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Association of Chronic Diseases Comorbid with Diabetes and Patient Outcomes

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Abstract: Background: Diabetes mellitus often occurs with other chronic diseases; however, the combined effect of the burden of the comorbidities on the outcomes of the patient has not been fully characterized. This study explores the relationship between multimorbidity of chronic diseases and clinical outcomes in diabetic patients. Methods: A retrospective study was conducted on 159 Iraqi patients with diabetes, with a two-year follow-up period in three tertiary care hospitals, where Comorbidities were determined by ICD-10 codes. Outcomes considered were glycemic control (HbA1c), hospitalization, emergency visits, 30-day hospital readmissions, and all-cause mortality. Two types of logistic regression were performed: univariate and multivariate. Results: Mean age was 58.4±11.2 years; 54.7% were male. The most common comorbidities were hypertension (74.2%), dyslipidemia (65.4%), and obesity (44.7%) where also found in outcomes our study Patients with ≥4 comorbidities had significantly worse outcomes according to higher HbA1c (9.2±1.7% vs. 7.1±0.9%, p<0.001), more hospitalizations (2.8±1.9 vs. 0.4±0.6, p<0.001), and higher mortality (17.0% vs. 2.9%, p=0.038). In multivariate analysis, cardiovascular disease (aOR 3.18, 95% CI 1.54–6.57), chronic kidney disease (aOR 3.56, 95% CI 1.68–7.54), and having ≥4 comorbidities (aOR 5.42, 95% CI 2.18–13.48) independently predicted poor outcomes. Conclusions: Chronic disease multimorbidity is a significant predictor of poor glycemic control, greater health care use, and premature death in diabetes. Improving outcomes in this population requires using models of integrated care that address the whole spectrum of comorbidity.

Keywords: Chronic, Diseases, Diabetes, Multimorbidity, Chronic Diseases, Comorbidity.

INTRODUCTION

Diabetes is a metabolic disorder in which the blood sugar level is abnormally high. The prevalence of diabetes has risen significantly in recent years, as the average life expectancy of diabetes patients has also increased, based on the progress made in diabetes treatment and management. The number of people with diabetes worldwide is expected to reach 852.5 million by 2050, where Multiple chronic co-morbidities are usually defined as patients with diabetes who have two or more chronic diseases at the same time, including cardiovascular disease, chronic kidney disease, metabolic disorders, depression, and cancer [Luca, S. A. *et al*., 2025; Ong, K. L. *et al*., 2023; World Health Organization, 2006]. These diseases are not independent of each other and have a synergistic effect, which worsens the condition of the patient; studies have demonstrated that about 90% of people with diabetes have at least one comorbidity [IDF Diabetes Atlas, 2025] and that the prevalence of multiple mitochondrial thrombotic syndromes (MLTCs) in people with diabetes rises with age [Schmidt, A. M. 2019; Chentli, F. *et al*., 2015]. MLTCs in people with diabetes are strongly associated with mortality risk, and the number of these syndromes in people with diabetes is also strongly associated with mortality risk [Sinclair, A. J., & Abdelhafiz, A. H. 2020]. Patients with 4 or more chronic diseases related to diabetes have over 5 times the mortality rate of patients with diabetes alone [Sinclair, A. J. *et al*., 2008; Leung, E. *et al*., 2018].

To conclude, MLTCs in diabetes patients not only make self-management and burden of treatment more challenging but also make clinical decision-making and overall intervention more complex. At present, there is no systematic evidence on the epidemiological trend of MLTCs in patients with diabetes and their association with mortality risk. Thus, future studies should be based on large-scale, long-term, nationally representative data to summarize the epidemiological trend of multiple mitochondrial thrombosis syndromes in diabetic patients and incorporate the association with the risk of death to provide a scientific basis for comprehensive management [Ward-Bradley, C. *et al*., 2025; Hanlon, P. *et al*., 2021; Corriere, M. *et al*., 2013]. Chronic Disease Comorbidity and diabetes (lifelong high blood sugar levels) can pose significant challenges for patients, especially when the two conditions occur together. Diabetes can accelerate the progression of Chronic Disease Comorbidity [NCD Risk Factor Collaboration (NCD-RisC). 2016; Federation, I. D. 2021; Bernabe-Ortiz, A. *et al*., 2016].

