Original Article

SAGE Open Medicine

SAGE Open Medicine
Volume 12: 1–10

DOI: 10.1177/20503121231218890
journals.sagepub.com/home/smo
Sage

Determinants of diabetic nephropathy among adult diabetic patients on follow-up at public hospitals in Addis Ababa, Ethiopia: A case-control study

Diriba Etana Tola[1], Zenebu Begna Bayissa[2], Tamene Abera Desissa[2], Lencho Kajela Solbana[3], Azeb Haile Tesfaye[3] and Bikila Fufa Eba[4]

Abstract

Background: Diabetic nephropathy is defined as patients with diabetes mellitus who have persistent proteinuria for at least three consecutive measurements per year, a high blood creatinine level (>130 mol/l), or a decrease in glomerular filtration rate (<60 ml/min). Limited studies were done in Ethiopia on determinants of diabetic nephropathy among diabetic patients. Therefore, this study aimed to identify determinants of nephropathy among adult diabetic patients on follow-up at public hospitals in Addis Ababa, Ethiopia, 2022.

Methods: A hospital-based unmatched case-control study design was conducted from 6 September to 9 November 2022, among diabetic patients on follow-up at public health hospitals in Addis Ababa. Using consecutive sampling techniques, a total of 442 (353 controls and 89 cases) were recruited, with a control-to-case ratio of 4:1. The data were collected using a structured and interview-administered questionnaire and variables like high-density lipoprotein, low-density lipoprotein, Glycated hemoglobin, and type of diabetes were extracted from the medical records of the patients using a checklist. The collected data were entered into Epidata 3.1 and analyzed by STATA version 15.0. Variables with a p-value < 0.25 in the bivariable logistic regression were selected for the final model. In multivariable logistic regression model fitting, variables with a p-value < 0.05 with 95% CI adjusted odds ratio have declared statistically significant risk factors of diabetic nephropathy.

Results: In this study, out of 442 study participants, 334 controls and 89 cases were included in the analysis, with a response rate of 94.6% and 100%, respectively. The majority of the study participants were 92.13% of cases and 84.13% of controls; 7.87% of cases, and 15.87% of controls were type 2 diabetes mellitus. Age 65 and above years old (AOR: 2.42; 95% CI: 1.28, 4.57); Smoking cigarette (AOR: 2.22; 95% CI: 1.18, 4.16); Non-adherent to diet (AOR: 2.11; 95% CI: 1.15, 3.84); Drinking alcohols (AOR: 1.95; 95% CI: 1.07, 3.52); Duration with diabetes more than 10 years (AOR: 3.39; 95% CI: 1.76, 6.54); Poor glycemic control (AOR: 2.19; 95% CI: 1.23, 4.28); and Low-density lipoprotein (AOR: 2.97; 95% CI: 1.69, 5.28) were found to be statistically significant risk factors of nephropathy among diabetic patients.

Conclusion: This study found that old age, smoking cigarettes, non-adherence to diet, duration of diabetes, alcohol drinking, Glycated hemoglobin A1C, and high low-density lipoprotein were risk factors for nephropathy. Hence, continuous health education on lifestyle modifications and diabetic-related complications in each follow-up visit via front-line health professionals are very essential to avert the problem.

Keywords

Nephropathy, diabetes mellitus, determinants, Ethiopia

Date received: 29 May 2023; accepted: 14 November 2023

[1]Department of Midwifery, College of Health Science, Assosa University, Assosa, Ethiopia
[2]Department of Public Health, College of Health Science and Medicine, Ambo University, Ambo, Ethiopia
[3]Department of Nursing, College of Health Science, Assosa University, Assosa, Ethiopia
[4]Department of General Medicine, School of Medicine, St. Petros' Referral Hospital, Addis Ababa, Ethiopia

Corresponding author:
Diriba Etana Tola, Department of Midwifery, College of Health Science, Assosa University, Assosa 12345, Ethiopia.
Email: diromom21@gmail.com

Introduction

Diabetic nephropathy (DN) is defined as patients with diabetes mellitus who have persistent proteinuria for at least three consecutive measurements per year, a high blood creatinine level (>130 mol/l), or a decrease in GFR (< 60 ml/min).[1–3] Diabetic nephropathy is a severe microvascular complication of both type 1 and type 2 diabetes mellitus and, thus, a public health problem today.[4,5] According to the Global Burden of Diabetic-Related Chronic Kidney Disease (CKD) from 1990 to 2019, there were 135 million people with 2.6 million incident cases of DN worldwide 2019.[5]

In sub-Saharan Africa, the estimated prevalence of CKD was 13.4%.[6,7] However, the exact severity and magnitude of the disease vary across countries. This is supported by the fact that the disease has a high burden in some countries, particularly developing countries.[5,8] This imposes a heavy financial burden on the health system between 2010 and 2016; the cost was estimated to be 1.2 billion (180 million dollars annually) with an escalating trend.[9]

In Ethiopia, the cumulative incidence of DN among type 2 diabetic patients was 10.8%.[10] DN is a serious long-term complication of diabetes mellitus that currently, deserves greater attention in global health policy, particularly since the burden is increasing in developing countries including our country, Ethiopia.[11,12]

