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Clinical Profile, Glycemic Management Practices, and Direct Medical Costs among Hospitalized Diabetic Patients in Ethiopia: A Multicenter Prospective Study

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Abstract

Background: Diabetes mellitus is a growing public health challenge that imposes a substantial clinical and economic burden on healthcare systems, particularly in low- and middle-income countries. Despite its association with poor inpatient outcomes and rising healthcare costs, evidence on inpatient glycemic management and direct medical costs remains limited in Ethiopia. This study aimed to assess the clinical profile, inpatient glycemic management practices, direct medical costs, and factors associated with healthcare expenditure among hospitalized patients with diabetes.

Methods: A multicenter prospective observational study was conducted from July 2023 to February 2024 at Tikur Anbessa Specialized Hospital, Zewditu Memorial Hospital, and St. Paul's Hospital Millennium Medical College. Data were collected from 398 hospitalized patients with diabetes through medical chart review and patient interviews. Sociodemographic and clinical characteristics, inpatient diabetes management practices, treatment outcomes, and direct medical costs were assessed. Descriptive statistics were used to summarize the study population, and multiple linear regression analysis was conducted to identify factors associated with direct medical costs.

Result: Among 398 hospitalized patients with diabetes, 82.9% had type 2 diabetes, and 48.2% had suboptimal glycemic control before admission ($HbA1c > 7\%$). Basal insulin with correctional insulin was the most frequently used inpatient regimen (45.5%). Nearly half of the patients (47.5%) developed at least one complication, most commonly acute kidney injury (13.1%), and 7.5% died before discharge. The median direct medical cost per hospitalization was US\$417.27 (IQR, US\$362.51). Longer hospital stays and a greater number of pre-admission medications were associated with 2.3% ($p < 0.001$) and 1.6% ($p = 0.049$) increases in costs, respectively. Patients who developed two or more in-hospital complications had 21.6% higher costs ($p = 0.002$), whereas those admitted with renal, gastrointestinal/hepatic, or hematologic/oncologic conditions had 14.9%, 18.2%, and 18.3% lower costs, respectively, compared with infectious disease admissions (all $p < 0.05$). The final model explained 42.1% of the variability in direct medical costs.

Conclusion: Hospitalized patients with diabetes experience a substantial clinical and economic burden. Improving inpatient glycemic management, preventing complications, and optimizing the use of hospital resources may help reduce the healthcare costs associated with diabetes.

Keywords: Diabetes mellitus, hospitalized patients with diabetes, inpatient glycemic management, direct medical costs, healthcare expenditure. cost determinants, Ethiopia.

1. Introduction

Diabetes mellitus (DM) is a group of metabolic disorders characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both(1). It has emerged as one of the major public health challenges of the 21st century, with an increasing burden worldwide. The disease continues to affect populations globally, with a disproportionate rise in developing countries, where healthcare systems face increasing challenges in addressing its growing burden(2). In 2021, the International Diabetes Federation (IDF) estimated that 537 million adults (aged 20-79 years) were living with diabetes, a number that is projected to escalate to 643 million by 2030 and 784 million by 2045 if current trends persist(3). This escalating burden is not uniformly distributed; the most dramatic increases are occurring in low- and middle-income countries (LMICs), particularly in regions such as sub-Saharan Africa, Southeast Asia, and the Middle East and North Africa(3). The African region is projected to experience the largest relative increase in diabetes burden globally, with the number of people living with diabetes expected to rise by 142% from 25 million in 2024 to 60 million by 2050. Ethiopia alone is estimated to have 2.3 million adults living with diabetes in 2024, with this number projected to increase substantially by 2050 (4). Consistent with these projections, local studies have reported diabetes prevalence ranging from 2% to 6.5%(5), reflecting the country's growing diabetes burden and the urgent need to strengthen prevention and healthcare services.

Beyond its global burden, diabetes contributes substantially to healthcare utilization, with affected individuals having three to four fold higher hospitalization risk than those without diabetes. Among hospitalized patients, hyperglycemia affects approximately one-quarter to nearly one-half of non-critically ill individuals and is linked to increased complications and mortality(6). Acute illness during hospitalization can disrupt glucose regulation by stimulating the release of counter-regulatory hormones, which promote insulin resistance, increase hepatic glucose production, and contribute to stress hyperglycemia (6, 7). Stress hyperglycemia is further aggravated by common inpatient factors, including variable nutritional intake, initiation or adjustment of medications such as corticosteroids, use of enteral or parenteral nutrition, and the physiological stress response associated with acute illness (6, 8). Consequently, poor inpatient glycemic control is associated with adverse outcomes; including infections, impaired wound healing, prolonged hospitalization, and increased mortality. Conversely, treatment-related hypoglycemia may result in serious complications, including cardiac events, neurological

impairment, and death. Together, hyperglycemia and hypoglycemia contribute to higher readmission rates and increased healthcare costs (9-13)

Although maintaining good glycemic control during hospitalization is essential for improving patient outcomes, recommended diabetes management practices are not consistently implemented across healthcare settings. Current guidelines support an individualized approach to inpatient glycemic management, with basal-bolus insulin therapy commonly recommended for many hospitalized patients with diabetes who require insulin therapy (10, 11, 14). However, real-world management practices may vary according to patient characteristics, clinical complexity, available healthcare resources, and institutional factors (11, 14). Evidence describing current inpatient glycemic management practices remains limited in many low-resource settings, including Ethiopia, highlighting the need for further investigation (5).

In addition to these clinical consequences, the complex care needs of hospitalized patients with diabetes place a considerable economic strain on healthcare systems globally. The economic consequences of diabetes continue to expand as increasing disease prevalence, management of complications, and greater healthcare utilization contribute to rising healthcare expenditures (15). This growing financial burden is expected to be more pronounced in low- and middle-income countries (LMICs), where increasing numbers of people with diabetes, limited healthcare resources, and competing health priorities create additional challenges for sustainable diabetes care(12, 15). In Africa, including Ethiopia, evidence describing the economic impact of diabetes remains scarce, with available studies often based on older single-center data that may not represent current clinical practices, treatment approaches, and healthcare costs (13, 16). Furthermore, evidence on the factors influencing direct medical costs among hospitalized patients with diabetes remains scarce, particularly in Ethiopia, where the contribution of patient characteristics, glycemic management practices, diabetes-related complications, and hospitalization-related factors has not been well described. Therefore, this multicenter prospective study was undertaken to characterize the clinical profile, describe inpatient glycemic management practices, estimate direct medical costs, and identify factors associated with healthcare expenditure among hospitalized diabetic patients in Ethiopia.

2. Methods

2.1. Study design and setting: A multicenter, hospital-based, prospective observational cohort study was conducted between July 15, 2023, and February 29, 2024, in the adult internal medicine wards of three tertiary hospitals in Addis Ababa, Ethiopia: Tikur Anbessa Specialized Hospital (TASH), St. Paul's

Hospital Millennium Medical College (SPHMMC), and Zewditu Memorial Hospital (ZMH). These hospitals are national referral centers with high admission volumes.

2.2. Population and eligibility: The source population comprised all adults (≥ 18 years) with diabetes mellitus admitted to the study hospitals. Eligible participants included patients with either newly diagnosed or pre-existing DM, hospitalized for > 24 hours, and willing to consent. Patients were excluded if they were admitted to intensive care units (ICUs), pregnant, had active psychiatric illness, were unwilling to provide consent, or were hospitalized for less than 24 hours.