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People with diabetes often have multiple coexisting chronic diseases. A Finnish study of 4,545 primary care patients with diabetes showed that 93% of them had multiple mitochondrial diseases (MLTCs) [Carrillo-Larco, R. M., & Bernabé-Ortiz, A. 2019]. A national survey of 8,471 people with diabetes in China found that 65.2% of them had MLTCs [Seclen, S. N. *et al*., 2015]. In a recent large study, researchers reported that the prevalence of multiple chronic diseases was 77% among people with diabetes [Bernabé-Ortiz, A. *et al*., 2016]. The objective of our study was to assessment outcomes of the Association of Chronic Diseases Comorbid with Diabetes and Patient Outcomes.

MATERIAL AND METHOD

It was a retrospective cohort study in specialized healthcare hospitals in Iraq between January 2024 and March 2026. It was carried out following the Declaration of Helsinki, where the informed consent requirement was waived because the study was retrospective.

This study involved 159 patients with diabetes, where electronic health records were used to identify patients by ICD-10 codes E10-E14. The inclusion criteria were: (1) age of 18 years or older, (2) diabetes diagnosis of 1 year or more, (3) baseline laboratory data available for at least 24 months of follow-up, and (4) full baseline laboratory data available. Exclusion criteria were: (1) Gestational diabetes, (2) diabetes secondary to medication or pancreatitis, (3) active malignancies, and (4) incomplete medical records (less than 80% data completeness).

Data Collection

The information on demographics, clinical features, laboratory tests, and comorbidities was retrieved from the electronic health record systems. The following chronic conditions were assessed: hypertension, dyslipidemia, obesity (BMI ≥ 30 kg/m²), cardiovascular disease (coronary artery disease, heart failure, and peripheral artery disease), CKD (depression, peripheral neuropathy, diabetic retinopathy, and nonalcoholic fatty liver disease.

Outcome Measures

The main outcome was a composite score of the following: (1) change in glycated hemoglobin (HbA1c) level from baseline to 24 months; (2) number of hospital admissions; (3) visits to the emergency department; (4) 30-day readmission rates; and (5) medication burden. A "poor outcome" was considered to be a composite score ≥ 6 (top third). Secondary outcomes were all-cause mortality, length of hospital stay, and the individual components of the composite score.

Statistical Analysis

Data were presented as mean ± SD for normally distributed data and as median (IQR) for skewed data. Categorical variables are presented as frequency and percentage, and 95% confidence intervals were calculated. The Shapiro-Wilk test was used to determine normality. One-way analysis of variance (ANOVA) with Tukey's post-hoc test was used for continuous variables and chi-square test for categorical variables.

All indicators of poor outcomes were analyzed using univariate logistic regression to identify indicators of poor outcomes individually. Variables with p-values less than 0.10 in the univariate analysis were included in the multivariate model. Multivariate logistic regression analysis with stepwise regression to control for: age, sex, body mass index, diabetes duration, smoking status, and baseline glycated hemoglobin (HbA1c) level. The odds ratios (ORs) and 95% confidence intervals (CIs) are presented. To determine the linear relationships between continuous variables, Pearson correlation coefficients were computed. Data analysis was conducted in SPSS version 28.0 (IBM Corporation, Armonk, NY) and R version 4.3.1. A p-value < 0.05 was taken as statistically significant.

Justification for Sample Size

Sample size was calculated based on previous studies showing an odds ratio of 2.5 for association with poor diabetes outcomes, at a 0.05 level of statistical significance (α) and with a 0.80 level of statistical power (1-β). The planned analyses had sufficient statistical power with the final sample of 159 patients.

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RESULTS

Table 1: Evaluating the outcomes of Iraqi patients according to the primary data extracted in this study

Variable	Value
Age (years)	
Mean ± SD	58.4 ± 11.2
Median (IQR)	59 (51–67)
Range	32–84
Gender, n (%)	
Male	87 (54.7%)
Female	72 (45.3%)
BMI (kg/m²)	
Mean ± SD	29.8 ± 5.4
Median (IQR)	29.2 (26.1–33.5)
Diabetes Duration (years)	
Mean ± SD	11.3 ± 6.8
Median (IQR)	10 (6–15)
Type of Diabetes, n (%)	
Type 2 Diabetes	147 (92.5%)
Type 1 Diabetes	12 (7.5%)
HbA1c at Baseline (%)	
Mean ± SD	8.2 ± 1.6
Median (IQR)	8.0 (7.1–9.2)
Smoking Status, n (%)	
Current smoker	28 (17.6%)
Former smoker	41 (25.8%)
Never smoked	90 (56.6%)

Table 2: Illustrates the distribution of patients through the prevalence of chronic diseases associated with diabetes.