Even if DN is one of the complications of diabetes mellitus, not all diabetes can develop DN, their progression varies, and some patients even revert and the microalbuminuria can disappear. This suggests that there are contributing factors for the development of complications.[13] At least 80% of DN caused by diabetes mellitus is potentially preventable.[4] Early screening, prevention, and treatment measures among diabetic patients play an important role in reducing the complications and their effects of burden; this may be achieved through interventions to ward off those contributing factors to the development of DN.[8]

Nowadays, the problem should be given attention by actively addressing the issues to meet the sustainable development goal (SDG) target to decrease the deaths related to non-infectious diseases by a third by 2030.[14] The SDGs map the actions toward achieving all of the SDGs that have the potential to improve understanding, measurement, prevention, and treatment of kidney disease in all age groups. These actions can also foster treatment innovations and reduce the burden of such diseases in future generations.[15] Currently, our country Ethiopia has signed to achieve SDGs, three[3] up to 2030.[16] DN and its adverse consequences have potentially been prevented or delayed by inexpensive interventions on associated factors.[11,12,15] According to previous studies, there are some studies conducted on identifying the factors contributing to the development of diabetic complications.[17–19] However, factors associated with this particular complication have not yet been thoroughly studied.[3,20] In addition, there is a limited study done on identifying factors associated with DN in the study area.[17] Identifying determinant factors for the development of DN is a crucial input for interventional planning and a significant role in preventing or reducing morbidities and mortality of related problems.[3,20] Therefore, this study aimed to identify the determinants of DN among adult diabetic patients at public hospitals in Addis Ababa, Ethiopia, in 2022.

Methods and materials

Study setting and period: The study was conducted at public hospitals in Addis Ababa. Based on the 2022 Ethiopian Fiscal Year (EFY) figures, Addis Ababa city has an estimated total population of 5,228,000 consisting of more female residents than males. According to 2012 (EFY), Health and Health Related Indicators Published by the Minister of Health, the city has 13 Public Hospitals and 98 Health centers. Out of 13 public hospitals, at the time this study was conducted, 10 hospitals were providing follow-up care services for diabetic patients. The study was conducted between 6 September 2022 to 9 November 2022.

Study design and population: A hospital-based unmatched case-control study design was employed. All adult diabetes patients on diabetic treatment follow-up in Addis Ababa public hospitals were the source population, and the study population was all adult diabetes patients on diabetic treatment follow-up who had been diagnosed with DN in five selected public hospitals in Addis Ababa during the study period (for cases) and all adult diabetes patients on diabetic treatment follow-up who were free from DN in five selected public hospitals in Addis Ababa during the study period (for controls). On the other hand, for cases, a study unit was an individual who fulfilled the inclusion criteria for cases during the time of the data collection whereas for controls was an individual who fulfilled the inclusion criteria of controls during the time of the data collection. The inclusion criteria for cases were diabetic patients who were >18 years old and diagnosed with DN but free from underlying causes of kidney disease, and for controls: diabetic patients who were >18 years old, and who were free from both DN and underlying causes of kidney disease. Diabetic patients who had less than three follow-ups for diabetic treatment before being first diagnosed with DN among cases and diabetic patients who had less than three follow-ups for diabetic treatment among controls were excluded from the study.

Sample size determination and sampling procedures

The sample size was estimated by Epi-Info version 7.0 software using the following statistical assumption: confidence level of 95%, power of 80%, a ratio of controls to case ratio of 4:1, the percent of exposure among controls = 24.62%, and odds ratio ((OR) = 2.13) and systolic hypertension (yes)

Table 1. Number of diabetic patients at each selected public hospital.

Public hospitals	Cases	Controls
St. Paul's Millennium Medical College Hospital	35	340
Menilik Compressive Specialized Hospital	10	100
Zewditu Memorial Hospital	21	203
Yikatit Hospital Medical College	24	231
St. Petros' Referral Hospital	19	178

was taken as exposure from a previous study.[19] Therefore, with the larger sample size (420), and after considering a 5% non-response rate, the final sample size was 442 (353 controls and 89 cases). In this study area, ten public hospitals were providing follow-up services for diabetic patients. Out of 10 hospitals, five (St. Paul's Millennium Medical College Hospital (SPMM), Menilik Compressive Specialized Hospital, Zewditu Memorial Hospital (ZMH), Yikatit Hospital Medical College (YHMC), St. Petros' Referral Hospital (SPRH)) were selected using a simple random sampling method. According to the 2-month follow-up record of diabetic patients, there were 1161, comprising 109 cases, and 1052 controls among the five selected hospitals. The number of patients at each hospital is described in Table 1 below.

Thus, the required sample size from the five selected hospitals for cases and controls was 442. Each hospital's sample size of cases and controls was determined through the proportional allocation method using a sampling fraction. One case and four corresponding controls were recruited from each of the hospitals that yielded the cases, using consecutive sampling techniques for both cases and controls until the necessary sample size was reached.

Operational definitions. *Cases*: A diabetic patient who has been diagnosed with DN by health professionals for which the diagnosis was written on the patient's file (card) at the hospital.

Controls: A diabetic patient who has been not diagnosed with DN by health professionals.

DN: diabetic patients who have been diagnosed with DN by a health professional.

Adherence: A patient behaves following the instructions or advice given by health care providers.

