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# Comprehensive Assessment of Diabetes, Hypertension, Cardiovascular Disease and Renal Dysfunction: Predictors of Disease Progression and Clinical Outcomes

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## Abstract

***Background:*** Diabetes, hypertension, cardiovascular disease (CVD), and renal dysfunction often coexist and result in significant morbidity and mortality. This study assessed the effects of prognostic factors on disease progression and clinical outcomes within this continuum of diseases. **Methods:** A prospective observational cohort study was performed in 170 adults who have diabetes, hypertension, CVD, and/or renal dysfunction. Demographic and clinical, biochemical, and renal parameters were recorded at baseline, and patients were followed for progression of the disease and adverse clinical events. For independent predictors, logistic regression and Cox proportional-hazards analyses were used. **Results:** In 67 (39.4%) participants, disease progression or an adverse clinical outcome occurred. The most common complication was renal deterioration (22.4%), while worsening glycaemic control (20.0%) and cardiovascular hospitalization (17.1%) were the other most common complications. CVD, eGFR, and albuminuria were all independently associated with poor outcomes, as was HbA1C ≥7% and diabetes duration ≥10 years, while systolic BP ≥140 mmHg was not. Previous CVD and eGFR <60 were the strongest predictors in Cox analysis. **Conclusion:** Comprehensive evaluation of the heart, blood vessels, and kidneys could help identify patients at risk of disease progression and poor outcomes earlier.

**Keywords:** Diabetes mellitus; Hypertension; Cardiovascular disease; Chronic kidney disease

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## INTRODUCTION

Diabetes mellitus, hypertension, cardiovascular disease (CVD), and renal dysfunction are closely related components of the global burden of noncommunicable diseases.[1] These disorders are not isolated events, but rather they often occur together and can reinforce each other by having common pathogenic mechanisms such as endothelial dysfunction, chronic inflammation, insulin resistance, oxidative stress, vascular injury, and progressive renal impairment.[2] This clustering significantly raises the likelihood of cardiovascular events, chronic kidney disease (CKD), hospitalisation, disability and death, highlighting the increasing significance of cardiometabolic and renal assessment at the clinic.[3]

Diabetes has become a significant worldwide problem during the past few decades. The latest IDF estimates show that there were around 589 million adults with diabetes aged 20-79 years in 2024 (11.1%) and will reach around 853 million by 2050. Importantly, there were estimated to be 252 million adults with diabetes who did not know that they had it, which means that vascular and renal complications could have developed without their knowledge.[4] Persistent hyperglycaemia is a key risk factor for microvascular and macrovascular damage, and is a risk factor for kidney failure, myocardial infarction, stroke and lower-leg complications, so diabetes is especially important.[5] According to WHO, diabetes and

kidney disease related to diabetes caused over 2 million deaths in 2021, and raised blood glucose was a risk factor for about 11% of cardiovascular deaths in 2021.[6]

Another significant and common risk factor for disease progression is hypertension. In 2024, it is estimated that there were 1.4 billion adults aged 30-79 years with hypertension, which is about one-third of all adults worldwide.[7] About 600 million people had hypertension, but they did not know it, and around 320 million had properly controlled hypertension.[8] The burden is heavily skewed to LMCs, in which access to healthcare, screening, adherence to treatment, and long-term monitoring of the disease are difficult. Chronic hypertension catalyzes vascular injury and arterial remodeling and significantly contributes to the risk of myocardial infarction, stroke, heart failure, and kidney damage.[9] Furthermore, diabetes and CKD can exacerbate blood pressure control, establishing a vicious cycle of cardiovascular and renal deterioration.[10]

Diabetes, hypertension, CVD and renal dysfunction are thus linked together as a cardiovascular–renal–metabolic continuum in which one disease can trigger the onset or exacerbation of another.[11] The global burden of cardiovascular-kidney-metabolic diseases is still significant, with atherosclerotic cardiovascular diseases (ASCVD) the biggest contributor, and type 2 diabetes, obesity, and chronic kidney disease (CKD) all continuing to grow in significance, as shown by recent worldwide analyses.[12] Regardless of this relationship, there is a tendency to make a diagnosis and just treat it, with little or no consideration of the interdependent role of demographic, clinical, biochemical, treatment-related, or renal factors that influence progression and adverse outcomes. The markers associated with disease progression, then, could prove to be useful in stratifying patients for earlier monitoring, treatment, and earlier identification of risk for further disease progression.

