RESEARCH PAPER

Impact Of Diabetes-Associated Complications On Cognitive Function, Quality Of Life, And Clinical Outcomes

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Abstract
Diabetes mellitus is a chronic metabolic disorder frequently complicated by microvascular and macrovascular dysfunction, leading to cognitive impairment, reduced quality of life (QoL), and psychological distress. This study aimed to evaluate the impact of diabetes-associated complications on cognitive function, health-related quality of life (HRQoL), and mental health in patients with type 2 diabetes mellitus (T2DM**).** A cross-sectional observational study was conducted among 188 adults with T2DM at a tertiary care center. After applying inclusion and exclusion criteria, 103 eligible participants were enrolled. Data were collected using the WHOQOL-BREF, SF-12 Health Survey, and Montreal Cognitive Assessment (MoCA). Descriptive, correlation, and regression analyses were performed using SPSS v26.0. Statistical significance was defined a priori at a p-value < 0.05 for all analyses. The mean age of participants was 56.3 ± 9.8 years, with average diabetes duration of 10.7 ± 4.5 years. The prevalence of major complications included neuropathy (28.1%), retinopathy (22.3%), and nephropathy (18.4%), and foot ulcers (11.6%). Participants with retinopathy had significantly lower MoCA scores (22.6 ± 3.4 vs. 25.1 ± 2.9, $p = 0.002$), indicating cognitive decline. Nephropathy was associated with poorer QoL (WHOQOL-BREF: 50.2 ± 7.4 vs. 58.3 ± 6.9, $p = 0.004$), while those with foot ulcers exhibited increased depressive symptoms (SF-12 MCS: 39.8 ± 5.1 vs. 46.2 ± 6.8, $p = 0.001$). Regression analysis confirmed that these associations remained significant after adjusting for age, gender, duration of diabetes, and comorbidities. Diabetes-related complications are associated with cognitive performance, psychological well-being, and QoL. Retinopathy was strongly linked with cognitive decline, nephropathy with lower QoL, and foot ulcers with depression. The findings underscore the need for integrated diabetes management strategies incorporating cognitive assessment, psychosocial support, and complication prevention to improve overall patient outcomes.

Keywords: Type 2 diabetes mellitus, Cognitive impairment, Quality of life, Diabetic complications, Depression, Clinical outcomes
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1. Introduction

Diabetes mellitus (DM) is a chronic, progressive metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin action, or both (1). Globally, DM has reached epidemic proportions, affecting an estimated 537 million adults aged 20–79 years in 2021, with projections rising to 643 million by 2030 and 783 million by 2045 (International Diabetes Federation, IDF) (2, 3). India is a major contributor to this burden, with over 77 million individuals living with diabetes, making it one of the largest affected populations worldwide (4). The disease is associated with substantially to morbidity, mortality, and healthcare expenditures, which globally exceed USD 966 billion annually (5).

Beyond glycemic dysregulation, the long-term course of diabetes is frequently complicated by microvascular (retinopathy, nephropathy, and neuropathy) and macrovascular (ischemic heart disease, stroke, peripheral vascular disease) complications, which profoundly affect clinical outcomes (6, 7). These complications are well recognized for their role in physical disability and premature mortality, but their broader impact on cognitive functioning, health-related quality of life (HRQoL), and psychological well-being is increasingly being recognized (8, 9). Studies suggest that microvascular complications such as retinopathy may share common pathophysiological mechanisms with cerebral microangiopathy, thereby predisposing individuals to cognitive impairment (10, 11). Similarly, nephropathy is linked to systemic inflammation, metabolic imbalance, and treatment burden, resulting in poorer QoL. Diabetic foot ulcers, a disabling complication, are associated with pain, immobility, and social stigma, often translating into depressive symptoms and emotional distress (12).

