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Prevalence and Predictors of Cognitive Decline Among Diabetes Mellitus Patients Attending Jinja Regional Referral Hospital: A Cross-Sectional Study in Eastern Uganda

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ABSTRACT

Background and Aims: The burden of cognitive impairment (CI) is high in diabetes mellitus. CI can adversely affect the self-care and management of diabetes, which results in an increase in the risk of hypo- or hyperglycaemic events and diabetic complications. The study aimed to determine the prevalence and predictors of CI in diabetic patients.

Methods: A hospital-based, cross-sectional study was conducted among diabetic patients who were attending Jinja Regional Referral Hospital (JRRH), Eastern Uganda, from April to June 2024. A pre-designed data collection tool was used to capture socio-demographics and clinic profiles of the participants. A Montreal Cognitive Assessment (MoCA), version 8.1, was used to assess the CI (score: ≥ 26 = normal, < 26 = cognitive impairment) in diabetic patients. We used a binary and multiple logistic regression analysis to identify predictors of CI in diabetes.

Results: The prevalence of CI among diabetic patients was 63.11% (95% CI: 58.3–67.9), and it was high among Type II diabetic patients (66.96%). Most of the patients have mild CI (73.77%). Delayed recall (78.96%) and language (73.77%) cognitive domains were greatly affected. Variables like advanced age (AOR = 6.08; 95% CI = 2.05–18.03), education (Illiterate: AOR = 5.90; 95% CI = 2.16–16.14; primary: AOR = 17.07; 95% CI = 5.64–51.71), alcohol use (AOR = 2.56; 95% CI = 1.22–5.37), no physical activity (AOR = 5.24; 95% CI = 2.52–10.91), type II diabetes (AOR = 7.02; 95% CI = 2.17–22.64), duration of diabetes (5–10 years: AOR = 14.09; 95% CI = 5.75–34.55; > 10 years: AOR = 78.80; 95% CI = 23.79–260.95), uncontrolled blood glucose (AOR = 5.13; 95% CI = 1.91–13.83), hypertension (AOR = 5.26; 95% CI = 2.08–13.34), and diabetic complications (AOR = 4.30; 95% CI = 1.38–13.36) were significantly associated with CI among diabetic patients.

Conclusion: The study concludes that more than half of the diabetic patients had CI. Factors such as age, education, alcohol use, physical activity, diabetes type, duration of diabetes, glycaemic control, hypertension, and diabetic complications were significantly associated with CI in diabetes. Therefore, the study recommends planning and implementing management strategies that focus on predictors of CI in diabetes.

1 | Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by elevated blood glucose levels, which can affect several organ systems [1]. Diabetes is often connected with multimorbidity because it can increase the risk of developing other chronic diseases, such as cardiovascular disease, chronic kidney disease, and other diabetes complications, such as eye and nerve damage [2]. According to the International Diabetes Federation (IDF), the global prevalence of DM was 9.3% in 2019, projected to be 10.2% by 2030% and 10.9% in 2045 [3]. This prevalence is higher in low- and middle-income countries compared to high-income countries [4]. The increase is most likely due to a combination of factors, such as lifestyle and dietary changes, an aging population, ethnicity, and limited access to healthcare services [4].

Prolonged diabetes mellitus (DM) is associated with an increased risk of cognitive impairment (CI), presenting as deficits in memory, executive function, attention, and decision-making capacity. These impairments can adversely affect patients' daily routine activities [5]. Several studies have found a strong link between DM and the risk of cognitive impairment, including dementia and Alzheimer's disease [6, 7]. The onset and progression of cognitive impairment were strongly linked with poor glycaemic management, elevated glycosylated hemoglobin (HbA1C), and diabetes for a longer period [8–11]. Several studies have found that cognitive impairment may have negative impacts on psychomotor efficiency, memory, attention, visuospatial construction, frontal executive skills, verbal fluidity, complex motor activities, and mental flexibility [12–14]. This results in functional disability, increased healthcare costs, and decreased quality of life. Cognitive impairment may significantly affect diabetes patients' adherence to the medication regimen, diet, physical exercise, self-care, and regular follow-up [5, 15]. Diabetic patients with cognitive impairment are at higher risk of developing complications due to inadequate glycaemic control [13].

The exact mechanisms contributing to cognitive impairment in diabetes are intricate. Various studies have found that brain vascular changes, disruptions in cerebral insulin signaling, glucose toxicity, concomitant hypertension, accumulation of advanced glycation end products, repeated hypoglycaemic events, dyslipidaemia, microangiopathy, amyloidosis, heightened oxidative stress, and inflammation all play a significant role in causing neuronal damage resulting in cognitive impairment in diabetes mellitus [12–14, 16, 17]. A study indicated that brain structural abnormalities such as hippocampal damage, altered white matter, diminished gray matter, and atrophy were associated with the development of neurocognitive dysfunction in diabetic individuals [18]. Furthermore, many diabetic drugs, such as metformin, sulfonylureas, and insulin, increase the risk of cognitive impairment and dementia [19–22].