Medication adherence: Medication adherence was measured using the Morisky 8-point scale for anti-diabetic drugs (Adherent for those who score >6 points and non-adherent for those who score $\leqslant 6$ points).[21]

Adherence to exercise: Classified as having good adherence to exercise, for those scores $>50\%$, and was classified as poor adherence to exercise for those scores $<50\%$ using diabetic self-management profile (DSMP) tools.[22,23]

Adherence to diet: Classified as having good adherence to diet if they score $>50\%$, and classified as poor adherence to diet for those scores $<50\%$ using DSMP tools.[22,23]

Glycemic control: A patient was classified as having a good glycemic control when HbA1c $<7\%$ and poor glycemic control when HbA1c $>7\%$.[24]

In this study, glycemic control was assessed by using haemoglobin A1c (HbA1c) or glycated haemoglobin which measures the glycemic status of the patients over the past 3 months.

Study variables

The dependent variable was DN whereas the independent variables were: socio-demographic characteristics (age, sex, marital status, educational status, occupation, and residence), behavioral-related characteristics (medication adherence, alcohol consumption, missed follow-up, smoking cigarettes, diet adherence, Khat chewing, and exercise), and clinically related factors (family history of diabetic kidney disease, high-density lipoprotein (HDL), low-density lipoprotein (LDL), Glycated hemoglobin, type of diabetes, duration with diabetes mellitus, and comorbidity).

Data collection tools and techniques

Data from study subjects were collected by using structured and interview-administered questionnaires which were adapted from previous related studies.[18,19,25] By using patients' identification numbers, cases and controls were separated from the data of the diabetes patients' logbooks. Following the division of study participants into cases and controls, a structured questionnaire was provided by an interviewer, and information was also taken from each review card of the study's records. A questionnaire translated into Amharic (the local language) was used for data collection. Three BSc nurses were recruited to collect data and were supervised by one BSc nurse. After the study unit (patients) completed their physician consultation (follow-up care), the data collectors identified cases or controls from the medical records of patients. Data were collected using a structured and interviewer-administered questionnaire to obtain information on socio-demographic characteristics like age, sex, marital status, educational status, occupation, and residence, along with variables under behavioral-related factors like medication adherence, alcohol consumption, missed follow-up, smoking cigarettes, diet adherence, Khat chewing, and exercise. While, variables under clinically related factors like HDL, LDL, Glycated hemoglobin, and type of diabetes were extracted from the medical records of the patients using a checklist. Moreover, variables like family history of diabetic kidney disease, comorbidity, and duration of diabetes were collected using both. Moreover, different standard tools were used for some variables under the study those are Morisky medication adherence scale (MMAS) was used to assess medication adherence status, while DSMP tools were used to assess the adherence status of diabetic patients for exercise and diet.

Table 2. Socio-demographic characteristics of adult diabetic patients on follow-up in public hospitals of Addis Ababa, Ethiopia, 2022.

Variables	Categories	Cases ($n=89$)	Controls ($n=334$)	Total ($n=423$)
		Frequency (%)	Frequency (%)	
Age (years)	<65	61 (68.54)	278 (83.23)	339 (80.14)
	>65	28 (31.46)	56 (16.77)	84 (19.86)
The biological sex of study participants	Male	54 (60.67)	203 (60.78)	257 (60.76)
	Female	35 (39.33)	131 (39.22)	166 (39.24)
Residence	Urban	83 (93.26)	312 (93.41)	395 (93.38)
	Rural	6 (6.74)	22 (6.59)	28 (6.62)
Marital status	Single	3 (3.37)	38 (11.38)	41 (9.69)
	Married	60 (67.42)	236 (70.66)	296 (69.98)
	Divorced	14 (15.73)	42 (12.57)	56 (13.24)
	Widowed	12 (13.48)	18 (5.39)	30 (7.09)
Occupation	Govt. employer	22 (24.72)	77 (23.05)	99 (23.4)
	Private employer	36 (40.45)	146 (43.71)	182 (43.03)
	Housewife	14 (15.73)	57 (17.07)	71 (16.78)
	Unemployed	10 (11.24)	38 (11.38)	48 (11.24)
	Others*	7 (7.87)	16 (4.8)	23 (4.44)
Educational status	No formal education	23 (25.84)	92 (27.54)	115 (27.19)
	Primary level	29 (32.58)	99 (29.64)	128 (30.26)
	Secondary level	17 (19.1)	63 (18.86)	80 (18.91)
	College and above	20 (22.47)	80 (23.95)	100 (23.64)

*Daily laborers and farmers.

Data quality control and management

The questionnaire was first adapted from published articles, after which it was translated into Amharic, and then back-translated into English to ensure consistency. The Morisky Medication Adherence Scale (MMAS-8) test items was found to have Cronbach's alpha ($\alpha=0.83$) and the Diabetic Self-Management Profile (DSMP) tools with (Cronbach s alpha($\alpha=0.835$) were used.[22] Additionally, the other tools have been developed from previously published articles.[18,19,25] Data collectors and supervisors took 1-day training on data collection tools and procedures. A week before the actual data collection, the questionnaire was pre-tested among 18 study participants. The supervisor has monitored the entire data collection process and the completeness of the collected data.