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Evidence from randomized controlled trials (RCTs), systematic reviews, and observational studies has consistently shown that patients with multiple complications have significantly poorer QoL and higher rates of cognitive dysfunction compared to those without complications (13, 14). For instance, cognitive decline in diabetic patients has been reported to be 1.5–2 times more common than in non-diabetic individuals, with greater risk observed in those with retinopathy and long disease duration (15, 16). Similarly, WHOQOL-BREF and SF-12 studies indicate that HRQoL declines in a stepwise manner with each additional complication. However, the majority of such evidence originates from high-income countries with robust healthcare systems, whereas data from low- and middle-income regions, including semi-urban Indian populations, remain scarce (17, 18).

While associations are known, data on the distinct impact of individual complications on cognitive, QoL, and mental health domains from semi-urban Indian populations is scarce. Therefore, the present study was conducted to assess the impact of diabetes-associated complications on cognitive function, quality of life, and clinical outcomes in patients with type 2 diabetes mellitus (T2DM) attending a tertiary care center in India.

2. Materials and Methods

2.1. Study Design

This study employed a cross-sectional observational design to assess the impact of diabetes-associated complications on cognitive function, health-related quality of life (HRQoL), and clinical outcomes in patients with type 2 diabetes mellitus (T2DM). The design enabled simultaneous collection of information on complications, cognitive status, and QoL at a single point in time, without altering patients' ongoing treatment regimens. By stratifying participants into groups with and without diabetes-related complications, comparisons could be made to identify associations between complication burden and outcomes such as cognitive decline or reduced QoL. Although causal relationships cannot be inferred, this approach was efficient, cost-effective, and reflective of real-world clinical practice, making it appropriate for generating evidence on how complication profiles influence patient-centered outcomes in a tertiary care setting.

2.2. Study Site and Sample Size

This study was conducted over a four-month period, from June to Oct 2025, across four tertiary and secondary care hospitals in Haryana, India. The participating institutions included Medanta-The Medicity and Paras Hospital in Gurugram, Pt. B.D. Sharma Post Graduate Institute of Medical Sciences (PGIMS) in Rohtak, and Holy Heart Hospital in Rohtak chosen based on their patient volume, diversity in demographics, and availability of structured diabetes care services. A total of 200 participants were estimated to be enrolled through sample size estimation based on a 95% confidence level, 80% statistical power, and an anticipated medium effect size for detecting differences in quality of life and cognitive function outcomes. This sample size was considered adequate to allow meaningful subgroup comparisons between patients with and without diabetes-associated complications, while ensuring sufficient statistical reliability to explore associations across multiple variables (**Figure 1**). The sample size was calculated using WHOQOL-BREF score as the primary outcome variable to detect differences between patients with and without diabetes-associated complications. Assuming a moderate effect size (Cohen's d=0.5), a two-tailed $\alpha=0.05$, and 80% statistical power, the minimum required sample size was 96 participants. To enable subgroup analyses, improve statistical robustness, and compensate for anticipated exclusions and incomplete data, the planned sample size was inflated to 200 participants. Due to eligibility constraints, 103 patients were ultimately included in the final analysis. Sample size estimation was performed using G*Power software (version 3.1.9.4) based on an independent samples t-test model.

2.3. Inclusion Criteria

The study included adults aged 40 years and above with a confirmed diagnosis of type 2 diabetes mellitus (T2DM) for at least five years, ensuring adequate disease duration for the development of complications. Only those patients who were willing to provide written informed consent and were able to communicate in either Hindi or English were considered eligible for participation, to ensure reliable data collection through standardized questionnaires and cognitive assessments (**Figure 1**).

2.4. Exclusion Criteria

Patients were excluded if they had a history of major psychiatric illness such as schizophrenia or bipolar disorder, or neurodegenerative diseases like dementia unrelated to diabetes, as these could independently affect cognitive outcomes. Individuals with severe visual, hearing, or motor impairments that could interfere with the administration of cognitive or quality-of-life assessments were also excluded. In addition, patients presenting with acute diabetic emergencies such as diabetic ketoacidosis (DKA) or hyperosmolar hyperglycemic state (HHS) at the time of recruitment were not included in the study (**Figure 1**).