Studies reported that advanced age, gender, lower education level, duration of diabetes, metformin use, hearing loss, traumatic brain injury, hypertension, poor health, incontinence, falls, sensory impairments, alcohol consumption, smoking, depression, social isolation, physical activity, residence, and air pollution are all risk factors for cognitive decline in diabetes mellitus patients [23–25]. The American Heart Association's (AHA) recent report emphasized modifiable factors (body weight, physical activity, blood pressure, lipid level, smoking, diet, alcohol consumption, sleep, stress, and well-being) that need to be controlled to prevent future events of dementia [26, 27].

Cognitive impairment in diabetes can adversely affect self-care behavior (poor adherence to medication, diet, and physical activity recommendations), seeking appropriate care, and attending regular follow-up visits [28, 29]. This can predispose diabetic patients to experience treatment-related complications, such as acute severe hyper- or hypoglycaemic events, and increased risk of micro- and macrovascular complications of diabetes [30, 31]. The association between abnormal glycaemic control and the development of cognitive impairment is a bidirectional process. A chronic hyperglycaemic state can damage the cerebral microvasculature, leading to reduced cerebral perfusion; it can also promote neurodegeneration through chronic oxidative stress and low-grade inflammation, promote the formation of advanced glycation end-products (AGEs) that impair neuronal function, and insulin resistance, which disrupts neuronal insulin signaling in the brain, ultimately contributing to cognitive impairment [32–34]. The ACCORD-MIND and Health ABC studies have clearly demonstrated that individuals with poor glycaemic control exhibit more rapid cognitive decline and are at increased risk of dementia [35, 36]. Additionally, hypoglycaemic events resulting from overtreatment can further impair cognitive performance [20]. This would be the probable reason why guidelines advise tailoring diabetes therapy to prevent hypoglycaemic events in elderly people [36].

A worldwide rise in the prevalence of diabetes and the aging population could significantly increase diabetes-related cognitive decline and its adverse effects. Although diabetic patients are at greater risk for cognitive impairment, there is no test to screen for it in routine diabetic clinical care.

Cognitive screening is essential among diabetic patients because there is a significant association between diabetes and risk of CI and dementia. Identification of CI among diabetic patients allows for early assistance and simplification of complex diabetic management tasks such as accurate insulin dosing, regular monitoring of blood glucose, and strict adherence to diet and medication therapy. Early and timely interventions can improve self-management and reduce the risk of poor glycaemic control and its associated complications [29]. The American Diabetes Association (ADA) recommends periodic cognitive screening,

especially for older adults and those with long-standing diabetes [37]. Exploring factors linked with CI is critical for developing and implementing preventive strategies to improve the quality of life for diabetic patients. To the best of our knowledge, no study has been conducted on the prevalence of CI in Uganda's diabetic community. The current study aimed to determine the prevalence and risk factors for cognitive impairment in diabetic patients.

2 | Materials and Methods

2.1 | Study Setting and Design

We conducted a cross-sectional study at the Jinja Regional Referral Hospital (JRRH) from April 1, 2024, to June 30, 2024. The JRRH is the biggest hospital in Eastern Uganda, with a capacity of 600 beds. The hospital is situated in the heart of Jinja city, near the origin of the Nile River. The study was conducted in adherence with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

2.2 | Study Participants and Eligibility

2.2.1 | Inclusion Criteria

Participants who met the below mentioned criteria were included in the study

- Participants aged over 18 years and with a history of diabetes mellitus (DM) for at least 1 year
- Patients with type 1 and 2 DM (I10.x according to the International Classification of Diseases-10) and receiving any modality of treatment (exercise, diet, insulin, and/or oral hypoglycaemic agents) [16].

2.2.2 | Exclusion Criteria

Participants who met below mentioned criteria were excluded from the study

- Patients who have speech or auditory disability
- Patients who are suffering from any co-morbidity that interferes with cognitive ability
- Patients who are under corticosteroid therapy
- Patients who are not willing to participate in the study

2.3 | Sample Size Determination

The sample size was determined by using a single population proportion formula. Since there was no cognitive impairment study in Ugandan diabetic population, we considered 50% prevalence of cognitive decline among diabetic patients, which gives maximal size that is adequately powered regardless of the true prevalence. It can minimize the risk of underestimating the required number of participants. Using a study power of 80%, a 5% margin of error, and a 95% confidence level, the calculated sample size was 384. After accounting for a 5% nonresponse rate, the final sample size was adjusted to 403.

2.4 | Sampling Procedure

A 5-month report of DM patients attending follow-up visits in JRRH was determined for the sample selection process. Then the determined number of diabetic patients in 5 months was averaged for 3 months because the data collection period is for only 3 months. The 3-month average number of diabetic patients was 1200. The study included diabetic patients attending follow-up appointments by applying a systematic random sample technique, based on a determined constant value (three), that is derived from the division of 1200 by 403, resulting in 2.97. The initial participant was selected by a lottery process, and then every third patient who came for a follow-up appointment was included in the study.

