Co-morbidities among People with Diabetes on Follow-up at Public Hospitals in Eastern Ethiopia: A Multicenter Study

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Background: Diabetes co-morbidities are the presence of one or more chronic illnesses besides diabetes. Having a better awareness of diabetic co-morbidities helps to reduce diabetes complications and enhance the quality of life. Despite its public health and clinical relevance, evidence on the extent and drivers of diabetes related co-morbidities in Eastern Ethiopia remains limited. Therefore, this study aimed to assess the prevalence of diabetes comorbidities and associated factors in the Eastern Hararghe Zone, Eastern Ethiopia.

Methods: A multi-center hospital-based cross-sectional study was conducted among 455 systematically selected people with diabetes at public hospitals in eastern Ethiopia from June 1-30, 2022. A face-to-face interview using a structured questionnaire was employed. Diabetes co-morbidities and biochemical data were extracted from medical records. A generalized Poisson regression model with robust variance estimation was used to investigate the association of independent variables with the outcome. An adjusted prevalence ratio with a 95% confidence interval (CI) was used to report a statistically significant association at a $p < 0.05$.

Results: The prevalence of diabetes co-morbidities was found to be 71.1% (95% CI: 67.2%, 75.6%). Hypertension (68%) and depression (44%) were the most prevalent concordant and discordant co-morbidities, respectively. Duration since diagnosis ≥5 years (APR=1.46; 95% CI: 1.26, 1.71), type 2 diabetes (APR= 1.28; 95% CI: 1.01, 1.62), poor glycemic control (APR= 1.19; 95% CI: 1.04, 1.37), non-adherence to diabetes medications (APR=1.55; 95% CI: 1.20, 2.01) and low self-efficacy (APR=1.28; 95% CI: 1.08, 1.49) were factors significantly associated with diabetes co-morbidities.

Conclusion: The prevalence of diabetes-related comorbidities was substantially high, with nearly seven in ten people with diabetes having at least one comorbidity. Hypertension and depression were the most common concordant and discordant diabetes comorbidities, respectively. Tailored behavioral interventions for people with diabetes, focusing on treatment adherence, optimal glycemic control, and self-efficacy, could reduce complications and improve quality of life.

Keywords: Diabetes, Concordant and Discordant Co-morbidities, Hararghe, Eastern Ethiopia

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Introduction

Diabetes co-morbidities are the presence of one or more chronic illnesses in addition to diabetes (ADA, 2022). It could be concordant and discordant co-morbidities based on having similar risk factors and sharing possibly the same therapeutic management (ADA, 2021, 2022; Magnan *et al.*, 2015). Concordant co-morbidities refer to diseases or conditions that share similar pathophysiological mechanisms, risk factors, and therapeutic strategies with diabetes, which include cardiovascular diseases, hyperlipidemia, and hypertension (Aga *et al.*, 2019; Baral and Baral, 2021; Magnan *et al.*, 2015). Discordant co-morbidities do not share the same pathophysiological mechanisms as diabetes and may require different treatment approaches. This includes tuberculosis, anemia, anxiety, and depression (Aga *et al.*, 2019a; Magnan *et al.*, 2015).

Globally, an increasing number of individuals with diabetes are living with multiple co-existing conditions (ElSayed *et al.*, 2023). In low- and middle-income countries, diabetes is frequently associated with a

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range of comorbidities (Lam *et al.*, 2021a). In sub-Saharan African countries, the diabetes population-attributable fraction for co-morbidities ranges from 6% to 64% (Ekoru *et al.*, 2019). These could be due to urbanization, longer duration with diabetes, uncontrolled blood glucose, older age, central obesity, family history of diabetes, overweight, and khat consumption (Jelinek *et al.*, 2017, Ekoru *et al.*, 2019, Magnan *et al.*, 2015; Abdissa and Kene, 2020). In the region, the reason for the high burden of diabetes and its complications includes a lack of simple equipment for diagnosis and monitoring, limited knowledgeable healthcare providers, and a shortage of treatments (Atun *et al.*, 2017). A study conducted in Eastern Ethiopia reported a lack of qualified diabetes educators, along with inadequate knowledge of diabetes and self-care practices among healthcare providers (Letta *et al.*, 2021).