2.3. Sample size and sampling; The sample size was estimated using the single population proportion formula: $n = Z^2 \cdot p \cdot (1-p) / d^2$, where $Z = 1.96$ (95% confidence), $p = 0.5$ (due to absence of prior estimates), and $d = 0.05$ (margin of error), yielding $n = 384$. Adding 5% for non-response gave a final target of 403 patients. Proportional allocation across hospitals and consecutive sampling were employed until the target was reached.

2.4. Data collection: Data were collected prospectively using a pretested semi-structured questionnaire and chart abstraction form (**Supplementary file 1**). Sociodemographic data were obtained by patient interview, while clinical, laboratory, and treatment data were extracted from medical records. Patients were followed from admission until discharge, transfer, or death. Cost data were collected from pharmacy receipts, hospital price lists, and standard bed charges. All costs were recorded in Ethiopian Birr and converted to U.S. dollars at the average exchange rate during the study period (1 USD = 55 ETB).

2.5. Data quality assurance: Data collectors received one day of training, and the tools were piloted on 5% of the sample at Yekatit 12 Hospital. Supervisors reviewed data daily for accuracy and completeness.

2.6. Data Analysis: Data were entered into Epi Info v7 and analyzed using SPSS v27. Categorical variables were described using frequencies and percentages, while continuous variables were summarized as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), depending on their distribution. The Shapiro–Wilk test was used to assess the normality of continuous variables. Multiple linear regression analysis was conducted to identify factors associated with direct medical costs among hospitalized patients with diabetes. Since healthcare cost data were positively skewed, direct medical costs were log10-transformed before performing the regression analysis. Variables with a p-value < 0.25 in bivariable analysis were considered for inclusion in the multivariable model. A purposeful backward selection approach was used, with non-significant variables removed stepwise while monitoring changes in the estimates of the remaining predictors. The regression model assumptions were evaluated by assessing residual normality using histograms and normal P–P plots, multicollinearity using variance

inflation factors and tolerance values, influential observations using Cook's distance, and independence of residuals using the Durbin–Watson statistic. Model performance was assessed using R^2 and adjusted R^2 , and findings were reported as regression coefficients (B) with 95% confidence intervals (CIs) and p-values. A p-value <0.05 was considered statistically significant.

2.7. Operational Definitions

- **Adults:** Individuals aged ≥ 18 years.
- **Physical activity:** Active if ≥ 150 minutes of walking weekly or ≥ 3 exercise sessions per week.
- **Newly diagnosed DM:** Diagnosis during admission or within the previous 3 months.
- **Short duration:** DM duration <5 years; **Long duration:** ≥ 5 years.

3. Result

3.1. Study participants: A total of 403 individuals were approached for participation. After excluding five patients who were hospitalized for less than 24 hours, 398 patients (98.8%) were included in the study.

3.2. Sociodemographic characteristics

The sociodemographic characteristics of the study participants are presented in Table 1. Among the 398 hospitalized patients with diabetes, 219 (55.0%) were male. The mean age of participants was 57.7 ± 14.9 years, with the majority aged 35–64 years (58.3%), followed by those aged ≥ 65 years (33.9%). Most participants were urban residents (74.1%). Regarding educational status, primary education was the most common level (36.2%), followed by college and above (32.7%). More than one-third of participants were in paid employment (38.7%), while 33.4% were currently not employed. Concerning medication access, nearly half of the participants paid out-of-pocket (46.5%), whereas 42.2% had partial health insurance coverage (**Table 1**).

Table 1: Sociodemographic characteristics of hospitalized patients with diabetes (N = 398)

Variable	Category	N (%)
Gender	Male	219 (55.0)
	Female	179 (45.0)
Age(years) mean $\pm$ SD	—	57.7 $\pm$ 14.9
Age group ,(years)	18–34	31 (7.8)
	35–64	232 (58.3)
	≥ 65	135 (33.9)

Residence	Urban	295 (74.1)
	Rural	103 (25.9)
Education	No formal education	64 (16.1)
	Primary school	144 (36.2)
	Secondary school	60 (15.1)
	College and above	130 (32.7)
Occupation	Paid employment	154(38.7)
	Self employed	111(27.9)
	Currently not employed	133(33.4)
Medication access	Paid(out of pocket)	185(46.5)
	Full health insurance coverage	45(11.3)
	Partial health insurance(Paid +insurance covered)	168(42.2)

3.3. Lifestyle and preventive factors

The lifestyle and preventive characteristics of the study participants are presented in Table 2. Nearly two-thirds of participants were physically active (62.1%), whereas 37.9% were physically inactive. Regarding dietary modification, most participants reported following multiple dietary restrictions recommended by their physicians (81.4%). The majority had no history of recreational substance use (89.4%). Most participants were never smokers (86.7%) and never alcohol consumers (88.2%), while smaller proportions were current or former users of tobacco and alcohol (**Table 2**).

Table 2: Lifestyle behaviors and preventive practices among hospitalized patients with diabetes (N = 398)

Variable	Category	N (%)
Physical activity	Active (≥ 30 min, ≥ 3 days/week)	247 (62.1)
	Inactive	151 (37.9)
Dietary restrictions	No dietary restriction	5(1.3)
	Single dietary restriction	69(17.3)
	Multiple dietary restriction	324(81.4)
Recreational substance use	No recreational drug use	356(89.4)
	Recreational drug user	42(10.6)
	Never smoked	345 (86.7)
Smoking status	Current smoker	25 (6.3)
	Former smoker	28 (7.0)
	Never	351 (88.2)
Alcohol consumption	Current	15 (3.8)
	Former	32 (8.0)

Adult immunization status and health-related characteristics are summarized in **Table 3**. More than half of the participants were not vaccinated (60.1%), while 39.9% had received at least one vaccine, predominantly COVID-19 vaccination. Hepatitis B vaccination was uncommon, either alone or in

combination with COVID-19 vaccination. Most participants reported having medication use support at home (90.2%). Regarding self-monitoring of blood glucose (SMBG), 56.5% practiced SMBG, whereas 43.5% did not. Approximately half of the participants reported a family history of diabetes (48.2%). Regarding BMI, more than half of the participants had normal weight (51.5%), while 30.4% were overweight, 14.8% were obese, and 3.3% were underweight (**Table 3**).

Table 3: Adult immunization status and health-related factors among hospitalized patients with diabetes (N = 398)

Variable	Category	N (%)
Vaccination status	None	239 (60.1)
	COVID-19 vaccine only	145 (36.4)
	Hepatitis B vaccine only	11 (2.8)
	COVID-19 and hepatitis B vaccines	3 (0.8)
Medication use support at home	Yes	359 (90.2)
	No	39 (9.8)
SMBG practice	Yes	225 (56.5)
	No	173 (43.5)
Family history of diabetes	Yes	192 (48.2)
	No	206 (51.8)
BMI category (kg/m ²)	Underweight	13 (3.3)
	Normal weight	205 (51.5)
	Overweight	121 (30.4)
	Obesity	59(14.8)

No participants reported receiving influenza, pneumococcal, or other assessed adult vaccines

Abbreviations: BMI: Body Mass Index, SMBG: Self-Monitoring of Blood Glucose, COVID-19: Coronavirus Disease 2019

3.4. Clinical presentations and admission diagnoses among hospitalized patients with diabetes

The clinical presentations and admission diagnoses among hospitalized patients with diabetes are summarized in Figure 1 and Table 4, respectively. The most frequently reported presenting clinical features were shortness of breath (49.0%), fever (36.4%), foot swelling (28.4%), loss of appetite (26.1%), and easy fatigability (25.9%). Other common presentations included decreased urine output (23.9%), chest pain (21.9%), productive cough (20.9%), vomiting of ingested matter (19.1%), and generalized body swelling (12.8%). Neurological manifestations, including failure to communicate (13.1%), abnormal body movement (10.1%), and unilateral body weakness (6.5%), were also observed. Foot-related clinical features, such as purulent foot discharge (5.8%) and foot ulceration (3.5%), were reported among a subset of participants (Figure 1).