2.5 | Ethical Considerations

The study protocol, data collection form, and informed consent process received approval from the Kampala International University Research Ethics Committee (KIU SPRC 008/24). The study was done following the guidelines of the Declaration of Helsinki concerning research involving human beings. The data collector, proficient in Luganda and English, approached all eligible participants. The researcher elucidated the study methodology and objectives to the eligible individuals and obtained both oral and written consent voluntarily. Informed consent was sought from a legally authorized representative or local guardian for illiterate participants. The participants were encouraged to openly discuss their ideas and questions regarding the study and received clarifications from the primary investigator. Participants had the full right to withdraw from the study at any point during the research process, including consent, beginning, progress, and completion. The study participants were not exposed to any harm or injury, as the survey was carried out through interviews and did not include any invasive procedures.

2.6 | Data Collection Tool

An interview-based data collection tool was prepared to collect data from the eligible participants. This tool comprises two components: 1. Sociodemographic and clinical characteristics, and 2. Cognitive impairment measurement by using Montreal Cognitive Assessment (MoCA) scale.

2.6.1 | Sociodemographic and Clinical Variables

An extensive literature search was performed to identify studies that assessed cognitive decline in diabetic patients. These studies were used to identify and select the sociodemographic and clinical variables in the data collection tool. Based on the literature-supported variables, the English version interview-based questionnaire was prepared and subjected to content validity by two public health experts.

Sociodemographic variables: Age, gender, marital status, education level, occupation, monthly income (UGX), residence, physical activity, smoking, and alcohol consumption status were included in this section.

Clinical variables: Type of DM, duration of DM, complications of DM, and medications used to manage diabetes were also included in this section. Recent clinical laboratory findings (HbA1C, lipid profile, blood pressure), anthropometric parameters (height, weight, BMI), and co-morbidities (hepatic, renal, neurological, cardiac) were also included in this section.

2.6.2 | Cognitive Impairment Measurement

Cognitive impairment was measured using the MoCA (version 8.1) after getting approval from the authors [38]. The scale assessed eight cognitive areas: visuospatial/executive function, naming, memory, attention, language, abstraction, delayed recall, and orientation. The maximal score for each cognitive domain: visuospatial/executive function (5), naming (3), memory (0), attention (6), language (3), abstraction (2), delayed recall (5), and orientation (6).

The MoCA scores range from 0 to 30, with higher scores reflecting better cognitive function. A score of 26 or above was classified as normal, while scores below 26 indicated cognitive impairment [39]. We interpreted the obtained results and categorized them into normal and cognitive impairment (CI). The prevalence of CI and the factors associated with it were determined among diabetic patients.

In severity assessment, levels of cognitive impairment were categorized by using MoCA scores according to Peterson's criteria. These include normal cognitive performance (26 and above), mild impairment (18–25), moderate impairment (10–17), and severe impairment (0–9).

2.7 | Data Collection and Management

After obtaining informed consent, we conducted a face-to-face interview with the patients using a validated data collection tool. A trained and certified individual conducted the MoCA test. The interview lasted approximately 20 to 30 min. The sociodemographic and clinical characteristics and cognitive parameters were obtained by interviewing the patient and medical records. We analyzed the collected data to estimate the prevalence and predictors of cognitive decline among diabetic patients. The principal investigator (NG) checked the correctness of the data abstraction according to the research protocol. Every day, the principal investigator conducted a quality check at the data collection site to eliminate any errors in the data collection process. The principal investigator checked the collected data for completeness, clarity, and consistency.

2.8 | Data Analysis

The data analysis was performed using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to present sociodemographic and clinical profiles and the prevalence of cognitive decline among diabetic patients. Binary and multiple logistic regression analyzes were used to identify the factors associated with cognitive decline among diabetic patients. Variables with a p value ≤ 0.20 in binary logistic regression were subjected to multiple logistic regression to minimize the confounding effects. A two-way p-value of less than 0.05 was considered statistically significant.

3 | Results

About 395 patients were accepted to participate in the study upon inviting 435 diabetic patients with a response rate of 90.80%. After removal participants who didn't meet the study criteria (5) and incomplete interview forms (5), about 385 were subjected to the data analysis. Figure 1 presents the flowchart of the participant selection process.

The study findings revealed that most of the patients were aged between 40 and 60 years (187; 48.57%), male (207; 53.77%), urban residents (205; 53.25%), Postsecondary school of education (145; 37.66%), married (283; 73.51%), employed (284; 73.77%), getting a monthly income between 100 and 500 K UGX (208; 54.03%), non-smokers (292; 75.84%), non-alcoholics (211; 54.81%), and had no regular physical activity (204; 52.99%). The clinical profile of the participants shows that most of the participants were suffering from Type II DM (339; 88.05%), under oral-hypoglycaemic agent therapy (208; 54.03%), had diabetes duration between 5 and 10 years (183; 47.53%), were under regular medication use (327; 84.94%), had controlled blood glucose (286; 74.29%), had no history of hypertension (291; 75.58%), and had no presence of diabetic complications (317; 82.34%). The distribution of demographic and clinical characteristics of the study participants is presented in Table 1.

The prevalence of cognitive impairment among diabetic patients was 63.11% (95% CI: 58.3–67.9). It was high (66.96%) among patients suffering from Type II diabetes. Table 2 presents the distribution of cognitive impairment according to type of diabetes.