In this context, it is appropriate to consider a broad-based assessment of patients within the diabetes–hypertension–cardiovascular–renal disease spectrum to advance from disease-specific assessment to recognition of patients at highest risk of progression and adverse clinical outcomes. The present study was thus conceived to evaluate the status of diabetes, hypertension, cardiovascular disease and renal dysfunction comprehensively and identify the demographic, clinical, biochemical and treatment-related parameters associated with disease progression and adverse clinical outcomes. This study aimed to determine independent predictors for disease progression and clinical outcomes for patients with these highly interconnected cardiometabolic and renal conditions, thereby providing evidence of earlier risk stratification and more integrated patient management.

## MATERIALS AND METHODS

A prospective observational cohort study was conducted over a period of 12 months, from June 2025 to May, 2026. Patient recruitment was performed during the first six months, and the subsequent follow-up assessments were performed throughout the remainder of the study. Baseline clinical and laboratory data were collected at the time of enrollment and repeated as per clinical needs of the patient and the study design.

Sample size determination was done in a cohort study in OpenEpi version 3.01. The calculation was based on an expected difference between those in higher and lower cardiovascular/renal risk, as the main objective was to identify factors that predict disease progression and clinical outcome. Determination of a sample size based on a previous longitudinal study of the progression of CKD in patients with hypertension yielded an estimated hazard ratio of about 1.72 for an important baseline risk factor, with the sample size calculated at a 95% confidence level and 80% power.[13] To achieve a minimum sample of 152 participants, the following assumptions were made in OpenEpi based on an expected outcome frequency of 25%, a 95% confidence level, 80% power, and a 1:1 exposed-to-unexposed ratio. Allowing for approximately 10% attrition or incomplete follow-up, the final target sample size was increased to 170 participants.

A non-probability consecutive sampling technique was used in the selection of participants. Patients were included if they were at least 18 years old at the time of the study and had a diagnosed history of diabetes mellitus, hypertension, cardiovascular disease, renal dysfunction, or a combination of these. A minimum of clinical and laboratory data was needed at baseline for the patient to allow for a baseline assessment of cardiovascular and renal function. Patients with informed consent and in attendance for the intended follow-up evaluation were recruited. Patients less than 18 years old, pregnant women, and patients with acute kidney injury and no underlying chronic renal dysfunction were excluded. Other exclusion criteria included patients who presented with acute cardiac events that would require immediate critical intervention, malignancy or severe systemic illness with an expected survival of less than 6 months, and absence of baseline medical information. Patients who were not able or willing to give informed consent or were not likely to meet the requirements for the planned follow-up were not included.

Eligible subjects were approached after institutional ethical approval was obtained and the purpose of the study was explained, and informed consent was obtained by signing the informed consent form. Data were collected on demographic

parameters such as age, sex, residence, smoking and body mass index (BMI) and other relevant socio-economic and lifestyle factors using a structured data collection proforma. Clinical information included duration and control of diabetes and hypertension, previous cardiovascular disease, family history of cardiovascular disease, medication use, history of hospitalization, previous cardiovascular events and other relevant comorbidities.

Baseline BP was obtained with a standard calibrated sphygmomanometer following a suitable rest period, and anthropometric measurements were taken. Laboratory examinations that were performed are fasting blood sugar, HbA1c, serum creatinine, estimated glomerular filtration rate (eGFR), urine albumin/protein assessment and lipid profile. The patient's medical record was used to record additional tests, which included hemoglobin, electrolytes, and other clinically indicated tests. The renal function was evaluated by the serum creatinine and the estimated glomerular filtration rate (eGFR), and the severity of renal disease was classified based on the level of renal impairment. Cardiovascular status was evaluated based on the clinical history, physical examination, electrocardiogram, and echocardiographic or other appropriate studies when available.

The participants were then followed to determine disease progression and clinical outcomes such as deterioration in glycaemic or blood pressure control, decrease in eGFR, progression of CKD stage, cardiovascular hospitalization, myocardial infarction, stroke, heart failure, need for renal replacement therapy and mortality. Modification and adherence to treatment in follow-up was also recorded. Reduced eGFR, albuminuria, diabetes and hypertension were particularly important for the longitudinal assessment, having been shown by previous cohort studies to be important determinants of renal progression and cardiovascular outcomes.

The data were entered and analyzed in IBM SPSS Statistics 24. Continuous variables were tested for normality with the Shapiro–Wilk test and are reported as mean ± SD values if they were normally distributed. The categorical variables were summarized by frequencies and percentages. Independent-samples t-test for continuous variables and chi-square test for categorical variables were used to compare the baseline characteristics of the patients with and without progression and/or adverse clinical outcomes.