The existence of co-morbidities in people with diabetes, managing multiple symptoms and complaints, could lead to frustrations towards health care providers (Young *et al.*, 2016). Diabetes with co-morbidities is documented to have unfavorable health outcomes compared to non-co-morbid diabetes. These include longer hospital stays, hospital admission, re-admission, the need for an advanced treatment regimen, higher health cost expenditure, increased risk of premature death, cognitive impairments, and non-adherence to diabetes self-care are among the well-established unfavorable outcomes (An and Le, 2016, Ejeta *et al.*, 2021). Lack of basic knowledge and overburdening owing to various obligations were key challenges to effective regimens for people with diabetes with co-morbidities (Magnan *et al.*, 2015). Having a better awareness of diabetes co-morbidities and associated factors could support healthcare providers in identifying and managing diabetes co-morbidities at an early stage, which significantly delays the progression of diabetes-related complications and promotes health (IDF, 2021).

In Ethiopia, limited studies were conducted on the prevalence of diabetic co-morbidities, which range from 54.9% in Mettu (Bereda and Bereda, 2021) to 77.9% in Addis Ababa (Demoz *et al*., 2019). A previous study conducted in eastern Ethiopia focused solely on concordant comorbidities (Ejeta *et al*., 2021). In addition, psychosocial and behavioral factors were less examined. Hence, this study aims to fill the evidence gap on the prevalence of co-morbidities and their associated factors among people with diabetes at public hospitals of East Hararghe zone, Eastern Ethiopia.

Materials and Methods

Study Setting, Design, and Period

A hospital-based cross-sectional study was conducted from June 1 to 30, 2022, in public hospitals within the Eastern Hararghe Zone. The zone, situated approximately 532 km east of Addis Ababa, has an estimated population of 3,066,150. It comprises seven public hospitals and 121 health centers. Out of seven, only four hospitals had established chronic follow-up clinics that provide services such as regular blood glucose tests, medication refills, and complication screening for people with diabetes. According to the hospital's Health Management Information System (HMIS) report 2021, nearly 1500 people with diabetes were attending follow-up care at the chronic follow-up clinic.

Population, Inclusion/ Exclusion Criteria

The study population consisted of adults people with diabetes who were on follow-up at selected public hospitals of the East Hararghe Zone during the data collection period. Adult people with diabetes aged 18 years or older and who had been on follow-up for at least three months were included in the study. People with severe illnesses or hearing impairments were excluded from the study. Severe illness was considered if the people's health condition made it difficult to respond to the interview, which might compromise their safety and treatment or confound the outcome of interest (i.e., advanced stage of chronic kidney disease or heart failure, hypertensive crisis, or schizophrenia).

Sample Size and Sampling Technique

The sample size was estimated using the double population proportion formula with Epi-Info V.7.2.5 software. The following assumptions were used to calculate the sample size: a factor of BMI >25kg/m2: CI=95%, Power=80%, Ratio=1:1, and 44.5% exposed 30.7% unexposed, AOR: 1.81 from the study by Regassa *et al*. (2021), which yielded 455 after considering a 10% non-response rate. Three of the 4 hospitals with established chronic follow-up clinics were selected. One hospital (Bisidimo General Hospital) was randomly selected for the pilot study. The average number of people with diabetes in selected public hospitals was estimated from the last six months' reports,

and a total of 990 (Deder General Hospital: 316; Haramaya General Hospital: 439; Chelenko Primary Hospital: 235) were considered as the study population. Then, the sample size was proportionally allocated for each hospital based on the probability proportional to size formula: Deder General Hospital (316), Haramaya General Hospital (439), and Chelenko Primary Hospital (235). Adult people with diabetes on follow-up were allocated respectively. Finally, a systematic random sampling technique (K value of 2) was used to select the study participants.