Data processing and analysis

First, the collected data were checked, coded, and entered into Epi-data version 3.1, and then exported to STATA version 15.0 for analysis. multiple imputation method was used to handle missing values for the variables. Descriptive statistics were used to describe variables in terms of frequencies and proportions. A binary logistic regression was fitted to identify the independent determinants of DN. In the bivariable binary logistic regression model, variables with a p-value < 0.25 were selected as candidate variables for the final model. All the candidate variables were entered into a multivariable binary logistic regression model to identify the effects of independent variables on the outcome variable. The fitness of the model was checked by the Hosmer and Lemeshow goodness-of-fit test ($Chi^2=11.66$, p-value $=0.473$). There are no detected Multi-collinearity effects among independent variables based on the assumption of the variance inflation factor. Using a p-value of 0.05, and AOR with its 95% CI the independent variables were declared a statistically significant determinant of DN.

Results

Socio-demographic characteristics of the study participants

In this study, out of the 442 study participants (353 controls and 89 cases), 423 (334 controls and 89 cases) were included who participated in the study, making response rates of 94.6% and 100%, respectively. Overall, study participants had a mean age of 48.9; of this, cases and controls had mean ages of 55.91 (SD = 14.9) and 47.1 (SD = 15.6), respectively. On the other hand, 278 (83.23%) controls and 61 (68.54%) cases were between the ages categories of 18–65 years. More than half, 257 (60.76%) of the study participants were males. The majority of the study participants, 83 (93.26%) of cases and 312 (93.41%) controls were from urban residences. Additionally, the majority of study participants were married, with 60 (67.42%) cases and 236 (70.66%) controls (Table 2).

Table 3. Behavioral-related characteristics of adult diabetic patients on follow-up in public hospitals of Addis Ababa, Ethiopia, 2022.

Variables	Categories	Cases ($n=89$)	Controls ($n=334$)	Total ($n=423$)
		Frequency (%)	Frequency (%)	
Ever alcohol drinker	Yes	39 (43.82)	126 (37.72)	165 (39.01)
	No	50 (56.18)	208 (62.28)	258 (60.99)
Currently alcohol drinkers	Yes	32 (35.96)	81 (24.25)	113 (26.71)
	No	57 (64.04)	253 (75.75)	310 (73.29)
Ever khat chewers	Yes	31 (34.83)	88 (26.35)	119 (28.13)
	No	58 (65.17)	246 (73.65)	304 (71.87)
Currently khat chewers	Yes	28 (31.46)	51 (15.27)	79 (18.68)
	No	61 (68.54)	283 (84.73)	344 (81.32)
Smoking cigarette	Yes	29 (32.58)	51 (15.27)	80 (18.91)
	No	60 (67.42)	283 (84.73)	343 (81.09)
Missed follow-up	Yes	27 (30.34)	83 (24.85)	110 (26)
	No	62 (69.66)	251 (75.15)	313 (74)
Exercise status	Non-adhered	56 (62.92)	156 (46.71)	211 (49.88)
	Adhered	33 (37.08)	178 (53.29)	212 (50.12)
Diet status	Non-adhered	60 (67.42)	157 (47.01)	217 (51.3)
	Adhered	29 (32.58)	177 (52.99)	206 (48.7)
Medication status	Non-adhered	56 (62.92)	128 (38.32)	184 (43.5)
	Adhered	33 (37.08)	206 (61.68)	(56.5)

Behavioral-related characteristics of the study participants

Among study participants who took part in the study, 32 (35.96%) of cases and 81 (24.25%) of controls were current alcohol drinkers. Regarding cigarette smoking habits, 29 (32.58%) of cases and 51 (15.27%) of controls were smoking cigarettes. Slightly more than half, 217 (51.3%) study participants did not adhere to the diet. Regarding medication adherence, 56 (62.92%) of cases and 128 (38.32%) of controls did not adhere to anti-diabetic medications (Table 3).

Clinical-related characteristics of the study participants

The majority of the participants, 82 (92.13%) of cases and 281 (84.13%) of controls were type 2 diabetic patients. About, 31 (34.83%) of cases and 92 (27.54%) of controls had a low HDL value, and about, 57 (64.04%) of cases and 116 (34.73%) of controls had a high LDL value. Among a total of study participants, slightly more than half of 62 (69.66%) cases and less than half of 145 (43.41%) controls had high Glycated hemoglobin values (Table 4).

Determinants of DN

At a p-value < 0.25 in bivariable binary logistic regression 14 variables were selected for the multivariable binary logistic regression. Those variables were age, cigarette smoking, alcohol consumption, Khat chewing, non-adherent to diet, non-adherent to anti-diabetic medication, non-adherent to exercise, duration of diabetes, comorbidity, hypertension, low levels of HDL, high levels of LDL, poor glycemic control, and type 2 diabetes mellitus were the factors found to be significantly associated with DN. In multivariable binary logistic regression model fitting, seven variables: age, smoking cigarettes, non-adherence to diet, LDL, drinking alcohol, poor glycemic control, and duration of diabetes were statistically significant determinants of DN at a p-value < 0.05, 95% CI of the AOR. Diabetic patients aged 65 and older were 2.42 times more likely to develop DN than those aged under 65. The odds of developing DN among diabetic patients who have a high level of LDL were 2.97 times more likely than those with a low level of LDL. The likelihood of developing DN was 2.11 times more likely among diabetic patients who did not adhere to their diet when compared to their counterparts. Patients who smoked cigarettes had nearly 2.22 times the risk of developing DN than those who did not. Diabetic patients who were drinking alcohol were 1.95 times more likely to be at risk of developing DN compared to those who were not drinking alcohol. Diabetic patients who had a duration with diabetes of more than 10 years were 3.39 times more likely to be at risk of developing DN compared to those with less than 10 years of diabetes. The odds of developing DN among diabetic patients who have poor glycemic control were approximately 2.19 times more likely at risk than those who have good glycemic control (Table 5).