Univariable analysis of the relationships between demographic, clinical, and biochemical variables and disease progression was first performed. Clinical variables that were clinically relevant or had a p-value <0.20 in univariable analysis were then added to a multivariable logistic regression model for the identification of independent predictors for adverse outcomes. The odds ratios (ORs) and 95% confidence intervals (CIs) were presented. If follow-up time was available after an event, Kaplan–Meier survival analysis and Cox proportional-hazards regression were used to assess for predictors of time to cardiovascular events, renal progression, or death. Hazard ratios (HRs) with 95% confidence intervals (CIs) were presented. Before interpretation, model assumptions, multicollinearity, and overall model fit were checked. Two tailed p value was less than 0.05 was considered significant.

## RESULTS

A total of 170 patients were included, with a mean age of 59.3 ± 11.7 years; 56.5% were male. Among the participants, 75.3% had a diagnosis of diabetes mellitus and 83.5% had a diagnosis of hypertension, while 43.5% had established CVD and 40.6% renal dysfunction. Obesity, smoking, poor medication adherence and long-standing diabetes or hypertension also were common, and more than half were ≥60 years old. (Table 1) The mean HbA1c was 7.9 ± 1.6%, with 70.0% having HbA1c ≥7%. The mean eGFR was 58.7 ± 21.4 mL/min/1.73 m², while 40.6% had eGFR 30–59 and 10.0% had eGFR <30 mL/min/1.73 m². The prevalence of albuminuria and elevated LDL cholesterol in the participants was 36.5% and 53.5%, respectively. (Table 2)

Patients who developed disease progression or adverse outcomes were significantly older and had longer durations of diabetes and hypertension, higher systolic blood pressure, poorer glycaemic control, higher LDL cholesterol, greater prevalence of previous CVD and albuminuria, and lower eGFR than those without adverse outcomes. Diabetes, hypertension, poor medication adherence, and decreased renal function were also significantly associated with poor outcomes. (Table 3)

In follow-up, there were 39.4% who had at least one disease progression or adverse clinical outcome. The most common progression event was a decline in eGFR, with worsening glycaemic control, cardiovascular hospitalisation and progression to a higher CKD stage, occurring at lower frequencies. Major cardiovascular events were observed in 11.2% of the participants, renal replacement therapy in 5.3% and all-cause mortality in 6.5%. (Table 4)

Previous CVD, reduced eGFR, albuminuria, HbA1c ≥7%, diabetes duration ≥10 years, systolic BP ≥140 mmHg, poor medication adherence and age ≥60 years remained independent predictors for disease progression or adverse outcomes on multivariable logistic regression. Previous CVD and eGFR <60 mL/min/1.73 m² had the strongest associations. (Table 5)

Poor event-free survival was observed in those with lower eGFR, albuminuria, poor glycaemic control, a history of CVD and higher SBP using Kaplan–Meier analysis. Adjusted Cox regression confirmed that eGFR <60 mL/min/1.73 m², previous CVD, albuminuria, HbA1c ≥7%, and diabetes duration ≥10 years and systolic BP ≥140 mmHg were significant predictors of earlier adverse clinical outcomes. (Table 6)

**Table 1. Baseline demographic, lifestyle and clinical characteristics of study participants (n=170)**

| Variable | n (%) / Mean ± SD |
|---|---|
| Age (years) | 59.3 ± 11.7 |
| Age ≥60 years | 91 (53.5) |
| Male sex | 96 (56.5) |
| Female sex | 74 (43.5) |
| Urban residence | 108 (63.5) |
| Current smoker | 38 (22.4) |
| Former smoker | 27 (15.9) |
| Non-smoker | 105 (61.8) |
| BMI (kg/m²) | 28.1 ± 4.6 |
| BMI ≥25 kg/m² | 132 (77.6) |
| Diabetes mellitus | 128 (75.3) |
| Duration of diabetes ≥10 years | 54 (31.8) |
| Hypertension | 142 (83.5) |
| Duration of hypertension ≥10 years | 61 (35.9) |
| Cardiovascular disease | 74 (43.5) |
| Previous myocardial infarction | 31 (18.2) |
| Previous stroke | 22 (12.9) |
| Heart failure | 27 (15.9) |
| Renal dysfunction | 69 (40.6) |
| Family history of CVD | 83 (48.8) |
| Poor medication adherence | 47 (27.6) |
| Previous cardiovascular hospitalization | 39 (22.9) |
| Systolic BP (mmHg) | 146.2 ± 19.8 |
| Diastolic BP (mmHg) | 87.4 ± 11.6 |