The diabetes characteristics and admission diagnoses among hospitalized patients with diabetes are summarized in Table 4. The majority of participants had type 2 diabetes mellitus (330, 82.9%), while 68 (17.1%) had type 1 diabetes mellitus. Most participants were previously diagnosed with diabetes (372, 93.5%), whereas 26 (6.5%) were newly diagnosed at admission.

Regarding admission diagnoses, infectious diseases were the leading category, accounting for 127 (31.9%) cases, followed by cardiovascular diseases (77, 19.3%) and renal diseases (53, 13.3%). Neurological and gastrointestinal/hepatic diseases each accounted for 34 (8.5%) admissions, followed by diabetic complications (31, 7.8%), respiratory diseases (26, 6.5%), and hematological/oncologic diseases (16, 4.0%). Among specific diagnoses, severe community-acquired pneumonia was the most common infectious condition (50, 12.6%), followed by acute decompensated heart failure (34, 8.5%), acute kidney injury superimposed on chronic kidney disease (34, 8.5%), and sepsis (32, 8.0%). Other important diagnoses included acute ischemic stroke (17, 4.3%), acute hemorrhagic stroke (15, 3.8%), diabetic foot ulcer (15, 3.8%), and hypoglycemia (15, 3.8%) (**Table 4**).

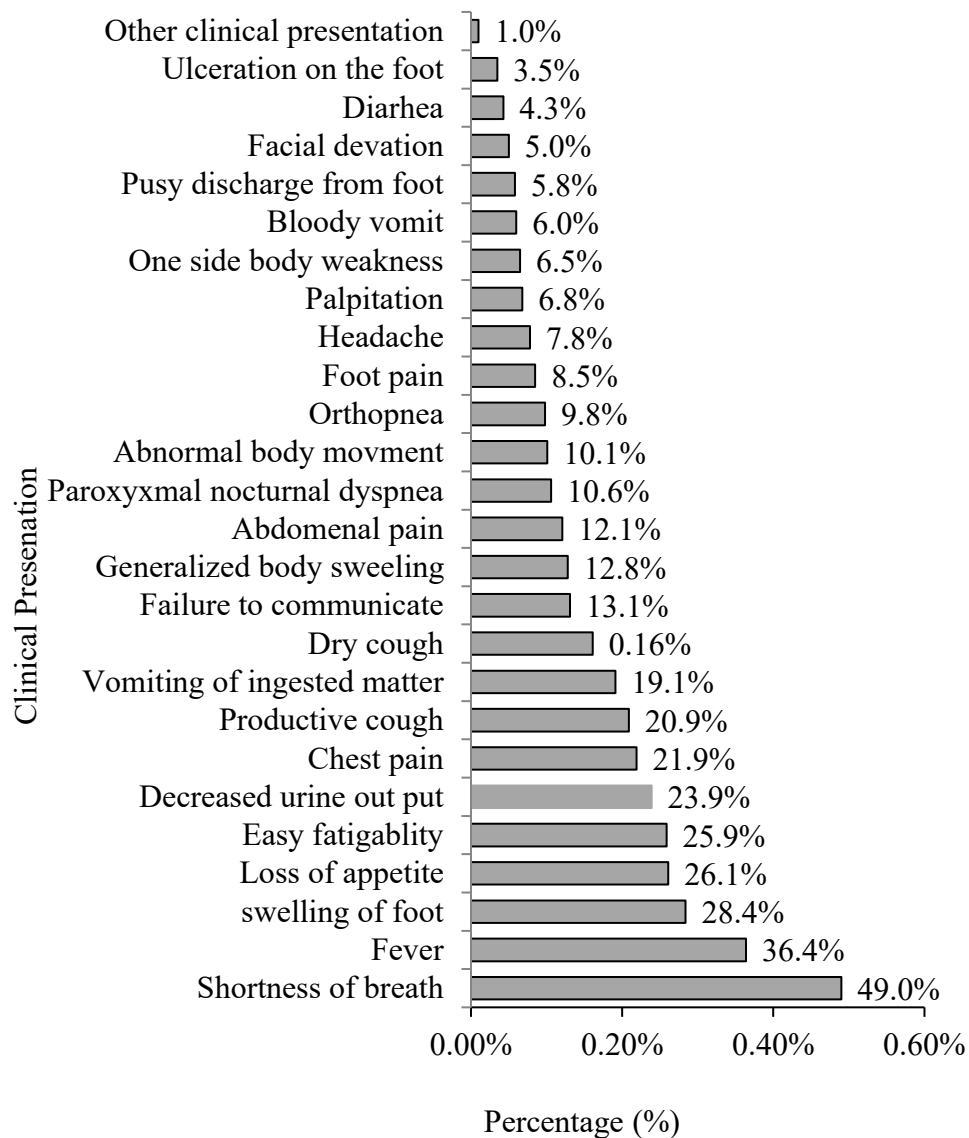


Figure 1: Clinical presentations among hospitalized patients with diabetes (N=398)

Other clinical presentations: Polyuria, polydipsia and polyphagia

Table 4: Diabetes characteristics and admission diagnoses among hospitalized patients with diabetes (N=398)

Clinical characteristics	N (%)
Type of diabetes	
Type 2 diabetes mellitus	330 (82.9)
Type 1 diabetes mellitus	68 (17.1)
Diabetes status	
Know diabetes mellitus	372 (93.5)
Newly diagnosed diabetes mellitus	26 (6.5)
Admission diagnosis	

Infectious disease	127 (31.9)
Cardiovascular disease	77 (19.3)
Renal disease	53 (13.3)
Neurological disease	34 (8.5)
Gastrointestinal/hepatic disease	34 (8.5)
Diabetic complication	31 (7.8)
Respiratory disease	26 (6.5)
Hematological/oncologic disease	16 (4.0)

3.5. Existing comorbidities and chronic diabetes-related complications

The distribution of existing comorbidities and chronic diabetes-related complications among hospitalized patients with diabetes is presented in **Table 5**. Hypertension was the most prevalent comorbid condition, affecting 244 (61.3%) participants, followed by heart failure (150, 37.7%). Other common comorbidities included chronic obstructive airway disease (50, 12.6%), hypertensive heart disease (48, 12.1%), chronic valvular heart disease (44, 11.1%), HIV infection (44, 11.1%), asthma (41, 10.3%), and chronic liver disease (27, 6.8%). Overall, 360 (90.5%) participants had three or fewer comorbidities, whereas 38 (9.5%) had more than three existing comorbid conditions.

Diabetic nephropathy was the most frequently documented chronic diabetes-related complication (114, 28.6%), followed by peripheral neuropathy (110, 27.6%), chronic kidney disease (78, 19.6%), diabetic retinopathy (66, 16.6%), and ischemic heart disease (61, 15.3%). Overall, 149 (37.4%) participants had no documented chronic diabetes-related complications **Table 5**.

As shown in Figure 2 and Figure 3, the prevalence and pattern of chronic diabetes-related complications differed according to disease duration. Among participants with diabetes duration of five years or less, nearly two-thirds had no documented chronic complications (99, 63.1%). In contrast, among those with a duration exceeding five years, only 50 (21.0%) had no chronic complications, while microvascular complications alone (86, 36.0%) and combined microvascular and macrovascular complications (88, 36.8%) accounted for the majority of cases.