Discussion

The objective of the study was to identify determinants of nephropathy among diabetic patients on follow-up at public

Table 4. Clinical-related characteristics of diabetic patients on follow-up in public hospitals of Addis Ababa, Ethiopia, 2022.

Variables	Categories	Cases ($n=89$)	Controls ($n=334$)	Total ($n=423$)
		Frequency (%)	Frequency (%)	
Duration of diabetes mellitus (years)	>10	30 (33.71)	42 (12.57)	72 (17.02)
	<10	59 (66.29)	292 (87.43)	351 (82.98)
Type of diabetes mellitus	T1DM	7 (7.87)	53 (15.87)	60 (14.18)
	T2DM	82 (92.13)	281 (84.13)	363 (85.82)
Serum HDL level	Low	31 (34.83)	92 (27.54)	123 (29.08)
	Normal	58 (65.17)	242 (72.46)	300 (70.92)
Serum LDL level	High	57 (64.04)	116 (34.73)	173 (40.9)
	Normal	32 (35.96)	218 (65.27)	250 (59.1)
Glycated hemoglobin (HbA1c) level	>7%	62 (69.66)	145 (43.41)	207 (48.94)
	<7%	27 (30.34)	189 (56.59)	216 (51.06)
Hypertension	Yes	33 (37.08)	79 (23.65)	112 (26.48)
	No	56 (62.92)	255 (76.35)	311 (73.52)
Family history of diabetic nephropathy	Yes	16 (17.98)	52 (15.57)	68 (16.08)
	No	73 (82.02)	282 (84.43)	355 (83.92)
Comorbidity	Yes	24 (26.97)	63 (18.86)	87 (20.57)
	No	65 (73.03)	271 (81.14)	(79.43)

hospitals in Addis Ababa, Ethiopia, in 2022. In this study, the odds of developing DN were 2.42 times more likely among diabetic patients aged 65 or above when compared to those below 65 years. This finding is supported by the study's findings in Indonesia,[26] Taiwan,[27] Korea,[14] Addis Ababa[28] and Tigray, Ethiopia.[18] The observed higher odds among people older than 65 years might be because individuals above 65 years old are more likely to experience a decline in kidney function, particularly a decrease in the glomerular filtration rate, than those under 65.[29] Therefore, clinicians should consider this age-related reduction in kidney function in older patients during follow-up visits so they can offer more opportunities for counseling. Therefore, giving special attention to old age diabetic patients is very important for reducing the complications.

This study also found that the odds of developing DN were approximately three times higher in diabetic patients with high LDL levels than in those with lower levels. This finding is supported by a study conducted in Zimbabwe and Addis Ababa, Ethiopia.[28,30] The possible justification for the observed higher odds of DN among patients with higher LDL might be due to cholesterol and triglyceride metabolism abnormalities, and lipid droplet accumulation. This higher HDL might occur since most diabetic patients do not know the type of foods that increase or decrease their cholesterol level. This indicates that counseling diabetic patients on suggested diets and maintaining their adherence is critical when providing care for diabetic patients and treating the case early.

In addition, diabetic patients who did not follow their diet habits had two times higher odds of developing DN than those who did. This finding is supported by a study conducted in Tigra, Ethiopia.[18] This observed higher odds might be because high protein intake may lead to increased intraglomerular pressures and hyperfiltration.[31] Failure of diabetic patients to adhere to diet recommendations by physicians might be due to a lack of awareness about the association between diet and DN, affordability of recommended diet, self-control on food, and physical activity.[32] Since this study did not focus on study participants' dietary habits, there will be implications for further study addressing this gap. Most of the diabetic patients do not adhere to the dietary plan offered by their doctors or they lack knowledge of diabetic-related complications. As a result, it's essential to educate patients on follow-up treatment, how to follow food regimens suggested by their medical professionals, and the consequences that may arise from non-adherence.

This study identified that the odds of developing DN were approximately two times higher among smokers than among those who did not smoke. This finding was consistent with studies done in India[33] and China.[34] The possible justification for higher odds of developing DN among smokers might be that smoking increases carboxyhemoglobin concentrations, platelet agreeability, and fibrinogen concentrations; these factors then lead to tissue hypoxia and contribute to vascular damage. Furthermore, smoking increases blood pressure and thereby affects kidney function. In addition, diabetic patients who are smokers are less likely to actively engage in self-care or adhere to diabetes care recommendations given by health professionals.[35] Therefore, diabetic patients who smoke are more likely to require clinical interventions and support.

In addition, this study identified that diabetic patients who were drinking alcohol were approximately two times more likely at risk of developing DN as compared to those who do not drink alcohol. The study finding was supported by a study conducted in Tigray, Ethiopia.[19] The possible

Table 5. Bivariable and multivariable binary logistic regression analysis on determinants of DN among diabetic patients on follow-up in public hospitals of Addis Ababa, Ethiopia, 2022.

