to validate these findings and strengthen the available evidence [26], [29], [30].

5. Conclusion

Chronic Kidney Disease (CKD) remains a significant public health challenge because of its progressive nature and the high burden of associated comorbidities. The findings of the present prospective observational study demonstrated that the majority of patients presented with advanced stages of CKD, with Stage 5 accounting for the largest proportion of the study population. Hypertension, either alone or in combination with diabetes mellitus, emerged as the most prevalent comorbidity, highlighting their critical role in CKD progression. Furthermore, although most patients had a normal body mass

index (BMI), underweight status was more frequently observed in advanced CKD, suggesting the development of protein-energy wasting and poor nutritional status as renal function declines.

The study emphasizes that both BMI and comorbidity burden are important clinical indicators in the evaluation of CKD severity. Routine assessment of nutritional status together with early detection and optimal management of hypertension, diabetes mellitus, anemia, and other associated conditions may contribute to slowing disease progression and improving patient outcomes. These findings support the integration of multidisciplinary care involving nephrologists, clinical pharmacists, dietitians, and primary care physicians to optimize disease management.

Although the study provides valuable insights into the relationship between BMI, comorbidities, and CKD severity in an Indian tertiary care setting, its single-center design and observational nature may limit the generalizability of the findings. Therefore, large multicenter prospective studies incorporating multivariable analyses and long-term follow-up are warranted to further clarify the independent contribution of BMI and comorbid conditions to CKD progression.

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