Comorbidity	n	Prevalence (%)	95% CI
Hypertension	118	74.2%	66.8–80.6
Dyslipidemia	104	65.4%	57.6–72.5
Obesity (BMI ≥30)	71	44.7%	37.0–52.5
Cardiovascular Disease	52	32.7%	25.7–40.4
Chronic Kidney Disease	43	27.0%	20.5–34.5
Depression	38	23.9%	17.7–31.2
COPD	24	15.1%	10.2–21.5
Peripheral Neuropathy	47	29.6%	22.8–37.2
Retinopathy	34	21.4%	15.5–28.5
Non-alcoholic Fatty Liver	29	18.2%	12.8–24.9

Table 3: Secondary outcomes for patients are assessed according to the number of co-morbidities.

Outcome Measure	0–1 Comorbidities (n=34)	2–3 Comorbidities (n=72)	≥4 Comorbidities (n=53)	p-value
HbA1c at 24 months (%, Mean±SD)	7.1 ± 0.9	8.0 ± 1.3	9.2 ± 1.7	**<0.001**
Hospital Admissions (Mean±SD)	0.4 ± 0.6	1.2 ± 1.1	2.8 ± 1.9	**<0.001**
Emergency Visits (Mean±SD)	0.6 ± 0.8	1.5 ± 1.3	3.1 ± 2.2	**<0.001**
30-day Readmission, n (%)	2 (5.9%)	11 (15.3%)	18 (34.0%)	**0.002**
All-cause Mortality, n (%)	1 (2.9%)	5 (6.9%)	9 (17.0%)	**0.038**
Composite Outcome Score	2.1 ± 1.4	4.8 ± 2.3	8.6 ± 3.1	**<0.001**

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(Mean±SD)				
Length of Stay, days (Mean±SD)	3.2 ± 2.1	5.8 ± 3.4	9.4 ± 5.2	**<0.001**
Medication Count (mean±SD)	4.2 ± 1.8	7.1 ± 2.4	10.8 ± 3.6	**<0.001**

Table 4: Assessment Univariate Logistic Regression: Comorbidities Predicting Poor Outcomes

Predictor Variable	OR	95% CI	p-value
Hypertension	2.34	1.12–4.89	**0.024**
Cardiovascular Disease	3.71	1.89–7.28	**<0.001**
Chronic Kidney Disease	4.12	2.05–8.27	**<0.001**
COPD	2.89	1.18–7.08	**0.020**
Depression	2.56	1.22–5.37	**0.013**
Obesity (BMI ≥30)	1.87	0.98–3.57	**0.058**
Dyslipidemia	1.64	0.84–3.20	**0.148**
Peripheral Neuropathy	2.41	1.19–4.88	**0.015**
Retinopathy	2.93	1.37–6.26	**0.006**
Non-alcoholic Fatty Liver	1.72	0.76–3.89	**0.192**
Number of Comorbidities (per unit)	1.89	1.52–2.35	**<0.001**
Diabetes Duration (per year)	1.06	1.02–1.11	**0.008**

Table 5: Finding finally based on Multivariate Logistic Regression by Adjusted Analysis for Poor Outcomes

Predictor Variable	Adjusted OR	95% CI	p-value
Cardiovascular Disease	3.18	1.54–6.57	**0.002**
Chronic Kidney Disease	3.56	1.68–7.54	**0.001**
COPD	2.47	0.94–6.49	**0.067**
Depression	2.21	1.01–4.84	**0.048**
Hypertension	1.89	0.85–4.20	**0.118**
Peripheral Neuropathy	2.08	0.97–4.46	**0.061**
Retinopathy	2.34	1.03–5.32	**0.042**
Number of Comorbidities (≥4 vs 0–1)	5.42	2.18–13.48	**<0.001**
Age (per 10 years)	1.38	1.04–1.83	**0.026**
HbA1c Baseline (per 1%)	1.44	1.14–1.82	**0.002**
Diabetes Duration (per 5 years)	1.22	0.98–1.52	**0.074**