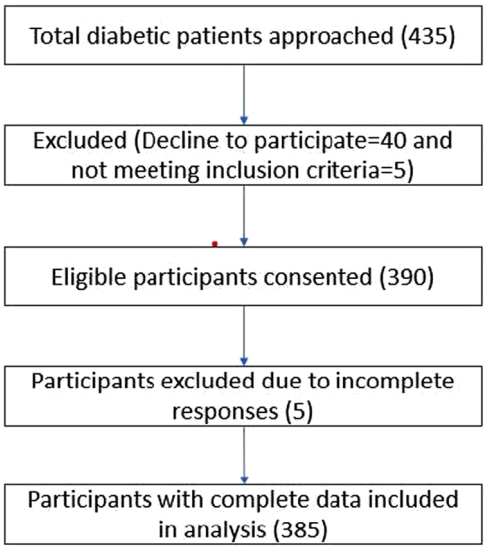

FIGURE 1 | Flowchart of the participants selection process.

TABLE 1 | Socio-demographic and clinical characteristics of the study participants ($n = 385$).

Variable	Frequency (%)
Age (years)	
< 40	89 (23.12)
40–60	187 (48.57)
> 60	109 (28.31)
Gender	
Male	207 (53.77)
Female	178 (46.23)
Residence	
Rural	180 (46.75)
Urban	205 (53.25)
Education	
Illiterate	73 (18.96)
Primary	98 (25.45)
Secondary	69 (17.92)
Postsecondary	145 (37.66)
Marital status	
Single	84 (21.82)
Married	283 (73.51)
Divorced	10 (2.60)
Widowed	8 (2.08)
Occupation	
Employed	284 (73.77)
Unemployed	101 (26.23)
Monthly income (UGX)	
< 100 K	103 (26.75)
100–500 K	208 (54.03)
> 500 K	74 (19.22)
Smoking	
Yes	93 (24.16)
No	292 (75.84)
Alcohol	
Yes	174 (45.19)
No	211 (54.81)
Physical activity	
Yes	181 (47.01)
No	204 (52.99)
Type of DM	
Type I DM	46 (11.95)
Type II DM	339 (88.05)
Type of medication	
Insulin	36 (9.35)
OHA	208 (54.03)
Both	141 (36.62)
Duration of DM (Years)	
< 5	104 (27.01)
5–10	183 (47.53)
> 10	98 (25.45)
Regular medication use	
Yes	327 (84.94)
No	58 (15.06)
Blood glucose status	
Controlled	286 (74.29)
Uncontrolled	99 (25.71)
Hypertension	
Yes	94 (24.42)
No	291 (75.58)
Diabetic complication(s)	
Yes	68 (17.66)
No	317 (82.34)

Abbreviations: DM, diabetes mellitus; OHA, oral hypoglycaemic agents; SD, standard deviation; UGX, Ugandan shillings.

The study findings reveal that most patients have mild cognitive impairment (208; 54.03%). The distribution of the severity levels of cognitive impairment was represented in Table 3.

The domain-wise cognitive impairment was presented in Table 4. The table findings represent the number and percentage of participants who scored below 60% of the total possible standardized score in each MoCA cognitive domain [1]. The majority of the participants were affected in the delayed recall (304; 78.96%) and language (284; 73.77%) domains. Only a small number of participants experienced issues in the orientation (55; 14.29%) and naming (68; 17.66%) domains.

The results of the logistic regression analysis indicated that diabetic patients aged over 60 were about six times more likely to develop cognitive impairment compared to those aged 60 or younger (AOR = 6.08; 95% CI: 2.05–18.03). Educational status was also a strong predictor: individuals who were illiterate were nearly six times more likely (AOR = 5.90; 95% CI: 2.16–16.14), and those with only primary education were over seventeen times more likely (AOR = 17.07; 95% CI: 5.64–51.71) to have cognitive impairment compared to those with higher education levels. Additionally, alcohol users have more than two times the risk of getting CI compared to non-alcoholics (AOR = 2.56; 95% CI: 1.22–5.37), and individuals without physical activity were five times more likely to experience CI (AOR = 5.24; 95% CI: 2.52–10.91).

Clinical variables such as Type II diabetes were seven times more likely linked with cognitive decline compared with Type I diabetes (AOR = 7.02; 95% CI: 2.17–22.64). Furthermore, diabetes duration was strongly linked with cognitive decline: those with

TABLE 2 | Prevalence of cognitive impairment in diabetic patients ($n = 385$).

Type of diabetes	Total number of patients	MOCA score ≥ 26 (Normal)	MOCA score < 26 (Cognition impairment)	Prevalence of cognition impairment
Type I	46	30	16	34.78%
Type II	339	112	227	66.96%
Total	385	142	243	63.11%

Abbreviation: MCI, mild cognition impairment.

TABLE 3 | Severity levels of cognition impairment in diabetic patients ($n = 385$).