Data Collection Instruments and Procedures

The questionnaire was adapted by reviewing previous similar studies and scales that were proven to be reliable and valid in different demographic and spatial diversities were utilized (Letta *et al.*, 2022; Moon *et al.*, 2017; Zeru *et al.*, 2021). The questionnaire consisted of a overall of 68 question items: Socio-demographic characteristics (10 items), behavioral related factors (23items), psychological related factors (11 items), clinical and bio-chemical related characteristics (10 items), and Hospital Anxiety and Depression Scale (14 items). Data such as fasting plasma glucose, current regimen, number of drugs used, and comorbidities were collected from the medical records of people with diabetes per prepared checklists. The data collection tool was first prepared in English and then translated into a local language (Afaan Oromo), and then retranslated back to English to verify the consistency and content of the questionnaire.

Diabetes self-care practice was measured using the summary of diabetes self-care activities (SDSCA) encompassing diet, exercise, blood glucose monitoring, foot care, and cigarette smoking. Applied 11 items of the SDSCA and response range from 0–7 days (Toobert and Glasgow, 1994), and its Cronbach's alpha is 0.72 (Sh *et al.*, 2019).

The Hospital Anxiety and Depression Scale (HADS) was used to assess depression and anxiety. HADS contains a 7-item subscale for depression and anxiety. The overall internal consistency of the scale was 0.87 and was validated among chronically ill patients (Reda, 2011).

Adopted Diabetes Self-Efficacy Scale (DSE) from the Diabetes Empowerment Scale-Short Form (DES-SF) was used. DSE contains eight items with responses ranging from "strongly disagree" to "strongly agree" and a summated composite score ranging from 1 to 40 (Anderson *et al.*, 2003a; Al-Khawaldeh *et al.*, 2012). The DES-SF reliability was 0.84, showing good internal consistency. DES-SF was categorized into terciles as low, moderate, and high perceived self-efficacy (Letta *et al.*, 2022).

Social support was measured using the Oslo Social Support Scale (OSS-3), which consists of three items. The response categories were assessed independently for each of the three items, and a sum score was created by summarizing the raw scores and sum score scale ranging from 3–14 (Bøen *et al.*, 2012). Oslo Social Support Scale (OSS-3) reliability was 0.76, showing good internal consistency (Abiola *et al.*, 2013).

Diabetes medication adherence was measured using Modified Morisky's Adherence Scale (MMAS) with eight items. The tool was validated in sub-Saharan Africa (Tandon *et al.*, 2015). All questions, except the last question, were answered with a yes or no response, corresponding to 1 and 0 values, respectively. Question item five was reversely coded. The last item is a five-point Likert response: - "Never: 1", "Once in a while: 2", "Sometimes: 3", "Usually: 4", and "Always: 5". It's further recoded to 1 as 0 (No difficulty in remembering) and 2 through 5 as 1(Has difficulty in remembering).

Data were collected by four nurses with a Bachelor of Science degree and supervised by two nurses with a Master of Science degree. First, a brief orientation was given to data collectors on the study objectives, sampling, consent, data privacy, and checking for data clarity and completeness. Next, data collectors described the intent of the study and sought consent from the study participants. Then, finally, the questionnaire was filled out and collected from the study participants through an interview. Data that were extracted from secondary data and physical measurements were taken after the interview.

Operational Definition/Definition of Terms

Diabetes co-morbidities: is the presence of at least one chronic condition. These include: hypertension, obesity, dyslipidemia, cardiovascular disease (coronary heart disease, heart failure, peripheral vascular diseases), and/or chronic kidney disease (CKD), rheumatoid arthritis, cancer, osteoporosis, asthma, chronic obstructive pulmonary disease (COPD), epilepsy, and hypothyroidism among people with diabetes. These data were collected based on the patients' medical records or charts (ADA, 2021).

Anxiety and depression; those who scored ≥ 8 on each of the anxiety and depression scales were classified as having "Anxiety" and "Depression", respectively (Nigussie *et al.,* 2023).

Diabetes self-care behavior: Participants were labeled to have "good self-care" if they scored the mean score of the total or above, and "poor self-care" otherwise (Sorato *et al.,* 2016).