Table 5: Existing comorbidities and chronic diabetes-related complications among hospitalized patients with diabetes (N = 398)

Category	Conditions	N (%)
Existing Comorbidity	Hypertension	244 (61.3)
	Heart failure	150 (37.7)
	Chronic obstructive airway disease	50 (12.6)
	Hypertensive heart disease	48 (12.1)

	Chronic valvular heart disease	44 (11.1)
	HIV infection	44 (11.1)
	Other [‡]	42 (10.6)
	Asthma	41 (10.3)
	Chronic liver disease	27 (6.8)
	Cancer	23 (5.8)
	Chronic anemia	13 (3.3)
	Depression	13 (3.3)
	Epilepsy	12 (3.0)
	Parkinson disease	11 (2.8)
	No existing comorbidities	43 (10.8)
Number of existing comorbidities	≤3 comorbidities	360 (90.5)
	>3 comorbidities	38 (9.5)
	Diabetic nephropathy	114 (28.6)
	Peripheral neuropathy	110 (27.6)
	Chronic kidney disease	78 (19.6)
	Diabetic retinopathy	66 (16.6)
Chronic diabetes related complications	Ischemic heart disease	61 (15.3)
	Ischemic stroke	41 (10.3)
	Peripheral arterial disease	29 (7.3)
	Chronic diabetic foot ulcer	23 (5.8)
	Hemorrhagic stroke	10 (2.5)
	No chronic diabetes-related complications	149 (37.4)

Percentages were calculated using multiple response analysis; each condition was coded as a dichotomous variable (1 = present, 0 = absent).

[‡]Prostatic hyperplasia, dyslipidaemia, chronic bronchitis, gouty arthritis, rheumatoid arthritis, peptic ulcer disease, chronic hepatitis C virus infection, chronic hepatitis B virus infection, bipolar disorder, osteoarthritis, autoimmune pancreatitis, metabolic syndrome, hyperparathyroidism, chronic otitis media, pulmonary hypertension, mixed nutritional deficiency, chronic deep vein thrombosis and Cushing syndrome

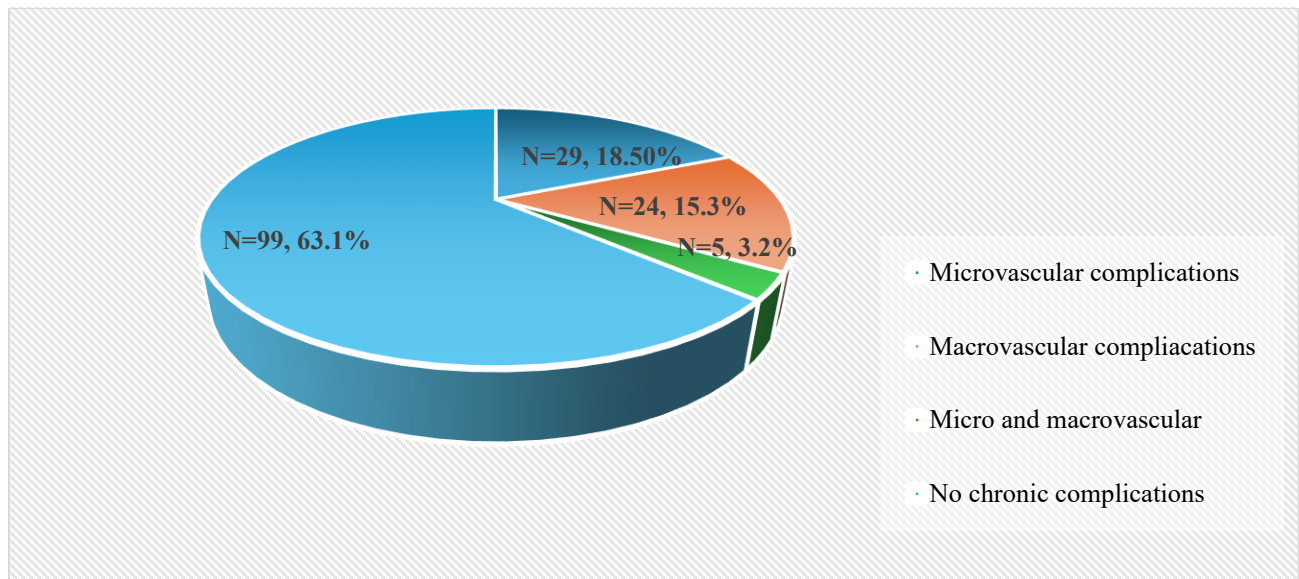


Figure 2: The prevalence of chronic complications of DM when the disease has been present for five years or less

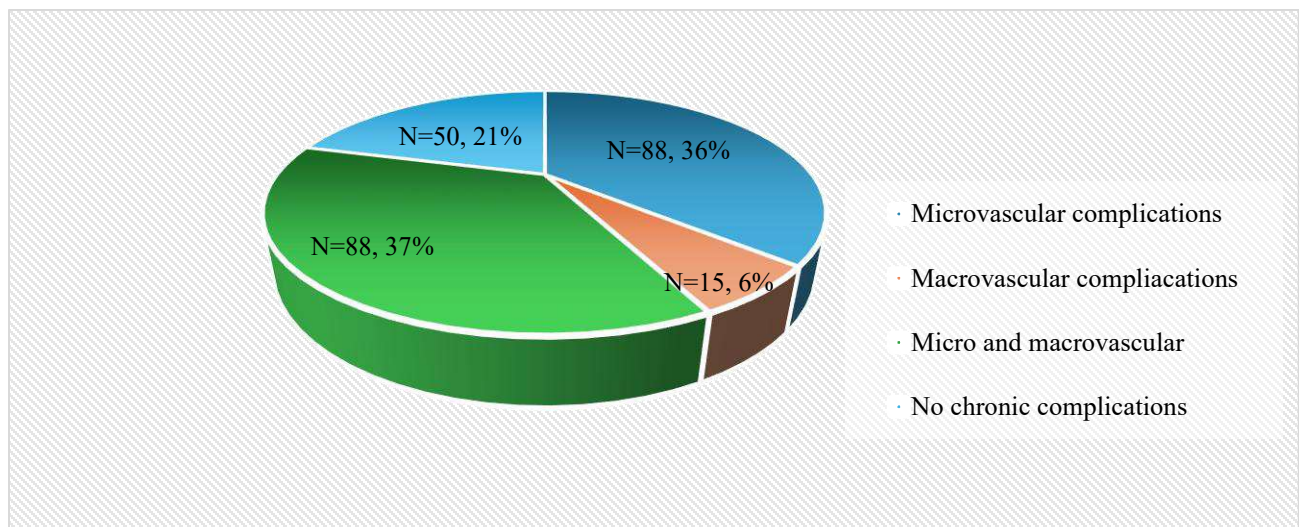


Figure 3: The prevalence of chronic complications of DM when the duration of DM ranged beyond five

3.6. Laboratory and Glycemic Parameters

HbA1c measurements were available for 379 (95.2%) participants, of whom 192 (48.2%) had suboptimal glycemic control (HbA1c >7%). At admission, elevated systolic blood pressure (≥ 130 mmHg) was observed in 139 (34.9%) participants, whereas elevated diastolic blood pressure (≥ 90 mmHg) was uncommon (29, 7.3%). Low HDL-C (<45 mg/dL) was the most frequent lipid abnormality, affecting 285 (71.6%) participants, followed by elevated triglycerides (≥ 150 mg/dL) in 136 (34.2%) and elevated LDL-C (≥ 100 mg/dL) in 133 (33.4%) participants Table 6.