Severity level	Frequency (%)
Normal	142 (36.88)
Mild cognition impairment	208 (54.03)
Moderate	34 (8.83)
Severe	1 (0.26)

Note: Normal = Score 26 and above; mild cognition impairment = Score 18–25; moderate cognition impairment = Score 10–17; Severe = Score 0–9.

TABLE 4 | Cognitive impairment by domain ($n = 385$).

Cognitive domain	Frequency (%)
Visuospatial/executive function	186 (48.31)
Naming	68 (17.66)
Attention	190 (49.35)
Language	284 (73.77)
Abstraction	203 (52.73)
Delayed recall	304 (78.96)
Orientation	55 (14.29)

5–10 years of diabetes had a 14-fold increased risk (AOR = 14.09; 95% CI: 5.75–34.55), while patients with a duration of more than 10 years were nearly 17 times more likely to develop cognitive impairment (AOR = 78.80; 95% CI: 23.79–260.95). Uncontrolled blood glucose was associated with a fivefold higher risk (AOR = 5.13; 95% CI: 1.91–13.83). Additionally, the presence of hypertension increased the odds by more than five times (AOR = 5.26; 95% CI: 2.08–13.34), and diabetic complications increased the odds to four times (AOR = 4.30; 95% CI: 1.38–13.36) for the development of cognitive decline. Factors associated with cognitive impairment among diabetic patients are presented in Table 5.

4 | Discussion

The MoCA is a widely acceptable tool for assessing cognitive impairment; it is mainly used to detect potential cognitive impairment among patients. We used the MoCA tool to determine the prevalence and risk factors associated with cognitive impairment among diabetic patients. Furthermore, we examined the diabetic patient's cognitive abilities and performance in various cognitive domains. To the best of our knowledge, this is the first hospital-based study conducted in Uganda that investigates the cognitive abilities and associated factors of diabetic patients.

Our study findings indicated that the prevalence of CI among diabetic patients was 63.11%. There has been no indigenous study conducted in Uganda to compare our findings and investigate the differences noticed across the country. Similar to our finding, a study conducted in Lebanon reported 68% CI among diabetic patients [40]. Contrast to our findings, studies conducted in Filipino (19.3%), Chile (30.6%), Egypt (34.0%), Ethiopia (56.3%), the Central Africa Republic and Congo (18.8%) and Cameron (14.8%) reported less prevalence of CI than our study [41–46]. Studies conducted in Saudi Arabia (80.3%), Japan (72.0%), and Pakistan (75.60%) were reported higher prevalence of CI than our study [1, 47]. The wide variation observed in the prevalence of CI among diabetic patients across the countries was due to the use of different cognitive impairment tools, variation in sample size, type of diabetic patients included in the study, educational and socioeconomic status of the study participants. Additionally, Uganda shows relatively high rate of diabetes compared to the other countries due to a rapid rise lifestyle factor such as increased urbanization, physical inactivity, unhealthy diet rich in sugar and processed foods, and growing obesity rate [48]. These metabolic risk factors play a crucial role in the increase in the incidence of diabetes and its complications, like CI. According to the International Diabetic Foundation (IDF), 89% of Ugandans with diabetes are neither on medication nor aware of their status; this can cause difficulty for health systems to deal with the complications associated with the diabetes [49]. This is a possible reason for high rate of cognitive impairment observed in our study compared to other studies.

More than half of the participants in our study have mild cognitive impairment (54.03%), and only one participant (0.26%) experienced a severe level of CI. A study conducted in Saudi Arabia demonstrated that more than one-third of the participants suffered from severe cognitive impairment [1]. An Ethiopian study demonstrated only 3.8% of participants were suffering from severe cognition impairment [43]. The primary reason for the low level of severe cognitive impairment observed in our study was justified by the change in the participants' characteristics. In our study, more than half of the participants were educated above the primary school level, whereas in other studies, the majority are from lower educational levels. The level of education has been considered one of the most important determinants that affect MoCA scores. In our study, a low level of education was significantly associated with cognitive impairment. These findings suggest that specific

TABLE 5 | Binary and multiple logistic regression analysis of variables predicting cognition impairment among diabetic patients ($n = 385$).