Medication adherence: Based on the Morisky Medication Adherence Scale-8 (MMAS-8), patients who score 0 are considered "Adherent" and those who score 1–8 are considered "Non-adherent" patients (Ali et al., 2017; Moon et al., 2017). The use of this scale was granted with the original publisher's permissions and considerations (Bress *et al*., 2017, Morisky *et al.,* 2008).

Social support: Based on the Oslo social support scale, 3–8 [poor social support], 9–11 [moderate social support], and 12–14 [strong social support] were considered (Bøen *et al*., 2012).

Diabetic self-efficacy: The adopted Diabetes Self-Efficacy Scale (DSE) from Diabetes Empowerment Scale-Short Form (DES-SF) was used (Al-Khawaldeh *et al.,* 2012). The DES-SF was categorized into terciles: low, moderate, and high perceived self-efficacy (Letta *et al*., 2022).

Sedentary lifestyle: Sedentary behavior was assessed with two questions about the time spent sitting or reclining during a usual weekday and weekend day over the past 7 days. Responses were recorded in hours and minutes and truncated at 960 minutes (16 hours) per day. The total sedentary time was summed to calculate daily averages, with "high sedentary behavior" defined as ≥ 8 hours per day (Motuma *et al*., 2021; Peltzer *et al.,* 2019).

Substance use (smoking/alcohol/chat): A "never substance user" is an individual who has never used a substance in their lifetime. A "former user" is an individual who had used the substance in the past but stopped 30 days before the data collection period. A "current user" is an individual who has used the substance at least one time in the past 30 days (Endeshaw *et al*., 2022).

Optimal glycemic control is defined as average fasting plasma glucose (FPG) between 70 mg/dl and 130 mg/dl of the last three months' measurements from the medical record; otherwise, "Sub-optimal glycemic control" (ADA, 2019).

Data Processing and Analysis

The data were checked for consistency and completeness, coded, checked, cleaned, and entered into Epi-Data software version 3.1 and then exported to Stata version 17.0 for further analysis. Proportions with 95% confidence intervals were calculated for categorical variables, and the mean with standard deviation was calculated for continuous variables. A Poisson regression model with robust variance estimate was fitted. Assumptions such as dispersion, linearity, log-link, and independence of observations were examined. The Standard Poisson Regression (SPR) model assumes that the mean and variance are the same. However, the data in our study showed underdispersion, meaning the variance is smaller than the mean. In this case, generalized Poisson regression (GPR) with robust variance is one method that can handle cases of overdispersion and underdispersion (Harris *et al*., 2012; Allo and Otok, 2019). A $p < 0.25$ at bi-variable Poisson regression was considered for multivariable Poisson regression analysis. The explanatory variables were checked for multicollinearity by the variance inflation factor, with cutoff points <5. Multivariate modifiable generalized Poisson regression with robust variance estimation was executed to determine the association of independent variables with diabetes co-morbidities. The results were reported as Adjusted Prevalence Ratios with 95% CI. Covariates with $p < 0.05$ were reported as statistically significantly associated with the outcome variable.

Data Quality Control

Training was given to data collectors on components of the tool, data collection methods, and procedures before the actual data collection. Tools were pre-tested at Bisidimo General Hospital among 10% of the sample size (n=45 people with diabetes), and some minor modifications were made for clarity of questions. To check the actual implementation of the procedures and the overall data collection process, the situation was closely followed by supervisors and investigators. The completeness and accuracy of collected data were checked daily during data collection.

Ethical Consideration

The study protocol was reviewed and approved by the Institutional Health Research Ethics Review Committee (IHRERC) of Haramaya University, College of Health and Medical Sciences [Ref. No: IRERC/047/

2022]. An official letter of support was written to each selected hospital to allow the execution of the research. Permission was obtained from the respective hospital administrators to recruit the study participants. Informed verbal and written consent was obtained from each study participant.