**Table 2. Baseline biochemical and renal characteristics (n=170)**

| Variable | Mean ± SD / n (%) |
|---|---|
| Fasting blood glucose (mg/dL) | 156.8 ± 48.7 |
| HbA1c (%) | 7.9 ± 1.6 |
| HbA1c ≥7% | 119 (70.0) |
| Total cholesterol (mg/dL) | 198.6 ± 43.1 |
| LDL cholesterol (mg/dL) | 119.7 ± 34.8 |
| LDL ≥100 mg/dL | 91 (53.5) |
| HDL cholesterol (mg/dL) | 42.6 ± 9.7 |
| Triglycerides (mg/dL) | 174.2 ± 71.5 |
| Serum creatinine (mg/dL) | 1.42 ± 0.61 |
| eGFR (mL/min/1.73 m²) | 58.7 ± 21.4 |
| eGFR ≥60 | 84 (49.4) |
| eGFR 30–59 | 69 (40.6) |
| eGFR <30 | 17 (10.0) |
| Albuminuria present | 62 (36.5) |
| Hemoglobin (g/dL) | 12.4 ± 1.7 |
| Serum sodium (mmol/L) | 138.5 ± 4.2 |
| Serum potassium (mmol/L) | 4.5 ± 0.5 |

**Table 3. Comparison of baseline characteristics according to disease progression/adverse clinical outcome**

| Variable | No progression/adverse outcome (n=103) | Progression/adverse outcome (n=67) | p-value |
|---|---|---|---|
| Age (years), mean ± SD | 56.8 ± 11.2 | 63.1 ± 11.4 | 0.001 |
| Male sex | 55 (53.4) | 41 (61.2) | 0.313 |
| BMI (kg/m²), mean ± SD | 27.7 ± 4.3 | 28.7 ± 4.9 | 0.168 |
| Current smoking | 19 (18.4) | 19 (28.4) | 0.112 |
| Diabetes mellitus | 72 (69.9) | 56 (83.6) | 0.043 |
| Diabetes duration ≥10 years | 24 (23.3) | 30 (44.8) | 0.005 |
| Hypertension | 81 (78.6) | 61 (91.0) | 0.028 |
| Hypertension duration ≥10 years | 28 (27.2) | 33 (49.3) | 0.004 |
| Previous CVD | 31 (30.1) | 43 (64.2) | <0.001 |
| Family history of CVD | 44 (42.7) | 39 (58.2) | 0.051 |
| Poor medication adherence | 21 (20.4) | 26 (38.8) | 0.011 |
| Systolic BP (mmHg) | 140.3 ± 17.1 | 155.3 ± 21.3 | <0.001 |
| HbA1c (%) | 7.4 ± 1.3 | 8.6 ± 1.8 | <0.001 |
| LDL cholesterol (mg/dL) | 113.2 ± 31.5 | 129.7 ± 37.2 | 0.003 |
| Albuminuria | 28 (27.2) | 34 (50.7) | 0.002 |
| Serum creatinine (mg/dL) | 1.26 ± 0.47 | 1.66 ± 0.72 | <0.001 |
| eGFR (mL/min/1.73 m²) | 65.4 ± 18.8 | 48.5 ± 21.4 | <0.001 |

**Table 4. Disease progression and clinical outcomes during follow-up (n=170)**

| Outcome | n (%) |
|---|---|
| Any disease progression/adverse clinical outcome | 67 (39.4) |
| Worsening glycaemic control | 34 (20.0) |
| Worsening blood-pressure control | 31 (18.2) |
| Decline in eGFR ≥25% | 38 (22.4) |
| Progression to higher CKD stage | 29 (17.1) |
| New/worsening albuminuria | 27 (15.9) |
| Cardiovascular hospitalization | 29 (17.1) |
| Myocardial infarction | 12 (7.1) |
| Stroke | 10 (5.9) |
| Heart failure hospitalization | 17 (10.0) |
| Major cardiovascular event | 19 (11.2) |
| Renal replacement therapy | 9 (5.3) |
| All-cause mortality | 11 (6.5) |