Variables and their categories	Cases ($n=89$)	Controls ($n=334$)	COR (95% CI)	AOR (95% CI)	p-Value
Age (years)					
>65	28 (31.46)	56 (16.77)	2.28 (1.34, 3.88)	**2.42 (1.28, 4.57)**	**0.006***
<65	61 (68.54)	278 (83.23)	1	1	
Drinking alcohol					
Yes	32 (35.96)	81 (19.16)	1.75 (1.06, 2.89)	**1.95 (1.07, 3.52)**	**0.028***
No	57 (61.8)	253 (80.84)	1	1	
Chewed Khat					
Yes	28 (31.46)	51 (15.27)	2.55 (1.49, 4.36)	1.10 (0.54, 2.16)	0.826
No	61 (68.54)	283 (84.73)	1	1	
Smoking cigarette					
Yes	29 (32.58)	51 (15.27)	2.68 (1.57, 4.58)	**2.22 (1.18, 4.16)**	**0.013***
No	60 (67.42)	283 (84.73)	1	1	
Exercise status					
Non-adhered	56 (62.92)	156 (46.71)	1.94 (1.19, 3.13)	1.34 (0.76, 2.36)	0.304
Adhered	33 (37.08)	178 (53.29)	1	1	
Dietary status					
Non-adhered	60 (67.42)	157 (47.01)	2.33 (1.43, 3.82)	**2.11 (1.15, 3.84)**	**0.015***
Adhered	29 (32.58)	177 (52.99)	1	1	
Medication status					
Non-adhered	56 (62.92)	128 (38.32)	2.73 (1.68, 4.43)	1.59 (0.89, 2.86)	0.116
Adhered	33 (37.08)	206 (61.68)	1	1	
Duration of diabetes (Years)					
>10	30 (33.71)	42 (12.57)	3.54 (2.05, 6.10)	**3.39 (1.76, 6.54)**	**< 0.001****
<10	59 (66.29)	292 (87.43)	1	1	
Low	31 (34.83)	92 (27.54)	1.41 (0.85, 2.31)	1.42 (0.78, 2.57)	0.250
Normal	58 (65.17)	242 (72.46)	1	1	
Serum LDL level					
High	57 (64.04)	116 (34.73)	3.35 (2.05, 5.45)	**2.97 (1.69, 5.19)**	**< 0.001****
Normal	32 (35.96)	218 (65.27)	1	1	
Glycated hemoglobin (HbA1c) level					
>7%	62 (69.66)	145 (43.41)	2.99 (1.81, 4.94)	**2.29 (1.23, 4.28)**	**0.009***
<7%	27 (30.34)	189 (56.59)	1	1	
Type of diabetes mellitus					
T2DM	82 (92.13)	281 (84.13)	2.21 (0.97, 5.05)	1.19 (0.47, 3.07)	0.707
T1DM	7 (7.87)	53 (15.87)	1	1	
Comorbidity					
Yes	24 (26.97)	63 (18.89)	1.59 (0.92, 2.73)	1.48 (0.75, 2.91)	0.260
No	65 (73.03)	271 (81.14)			
Hypertension (HTN)					
Yes	33 (37.08)	79 (23.65)	1.90 (1.16, 3.13)	1.14 (0.59, 2.18)	0.698
No	56 (62.92)	255 (76.35)	1	1	

COR = crude odds ratio; AOR = adjusted odds ratio; CI = confidence interval.
*indicates p-value < 0.05 and greater than 0.001, **indicate p-value < 0.001.
Shows those variables statistically significant at <0.05, [1]Reference.
The bold values indicate those independent variables significantly associated with the outcome variable, whose adjusted odds ratio did not include one.

reason is that Alcohol consumption can worsen blood sugar control in diabetic patients. However, Contrary to this, studies done in Korea,[36] and Zimbabwe[30] show that alcohol consumption is not associated with DN. This is due to differences in study design, or geographical disparities. Despite the fact that moderate alcohol consumption is advised for them, it is the cause of the drop in blood glucose levels. There were no standard measures of the amount or how much they were taking, which is considered one limitations of this study. So, educating the patients about the amount they taking is important, in the levels under guideline.

This study also identified that those diabetic patients who had diabetes for more than 10 years were 3.4 times more likely to develop DN than those who had the disease for less

than 10 years. This finding is in line with studies in Zimbabwe,[30] and Saudi Arabia.[37] However, the findings of studies done in Korea,[36] and Gondar[38] did not support this finding. The reason for the discrepancy in the findings may be due to a difference in study design, study population, and study area, and also, those studies only included study participants of patients with type 2 diabetes mellitus. The possible reason is that high sugar levels in the blood over a long period can seriously damage the blood vessels. The other possible reason may be that most cases of type 2 diabetes are asymptomatic, and most patients were diagnosed too late.

This study also shows that diabetic patients with poor glycemic control were two times more likely to experience DN than those with good glycemic control. This finding is consistent with studies done in Tigray.[18] However, there is inconsistency with a study done in Shakiso,[25] Gondar,[38] Zimbabwe,[30] and China;[39] based on these study findings poor glycemic control was not associated with DN. This difference may be due to study design, and study participants' differences or measurement differences. Poor glycemic control mostly occurs due to a lack of knowledge about self-monitoring of blood glucose and/or the unavailability of glucometers. Therefore, educating each diabetic patient about how to measure their blood glucose and also availing the glucometers for all is a significant contribution to early diagnosis of the glucose level, which helps in early treatment and further reduces the related complications.