Results

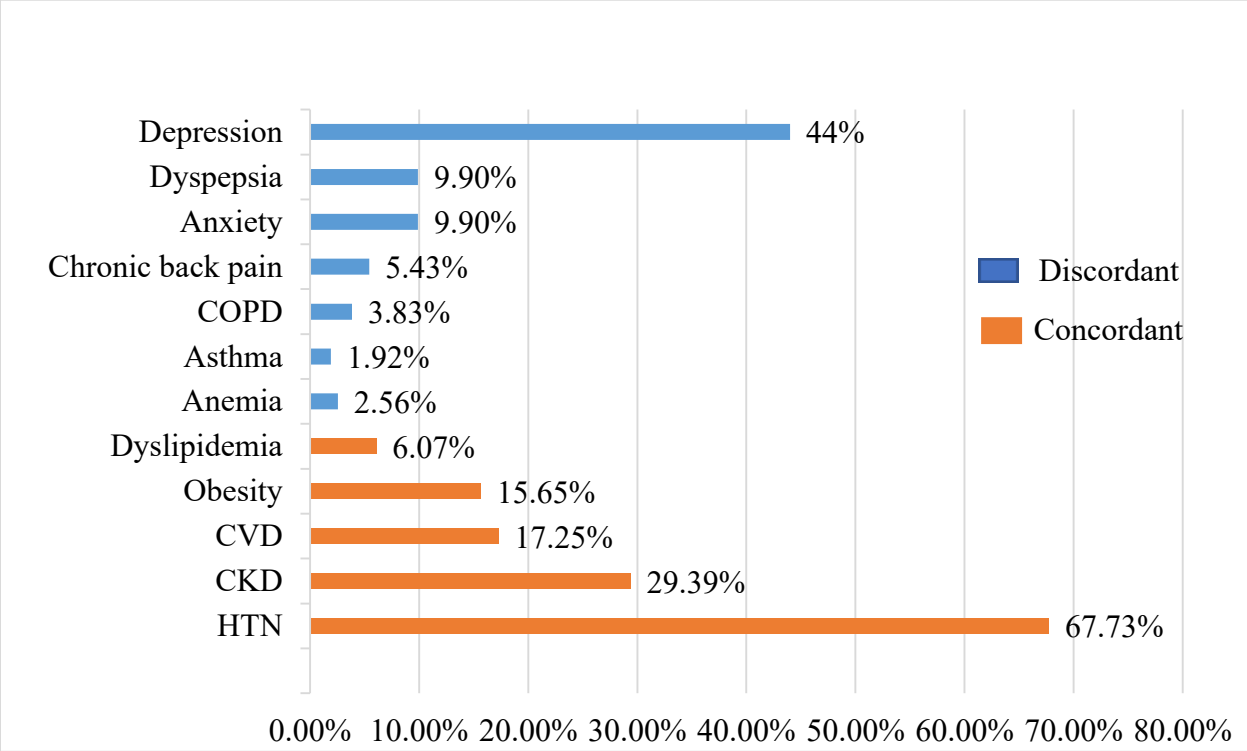
Socio-demographic characteristics of participants. Out of 455 expected participants, 440 people with diabetes were enrolled, making the response rate 96.7%. Most of the study participants, 284 (64.6%), were males. The mean age was 50.12 (± SD 11.65) years. Two hundred seventy-four (62.3%) were within the age range of 40-59 years. One hundred fifty-four participants (35.0%) had no formal education. More than half of the study participants (54.3%) had community-based health insurance. Three-fourths (75.7%) of participants were rural residents. The mean duration of diabetes since diagnosis was 5.5 (SD ±3.2) years. The majority, 345 (78.4%) of the people with diabetes were diagnosed with Type 2 diabetes. The mean Fasting Blood Sugar (FBS) level of the participants was 199.21 mg/dl (±116.3 SD) (Table 1).

Table 1: Socio-demographic and clinical characteristics of adults on diabetic follow-up at public hospitals in Eastern Hararghe Zone, Eastern Ethiopia, 2022 (n=440).