Variable	Total (%)	Cognition impairment (%)	COR (95% CI)	*p* value	AOR (95% CI)	*p* value
Age (years) R						
< 40	89 (23.12)	47 (52.81)	1.00	1.00	1.00	1.00
40–60	187 (48.57)	102 (54.54)	1.07 (0.65–1.78)	0.787	0.97 (0.41–2.31)	0.946
> 60	109 (28.31)	94 (86.24)	**5.60 (2.82–11.12)**	**< 0.001**	**6.08 (2.05–18.03)**	**0.001**
Gender						
Male	207 (53.77)	128 (61.84)	1.00	1.00	NA	NA
Female	178 (46.23)	115 (64.61)	1.13 (0.74–1.71)	0.574	NA	NA
Residence						
Rural	180 (46.75)	113 (62.78)	1.00	1.00	NA	NA
Urban	205 (53.25)	130 (63.41)	1.03 (0.68–1.56)	0.897	NA	NA
Education						
Illiterate	73 (18.96)	60 (82.19)	**6.36 (3.21–12.59)**	**< 0.001**	**5.90 (2.16–16.14)**	**0.001**
Primary	98 (25.45)	87 (88.78)	**10.89 (5.36–22.12)**	**< 0.001**	**17.07 (5.64–51.71)**	**< 0.001**
Secondary	69 (17.92)	35 (50.72)	1.42 (0.79–2.52)	0.235	1.35 (0.53–3.44)	0.534
Postsecondary	145 (37.66)	61 (42.07)	1.00	1.00	1.00	1.00
Marital status						
Single	84 (21.82)	52 (61.90)	1.00	1.00	NA	NA
Married	283 (73.51)	180 (63.60)	1.07 (0.65–1.78)	0.777	NA	NA
Divorced	10 (2.60)	6 (60.00)	0.92 (0.24–3.52)	0.907	NA	NA
Widowed	8 (2.08)	5 (62.50)	1.03 (0.23–4.58)	0.974	NA	NA
Occupation						
Employed	284 (73.77)	176 (61.97)	0.83 (0.51–1.33)	0.435	NA	NA
Unemployed	101 (26.23)	67 (66.34)	1.00	1.00	NA	NA
Monthly income (UGX)						
< 100 K	103 (26.75)	65 (63.11)	0.98 (0.53–1.83)	0.956	NA	NA
100–500 K	208 (54.03)	131 (62.98)	0.98 (0.56–1.69)	0.935	NA	NA
> 500 K	74 (19.22)	47 (63.51)	1.00	1.00	NA	NA
Smoking						
Yes	93 (24.16)	61 (65.59)	1.15 (0.17–1.88)	0570	NA	NA
No	292 (75.84)	182 (62.33)	1.00	1.00	NA	NA
Alcohol (R)						
Yes	174 (45.19)	135 (77.59)	**3.30 (2.11–5.16)**	**< 0.001**	**2.56 (1.22–5.37)**	**0.013**
No	211 (54.81)	108 (51.18)	1.00	1.00	1.00	1.00
Physical activity						
Yes	181 (47.01)	90 (49.72)	1.00	1.00	1.00	1.00
No	204 (52.99)	153 (75.00)	**3.03 (1.97–4.66)**	**< 0.001**	**5.24 (2.52–10.91)**	**< 0.001**
Type of DM						
Type I DM	46 (11.95)	16 (34.78)	1.00	1.00	1.00	1.00
Type II DM	339 (88.05)	227 (66.96)	**3.80 (1.99–7.26)**	**< 0.001**	**7.02 (2.17–22.64)**	**0.001**
Type of medication						
OHA	208 (54.03)	130 (62.50)	1.00	1.00	NA	NA
Insulin	36 (9.35)	23 (63.89)	1.06 (0.51–2.21)	0.874	NA	NA
Both	141 (36.62)	90 (63.83)	1.06 (0.68–1.65)	0.801	NA	NA

(Continues)

TABLE 5 | (Continued)

Variable	Total (%)	Cognition impairment (%)	COR (95% CI)	*p* value	AOR (95% CI)	*p* value
Duration of DM (Years)						
< 5	104 (27.01)	22 (21.15)	1.00	1.00	1.00	1.00
5–10	183 (47.53)	131 (71.58)	**9.39 (5.31–16.60)**	**< 0.001**	**14.09 (5.75–34.55)**	**< 0.001**
> 10	98 (25.45)	90 (91.84)	**41.93 (17.69–99.36)**	**< 0.001**	**78.80 (23.79–260.95)**	**< 0.001**
Regular medication use						
Yes	327 (84.94)	206 (63.00)	1.00	1.00	NA	NA
No	58 (15.06)	37 (63.79)	1.03 (0.58–1.85)	0.908	NA	NA
Blood glucose status						
Controlled	286 (74.29)	158 (55.24)	1.00	1.00	1.00	1.00
Uncontrolled	99 (25.71)	85 (85.86)	**4.92 (2.67–9.07)**	**< 0.001**	**5.13 (1.91–13.83)**	**0.001**
Hypertension						
Yes	94 (24.42)	82 (87.23)	**5.52 (2.88–10.55)**	**< 0.001**	**5.26 (2.08–13.34)**	**< 0.001**
No	291 (75.58)	161 (55.33)	1.00	1.00	1.00	1.00
Diabetic complication(s)						
Yes	68 (17.66)	58 (85.29)	**4.14 (2.04–8.39)**	**< 0.001**	**4.30 (1.38–13.36)**	**0.012**
No	317 (82.34)	185 (58.36)	1.00	1.00	1.00	1.00

Note: Diabetic complications = renal, cardiac, neuro, ophthalmic, and self-reported numbness, NA = not applicable, variables $p < 0.2$ in binary logistic regression analysis were subjected to multiple regression analysis, $p < 0.05$ was considered statistically significant value in multiple logistic regression analysis.

interventions need to be developed according to the educational level of the patient to improve or sustain the cognition levels in diabetic patients.