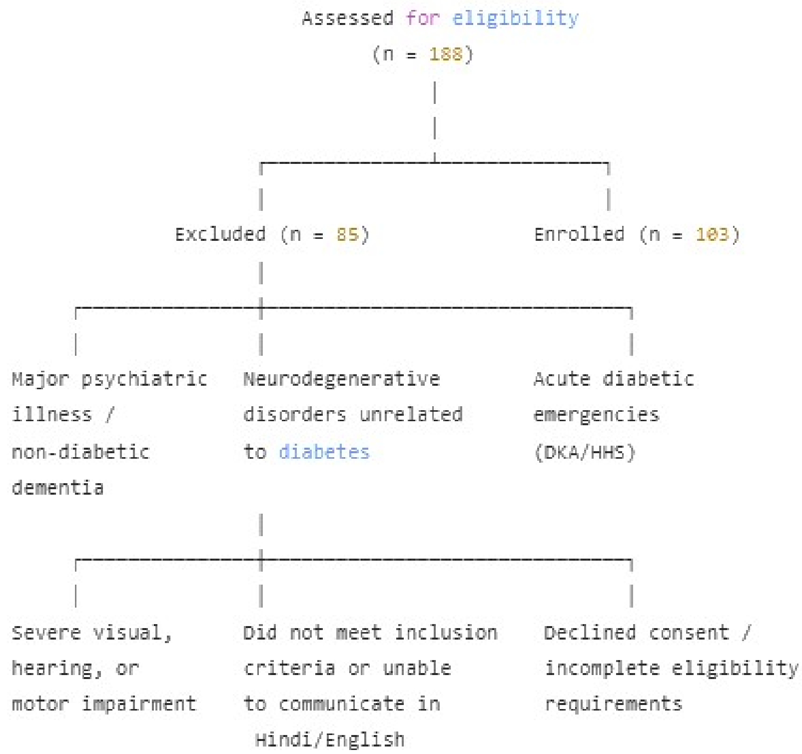

Figure 1: CONSORT flow diagram illustrating participant screening, exclusions, and final enrollment in the study.

2.5. Tools and Instruments

The study employed a set of validated tools and instruments to comprehensively assess quality of life, cognitive function, and clinical outcomes. The WHOQOL-BREF (Hindi version) was used to evaluate four domains of quality of life, namely physical health, psychological health, social relationships, and environment. The SF-12 Health Survey provided additional insights into health-related quality of life by generating both physical component summary (PCS) and mental component summary (MCS) scores. To measure cognitive function, a standardized screening tool such as the Montreal Cognitive Assessment (MoCA) was administered, covering memory, attention, executive function, and visuospatial abilities. MoCA cutoff of <26 was used to define cognitive impairment. Clinical information was obtained using a structured history and complication checklist**,** which documented both microvascular complications (retinopathy, nephropathy, neuropathy) and macrovascular complications (ischemic heart disease, stroke, peripheral vascular disease). All clinical details were verified through hospital records, laboratory reports, and physician notes to ensure accuracy and reliability.

2.6. Data Collection Procedure

Data were collected systematically to ensure reliability and accuracy. Eligible patients were approached during routine outpatient visits, and after obtaining written informed consent, face-to-face interviews were conducted using structured questionnaires to capture sociodemographic and quality-of-life information. Standardized cognitive assessments were administered in a quiet, distraction-free environment to minimize external influences on performance. In addition, detailed clinical history and complication profiles were extracted from hospital records and subsequently cross-verified through patient interviews to confirm consistency and completeness of data.

2.7. Data Analysis

Data were analyzed using SPSS (Version 26.0) with a combination of descriptive and inferential statistical methods. Descriptive statistics such as mean, standard deviation, and percentages were used to summarize demographic and clinical characteristics of the study population. For group comparisons, independent t-tests and one-way ANOVA were applied to evaluate differences in quality-of-life and cognitive scores across subgroups defined by the presence or absence of complications. To assess relationships between variables, Pearson or Spearman correlation analyses were performed, examining associations between the number and severity of complications, HbA1c levels, cognitive performance, and QoL scores. The number of complications was quantified using a simple cumulative count of diagnosed diabetes-related complications per patient. Finally, multiple linear regression models were employed to identify independent predictors of poor quality of life and cognitive impairment, adjusting for potential confounders such as age, gender, duration of diabetes, and comorbid conditions.