There are variables like educational status,[28] hypertension,[17] triglycerides,[28] and diabetic retinopathy[28] were significantly associated in other articles indicated in the listed references but they were not significantly associated with the outcome variable in this study, the possible reason is that (those studies are only done in single hospital, study design difference, sample size, and also study participants). So, this study tried to include many public hospitals in Addis Ababa and a higher (4:1) controls to case ratio which makes the findings more generalizable and gives higher statistical power, respectively. There were missed values of variables like LDL, HDL and haemoglobin A1c (HbA1c) or glycated haemoglobin for some patients, so these missing problem was handled by imputation method of missing data handling method of analysis this was the strength of the study. But, variables like medication type and dietary habits were not included as independent variables as one limitation and Inaddtion to this since data collectors were health professionals, there might have been observer bias are some of limitation of the study.

Conclusions

In this study, smoking cigarettes, non-adherence to diet, drinking alcohol, having a high LDL level, poor glycemic control, duration of diabetes, and age 65 or older were identified as determinants of DN. Therefore, to prevent and delay this serious complication of diabetes one must work intensively on those factors through different strategies, like a continuous health education program at the time of providing care for diabetic patients and their diabetic-related complications. The education given to diabetic patients in line with their care was to strictly follow their dietary plan, quit smoking, and reduce alcohol consumption. Furthermore, those over the age of 65 and those with long-term diabetes will require special attention. Therefore, in light of these findings, targeted interventions should be designed at the follow-up clinic visit to address the risk of developing DN among the risk groups.

Acknowledgements

We would like to express our appreciation to the study participants for their willingness to give samples and required information and to the staff of the diabetes and renal clinic of selected Hospitals of Addis Ababa for their cooperation during the data collection process.

Authors' contributions

DE's conceptualization, design, analysis, interpretation, and report and writing the manuscript was the major contribution to the writing of the research paper. ZB and TA reviewed the design, interpretation, and report writing, and LK, AH, and BF reviewed the design and manuscript writing. All authors read and approved the final manuscript.

Availability of data and materials

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethics approval

Ethical approval with Reference number: AU/PGC/396/2014 was first obtained from the Ethical Review Board of the Ambo University College of Health Sciences Post Graduate Coordinating Office, Then, ethical approval letters were obtained from the Addis Ababa Health Bureau Public Health Research and Emergency Management Directorate (AAPHREM) those hospitals under it Ref. No. A/A/T/2388/227 (For- Menilik Compressive Specialized Hospital, Zewditu Memorial Hospital (ZMH), Yikatit Hospital Medical College (YHMC)), the Institutional Review Board of St. Paul's Millennium Medical College (SPMMC): Ref. No. PM 23/229 and from Research Ethical Review Committee Office (RERCO) of St. Petros' Referral Hospital (SPRH): Protocol/ Version no: V558/11/10/2022.

Informed consent

Before data collection, the data collectors were read the written consent form about the purpose of the study and they were informed

that the information they provided in the following questionnaire would be kept confidential. Thereafter they were told that whether or not they participate in the study will not cause problems in their personal life. The data collectors read this written consent for all study participants and asked them verbally so the study participants could declare that they voluntarily participated in the study.

Trial registration

Not applicable.

