



A cross-sectional study to evaluate diabetes management, control and complications in 1631 patients with type 2 diabetes mellitus in Vietnam (DiabCare Asia)

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Abstract

Aims To assess diabetes care delivery and prevention of short- and long-term diabetes-related complications in patients with type 2 diabetes mellitus (T2DM) in Vietnam.

Methods DiabCare Asia is an observational, non-interventional, cross-sectional study of hospital-based outpatient care for patients diagnosed with T2DM.

Results A total of 1631 patients (mean age 62.7 years; 58.9% female) participated in the study. The percentage of patients with HbA1c < 7.0% (< 53 mmol/mol) was 36.1% and mean (standard deviation) HbA1c was 7.9 ± 1.8% (63 ± 19 mmol/mol). The proportion of patients using insulin was 40%, at a mean total daily dose of 35.4 U. Apart from dyslipidemia (81.2%) and hypertension (78.4%), the most common diabetes-related complications were peripheral neuropathy (37.9%) and eye complications (39.5%). Current insulin therapy was associated with peripheral vascular disease (odds ratio [OR] = 2.28 [95% confidence interval (CI) 1.68; 3.09]) and eye complications (OR = 1.70 [95% CI 1.37; 2.11]).

Conclusion In this sample of patients with T2DM in Vietnam, the majority had poor glycemic and metabolic control. Concerted efforts are needed to optimize control and prevent complications in these patients. Trial registration: NCT02066766

Keywords Diabetes mellitus · Hospital care · Prevention · Diabetes complications · Treatment adherence · Hypoglycemia

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Introduction

In 2017, there were 425 million people diagnosed with diabetes worldwide. The Southeast Asia region is home to approximately 82 million people living with diabetes, and there are approximately 159 million people living with diabetes in the Western Pacific region. The prevalence of diabetes in both regions already exceeds that of Europe, South and Central America, and Africa, and, by 2045, the prevalence in the Western Pacific region is expected to reach 183 million [1]. Furthermore, undiagnosed diabetes represents a significant health problem [2], leading to an increase in the burden of disease, which includes diabetes-related complications. Therefore, diabetes presents significant challenges to developing countries in the above regions [2–5]. Between 1990 and 2010, the total disability-adjusted life years (DALYs), a measure of overall disease burden, attributable to diabetes increased by nearly 70%, while DALYs attributed to cardiovascular disease (CVD) and cancer each increased by approximately 25% in the Asia-Pacific region [5].

In Vietnam, the prevalence of diabetes has almost doubled within the past 10 years and has consequently been recognized as a major public health burden. In 2012, the prevalence of diabetes was 5.4%, with an additional 13.7% of individuals exhibiting impaired glucose tolerance. Recent studies have reported a diabetes prevalence of 7.2% in central Vietnam [6–8]. Factors contributing to this increase in prevalence of diabetes in Vietnam include a change in the economic landscape toward a more industrial-based economy, urbanization, a change in dietary habits (i.e., an increase in meat and fat intake), aging of the population, increased tobacco smoking, and an increased prevalence of hypertension [6, 9–11].

Severe micro- and macrovascular complications are common in patients with diabetes, particularly in those with poor glycemic control [12, 13]. There were 480,000 diabetes-related deaths associated with the above complications in people < 60 years of age in the Western Pacific region in 2017 [1]. Treatment costs for diabetes-related complications can be significant, with a recent Vietnamese study reporting that type 2 diabetes mellitus (T2DM) therapy costs 246.10 USD annually per patient [14]—an appreciable cost within the context of the 150 USD average Vietnamese monthly salary.

The series of cross-sectional, observational DiabCare studies aimed to assess diabetes management, control, and diabetes-related complications in patients with T2DM [15–23]. The studies also evaluated both primary and secondary preventative efforts, and patients' treatment adherence to inform healthcare policy and modify diabetes management programs [15–23]. In 1998, DiabCare Asia conducted the first regional survey that included Vietnam [15, 16]. Since this survey, only local and smaller studies have been conducted. Thus, there is a need for national data to inform the treatment and prevention of T2DM and to help raise awareness of diabetes among Vietnamese healthcare professionals (HCPs), as

well as to plan educational programs and the provision of medical insurance. The current DiabCare Asia study aims to report on diabetes management, glycemic and metabolic control, and prevalence of diabetes-related complications in patients with T2DM in Vietnam.