The findings of cognitive domains revealed that delayed recall (78.96%) and language (73.77%) were greatly affected in our study. About half of the participants affected with attention, executive, and abstraction domains of the cognition. The domains with the least impact were naming (17.66%) and orientation (14.29%). A Saudi Arabian study's findings are in line with our findings, and these findings revealed that diabetic patients were greatly affected in delayed recall, verbal fluency, and executive function domains [1]. A Japanese study also showed almost similar findings of our study that attention, language, and abstraction were the worst affected cognitive domains [7]. A study conducted among elderly patients with hyperinsulinemia had lower cognitive scores in delayed memory, attention, and orientation [50]. Identification of the most commonly affected cognitive domain among diabetic patients aids planning domain-specific interventions for the treatment or prevention. The most commonly recommended interventions to enhance or preserve cognitive function in diabetes mellitus include behavioral rehabilitation, physical activity and exercise, stress management, cognitive training programs, diet control, and medication adherence for blood sugar management [51–53].

Our study findings revealed that low educational level was significantly associated with cognitive impairment. These findings closely resembled those from studies conducted in Saudi Arabia, India, Cameroon, and Ethiopia [1, 41, 43, 54]. Evidence shows that educated individuals have better language, executive, and memory skills than the individuals with no formal education [55, 56]. This could be a possible reason for high CI among patients with no formal education and having primary education compared to highly educated patients. Additionally, cognitive reserve theory says that educational level, professional complexity, and cognitive activities are responsible for the building of cognitive reserve in the individuals [57]. This reserve can maintain the integrity of the cognitive function and prevent the CI by using alternative neuronal networks and compensating neuronal damage [58]. Our study findings on education and CI suggest to improve the knowledge of the general public regarding compulsory education and its role in cognitive reserve.

The current study shows that advanced age was significantly associated with CI in diabetes. Similar to our findings, studies conducted in Egypt and China among diabetic patients also showed that age is a risk factor for the CI [44, 59]. Evidence indicates that approximately one-third of older adults with diabetes are at risk for CI [60]. Additionally, various studies conducted in elderly diabetic patients revealed worse performance and a stronger decline in cognitive function [60–62]. Age-related brain atrophy, reduced hippocampal size, and neuronal structural changes such as a decline in dendritic length and number, a reduction in the number of axons, and significant loss of synapses and dendritic spines are proposed mechanisms for CI among elderly diabetic patients [63]. These findings clearly instruct therapists about the need for age-specific interventions to enhance the cognitive skills of diabetic patients.

Our study findings revealed that alcohol consumption was significantly associated with CI in diabetes. Our findings are in line with the study conducted in Ethiopia [43]. Alcohol can cause depression of the central nervous system, which can lead to distraction and result in low cognitive scores. Additionally,

alcohol can inhibit the neuronal activity in the hippocampus and affect the formation of new declarative memory [64]. Also, alcohol consumption can affect the glycaemic control in the diabetic patients, and it can result in CI [65]. Even our study findings also showed a significant association between uncontrolled blood glucose and the development of CI.

In our study, uncontrolled blood glucose status was significantly associated with CI. Diabetic patients whose HbA1C is more than or equal to 6.5% were 5.13 times more likely to have CI than patients with HbA1C less than 6.5%. Similar to our study findings, various studies reported that HbA1C more than or equal to 6.5% was associated with CI [1, 43, 66, 67]. Persistent hyperglycaemic condition can induce neuronal toxicity and free radical-mediated oxidative stress on neurons that results in impaired cognitive function [68]. These findings recommend that strict glycaemic control by adherence to pharmacological and nonpharmacological regimens in diabetes plays a vital role in delaying or preventing the neuronal damage associated with hyperglycemia [69].

Our study findings revealed that no physical activity was significantly associated with CI in diabetes mellitus. This finding was similar to a study conducted in China [61]. However, previous studies have inconsistently supported the effects of physical activity on cognitive performance [70–72]. The exercise can promote neuroprotection of brain structure by synaptogenesis, improved vascularization, and reduced disordered protein deposition [73]. Also, exercise can improve cognitive function by mediating the cardiovascular risk factors such as hypertension, dyslipidaemia, and obesity. In a nutshell, physical activity is a core intervention to manage glycaemic control, reduce cardiovascular risk, and improve cognitive abilities in diabetes mellitus.

Our study findings revealed that type II diabetes was significantly more associated with CI than type I diabetes. In line with our findings, evidence shows that Type II diabetes has a stronger association with developing CI than Type I diabetes [74, 75]. The possible mechanisms underlying cognitive impairment (CI) in type II diabetes include insulin resistance, decreased insulin signaling, defects in autonomic function, and neuroinflammatory pathways that can disrupt cognitive function [75]. Though there were several promising agents identified in the preclinical trials to preserve cognitive function in diabetes, but it need to be validated in clinical trial level [75].

In our study, we found that the long duration of diabetes was significantly associated with CI. Several studies reported that long-standing diabetes is the key risk predictor for the development of CI [1, 44, 76, 77]. A long duration of diabetes can increase the risk of hyperglycaemic events, which impose oxidative stress, cause glucose and glutamate toxicity, and directly damage neurons [1]. Additionally, prolonged periods of diabetes increase the risk of developing a microvascular complication known as microangiopathy, which can lead to cognitive impairment. Our study findings recommend CI screening tests for patients with long-standing diabetes. These tests can provide insights for interventions to enhance or reserve the cognitive function among diabetic patients.