Table 6: Baseline Laboratory Findings and Vital Signs of Hospitalized Diabetes Patients (N = 398)

Laboratory tests/Vital sign values	N (%)
HbA1c	
≤7%	187 (47.00)
>7%	192 (48.20)
Missing	19 (4.80)
Systolic BP during admission	
<130 mmHg	259 (65.10)
≥130 mmHg	139 (34.90)
Diastolic BP during admission	
<90 mmHg	369 (92.70)
≥90 mmHg	29 (7.30)
Total cholesterol	
<200 mg/dL	313 (78.60)
≥200 mg/dL	60 (15.10)
Missing	25 (6.30)
Low-density lipoprotein	
<100 mg/dL	239 (60.10)
≥100 mg/dL	133 (33.40)
Missing	26 (6.50)
High-density lipoprotein	
<45 mg/dL	285 (71.60)
≥45 mg/dL	88 (22.10)
Missing	25 (6.30)
Triglycerides	
<150mg/dL	237 (59.50%)
≥150mg/dL	136 (34.20%)
Missing	25 (6.30)

Patients were taking a mean of 4.56 ± 2.45 medications before admission. The most frequently used medications for comorbidities were statins (48.0%), calcium channel blockers (47.0%), and diuretics (43.5%). Metformin monotherapy was the most common pre-admission glucose-lowering regimen (32.7%), followed by metformin plus sulfonylurea and basal insulin alone (14.6% each) (**Table 7**). During hospitalization, basal insulin with correctional insulin was the predominant regimen (45.5%), followed by basal-bolus insulin (24.4%) and basal insulin alone (19.1%) (**Table 8**).

Table 7:Pre-admission medication burden and medication use among hospitalized patients with diabetes (N = 398)

Medication characteristics	n (%)
Number of pre-admission medications	
Mean ±SD	4.56±2.45
<5 medications	196 (49.2)
≥5 medications	202 (50.8)
Medications for comorbidities^a	
Statins	191 (48.0)
Calcium channel blockers	187 (47.0)
Diuretics	173 (43.5)
Aspirin	165 (41.5)

Angiotensin-converting enzyme inhibitors	159 (39.9)
Beta-blockers	134 (33.7)
Amitriptyline	53 (13.3)
Highly active antiretroviral therapy	43 (10.8)
Angiotensin receptor blockers	31 (7.8)
Beclomethasone inhaler	29 (7.3)
Gabapentin	28 (7.0)
Warfarin	27 (6.8)
Budesonide/salmeterol inhaler	25 (6.3)
Digoxin	17 (4.3)
Levodopa/carbidopa	12 (3.0)
Other medications ^β	34 (8.5)
No medication used	47 (11.8)
Glucose-lowering medications	
Metformin monotherapy	130 (32.7)
Metformin + sulfonylurea	58 (14.6)
Basal insulin only	58 (14.6)
Basal-bolus insulin	47 (11.8)
Basal insulin + metformin	24 (6.0)
Not on antidiabetic medication	21 (5.3)
Mixed insulin	15 (3.8)
Metformin + SGLT2 inhibitor	14 (3.5)
Basal insulin + metformin + SGLT2 inhibitor	8 (2.0)
Sulfonylurea monotherapy	8 (2.0)
Metformin + DPP-4 inhibitor	7 (1.8)
Other glucose-lowering therapy*	6 (1.5)
Metformin + sulfonylurea + SGLT2 inhibitor	2 (0.5)

Abbreviation: SU: Sulphonyl urea; SGLT2I: sodium glucose cotransporter 2 inhibitor; DPP4I: dipeptidyl peptidase 4 inhibitors.

^β Phenytoin, Allopurinol, Sodium valproate, Amiodarone, Alfuzosin, Tamsulosin, Epoetin Alpha, Fluoxetine, Omeprazole, Tenofovir, and Pregabalin Ferrous sulphate

*Basal+SGLT2inhibitor

^a Multiple-response analysis; each medication was coded as a dichotomous variable (**Yes = 1, No = 0**). Percentages are calculated based on the total sample (N = 398) and may not sum to 100%

Table 8: In-hospital glycemic management regimens among patients with diabetes (N = 398)

Type of Regimen	N (%)
Basal insulin regimens	
Basal with correctional insulin	181 (45.5)
Basal bolus	97 (24.4)
Basal insulin only	76 (19.1)
Alternative regimens	
Sliding scale only	28 (7.0)
Basal with SGLT2 inhibitor	10 (2.5)
Other*	6 (1.5)

Abbreviations: SGLT2 I= Sodium glucose cotransporter-2 inhibitor

* Dapagliflozin only, Metformin + SGLT2I, Metformin only, and Basal + bolus insulin + SGLT2I. SGLT2I, DPP4.

3.7. Discharge antidiabetic medication regimen among hospitalized patients with diabetic

At discharge, metformin monotherapy was the most frequently prescribed antidiabetic regimen, used by 35.0% of patients. This was followed by metformin combined with sulfonylurea (17.1%) and metformin with basal insulin (16.8%). Overall, most patients were discharged on metformin-based therapies, either alone or in combination with other glucose-lowering agents, while insulin-only and more intensive insulin regimens were prescribed less frequently (**Figure 4**).

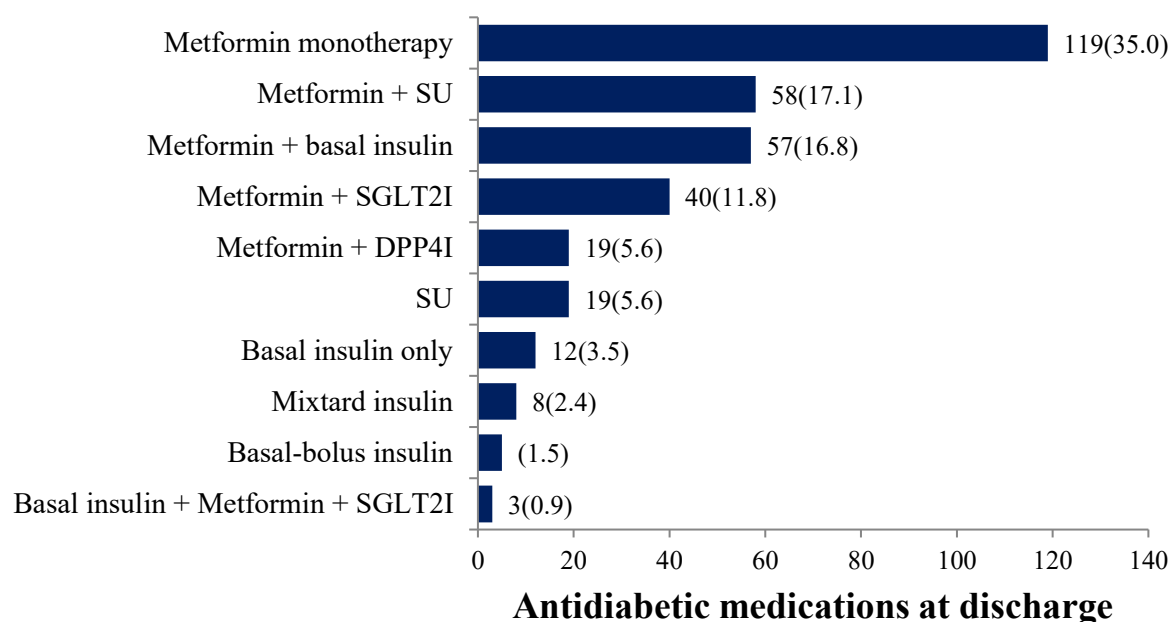


Figure 4: Discharge antidiabetic medication regimens among patients with diabetes (N = 398)

Abbreviation: SGLT2I; Sodium glucose cotransporter 2 inhibitor, DPP4; Dipeptidyl peptidase 4 inhibitor

3.8. In-hospital complication profile and burden

Among hospitalized patients with diabetes, 189 (47.5%) developed at least one in-hospital complication, while 209 (52.5%) had no complications. Most patients with complications developed one complication (132, 33.2%), followed by two (46, 11.6%) and three or more complications (11, 2.8%). Acute kidney injury (52, 13.1%), electrolyte disturbance (38, 9.5%), and hypoglycemia (37, 9.3%) were the most frequently observed complications (**Table 9**). The incidence of in-hospital complications generally increased with longer hospital stays (**Figure 5**).