Methods

Study design

DiabCare Asia was an observational, non-interventional, cross-sectional study conducted in Bangladesh, Indonesia, Malaysia, Philippines, Sri Lanka, and Vietnam (Clinicaltrials.gov registration number: NCT02066766). The current manuscript reports data from the Vietnam cohort only, involving diabetes clinics/units of 43 districts, provincial, and central hospitals in Vietnam between April 2015 and August 2015. Due to the observational nature of this study, there were no study-specific visits or investigational products and patients were treated according to routine clinical practice at the discretion of their physician.

Study participants

Patients routinely visiting the centers during the study period were screened for eligibility. Adults > 18 years with T2DM receiving non-pharmacological or pharmacological treatment at a particular center for ≥ 1 year and who had visited the center within the last 3–6 months were included. Patients who had suspected or confirmed pregnancy, or who were unable to comply with protocol requirements (any procedure related to recording of data, including patient interview and completion of questionnaires), were excluded from the study. Patients could withdraw from the study at any time. All patients meeting the inclusion criteria during the recruitment period were enrolled in the study.

Study endpoints

The primary endpoint of the study was the proportion of patients with glycosylated hemoglobin (HbA1c) < 7.0% (< 53 mmol/mol). Secondary endpoints included duration of diabetes, duration and type of antidiabetic treatment, measures of glycemic control and lipid control, and presence of known risk factors or diabetes-related complications. Potential risk factors were analyzed for their relationship with diabetes-related complications. Full details of secondary endpoints and potential risk factors are detailed in [Supplementary Methods](#).

Assessments

Relevant data were collected by patient interview and from patients' medical records and recorded in study-specific case report forms. Data collected from the medical records included demography, medical history, diabetes-related complications, eye and foot examinations, diabetes management, and most recent laboratory investigations performed in the previous year. Blood samples obtained from all patients at study entry were assessed centrally for HbA1c. Patients completed a treatment adherence questionnaire, a hypoglycemia questionnaire, and the EQ-5D health-related quality of life questionnaire [24], as detailed in [Supplementary Methods](#).

Patient data were kept confidential and stored according to local data protection regulations.

Sample size

The prevalence estimates and sample size were estimated based on published data [25]; local external experts advised on the list of clinics visited by most patients for diabetes care, to ensure a representative national sample to fulfill the objectives of the study.

Prevalence of CVD was used as a basis for the sample size target as available literature suggests that this is the least prevalent of all diabetes-related complications and its use confers the maximum possible representativeness to the sample size estimate. Assuming a CVD prevalence of 1%, a sample of 2000 patients from Vietnam was required to attain a 5% level of significance and a 30% margin of error.

Statistical analysis

The full analysis set included all patients enrolled in the study with at least one data point, and was used for all analyses. Missing data were not replaced. Continuous variables were summarized using descriptive statistics (*n*, mean, SD). Categorical variables were presented as number and percentages of patients (%). The number of missing observations is displayed and percentages are calculated based on the total number of patients in each category. For diabetes-related complications, patients with missing values were assumed not to have the complication in question.

The association between potential risk factors and diabetes-related complications was analyzed as detailed in [Supplementary Methods](#).

Results

Patient characteristics

In total, 1631 patients participated in the study. Mean patient age was 62.7 years and the majority of patients (58.9%) were female. Mean duration of diabetes was 9.5 years. A large proportion of patients (39.4%) had a family history of diabetes, 49.2% of patients led a sedentary lifestyle, and 14.1% were current smokers (Table 1).

Diabetes management

The majority of patients (86.3%) were receiving oral or non-insulin injectable therapies, and 40.0% were on insulin treatment at a mean total daily dose of 35.4 U (Table 2).

Table 1 Patient characteristics

Variable	
Age (years)	
<i>N</i>	1631
Mean (SD)	62.7 (10.4)
Gender, <i>N</i> (%)	
Male	671 (41.1)
Female	960 (58.9)
Race, <i>N</i> (%)	
Vietnamese	1626 (99.7)
Danish	2 (0.1)
German	1 (0.1)
Missing	2 (0.1)
Body weight (kg)	
<i>N</i>	1620
Mean (SD)	59.7 (10.4)
BMI (kg/m ²)	
<i>N</i>	1609
Mean (SD)	23.9 (3.5)
Duration of diabetes (years)	
<i>N</i>	1630
Mean (SD)	9.5 (6.5)
Duration of treatment (years)	
<i>N</i>	1630
Mean (SD)	9.3 (6.4)
Duration of OAD treatment (years)	
<i>N</i>	1589
Mean (SD)	8.6 (6.0)
Duration of insulin treatment (years)	
<i>N</i>	674
Mean (SD)	3.8 (3.9)