Characteristics	Category	Frequency (n)	Percent (%)
Sex	Male	284	64.6
	Female	156	35.4
Age in years	18-39	72	16.4
	40-59	274	62.3
	60 and above	94	21.3
Marital status	Married	308	70.0
	Single	30	6.8
	Divorced	41	9.3
	Widowed	61	13.9
Education level	No formal education	154	35.0
	Primary (grades 1–8)	58	13.2
	Secondary (grades 9–12)	83	18.9
	Tertiary (grades 12+)	145	32.9
Occupation	Government employee	84	19.1
	Farmer	141	32.1
	Retired	49	11.1
	Merchant	78	17.7
	House-wife	39	8.9
	Other[a]	49	11.1
Place of residence	Rural	333	75.7
	Urban	107	24.3
Health insurance	Yes	239	54.3
	No	201	45.7
Type of diabetes	Type 1	95	21.6
	Type 2	345	78.4
Glycemic control	Optimal	166	37.7
	Sub-optimal	274	62.3
Medication used	Insulin	103	23.4
	Oral hypoglycemic agent (Monotherapy)	16	3.6
	Combination of oral hypoglycemic agents	321	73.0
Body mass index	Underweight	44	10.0
	Normal	168	38.2
	Overweight	179	40.7
	Obese	49	11.1
Poly pharmacy	Yes	123	27.9
	No	317	72.1

Prevalence of diabetes co-morbidities

More than two-thirds of the study participants (71.1%) (95% CI: 67.2–75.6) had at least one diabetes-related comorbidity, from which 30% had only one and 20.7% had two comorbid illnesses. At least half, 52.7%, presented with concordant comorbidities. Hypertension was the most commonly reported concordant condition (67.7%), followed by chronic kidney disease (29.4%). In contrast, depression emerged as the most common discordant comorbidity, affecting 44% of participants (Figure 1).



COPD: Chronic Obstructive Pulmonary Disease, CVD: Cardio-Vascular System disorders, CKD: Chronic Kidney Disease, HTN: Hypertension

Figure 1: Distribution of co-morbidities among adult people with diabetes on follow-up at public hospitals in Eastern Hararghe Zone, Eastern Ethiopia, 2022 (n=440)

Factors associated with diabetes co-morbidities

In the bivariate Poisson analysis with robust variance, eight variables, such as age, residence, type of diabetes, duration of illness, glycemic control level, medication adherence, self-efficacy level, and social support status, were significantly associated with diabetes co-morbidity. Nevertheless, in multivariable analysis, five variables: type of diabetes, duration since diagnosis, glycemic control, medication adherence, and self-efficacy were significantly associated with diabetes co-morbidity. The prevalence of diabetes co-morbidities was 1.3 times greater (APR = 1.28; 95% CI: 1.01, 1.62) in individuals with type 2 diabetes compared to those with type 1 diabetes. Similarly, people with diabetes for 5 or more years had a 1.46 times higher prevalence (APR = 1.46; 95% CI: 1.26, 1.71) of co-morbidities than those diagnosed less than five years ago. Participants with sub-optimal glycemic control showed a 1.2 times increased prevalence (APR = 1.19; 95% CI: 1.04, 1.37) compared to those with optimal control. Additionally, individuals who did not adhere to diabetes medication were 1.55 times more likely (APR = 1.55; 95% CI: 1.20, 2.01) to have co-morbidities than adherent patients. Finally, the prevalence was 1.28 times higher (APR = 1.28; 95% CI: 1.08–1.49) among participants with low self-efficacy and 1.2 times higher (APR = 1.20; 95% CI: 1.03, 1.41) among those with moderate self-efficacy, compared to individuals with good self-efficacy (Table 2).

Table 2: Factors associated with co-morbidities among adult people with diabetes on follow-up at public hospitals in Hararghe Zone, Eastern Ethiopia, 2022 (n=440)