Our study found that hypertension as a comorbidity in diabetes is a major predictor for CI. Evidence shows that patients suffering from diabetes and hypertension can produce pronounced CI [78–80]. The proposed mechanism for cognitive impairment in hypertension includes changes in brain structure and function caused by disturbances in the autoimmune regulation of the brain, reductions in brain perfusion, and limited elimination of the potentially harmful protein β-amyloid [80]. Evidence indicates that the presence of cardiovascular pathologies can increase the severity of the cognitive decline among diabetic patients [81]. Controlling blood pressure and glucose levels in hypertensive and diabetic patients is critical for mitigating the risk of future cognitive impairment [82].

The current study findings revealed that diabetic patients experiencing complications (renal, cardiac, neurological, ophthalmic, and self-reported numbness) were significantly more associated with CI than those without complications. Evidence shows that cardiac, renal, neurological, and ophthalmic complications were individually significantly associated with CI [1, 83, 84]. These findings suggest that appropriate glycaemic control can reduce the risk of micro- and macrovascular complications that can reduce future development of CI in diabetes.

4.1 | Strengths and Limitations

While interpreting the current study findings, researchers need to shed light on the following limitations in the context of predictors of CI among diabetic patients in Uganda: Firstly, the cross-sectional nature of the study design can limit the causal association between predictors and the development of CI in diabetes. Secondly, the study was limited to Jinja Regional Referral Hospital, Eastern Uganda. The above factors can affect the generalizability of the finding to other hospitals or regions of Uganda due to variation in the self-care and hospital-based management practices of diabetes. Thirdly, the absence of non-diabetic control can cause interference of the confounders in the outcome (CI) development. Fourth, past information obtained from the study participants was subjected to recall bias. Despite these limitations, our study has several strengths; the primary one is that this was the first Ugandan study that examined the extent of CI and its predictors in diabetes mellitus. Secondly, having a high response rate, including a representative sample from the diabetic population, and randomly selecting participants can make the findings more applicable to a wider group. Finally, the study can provide insights for interventions to reduce cognitive impairment in diabetics in Uganda.

5 | Conclusion

The study concludes that more than half of the diabetic patients attending follow-up treatment at Jinja Regional Referral Hospital were suffering cognitive impairment. Factors such as age, education level, alcohol consumption status, physical activity, type of diabetes, duration of diabetes, blood glucose control, presence of hypertension, and diabetic complications were significantly associated with cognitive impairment in diabetes. Policy makers can plan and implement the strategies targeting the factors of CI identified in our study for effective management of CI in diabetes. Additionally, it is essential to incorporate cognitive screening tests into the regular diabetes monitoring schedule for early

identification of cognitive impairment. Early detection helps tailor the medication regimen, improve self-care, reduce diabetic complications, and improve QoL among diabetic patients.

Author Contributions

Jasper Silver Makasi: conceptualization, investigation, methodology, writing – review and editing, formal analysis, project administration, data curation, resources. **Narayana Goruntla:** conceptualization, investigation, writing – original draft, methodology, validation, visualization, writing – review and editing, software, formal analysis, project administration, data curation, supervision, resources. **Bhavana Reddy Bommireddy:** conceptualization, investigation, writing – original draft, writing – review and editing, methodology, validation, software, formal analysis, supervision, resources. **Bhavani Mopuri:** conceptualization, writing – original draft, writing – review and editing, methodology, formal analysis, software, resources, validation. **Easwaran Vigneshwaran:** conceptualization, writing – original draft, writing – review and editing, methodology, validation, software, formal analysis, resources, data curation. **Mohammad Jaffar Sadiq Mantargi:** conceptualization, writing – original draft, methodology, validation, writing – review and editing, software, formal analysis, data curation, resources. **Vishnuvandana Bandaru:** Conceptualization, writing – original draft, methodology, validation, writing – review and editing, software, formal analysis, data curation. **Joseph Obiezu Chukwujekwu Ezeonwumelu:** conceptualization, investigation, writing – original draft, writing – review and editing, methodology, validation, software, formal analysis, project administration, data curation, resources. **Tadele Mekuriya Yadesa:** conceptualization, writing – original draft, methodology, visualization, validation, writing – review and editing, software, formal analysis, project administration, data curation, resources, supervision.

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Ethics Statement

The study protocol, survey instrument, and informed consent process were approved by the Kampala International University—School of Pharmacy Research Committee (KIU SPRC 008/24). The researcher explained the study protocol and objectives to the eligible participants and received oral and written consent voluntarily. All participants had the right to withdraw from the study at any point during the research process (consent, initiation, process, and completion). The study followed the guidelines of the Declaration of Helsinki 1975 for research on human volunteers.

Conflicts of Interest

The authors declare that they have no conflicts of interest and no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or nonfinancial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this article.

Data Availability Statement

All authors have read and approved the final version of the manuscript. Narayana Goruntla had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

Transparency Statement

The lead author Narayana Goruntla affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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