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2.8. Ethical Considerations

The present study was conducted following approval from the Institutional Ethics Committee (IEC) of NIMS University, Rajasthan, Jaipur (Approval No.: NIMS/UR/IEC/2022/350, dated 23 September 2022). The research protocol was reviewed in accordance with the ethical principles outlined in the ICMR National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017). The study adhered strictly to all applicable ethical standards for research involving human participants. Prior to participation, informed consent was obtained from all subjects after explaining the purpose, procedures, potential risks, and benefits of the study in a language understandable to them. Participation was entirely voluntary, and participants were free to withdraw from the study at any stage without any consequences. Confidentiality and anonymity of participant data were maintained throughout the study. All collected data were used solely for research purposes and were securely stored to prevent unauthorized access. No personal identifiers were disclosed in any publications or presentations arising from this work. The study protocol complied with all conditions laid down by the Institutional Ethics Committee, including timely reporting of study progress, documentation of any protocol deviations, and reporting of adverse events, if any. No conflict of interest was reported by the investigators, and all procedures were conducted in accordance with the approved protocol.

3. Results

3.1. Participant Demographics and Disease History

Total 188 patients could be enrolled and 85 of them were excluded based on eligibility criteria, resulting in a final sample of 103 participants. The mean age of the study population was 56.8 ± 9.4 years, with a slight male predominance (54.4% male, 45.6% female). The mean duration of diabetes was 10.6 ± 4.8 years, and more than half of the patients (57.3%) had at least one diabetes-associated complication. **Figure 2 and Table 2** present the clarity of overlapping of the proposed complications, where neuropathy (28.1%), retinopathy (22.3%), and nephropathy (18.4%) were the most common microvascular conditions, while ischemic heart disease (15.5%) and stroke (7.8%) represented key macrovascular complications. The mean HbA1c across the cohort was 8.2 ± 1.3%, indicating suboptimal glycemic control (**Table 1**).

Table 1: Participant Demographics and Disease History (N = 103)

Variable	Value
Age (years), mean ± SD	56.3 ± 9.4
Gender (Male/Female)	56 (54.4%) / 47 (45.6%)
Duration of Diabetes (years)	10.7 ± 4.5
Mean HbA1c (%)	8.2 ± 1.3
Patients with ≥1 complication	59 (57.3%)
Neuropathy	29 (28.1%)
Retinopathy	23 (22.3%)
Nephropathy	19 (18.4%)
Ischemic Heart Disease	16 (15.5%)
Stroke	8 (7.8%)
Foot Ulcers	12 (11.6%)

The total number of specific complications exceeds the number of patients with ≥1 complication (n = 59) because some patients had multiple concurrent complications.

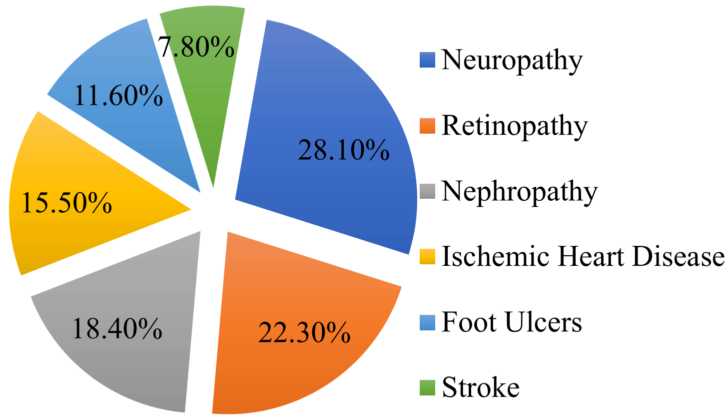
Table 2 summarizes patients according to the number of diabetes-related complications per individual rather than individual conditions. Although the cumulative frequencies of specific complications exceed the total affected population, this reflects the presence of multiple coexisting complications in the same patient. Of the 103 patients, 59 (57.3%) had at least one complication, with a substantial proportion experiencing two or more concurrent complications, highlighting the burden of multimorbidity in this cohort. The demographic profile of the participants reflects a middle-aged diabetic population with a long duration of disease and poor glycemic control, consistent with national trends reported in India. More than half of the patients exhibited at least one diabetes-related complication, with neuropathy, retinopathy, and nephropathy being predominant. The prevalence of macrovascular complications such as ischemic heart disease and stroke was also notable, underscoring the dual burden of micro- and macrovascular sequelae. These findings emphasize the progressive nature of type 2 diabetes and highlight the need for early detection, better glycemic management, and integrated care approaches to prevent or delay complications that adversely affect cognitive function and quality of life.