Table 9: In-hospital complications and their burden among hospitalized patients with diabetes (N=398)

Complication profile	n (%)
Burden of in-hospital complications	
No complication during hospitalization	209 (52.5)
One complication	132 (33.2)
Two complications	46 (11.6)
Three or more complications	11 (2.8)
Types of in-hospital complications^a	
Acute kidney injury	52 (13.1)
Electrolyte disturbance	38 (9.5)
Hypoglycemia	37 (9.3)

Hospital-acquired pneumonia	27 (6.8)
Sepsis	24 (6.0)
Urinary tract infection	23 (5.8)
Other complications ^e	23 (5.8)
Amputation	12 (3.0)
Acute deep vein thrombosis	11 (2.8)
Bed sore	9 (2.3)
Thrombophlebitis	2 (0.5)
Diabetic ketoacidosis	2 (0.5)

^a Percentages were calculated using multiple response analysis; each condition was coded as a dichotomous variable (1 = present, 0 = absent). ^eAspirational pneumonia, acute pulmonary embolism, atrial flutter, atrial fibrillation and pulmonary vasculitis

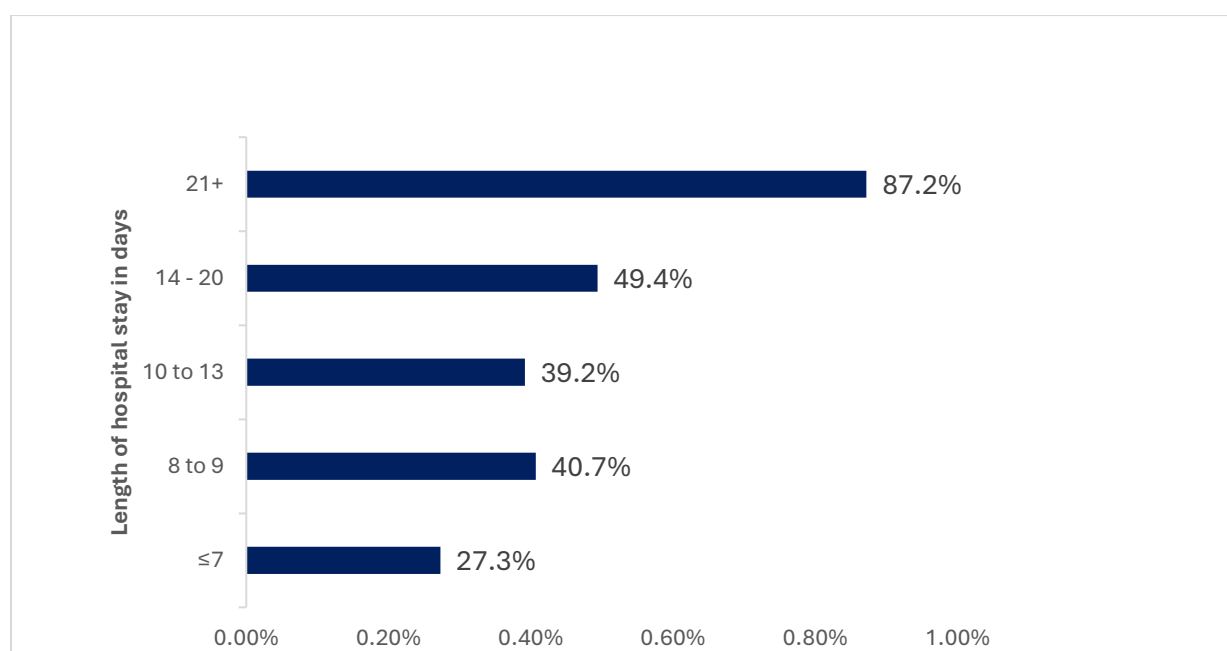


Figure 5: The trend of complication incidence among DM patients during hospital stay (N=398)

4. In hospital outcomes

Among the 398 hospitalized patients with diabetes, 85.4% (n=340) were discharged home after clinical improvement. The overall in-hospital mortality rate was 7.5% (n=30). Twenty patients (5.0%) were transferred to other hospital units, while 2.0% (n=8) were discharged against medical advice (**Table 10**).

Table 10: In-hospital outcomes among hospitalized patients with diabetes-by-diabetes type (N=398)

Outcomes	Overall (N = 398)	T2DM (N = 330)	T1DM (N = 68)
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Discharged home after improvement	340 (85.4%)	279 (84.5%)	61 (89.7%)
Died in hospital	30 (7.5%)	26 (7.9%)	4 (5.1%)
Transferred to other units	20 (5%)	17 (5.2%)	3 (3.4%)
Discharged against medical advice	8 (2%)	8 (2.4%)	0 (0%)

Abbreviation: T2DM, type 2 diabetes mellitus; T1DM, type 1 diabetes mellitus

4.1. Direct medical costs

The total direct medical expenditure for the cohort was \$166,074.14. The median cost per patient was \$417.27 (IQR: \$362.51). The largest cost drivers were medications and medical supplies (median \$133.02, total \$65,804.70) and laboratory procedures (median \$128.39, total \$53,649.76). Imaging and bed occupancy accounted for \$26,174.33 and \$18,416.46, respectively (**Table 11**).

Table 11: Direct medical costs among hospitalized patients with diabetes (N=398)

Direct medical cost types	N	Median	IQR	Total Cost (\$)
Total cost for medication and medical supplies	398	\$133.02	\$113.20	\$65,804.70
Total cost for laboratory procedures	398	\$128.39	\$68.97	\$53,649.76
Total cost for imaging procedure	398	\$47.27	\$80.69	\$26,174.33
Total cost for bed occupancy	398	\$38.18	\$37.47	\$18,416.46
Cost of medical record	398	\$1.82	\$1.00	\$602.94
Other direct medical costs ^a	398	\$0.00	\$0.00	\$1,425.95
Grand Total				\$166,074.14

^aIncludes cost for wound care; IQR, Interquartile range; USD, United States dollar

4.2- Factors associated with direct medical costs among hospitalized DM patients

The final multiple linear regression model was statistically significant ($F(12, 366) = 22.210$, $p < 0.001$), explaining 42.1% of the variation in log-transformed direct medical costs ($R^2 = 0.421$; adjusted $R^2 = 0.402$). The Durbin–Watson statistic (1.880) indicated that the residuals were independent. There was no evidence of multicollinearity, with tolerance values ranging from 0.695 to 0.919 and variance inflation factors (VIFs) ranging from 1.088 to 1.438. Although a few observations had relatively large, standardized residuals, none had an undue influence on the model, as indicated by a maximum Cook's distance of 0.118.