Variable		Co-morbidities		CPR (95% CI)	APR (95% CI)	p-value
		Yes	No			
Age	18-39	37 (51.39)	35 (48.61)	1	1	
	40-59	196 (71.53)	78 (28.47)	1.39 (1.09-1.76)	1.01 (0.76-1.34)	0.924
	≥ 60	80 (85.11)	14 (14.89)	1.66 (1.30-2.10)	0.95 (0.78-1.42)	0.718
Residence	Rural	88 (82.24)	19 (17.76)	1.21(1.08-1.36)	1.09 (0.98-1.21)	0.104
	Urban	225 (67.57)	108 (32.43)	1	1	
Type of DM	Type 1	49 (51.58)	46(48.42)	1	1	
	Type 2	264 (76.52)	81(23.48)	1.48 (1.21-1.82)	1.28(1.01-1.62)	0.043*
Duration since diagnosis	< 5	157 (60.15)	104(39.85)	1	1	
	≥ 5	156 (87.15)	23 (12.85)	1.45 (1.29-1.62)	1.46 (1.26-1.71)	0.000*
Glycemic control	Good	94 (56.63)	72(43.37)	1		
	Poor	219(79.93)	55(20.07)	1.41 (1.22-1.63)	1.19 (1.04-1.37)	0.014*
Medication adherence	Adherent	32 (42.11)	44(57.89)	1	1	
	Non-adherent	281(77.20)	83(22.80)	1.55 (1.40-2.40)	1.55 (1.20-2.01)	0.001*
Self-efficacy	Low	124(84.35)	23(15.65)	1.49 (1.27-1.74)	1.28 (1.08-1.49)	0.001*
	Moderate	107(72.30)	41(27.70)	1.27 (1.07-1.52)	1.20 (1.03-1.41)	0.019*
	High	82 (56.55)	63(43.45)	1	1	
Social support	Poor	114(77.03)	34(22.97)	1.12 (1.02-1.42)	1.12 (0.96-1.31)	0.128
	Moderate	128(70.72)	53(29.28)	1.10 (0.93-1.30)	1.09(0.93-1.27)	0.255
	Good	71 (63.96)	40(36.04)	1	1	

** Statistically significant at p-value<0.05, CPR: Crude Prevalence Ratio and APR: Adjusted Prevalence Ratio*

Discussion

The study aimed to determine the prevalence of diabetic co-morbidities and associated factors among adult people with diabetes at public hospitals in Eastern Hararghe Zone, Eastern Ethiopia. The findings revealed that 71% of participants (95% CI: 67.2–75.6%) had at least one diabetes-related comorbidity. Factors significantly associated with the presence of comorbidities include a diabetes duration of five years or more, type 2 diabetes, suboptimal glycemic control, non-adherence to prescribed medications, and low self-efficacy.

The prevalence of co-morbidities in the current study's findings is higher than studies conducted in Nepal, 45.3 % (Baral and Baral, 2021), Nigeria, 22% (Kayode *et al.*, 2015), and Ambo, Ethiopia, 53.9% (Woldu *et al.*, 2014). The discrepancy might be due to the variations in our study population characteristics (both types of DM), study settings (rural residence), lifestyle, and health-seeking behavior (Aga *et al.*, 2019; Aung *et al.*, 2015). On the contrary, our finding is lower than studies conducted in Canada (78.4%) (Petrosyan *et al.*, 2020), the Netherlands (84.6%) (Luijks *et al.*, 2012), Spain (82%) (Mata-Cases *et al.*, 2019), and Saudi Arabia (82.46%) (Gazzaz *et al.*, 2020). This variation could be attributed to the relatively younger mean age of participants in the present study (50.1 years vs. 76, 63.2, 70.3, 60.1, and 56 years, respectively) and their shorter mean diabetes duration (5.5 years vs. 10, 11.1, 8.7, and 11.6 years, respectively). In addition a lower smoking and alcohol consumption incidents might lower the occurrence of diabetes co-morbidities (Akın and Bölük, 2020; Lam *et al.*, 2021b).

In this study, a longer duration of diabetes was significantly associated with the presence of comorbidities, which is consistent with reports from Turkey (Akın and Bölük, 2020), Iran (Nouh *et al.*, 2017), and Ethiopia (Shiferaw *et al.*, 2020, Asefa *et al.*, 2020). This might be due to prolonged exposure to hyperglycemia results in an autonomous imbalance and blood vessel stiffening, both of which are strongly linked to various cardiovascular problems, including hypertension, coronary artery disease, heart attack, stroke, and atherosclerosis (Li *et al.*, 2023; Pati *et al.*, 2021).