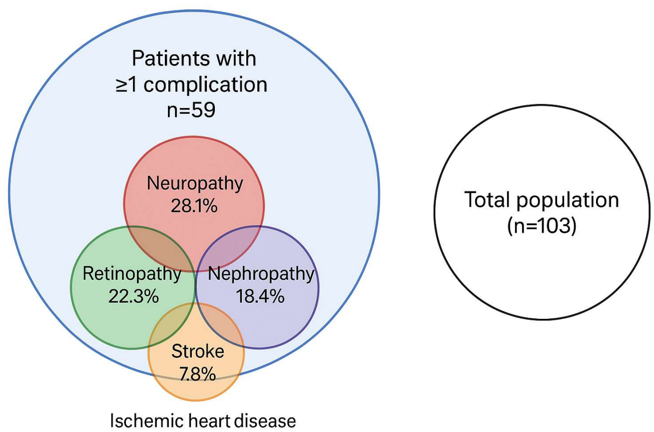
3.2. Prevalence of Complications:

3.2.1. Percentage population with nephropathy, retinopathy, neuropathy, foot ulcers

Among the 103 participants, the prevalence of diabetes-related complications was substantial. Neuropathy was the most frequent, affecting 28.1% of the study population, followed by retinopathy (22.3%)**,** nephropathy (18.4%)**,** Ischemic Heart Disease (15.5%)**,** and diabetic foot ulcers (11.6%). A considerable proportion of patients had multiple complications, indicating advanced disease burden and prolonged exposure to hyperglycemia (**Figure 2** and **Table 2 and 3**).

Figure 2: Distribution and overlap of diabetes-related complications among patients with ≥1 complication (n = 59)





Note: The pie chart depicts the relative proportion of individual diabetes-related complications among patients who had at least one complication (n = 59). The Venn diagram illustrates the overlap between major complications, indicating that several patients experienced more than one condition simultaneously. Therefore, the summed percentages of individual complications exceed 100%. The outer circle represents the total study population (n = 103), while the shaded area highlights patients with ≥1 complication. This presentation clarifies that complication counts are not mutually exclusive but reflect comorbid disease burden.

The findings indicate a high prevalence of diabetes-associated complications, with nearly one-third of patients suffering from neuropathy, in line with previously reported Indian and global trends. Retinopathy and nephropathy also emerged as major contributors to morbidity, reflecting the microvascular impact of poorly controlled diabetes. Although less common, foot ulcers were reported in over one-tenth of participants, underscoring the ongoing risk of severe sequelae such as infection and amputation. The coexistence of multiple complications in many patients highlights the need for routine screening and multidisciplinary management to mitigate progression and improve quality of life.

Table 2: Distribution of Patients by Number of Diabetes-Related Complications (n=59)

Number of Complications per Patient	Number of Patients (n)	Percentage (%)
0 (No complications)	44	42.7
1 complication	21	20.4
2 complications	18	17.5
3 complications	12	11.7
≥4 complications	8	7.7

Number of Complications per Patient	Number of Patients (n)	Percentage (%)
Total with ≥1 complication	59	57.3

Patients may have more than one diabetes-related complication; therefore, the sum of individual complications exceeds the total number of affected patients. This table presents patient-level clustering of complications to avoid overlap-related confusion.