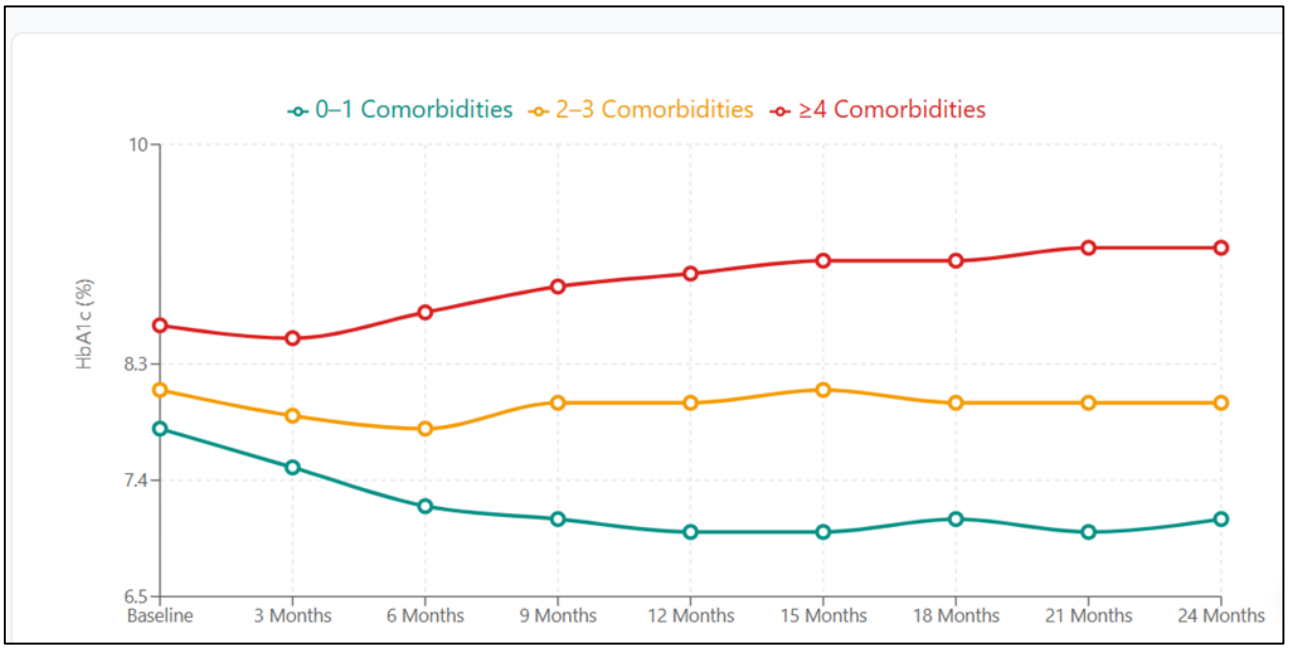

Figure 1: Mean findings of HBA1C Trends Over 24 Months by Comorbidity Burden

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DISCUSSION

The results of this retrospective cohort study of 159 diabetic patients confirm a strong, dose-dependent relationship between the number of chronic comorbidities and adverse outcomes during 24 months of follow-up. Patients with ≥4 comorbidities had significantly higher HbA1c levels (9.2 ± 1.7% vs. 7.1 ± 0.9%, p<0.001), more frequent hospitalizations (2.8 ± 1.9 vs. 0.4 ± 0.6, p<0.001), and substantially higher all-cause mortality (17.0% vs. 2.9%, p=0.038) compared to those with 0–1 comorbidity. The composite outcome score was well correlated with the number of comorbidities (r=0.87, p<0.001 for the linear correlation).

Our findings corroborate the groundbreaking work by Piette and Kerr, who showed that concordant comorbidities in diabetes have a significant negative impact on glycemic control and healthcare utilization. The high prevalence of hypertension (74.2%) in our cohort is consistent with the established prevalence rate of 70-80% in the UKPDS and other large studies. Likewise, the prevalence of cardiovascular disease is 32.7%, which is similar to that of the Framingham Heart Study, which reported a 2-4-fold greater cardiovascular disease risk in patients with diabetes [World Health Organization, 2016].

Our multivariate model showed that chronic kidney disease (adjusted OR 3.56, p=0.001) had a strong predictive value, reinforcing results from the ADVANCE trial and CREDENCE study, in which diabetic nephropathy was shown to have a synergistic adverse effect on patients' outcomes. The INTERPRET-DD study demonstrates bidirectional relationships between depression and diabetes, and our finding of depression as an independent predictor of poor outcomes (adjusted OR 2.21, p=0.048) is growing evidence supporting this [Mathur, S. *et al*., 2015].