ORCID iD

Diriba Etana Tola https://orcid.org/0009-0009-4750-5552

References

1. Levey AS, de Jong PE, Coresh J, et al. The definition, classification, and prognosis of chronic kidney disease: a KDIGO controversies conference report. *Kidney Int* 2010; 80(1): 17–28.
2. Reutens AT. Epidemiology of diabetic kidney disease. *Med Clin North Am* 2013; 97(1): 1–18.
3. Lin YC, Chang YH, Yang SY, et al. Update of pathophysiology and management of diabetic kidney disease. *J Formos Med Assoc* 2018; 117(8): 662–675.
4. Roglic G. Review article WHO global report on diabetes: a summary. *Int J Noncommun Dis* 2016; 1: 3–8.
5. Deng Y, Li N, Wu Y, et al. Global, regional, and national burden of diabetes-related chronic kidney disease from 1990 to 2019. *Front Endocrinol (Lausanne)* 2021; 12: 672350.
6. Al-Shdaifat EA and Manaf MRA. The economic burden of hemodialysis in Jordan. *Indian J Med Sci* 2013; 67(5): 103–116.
7. Hodel NC, Hamad A, Praehauser C, et al. The epidemiology of chronic kidney disease and the association with non-communicable and communicable disorders in a population of sub-Saharan Africa. *PLoS One* 2018; 13(10): e0205326.
8. Thomas B. The global burden of diabetic kidney disease: time trends and gender gaps. *Curr Diab Rep* 2019; 19(4): 18.
9. Wang J, Yen F, Lin K, et al. Epidemiological characteristics of diabetic kidney disease in Taiwan. *J Diabetes Investig* 2021; 12(12): 2112–2123.
10. Ahmed MA, Ferede YM and Takele WW. Incidence and predictors of chronic kidney disease in type-II diabetes mellitus patients attending at the Amhara region referral hospitals, Ethiopia: a follow-up study. *PLoS One* 2022; 17(1): e0263138.
11. Bikbov B, Purcell CA, Levey AS, et al. Articles global, regional, and national burden of chronic kidney disease, 1990–2017: a systematic analysis for the global burden of disease study 2017. *Lancet* 2020; 395(10225): 709–733.
12. FMOH. Ethiopian health sector transformation plan. 2015/16–2019/20. *Fed Democr Repub Ethiop Minist Heal* 2015; 20: 50.
13. Wang G, Ouyang J, Li S, et al. The analysis of risk factors for diabetic nephropathy progression and the construction of a prognostic database for chronic kidney diseases. *J Transl Med* 2019; 17(1): 264.
14. United Nations. *Transforming our world: the 2030 agenda for sustainable development*, 2015.
15. Luyckx VA, Tonelli M and Stanifer JW. The global burden of kidney disease and the sustainable development goals. *Bull World Health Organ* 2018; 96(6): 414–422D.
16. Ethiopia UNSDG in. Sustainable development goals – United Nations in Ethiopia, 2015. https://wedocs.unep.org/20.500.11822/9814
17. Berhanu A. Prevalence and predictors of diabetic kidney disease among diabetes patients in diabetic clinic of Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia: a cross sectional study. 2021.
18. Mariye Zemicheal T, Bahrey Tadesse D, Tasew Atalay H, et al. Determinants of diabetic nephropathy among diabetic patients in general public hospitals of Tigray, Ethiopia, 2018/19. *Int J Endocrinol* 2020; 2020: 6396483.
19. Hintsa S, Dube L, Abay M, et al. Determinants of diabetic nephropathy in Ayder Referral Hospital, Northern Ethiopia: a case-control study. *PLoS One* 2017; 12(4): e0173566.
20. Bian C and Ren H. Sirtuin family and diabetic kidney disease. *Front Endocrinol (Lausanne)* 2022; 13: 901066.
21. Morisky DE, Ang A, Krousel-Wood M, et al. Predictive validity of a medication adherence measure in an outpatient setting. *J Clin Hypertens* 2008; 10(5): 348–354.
22. Barola A, Tiwari P, Bhansali A, et al. Cross-cultural adaptation and psychometric evaluation of Hindi version of diabetes self-management profile—self report in Indian type 1 diabetes patients. *Pediatr Diabetes* 2021; 22(1): 101–111.
23. Geneti Y, Wondwossen K, Adimasu M, et al. Adherence to diabetes self-management and associated factors among adolescents with type 1 diabetes in public hospitals of Addis Ababa, Ethiopia, 2021: a cross_sectional study. *Diabetes Metab Syndr Obes* 2021; 15: 659–670.
24. American Diabetes Association. Glycemic targets: standards of medical care in diabetes. *Diabetes Care* 2018; 41: S55–S64.
25. Tefera G. Determinants of proteinuria among type 2 diabetic patients at Shakiso Health Center, Southern Ethiopia: a retrospective study. *J Infect Dis* 2020; 2(4): 48–54.
26. Samsu N. Review article diabetic nephropathy: challenges in pathogenesis, diagnosis, and treatment. *Biomed Res Int* 2021; 2021: 1497449.
27. Chang PY, Chien LN, Lin YF, et al. Nonadherence of oral antihyperglycemic medication. *Medicine (Baltimore)* 2015; 94(47): e2051.
28. Aberra T, Feleke Y, Tarekegn G, et al. Prevalence and associated factors of diabetic nephropathy at Tikur Anbessa Comprehensive Specialized University. *Afr J Nephrol* 2022; 25(1): 35–45.
29. Toyama T, Kitagawa K, Oshima M, et al. Age differences in the relationships between risk factors and loss of kidney function: a general population cohort study. *BMC Nephrol* 2020; 21: 477.
30. Tapera S. Prevalence and risk factors for diabetes chronic complications in harare Harare. *Medicine (Baltimore)* 2014.
31. Ko GJ, Rhee CM, Kalantar-Zadeh K, et al. The effects of high-protein diets on kidney health and longevity. *J Am Soc Nephrol* 2020; 31(8): 1667–1679.
32. Baral J, Karki KB, Thapa P, et al. Adherence to dietary recommendation and its associated factors among people with type 2 diabetes: a cross-sectional study in Nepal. *J Diabetes Res* 2022; 2022: 6136059.

33. Chakkarwar VA. Smoking in diabetic nephropathy: sparks in the fuel tank? *World J Diabetes* 2012; 3(12): 186.
34. Jiang N, Huang F and Zhang X. Smoking and the risk of diabetic nephropathy in patients with type 1 and type 2 diabetes: a meta-analysis of observational studies. *Oncotarget* 2017; 8(54): 93209–93218.
35. Solberg LI, Desai JR, O'Connor PJ, et al. Diabetic patients who smoke: are they different? *Ann Fam Med* 2004; 2: 26–32.
36. Ahn JH, Yu JH, Ko S-HH, et al. Prevalence and determinants of diabetic nephropathy in Korea: Korea national health and nutrition examination survey. *Diabetes Metab J* 2014; 38(2): 109–119.
37. Al-Rubeaan K, Youssef AM, Subhani SN, et al. Diabetic nephropathy and its risk factors in a society with a type 2 diabetes epidemic: a Saudi National Diabetes Registry-based study. *PLoS One* 2014; 9(2): e88956.
38. Kebede SA, Tusa BS, Weldesenbet AB, et al. Incidence of diabetic nephropathy and its predictors among type 2 diabetes mellitus patients at University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia. *J Nutr Metab* 2021; 2021: 6757916.
39. Xia L, Cheng L, Jiang T, et al. Estimation of the prevalence of type 2 diabetes in combination with diabetic kidney disease and identification of the associated factors in patients attending primary hospitals in Anhui Province, China. *J Int Med Res* 2021; 49(10): 3000605211051225.