3.2.2. Cognitive Function Scores and Complication Status

Cognitive performance assessed using the Montreal Cognitive Assessment (MoCA) showed an overall mean score of 24.3 ± 3.8, with 38.8% (n = 40) of participants classified as cognitively impaired (MoCA < 26). Stratification by complication status demonstrated a clear gradient in cognitive decline. Patients with two or more complications had significantly lower mean MoCA scores (22.8 ± 3.6) compared to those with one complication (24.7 ± 3.2) and those with no complications (26.1 ± 2.9). This difference across groups was statistically significant (p = 0.004), indicating a cumulative adverse impact of diabetes-related complications on cognitive function (**Table 3**).

Table 3: Cognitive Function Scores by Complication Status (N = 103)

Complication Status	n	Mean MoCA ± SD	Cognitive Impairment (%)
None are cognitively impaired	28	26.1 ± 2.9	21.4% (6)
At least one is cognitively impaired	35	24.7 ± 3.2	34.3% (12)
≥ Two are cognitively impaired	40	22.8 ± 3.6	55.0% (22)
Overall	103	24.3 ± 3.8	38.8% (40) * p = 0.004

Note: Cognitive impairment defined as MoCA score < 26. P-value represents overall comparison of mean MoCA scores across complication groups using one-way ANOVA. A p-value < 0.05 was considered statistically significant.

The results demonstrate a clear association between the burden of diabetes-related complications and cognitive decline. Patients with multiple complications exhibited significantly lower MoCA scores and a higher prevalence of cognitive impairment compared to those with fewer or no complications. This supports the hypothesis that microvascular and macrovascular complications may increase cognitive dysfunction through mechanisms such as vascular damage, oxidative stress, and chronic inflammation. The findings align with earlier reports linking diabetes complications with mild cognitive impairment and dementia risk, emphasizing the importance of cognitive screening as part of routine diabetes care, especially for those with advanced disease. The association between diabetic complications and impaired cognition is supported by the systematic review and meta-analysis by Satapathy et al. (2025), which reported a high prevalence of cognitive impairment, defined using the Montreal Cognitive Assessment (MoCA) threshold of <26, among patients with diabetic microvascular complications, particularly nephropathy and retinopathy. Their pooled estimates demonstrated that individuals with these complications were significantly more likely to fall below the MoCA cutoff, indicating clinically meaningful global cognitive dysfunction (19). Mechanistic insights into MoCA-defined cognitive impairment (score <26) are further reinforced by Roy (2025), who described how chronic hyperglycemia induces oxidative stress–driven microvascular and macrovascular injury in cerebral vessels. These processes—endothelial dysfunction, chronic inflammation, and reduced cerebral perfusion—provide a biological rationale for the increased proportion of diabetic patients scoring below the MoCA threshold in the presence of vascular complications (20). Direct clinical validation is provided by Sumbul-Sekerci et al. (2025), who employed the MoCA with a cutoff score of 26 to demonstrate significantly lower cognitive performance in individuals with T2DM and prediabetes compared with healthy controls. Their findings linked sub-threshold MoCA scores to biomarkers of endothelial dysfunction, inflammation, oxidative stress, and neuronal injury, underscoring that diabetes-related vascular pathology translates into measurable cognitive decline detectable by standard screening tools (21).

3.2.3. QoL Scores Compared Across Complication Subgroups

Quality of Life (QoL) was assessed using the WHOQOL-BREF and SF-12 Health Survey**.** The overall mean scores were WHOQOL-BREF: 55.2 ± 7.6 and SF-12 PCS: 41.8 ± 3.7; MCS: 44.5 ± 4.2**.** Patients with two or more complications reported the lowest scores across both instruments. Specifically, mean WHOQOL-BREF scores declined progressively from 62.4 ± 6.1 in patients with no complications, to 56.2 ± 4.8 in those with one complication, and further down to 49.1 ± 5.3 in those with ≥2 complications (p < 0.001). Similarly, SF-12 PCS and MCS scores were significantly poorer among participants with multiple complications (**Table 4**).