**Table 5. Multivariable logistic regression analysis of predictors of disease progression/adverse clinical outcomes**

| Predictor | Adjusted OR | 95% CI | p-value |
|---|---|---|---|
| Age ≥60 years | 1.94 | 1.01–3.73 | 0.046 |
| Male sex | 1.18 | 0.63–2.22 | 0.602 |
| BMI ≥25 kg/m² | 1.31 | 0.61–2.82 | 0.488 |
| Current smoking | 1.52 | 0.72–3.19 | 0.270 |
| Diabetes duration ≥10 years | 2.41 | 1.22–4.77 | 0.011 |
| Hypertension duration ≥10 years | 1.76 | 0.91–3.41 | 0.092 |
| Previous CVD | 3.28 | 1.70–6.34 | <0.001 |
| Poor medication adherence | 2.06 | 1.04–4.09 | 0.038 |
| Systolic BP ≥140 mmHg | 2.17 | 1.10–4.28 | 0.026 |
| HbA1c ≥7% | 2.69 | 1.27–5.69 | 0.010 |
| LDL ≥100 mg/dL | 1.57 | 0.82–3.00 | 0.171 |
| Albuminuria | 2.87 | 1.45–5.68 | 0.002 |
| eGFR <60 mL/min/1.73 m² | 3.46 | 1.76–6.79 | <0.001 |

**Table 6. Cox proportional-hazards analysis of predictors of time to adverse clinical outcome**

| Predictor | Adjusted HR | 95% CI | p-value |
|---|---|---|---|
| Age ≥60 years | 1.61 | 0.91–2.85 | 0.101 |
| Diabetes duration ≥10 years | 1.88 | 1.05–3.37 | 0.034 |
| Previous CVD | 2.74 | 1.56–4.81 | <0.001 |
| Poor medication adherence | 1.72 | 0.98–3.01 | 0.059 |
| Systolic BP ≥140 mmHg | 1.84 | 1.06–3.19 | 0.030 |
| HbA1c ≥7% | 2.12 | 1.15–3.92 | 0.016 |
| Albuminuria | 2.46 | 1.41–4.29 | 0.002 |
| eGFR <60 mL/min/1.73 m² | 3.19 | 1.85–5.51 | <0.001 |

## DISCUSSION

The current study aimed to assess the multidimensional burden of diabetes mellitus, hypertension, cardiovascular disease (CVD) and renal dysfunction, and to determine factors that were associated with disease progression and poor clinical outcomes. There were 170 participants, of whom 39.4% had at least one follow-up progression or adverse outcome. The univariable analysis showed that older age, longer duration of diabetes and hypertension, previous CVD, poor medication adherence, elevated systolic blood pressure, poor glycaemic control, albuminuria, and reduced eGFR were associated with poorer outcomes. Importantly, previous CVD, diabetes duration ≥10 years, HbA1c ≥7%, systolic BP ≥140 mmHg, albuminuria and eGFR <60 mL/min/1.73 m² persisted as independent predictors when analyzed after multivariable adjustment. These responses suggest that diabetes, hypertension, cardiovascular disease and renal dysfunction are closely allied clinical syndromes, rather than distinct clinical entities.

This identified that decreased eGFR was among the strongest determinants of adverse outcomes, consistent with the prospective Chronic Renal Insufficiency Cohort (CRIC) study by Anderson et al. (2021), which included 3,379 adults with CKD and found that baseline kidney function, albuminuria and systolic blood pressure were important factors in determining outcomes with a focus on CKD progression. Several biomarkers of cardiac and renal injury were associated with a nearly twofold or higher risk of progression among those with diabetes, highlighting a close association between cardiovascular and renal injury.[14] In a similar study, a multicentre prospective study of 1,261 people with diabetes and/or hypertension in Ghana was conducted in 2022, and 13% of these individuals had a rapid drop in eGFR over 18 months, with older age, smoking, and factors related to access to medications for diabetes and hypertension being associated with progression.[15] Thus, our adjusted hazard ratio of more than 3-fold for eGFR of <60 mL/min/1.73 m² further emphasizes the critical early role of renal function as an indicator of systemic disease severity.

The present study also confirmed that there was a strong association between albuminuria and adverse clinical outcomes, with albuminuria being an independent predictor of disease progression in logistic regression and time to adverse outcome in Cox regression. This is an important finding as albuminuria itself may offer prognostic information without a significant loss of renal filtration. In a large 2023 study of 36,509 Chinese people with type 2 diabetes, people with albuminuria were at significantly higher risk for cardiovascular outcomes, death, renal outcomes, and even among those with reduced eGFR but not albuminuria, risk for major cardiovascular events and mortality.[16] Similarly, in the Hoorn Diabetes Care System cohort, eGFR and albuminuria were independently associated with various cardiovascular outcomes such as myocardial infarction, coronary heart disease, stroke, heart failure, and cardiovascular mortality.[17] These findings are similar to ours and suggest that renal evaluation should involve measurement of urinary protein loss as well as renal filtration, not just serum creatinine or eGFR.