Demographic parameters and clinical and treatment history data were collected from medical records

BMI, body mass index; *OAD*, oral antidiabetic drug; *SD*, standard deviation

Table 2 Antidiabetic therapies

Variable	
Receiving current oral or non-insulin injectable therapy	
<i>N</i> (%)	1407 (86.3)
Missing	0 (0.0)
Antidiabetic therapy, <i>N</i> (%)	
Metformin	1213 (86.2)
Sulfonylurea	980 (69.7)
Glucosidase inhibitor	208 (14.8)
Thiazolidinedione	8 (0.6)
Herbal	17 (1.2)
Glinide	7 (0.5)
DPP-4 inhibitor	198 (14.1)
GLP-1RA	2 (0.1)
Missing	1 (0.1)
Receiving current insulin therapy	
<i>N</i> (%)	653 (40.0)
Missing	1 (0.1)
Insulin injection type, <i>N</i> (%)	
Pen	420 (64.3)
Vial/syringe	231 (35.4)
Missing	2 (0.3)
Insulin regimen, <i>N</i> (%)	
Basal + OAD	97 (14.9)
Basal–bolus	38 (5.8)
Premix BID	416 (63.7)
Premix OD	17 (2.6)
Premix TID	42 (6.4)
Other	41 (6.3)
Missing	2 (0.3)
Number of daily injections	
<i>N</i>	651
Missing	2
Mean (SD)	2.1 (0.7)
Total daily insulin dose (U)	
<i>N</i>	638
Missing	15
Mean (SD)	35.4 (18.1)

Treatment history data were collected from medical records

BID, twice daily; *DPP-4*, dipeptidyl peptidase-4; *GLP-1RA*, glucagon-like peptide-1 receptor agonist; *OAD*, oral antidiabetic drug; *OD*, once daily; *TID*, three times daily

The most commonly used oral antidiabetic drug (OAD) was metformin (86.2%) and the most commonly prescribed insulin regimen was premix twice-daily (BID) (63.7%). Most patients had been evaluated for HbA1c (91.9%) in the previous year (Table 3), with a mean of 2.8 tests per year.

Treatment adherence

A large proportion of patients only partially adhered to clinical recommendations regarding diet (47.8%) and

Table 3 Glycemic and metabolic parameters

Variable	
HbA1c	
<i>N</i>	1622
Mean (SD), %	7.9 (1.8)
Mean (SD), mmol/mol	63 (19)
HbA1c categories, <i>N</i> (%)	
< 7.0% (< 53 mmol/mol)	589 (36.1)
7.0–< 8.0% (53–< 64 mmol/mol)	397 (24.3)
8.0–< 9.0% (64–< 75 mmol/mol)	282 (17.3)
9.0–< 10.0% (75–86 mmol/mol)	158 (9.7)
≥ 10.0% (≥ 86 mmol/mol)	196 (12.0)
Missing	9 (0.6)
HbA1c tested in last year	
<i>N</i> (%)	1499 (91.9)
Missing	7 (0.4)
Number of HbA1c tests in previous year	
<i>N</i>	1437
Mean (SD)	2.8 (1.2)
SMBG tested in last year	
<i>N</i> (%)	773 (47.4)
Missing	2 (0.1)
Number of SMBG tests in previous year	
<i>N</i>	764
Mean (SD)	6.2 (8.6)
FPG (mmol/l)	
<i>N</i>	1592
Mean (SD)	8.0 (2.7)
PPG (mmol/l)	
<i>N</i>	492
Mean (SD)	11.6 (4.0)
Systolic blood pressure (mmHg)	
<i>N</i>	1618
Mean (SD)	129.1 (15.9)
Diastolic blood pressure (mmHg)	
<i>N</i>	1618
Mean (SD)	76.6 (8.6)
Total cholesterol (mmol/l)	
<i>N</i>	1436
Mean (SD)	7.6 (27.4)
HDL cholesterol (mmol/l)	
<i>N</i>	1394
Mean (SD)	1.9 (6.8)
LDL cholesterol (mmol/l)	
<i>N</i>	1377
Mean (SD)	5.0 (20.6)
Triglycerides (mmol/l)	
<i>N</i>	1443
Mean (SD)	5.4 (12.7)

Blood samples were obtained from all patients at study entry for HbA1c assessment by a central laboratory. Clinical history and data from most recent laboratory investigations within the past year were collected from medical records

FPG, fasting plasma glucose; *HDL*, high-density lipoprotein; *LDL*, low-density lipoprotein; *PPG*, postprandial plasma glucose; *SD*, standard deviation; *SMBG*, self-measured blood glucose

exercise (37.8%; Supplementary Table 1). Many patients never self-tested (40.6%), 9.0% of patients did not fully adhere to their prescribed medications, and 10.7% did not completely adhere to scheduled appointments with HCPs.