Table 4: QoL Scores Across Complication Subgroups (N = 103)

Complication Status	n	WHOQOL-BREF (Mean ± SD)	SF-12 PCS (Mean ± SD)	SF-12 MCS (Mean ± SD)
No complications	28	62.4 ± 6.1	46.9 ± 3.3	49.2 ± 5.4

Complication Status	n	WHOQOL-BREF (Mean ± SD)	SF-12 PCS (Mean ± SD)	SF-12 MCS (Mean ± SD)
One complication	35	56.2 ± 4.8	42.3 ± 6.1	45.8 ± 7.8
≥ Two complications	40	49.1 ± 5.3	38.4 ± 4.7	40.2 ± 6.1
Overall	103	55.2 ± 7.6*	41.8 ± 3.7*	44.5 ± 4.2*

Note: P-values (*) represent overall between-group comparisons across complication categories (no complications, one complication, ≥2 complications) using one-way ANOVA. A p-value < 0.05 was considered statistically significant.

The findings reveal that diabetes-associated complications significantly impair health-related quality of life, with a stepwise decline in both physical and mental health scores as the number of complications increases. This finding can be supported by Wonde *et al.* (2022), who reported that the presence of diabetic complications and comorbidities was independently associated with significantly poorer health-related quality of life, with patients without complications demonstrating substantially better physical and psychological well-being compared to those with complications (22). The greatest reductions were observed in patients with multiple complications, reflecting the compounded burden of micro-vascular and macro-vascular outcomes on physical functioning, psychological well-being, and social participation. These results are consistent with prior studies demonstrating that QoL diminishes with advancing complication severity, particularly in domains of mobility, independence, and emotional health. An investigation carried out by Minata et al. (2024), demonstrate that diabetes-related complications in maintenance hemodialysis patients are associated with significant declines in physical function and muscle mass, highlighting how complication burden accelerates functional deterioration and adversely impacts overall quality of life (23). Integrating QoL assessment into clinical management can help tailor interventions to support both physical and psychosocial dimensions of diabetes care.

3.3. Impact of Specific Complications on Cognitive, Quality of Life (QoL), and Mental Health Domains

Analysis of complication-specific associations revealed distinct and measurable effects of diabetes-related complications on cognitive function, quality of life, and psychological well-being (**Table 5**). Among 103 participants, the most prevalent complications were neuropathy (29, 28.1%), followed by retinopathy (23, 22.3%), nephropathy (19, 18.4%), and foot ulcers (12, 11.6%). Patients with retinopathy exhibited significantly reduced cognitive function scores (MoCA: 22.6 ± 3.4) compared to those without retinopathy (25.1 ± 2.9, p = 0.002). Nephropathy was primarily associated with a poorer overall QoL, with mean WHOQOL-BREF scores of 50.2 ± 7.4 versus 58.3 ± 6.9 among those without nephropathy (p = 0.004). Foot ulcer patients reported notably lower mental health scores (SF-12 MCS: 39.8 ± 5.1 vs 46.2 ± 6.8, p = 0.001), suggesting a strong association with depressive symptoms. Similarly, neuropathy was linked to declines across all domains, particularly cognitive and QoL scores (MoCA: 23.0 ± 3.2 vs 25.0 ± 3.0, p = 0.01; WHOQOL-BREF: 52.3 ± 7.9 vs 57.2 ± 6.8, p = 0.02). Even after adjustment for potential confounders including age, gender, duration of diabetes, HbA1c, and comorbidities, these associations remained significant, confirming that diabetes complications independently contribute to cognitive and psychosocial decline.