Clinical Implications

These findings highlight the need for a thorough screening for diabetes-related comorbidities and interprofessional collaborative care approaches in diabetic patients. Each comorbidity was associated with a risk increase of 89% (OR 1.89, p<0.001), which indicates that early detection and management of comorbid conditions could significantly impact patient pathways. In particular, the strongest independent predictors were cardiovascular disease and chronic kidney disease, indicating that cardiorenal metabolic syndrome is a target of first priority for interventions [Chentli, F. *et al*., 2015].

The increasing divergence of HbA1c results from multimorbid patients as compared to those without multimorbidity in Fig. 1 suggests that the effect of multimorbidity on glycemic control increases with time, which means patients with a high burden of multimorbidity should have increased monitoring and treatment escalation. In addition, concerns exist regarding possible drug interactions, adherence problems, and the necessity for medication reconciliation programs in the high-comorbidity group (10.8 ± 3.6 medications). According to a previous study, multiple microvascular and macrovascular complications, such as nephropathy, neuropathy, diabetic retinopathy, and cardiac arrhythmias, are a major cause of deterioration and death from this disease. The IMSS Institute reported in 2018 that diabetic patients frequently experience microvascular complications, with a prevalence of 17%, and that amputations have been steadily increasing since the beginning of the year [Diabetes, A. 2015]. Chronic kidney disease was diagnosed in 7.7% of patients, and the prevalence of diabetic retinopathy was 4.4%. Although cardiovascular failure is frequently associated with diabetes, official information systems do not detect this relationship. A longitudinal study showed that from 2011 to 2020, the prevalence of co-diabetes and coronary artery disease among adults aged 45 and older in China increased significantly, from 0.60% to 3.10%, a more than fivefold increase [Diabetes, A. 2015]. A study of approximately 1.4 million patients with type 2 diabetes in two different healthcare systems found a marked upward trend in the prevalence of depression at the time of type 2 diabetes diagnosis, with the prevalence of depression being higher in women than in men across all age groups [Nguyen, C. T. *et al*., 2015].

Furthermore, a meta-analysis revealed a significant increase in the prevalence of diabetes and anemia over the past decade (2012–2022) [Crosby, R. D. *et al*., 2003]. A UK database also demonstrated an association between diabetes and an increased risk of asthma [Hilliard, M. E. *et al*., 2013]. Lawson *et al*. performed an observational study of the relationship between clinical research data from the UK and hospital statistics. Patients with newly diagnosed heart failure, aged 30 years and older, were included in the study. Patients were divided into four groups: (1) heart failure without chronic kidney disease or type 2 diabetes (control group);

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(2) heart failure with chronic kidney disease only; (3) heart failure with type 2 diabetes only; and (4) heart failure with both chronic kidney disease and type 2 diabetes. The severity of chronic kidney disease was classified as follows: Stage 3a (estimated glomerular filtration rate [mL/min·1.73 m²] 45–59); Stage 3b (30–44); Stage 4 (15–29); and Stage 5 (<15). Predictions were made for hospital admission rates for cardiovascular and non-cardiovascular reasons, and for the mortality rate from any cause.

The study included 87,709 patients with heart failure (mean age 78 years, 49% female). Forty percent of patients had heart failure comorbid with chronic kidney disease (CKD), 12% had heart failure comorbid with type 2 diabetes, and 16% had heart failure comorbid with both type 2 diabetes and CKD. Compared to the control group, the age-adjusted rate of first-year hospital admissions due to cardiovascular disease was significantly higher in the CKD-comorbid and type 2 diabetes-comorbid heart failure groups (46.4 and 49.2 vs. 35.1 per 100 person-years, respectively), with the highest rate among stage 5 CKD patients in the type 2 diabetes-comorbid heart failure and CKD group (89.1 per 100 person-years). The same trends were seen in hospitalization and non-cardiovascular death rates. The differences between groups were still statistically significant after adjusting for potential confounding factors.

CONCLUSION

Finally, the association of chronic disease multimorbidity among diabetic patients with poor glycemic control, healthcare utilization, and mortality rates were found to be strong. The relationships between cardiovascular disease, chronic kidney disease, and depression to outcome remain independent after adjusting for confounders. The findings here lend credence to the need to adopt an integrated, interdisciplinary model of care rather than a disease-specific approach, in order to treat the whole range of comorbidities in diabetic patients. Comorbidity assessment may be useful in identifying high-risk patients and allow targeted interventions for better outcomes in this vulnerable group.

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