A large individual-participant data analysis published in the Journal of the American Medical Association (JAMA) with over 27 million people in 114 cohorts further supports our findings. That study showed that eGFR progressively decreased and albuminuria was independently associated with adverse kidney outcomes as well as cardiovascular mortality, heart failure, and atrial fibrillation.[18] More recently, in a cohort of 456015 individuals from UK Biobank, even those with early stage CKD and albuminuria had higher rates of major adverse cardiovascular events, heart failure and all-cause death.[19] Our results have therefore shown that albuminuria is an independent predictor even when several of the well-known cardiovascular and metabolic risk factors are taken into account, highlighting the possible clinical relevance of this parameter for early risk stratification.

The strong links between poor glycaemic control and adverse outcomes in our cohort agreed with previous studies. The risk of disease progression was significantly higher in patients with HbA1c ≥7%, with HbA1c ≥7% being an independent

predictor even after adjustment. HbA1c levels of 7.0–7.9% and ≥8.0% were found to be significantly associated with risks for major cardiovascular events or death in the KNOW-CKD prospective cohort of 707 patients with CKD and type 2 diabetes. The associations were particularly evident for cardiovascular events and mortality.[20] Thus, poor glycaemic control may be a factor in the overall progression of cardiovascular and renal disease, rather than just a measure of diabetes severity.

The association of longer diabetes duration with poor outcomes was another important finding. In participants with a duration of diabetes of at least 10 years, the adjusted odds of progression/adverse outcomes were over 2 times the odds for those with a shorter duration of diabetes, and a longer duration of diabetes was also significant in the Cox model. This is biologically feasible since chronic hyperglycaemia has been shown to lead to progressive endothelial dysfunction, vascular inflammation, oxidative stress and microvascular injury, thereby also raising the heart and kidney burden. In a study in 2022, patients with long-standing type 2 diabetes had higher diabetes risk categories as well as hypertension and hyperlipidaemia, and an increasing number of risk factors was associated with more severe renal disease.[21] In view of the consistency of these observations, it appears that duration of diabetes should be routinely included in the evaluation of cardiorenal risks.

In summary, the results show that renal dysfunction and cardiovascular disease are not late complications of diabetes and hypertension, but rather are associated and represent progressive cardiometabolic disease. Low eGFR, albuminuria, poor glycaemic control, high SBP, long duration of diabetes and established CVD were significant markers of patients' risk of progression. The findings provide a rationale to move away from a disease-spectrum approach to a cardiorenal-metabolic risk assessment, where early detection of renal and cardiovascular abnormalities may present a chance to intervene before irreversible disease progression and major clinical events have occurred.

**Limitations**

There were a number of limitations to the study. First, the study was carried out at a single tertiary-care hospital with a relatively small sample size, which might restrict the generalizability of the results to other groups and health systems. Second, the study did not assess the effects of the intervention in the general population or on children with targeted measurements of outcomes. Second, the observed outcomes of long-term cardiovascular and renal events may have been under-estimated, given the relatively short follow-up period. Third, the observational design enabled identification of associations and failed to provide causal information about the identified predictors and disease progression. Patient-reported information about medication adherence and lifestyle factors may have been recalled or reported, and thus could have been subject to reporting or recall bias. Lastly, residual confounding from unmeasured factors, such as dietary habits, socioeconomic status, treatment modifications and genetic susceptibility, could not be ruled out.

## CONCLUSION

The study showed marked burden of disease progression and adverse clinical outcomes in patients suffering from diabetes, hypertension, cardiovascular disease and renal dysfunction. Lower eGFR, albuminuria, and history of cardiovascular disease, poor glycaemic control, higher systolic blood pressure, longer diabetes duration, and poor medication adherence were important predictors of poor outcomes. These results emphasize that cardiometabolic and renal disease are closely linked and recommend a holistic evaluation and not a piecewise approach to the management of these conditions. The identification of high-risk patients, based on integrated assessment of glycaemic status, blood pressure, cardiovascular history and renal markers, may help to provide timely treatment and lower progression of disease, hospitalizations and mortality.

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