Table 5: Associations between Specific Complications and Outcome Measures (N = 103)

Complication	Subgroup (n)	Cognitive Function (MoCA, Mean ± SD)	WHOQOL-BREF (Mean ± SD)	SF-12 MCS (Mean ± SD)	p-value
Neuropathy	Present (30)	23.0 ± 3.2	52.3 ± 7.9	42.5 ± 4.3	0.010*
	Absent (73)	25.0 ± 3.0	57.2 ± 6.8	45.6 ± 5.7	
Retinopathy	Present (23)	22.6 ± 3.4	52.1 ± 5.7	43.9 ± 5.5	0.002*
	Absent (80)	25.1 ± 2.9	56.8 ± 5.1	45.3 ± 6.2	
Nephropathy	Present (19)	23.4 ± 3.3	50.2 ± 7.4	42.8 ± 5.4	0.004*
	Absent (84)	24.6 ± 3.1	58.3 ± 6.9	45.8 ± 4.9	
Foot Ulcers	Present (12)	23.1 ± 3.2	51.8 ± 6.3	39.8 ± 5.1	0.001*
	Absent (91)	24.5 ± 3.0	56.1 ± 5.6	46.2 ± 6.8	

Note: P-values represent between-group comparisons (presence vs absence of complication) using independent samples t-tests. Statistical significance was set at p < 0.05.

The findings demonstrate a progressive decline in both cognitive and psychosocial parameters with the presence of specific diabetes complications. Neuropathy and retinopathy were particularly associated with reduced cognitive performance, likely due to shared vascular and neuronal injury pathways. Nephropathy showed the greatest impact on overall QoL, reflecting the multifactorial burden of renal impairment, including fatigue, dietary restrictions, and treatment complexity. Foot ulcers emerged as a strong predictor of depressive symptoms, emphasizing the psychosocial consequences of chronic pain, immobility, and social withdrawal. Collectively, these results highlight that the type and severity of complications distinctly shape patient outcomes, necessitating personalized clinical management strategies. The observed associations underscore the multidimensional impact of diabetes complications beyond glycemic control. The cognitive decline observed among patients with retinopathy and neuropathy aligns with prior evidence linking chronic hyperglycemia and microvascular damage to cerebral small vessel disease and neurodegeneration. Diabetic retinopathy may serve as a stronger marker of cerebral microvascular dysfunction because the retinal and cerebral microvasculature share similar embryological origins, anatomical features, and susceptibility to chronic hyperglycemia-induced endothelial damage, making retinal microvascular changes a visible surrogate for parallel pathological processes occurring in the brain (24). Similarly, the reduced QoL among nephropathy patients is consistent with reports that chronic kidney disease amplifies fatigue, anxiety, and treatment burden (25). Gregg et al. (2021) report that nearly 70% of patients with CKD experience clinically significant fatigue, with a substantial proportion reporting severe symptoms, which are strongly associated with hospitalization, dialysis initiation, and mortality. The multifactorial pathophysiology of CKD-related fatigue, including metabolic acidosis, sarcopenia, anemia, and depression, contributes to heightened physical limitation, psychological distress, and overall treatment burden, thereby markedly diminishing health-related quality of life (25). Foot ulcer-related depression mirrors the psychological stress of functional limitation, pain, and prolonged treatment cycles. Importantly, these findings suggest that each complication uniquely associated to the overall disease burden, cognitive, emotional, and functional. Thus, routine screening for cognitive dysfunction, QoL deficits, and depression should be integrated into diabetes care pathways, particularly for patients presenting with microvascular and neuropathic complications. Multidisciplinary interventions that combine pharmacological management, psychological counseling, and lifestyle modification could significantly enhance patient well-being and functional independence.

4. Conclusion

This study demonstrates that diabetes-associated complications are associated with a profound and multidimensional impact on patient outcomes, extending beyond glycemic control to affect cognitive function, psychological well-being, and overall quality of life. Among the evaluated complications, neuropathy and retinopathy were significantly associated with cognitive decline, while nephropathy contributed to a marked reduction in health-related quality of life. Foot ulcers showed the strongest link with depressive symptoms, reflecting the emotional and social burden of chronic, disabling complications. These findings emphasize that the cumulative burden of diabetes complications is linked independently to cognitive and psychosocial deterioration, even after controlling for demographic and clinical factors. Integrating cognitive screening, mental health assessment, and quality-of-life evaluation into routine diabetes care can facilitate early identification of vulnerable patients. A multidisciplinary approach-combining clinical pharmacy support, lifestyle modification, psychological counseling, and complication prevention, may therefore enhance long-term outcomes and improve patient-centered diabetes management.

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