Longer hospital stays and a higher number of pre-admission medications were associated with increased direct medical costs. Each additional day of hospitalization increased costs by

approximately 2.3% (B = 0.010, 95% CI: 0.008–0.011; p < 0.001), while each additional pre-admission medication increased costs by approximately 1.6% (B = 0.007, 95% CI: 0.000–0.015; p = 0.049). Compared with infectious disease admissions, patients admitted with renal, gastrointestinal/hepatic, or hematologic/oncologic conditions incurred approximately 14.9% (B = –0.070, 95% CI: –0.123 to –0.018; p = 0.009), 18.2% (B = –0.087, 95% CI: –0.150 to –0.025; p = 0.006), and 18.3% (B = –0.088, 95% CI: –0.173 to –0.004; p = 0.041) lower direct medical costs, respectively. Patients who developed two or more in-hospital complications incurred approximately 21.6% higher direct medical costs than those without complications (B = 0.085, 95% CI: 0.032–0.137; p = 0.002). In contrast, HbA1c, cardiovascular, respiratory, neurologic, and diabetes-related admission diagnoses, as well as the development of a single in-hospital complication, were not independently associated with direct medical costs (**Table 12**).

Table 12: Factors associated with log-transformed direct medical costs among hospitalized patients with diabetes (N=379)

Variables	B	SE	B	95% CI for B	p-value
Length of hospital stay (days)	0.010	0.001	0.524	0.008, 0.011	<0.001
Number of pre-admission medications	0.007	0.004	0.091	0.000, 0.015	0.049
HbA1c (%)	0.002	0.004	0.016	-0.006, 0.009	0.698
Admission diagnosis (Ref: Infectious disease)					
Cardiovascular disease	-0.011	0.025	-0.021	-0.060, 0.038	0.657
Renal disease	-0.070	0.027	-0.119	-0.123, -0.018	0.009
Respiratory disease	-0.041	0.035	-0.051	-0.110, 0.027	0.240
Neurologic disease	-0.006	0.032	-0.009	-0.068, 0.056	0.845
Diabetic complication	-0.004	0.032	-0.005	-0.067, 0.060	0.908
Gastrointestinal/hepatic disease	-0.087	0.032	-0.120	-0.150, -0.025	0.006
Haematologic/oncologic disease	-0.088	0.043	-0.085	-0.173, -0.004	0.041
In-hospital complication burden (Ref: No complication)					
One complication	0.026	0.019	0.062	-0.012, 0.064	0.171
Two or more complications	0.085	0.027	0.146	0.032, 0.137	0.002

Note: The dependent variable was log10-transformed direct medical cost. Percentage changes in cost were calculated as $(10^B - 1) \times 100$.

5. Discussion

This multicenter study highlights the considerable clinical and economic challenges faced by hospitalized patients with diabetes. A substantial proportion of patients were admitted with inadequate glycemic control, and nearly half experienced one or more complications during their hospital stay, contributing to the overall burden of illness and mortality. The median direct medical cost of US\$417.27 per hospitalization further demonstrates the financial impact of inpatient diabetes care. Furthermore, the regression model showed that hospitalization duration, medication burden, in-hospital complications, and admission diagnosis were important factors influencing healthcare costs, together explaining 42.1% of the variation in direct medical expenditures.

In this study, most hospitalized patients had type 2 diabetes mellitus (82.9%), and the majorities were already known to have diabetes before admission (93.5%). This pattern is consistent with the global distribution of diabetes, where type 2 diabetes represents approximately 90–95% of all diabetes cases worldwide (17, 18). The high proportion of patients with established diabetes in our cohort may reflect the chronic and progressive nature of the disease, as longer diabetes duration is often accompanied by the development of chronic complications, multiple comorbidities, and increasing healthcare needs (19, 20).

The participants had a mean age of 57.7 ± 14.9 years, with nearly one-third aged ≥ 65 years. This age distribution reflects the demographic pattern commonly observed among hospitalized patients with diabetes, where older adults constitute a substantial proportion of admissions due to the increasing burden of diabetes-related complications and coexisting chronic conditions. With advancing age, patients with diabetes often develop greater clinical complexity, including a higher prevalence of cardiovascular disease, renal impairment, infections, and other comorbidities, which may require more individualized and comprehensive inpatient management (21, 22).

Hypertension was the most common comorbidity identified in this study, affecting 61.3% of participants, followed by heart failure (37.7%). This finding reflects the high burden of cardiovascular conditions among people with diabetes, as diabetes frequently coexists with cardiovascular diseases and contributes to increased overall disease burden (23). The greater cardiovascular risk observed in diabetes is related to several interconnected mechanisms, including prolonged hyperglycemia, endothelial dysfunction, chronic inflammation, oxidative stress, and

accelerated atherosclerotic changes (24). The presence of diabetes together with cardiovascular comorbidities increases patients' clinical complexity and may require closer monitoring, more comprehensive management, and greater healthcare resources during hospitalization (23, 25).

The higher burden of complications observed among patients with a longer duration of diabetes in this study is in line with previous evidence showing that the risk of both microvascular and macrovascular complications increases as diabetes progresses. This may be related to the cumulative effects of prolonged hyperglycemia and ongoing metabolic changes associated with long-standing diabetes (19).

The substantial burden of renal complications observed in this study is clinically significant, as diabetes remains one of the leading causes of chronic kidney disease worldwide(26). The presence of diabetic kidney disease can make inpatient diabetes management more challenging by increasing the risk of medication-related complications, reducing available treatment options, and making patients more susceptible to acute kidney injury during episodes of acute illness (27).

Nearly half of the participants in this study had suboptimal glycemic control before hospitalization, with HbA1c levels above 7% observed in 48.2% of patients. Similar patterns of inadequate glycemic control among hospitalized individuals with diabetes have been reported across different healthcare settings. This may reflect several factors, including progressive deterioration of diabetes over time, delays in treatment intensification, limited access to diabetes care, and the challenges of achieving individualized glycemic targets in routine clinical practice (28, 29). Furthermore, poor glycemic control before admission, reflected by elevated HbA1c levels, is associated with a greater risk of diabetes-related complications and poorer clinical outcomes, including cardiovascular events and mortality (30-32).

During hospitalization, basal insulin combined with correctional insulin was the most commonly used regimen (45.5%), followed by basal-bolus insulin therapy (24.4%). This pattern is consistent with current recommendations, which highlight the importance of tailoring inpatient glycemic management to each patient's clinical condition, nutritional status, pre-existing diabetes treatment, and risk of hypoglycemia. For most non-critically ill hospitalized patients who require insulin, a scheduled basal insulin regimen with nutritional and correctional components is preferred, while the use of correctional insulin alone is discouraged due to its association with poorer glycemic control (17, 33).

Evidence from randomized clinical trials supports the use of scheduled insulin regimens over sliding-scale insulin alone for managing hyperglycemia in hospitalized patients with type 2 diabetes. The RABBIT 2 trial showed that patients treated with a basal-bolus insulin regimen achieved better glycemic control and experienced fewer treatment failures compared with those receiving sliding-scale insulin alone(20). Similarly, the Basal Plus trial demonstrated that a basal insulin regimen combined with correctional insulin can provide effective glycemic management, particularly among patients with reduced oral intake, while maintaining comparable glycemic control (34).