The findings also demonstrated a significant association between type 2 diabetes and the presence of

comorbidities, consistent with previous studies conducted in Korea (Kim *et al.*, 2012) and Malaysia (Muhamad *et al.*, 2018; Kim *et al.*, 2012). This could be due to the metabolic dysregulation, chronic inflammation and oxidative stress, older mean age and predisposed lifestyle, which are typical in people with type 2 diabetes (Oguntibeju, 2019, Caturano *et al.*, 2023). These findings highlight the necessity for comprehensive care strategies tailored to people with type 2 diabetes through regular screening for co-morbidities, early intervention, and integrated treatment plans.

A significant association between suboptimal glycaemic control and the presence of diabetes-related comorbidities in this study was consistent with findings from Poland (Gorska-Ciebiada *et al.,* 2014) and Turkey (Akın & Bölük, 2020). This might be due to the accumulation of advanced glycation end products and their significant impact on end-organ damage (Khalid *et al.*, 2022). Ensuring patients maintain optimal blood glucose levels through continuous monitoring and tailored treatment plans is essential for reducing the occurrence of co-morbid conditions (Klupa *et al.*, 2023).

Non-adherence to the diabetes regimen was significantly associated with diabetes co-morbidities. This is supported by studies in Ethiopia (Mariye *et al.*, 2019; Tusa *et al.*, 2020) and China (Wong *et al.*, 2014). Adherence to a diabetes regimen is previously reported to be key in maintaining optimal blood sugar levels (Lin *et al.*, 2017). Addressing non-adherence through patient education, simplifying treatment regimens, and providing support could help mitigate these risks and improve overall health outcomes for people with diabetes (Polonsky and Henry, 2016; Baryakova *et al.*, 2023; Kardas, 2024).

In this study, low self-efficacy was significantly associated with the presence of diabetes-related comorbidities, which is consistent with reports from studies in the UK (Peters *et al.*, 2019) and Italy (Buck *et al.*, 2015). This might be due to the psychological stress and depression resulting from low self-efficacy could cause hormonal and inflammatory changes that worsen cardiovascular and metabolic outcomes (Kivimäki *et al.*, 2023). It is also reported that people with low self-efficacy had reduced healthcare engagement and sought timely medical care (Farley, 2020). This highlights the importance of incorporating psychological support and education into diabetes care programs to boost patients' self-efficacy.

Strengths and Limitations

The study was conducted across multiple health facilities, enhancing validity and generalizability. The nature of the cross-sectional design limits the study's findings for causal inference. Diabetic self-care activities and medication adherence could be affected by recall bias, and we limited the recall period to the past 7 days, rather than longer durations. Even though behavioral factors such as substance use were analyzed, the dose-associated effect was not considered.

Conclusion

The prevalence of diabetes co-morbidities was considerably high, with nearly seven in ten people with diabetes having at least one co-morbidity. Hypertension was the most common concordant condition, while depression was the most prevalent discordant comorbidity. Diabetes co-morbidities were significantly associated with longer diabetes duration, type 2 diabetes, medication non-adherence, sub-optimal glycemic control, and low self-efficacy. Therefore, for effective and efficient diabetes management and control, it is highly recommended to tailor diabetes self-management education programs focusing on medication adherence, optimal glucose monitoring and control, and behavior modification to enhance self-efficacy.

Author Contributions

NA, SL, SG, AM, and AT made a significant contribution to the conception of the study, proposal drafting, and execution of the study.NA, HL, AA, LA, and FW greatly participated in the acquisition of data, analysis, interpretation, writing up of the data, and critical drafting of the manuscript. The manuscript was critically reviewed and revised by NA, HL, SG, SL, and AM. All the authors gave final approval of the version to be published.

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Competing Interests

The author declares that they have no competing interests.

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List of Abbreviations

APR; Adjusted Prevalence Ratio, CKD; Chronic Kidney Disease, COPD; Chronic Obstructive Pulmonary Diseases, CPR); Crude Prevalence Ratio, CVS; Cardiovascular System, DSCAS, Diabetes Self-care Activities, DSES; Diabetic Self Efficacy Scale, FGP; Fasting Plasma Glucose, HTN; Hypertension, MMAS-8; Morisky Medication Adherence Scale-8, T1D; Type 1 Diabetes, T2D; Type 2 Diabetes.

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