Despite established guideline recommendations, considerable variation in inpatient insulin management practices continues to be observed worldwide, influenced by differences in healthcare resources, institutional protocols, provider experience, and patient-related factors (33, 35). The frequent use of basal insulin combined with correctional insulin in our study may reflect the complexity of hospitalized patients and the need to achieve adequate glycemic control while minimizing the risk of hypoglycemia. Improving institutional protocols and strengthening multidisciplinary diabetes care teams could help promote more consistent and effective inpatient diabetes management, particularly in resource-limited settings.

Nearly half of the patients in our study experienced at least one in-hospital complication, with acute kidney injury (13.1%), electrolyte disturbances (9.5%), and hypoglycemia (9.3%) being the most frequently observed. Patients with diabetes are particularly susceptible to complications during hospitalization, as acute illness triggers stress-related physiological changes that promote insulin resistance, disrupt glucose regulation, and contribute to metabolic instability (17, 33, 36).

Acute kidney injury was the most commonly observed complication in our study. This finding is consistent with previous evidence showing that patients with diabetes are at increased risk of acute kidney injury due to factors such as diabetic kidney disease, vascular changes, infections, and exposure to nephrotoxic medications during acute illness (37). Among hospitalized patients with diabetes, the development of acute kidney injury has been associated with prolonged hospital stay, higher mortality risk, and increased healthcare resource utilization (37, 38).

Hypoglycemia was another clinically important complication observed in our study. While achieving adequate glycemic control is a key component of inpatient diabetes management,

intensive glucose-lowering approaches may increase the risk of hypoglycemia, particularly among patients with renal impairment, inadequate nutritional intake, or complex insulin regimens (17, 39). Among hospitalized patients, hypoglycemia has been linked to poorer clinical outcomes, including cardiovascular events, neurological complications; longer hospital stays, and increased mortality (30, 33, 38)

The overall in-hospital mortality rate in our study was 7.5%. Previous studies have shown that diabetes is associated with an increased risk of mortality among hospitalized patients, especially when accompanied by conditions such as infections, cardiovascular disease, renal dysfunction, and poor glycemic control (18, 24, 30). The observed mortality rate may reflect the clinical complexity of our study population, including the high burden of comorbidities, chronic diabetes-related complications, and acute illnesses requiring hospital care.

The median direct medical cost per hospitalization was US\$417.27, with medications and medical supplies, followed by laboratory investigations, accounting for the largest share of total costs. This finding highlights the substantial economic burden of inpatient diabetes care, which is driven by the need for intensive treatment, close monitoring, and management of diabetes-related complications and acute illnesses.

Our findings are consistent with previous studies showing that diabetes places a considerable financial burden on healthcare systems through increased hospitalizations, treatment of complications, and ongoing disease management (3, 40, 41). This challenge is particularly pronounced in low- and middle-income countries, where limited healthcare resources must meet the growing demand for diabetes care as the prevalence of the disease continues to rise(42).

In this study, length of hospital stay emerged as the strongest independent predictor of direct medical costs. Each additional day in the hospital was associated with an approximately 2.3% increase in costs. This finding agrees with previous studies showing that prolonged hospitalization is a major contributor to healthcare expenditure among patients with diabetes (41, 43, 44). Longer stays generally reflect greater clinical needs and require continued use of healthcare resources, including hospital beds, laboratory monitoring, medications, and supportive care, which together increase the overall cost of care (43).

A greater number of pre-admission medications were also independently associated with higher direct medical costs, with each additional medication increasing costs by approximately 1.6%. This likely reflects the greater clinical complexity of patients receiving multiple medications, as polypharmacy is common among individuals with diabetes and coexisting chronic conditions (43, 45, 46). Previous studies have similarly shown that multimorbidity and polypharmacy are associated with increased healthcare utilization, more complex treatment, and higher healthcare costs in patients with diabetes (46, 47).

Patients who developed two or more in-hospital complications had approximately 21.6% higher costs compared with those who experienced no complications. This finding is in line with previous evidence showing that diabetes-related complications contribute substantially to healthcare expenditure by increasing the need for treatment, close monitoring, and prolonged use of healthcare services (24, 44). The increased costs associated with multiple complications emphasize the importance of early identification of clinical deterioration, prompt management of infections and renal problems, and effective glycemic control to reduce preventable complications and their associated financial burden.

6. Clinical implications

The findings of this study have important implications for improving diabetes care in Ethiopia. The high burden of poor glycemic control, chronic complications, and in-hospital complications highlights the need to strengthen both outpatient diabetes management and inpatient care systems. Early identification and timely management of diabetes-related complications may help reduce preventable hospital admissions and associated healthcare costs.

At the hospital level, implementing standardized inpatient diabetes care protocols, maintaining regular glucose monitoring, ensuring appropriate insulin management, and promoting collaboration among physicians, nurses, and clinical pharmacists may help improve the quality and consistency of diabetes care and lead to better patient outcomes (17, 33). In addition, targeted strategies to prevent complications such as acute kidney injury, hypoglycemia, and other adverse events may provide both clinical and economic benefits.

7. Strengths and limitations

This study has several important strengths. The multicenter prospective design, involving three tertiary hospitals, enabled a comprehensive assessment of clinical characteristics, diabetes management practices, patient outcomes, and direct medical costs using prospectively collected data. Furthermore, obtaining cost information from hospital records improved the reliability of expenditure estimates.

However, several limitations should be considered. First, the study was conducted in tertiary hospitals in Addis Ababa, which may limit the generalizability of the findings to primary healthcare facilities and other regions of Ethiopia. Second, indirect costs, including productivity losses and caregiver expenses, were not assessed. Third, although a range of clinical and treatment-related factors were evaluated; other unmeasured factors may have contributed to variations in healthcare costs.

8. Conclusion

This multicenter prospective study demonstrates a considerable clinical and economic burden among hospitalized patients with diabetes in Ethiopia. Many patients experienced poor glycemic control, chronic diabetes-related complications, and in-hospital complications, resulting in increased healthcare needs and resource utilization. Longer hospitalization, greater medication burden, and multiple complications were important factors associated with higher direct medical costs. Strengthening inpatient diabetes management, preventing complications, and improving the efficiency of hospital resource utilization may help reduce the clinical and economic burden of diabetes care.

List of Abbreviations

Abbreviation	Full form
BMI	Body Mass Index
CI	Confidence Interval
COVID-19	Coronavirus Disease 2019
DM	Diabetes Mellitus
DPP4	Dipeptidyl Peptidase 4

HbA1c	Glycated Hemoglobin
HDL-C	High-Density Lipoprotein Cholesterol
HIV	Human Immunodeficiency Virus
ICU	Intensive Care Unit
IDF	International Diabetes Federation
IQR	Interquartile Range
LDL-C	Low-Density Lipoprotein Cholesterol
LMIC	Low- and Middle-Income Country
SD	Standard Deviation
SGLT2	Sodium-Glucose Cotransporter 2
SMBG	Self-Monitoring of Blood Glucose
SPHMMC	St. Paul's Hospital Millennium Medical College
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
TASH	Tikur Anbessa Specialized Hospital
VIF	Variance Inflation Factor
ZMH	Zewditu Memorial Hospital

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Institutional Review Board of the College of Health Sciences, Addis Ababa University (protocol number to be inserted). Written informed consent was obtained from all participants prior to data collection. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form (including individual details, images, or videos).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YDB contributed to the study conception, data collection, data analysis, and drafting of the manuscript. ABB contributed to the study design, data interpretation, and critical revision of the manuscript. AA contributed to the clinical supervision, data interpretation, and critical revision of the manuscript. LC contributed to the study design, supervision, data analysis, data interpretation, and critical revision of the manuscript. All authors read and approved the final manuscript.

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Authors' information (optional)

Not applicable.

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