Glycemic and metabolic endpoints

Mean HbA1c was $7.9\% \pm 1.8\%$ (63 ± 19 mmol/mol; Table 3). HbA1c target of $< 7.0\%$ (< 53 mmol/mol), as recommended by the American Diabetes Association (ADA) [25], was met by 36.1% of patients, with 51.3% of patients having HbA1c of 7.0 – $< 10.0\%$ (53 – < 86 mmol/mol) and 12.0% of patients having HbA1c $\geq 10.0\%$ (≥ 86 mmol/mol).

A high proportion of patients (78.4%) had hypertension (defined as [i] currently taking medication for hypertension, or [ii] systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg), and 74.9% were receiving anti-hypertensive medication. There was also a high proportion of patients (81.2%) with dyslipidemia (defined as [i] low-density lipoprotein [LDL] cholesterol > 2.6 mmol/l, or [ii] high-density lipoprotein [HDL] cholesterol < 1.0 mmol/l in males and < 1.3 mmol/l in females, or [iii] triglycerides > 1.7 mmol/l or currently taking medication for dyslipidemia), and 69.8% were on dyslipidemia medication.

Diabetes-related complications and management

Aside from hypertension and dyslipidemia, the most prevalent complications were peripheral neuropathy (37.9%) and eye complications (39.5%; Table 4). One-third of patients (33.4%) had cardiovascular complications, of which angina was the most frequently reported (19.9%), and almost a quarter of patients had renal complications (24.1%).

Anti-hypertensive treatment (angiotensin-converting-enzyme inhibitors and/or angiotensin-receptor blockers) was the most common intervention for primary and secondary prevention of complications (47.8% and 46.8%, respectively), followed by lipid-lowering treatment (statins; 47.1% and 40.3%, respectively), and anti-platelet treatment (aspirin; 22.8% and 22.7%, respectively). A small proportion of patients were on primary and secondary foot ulcer prevention programs (9.3% and 5.7%, respectively), or foot ulcer special care treatment (8.9%). Over the previous 2 years, 62.0% and 46.4% of patients had been screened for eye complications and peripheral neuropathy, respectively.

In the multivariate analysis assessing potential risk factors for diabetes complications, dyslipidemia was independently associated with age (adjusted OR, 1.01), male gender (OR, 1.33), and fasting plasma glucose (FPG) (OR, 0.95; Table 5). Hypertension was independently associated with use of multiple OADs (OR, 0.71), insulin therapy (OR, 0.37), body mass index (BMI) (OR, 0.85), and age (OR, 0.92).

Diabetes duration was associated with peripheral vascular disease (OR, 1.03), diabetic nephropathy (OR, 1.05) and eye complications (OR, 1.06). Current treatment with insulin, and hypertension were both independently associated with higher odds of cardiovascular complications (OR, 1.46 and 2.88, respectively), peripheral vascular disease (OR, 2.28 and

Table 4 Proportion of patients with diabetes-related complications

Complication, <i>N</i> (%)	All subjects (<i>N</i> = 1631)
Dyslipidemia ^a	1324 (81.2)
Missing	1 (0.1)
Hypertension ^b	1278 (78.4)
Missing	0 (0.0)
Any recorded eye complications	644 (39.5)
Missing	10 (0.6)
Cataract	467 (28.6)
Missing	11 (0.7)
Non-proliferative diabetic retinopathy	213 (13.1)
Missing	16 (1.0)
Diabetic retinopathy	189 (11.6)
Missing	15 (0.9)
Proliferative diabetic retinopathy	73 (4.5)
Missing	16 (0.1)
Severe vision loss	52 (3.2)
Missing	10 (0.6)
Macular edema	42 (2.6)
Missing	16 (0.1)
Peripheral neuropathy	618 (37.9)
Missing	4 (0.2)
Erectile dysfunction ^c	223 (33.2)
Missing	2 (0.3)
Any recorded cardiovascular complications	544 (33.4)
Missing	1 (0.1)
Angina	324 (19.9)
Missing	2 (0.1)
Peripheral vascular disease	188 (11.5)
Missing	1 (0.1)
Left ventricular hypertrophy	158 (9.7)
Missing	1 (0.1)
Stroke	71 (4.4)
Missing	1 (0.1)
Myocardial infarction	45 (2.8)
Missing	1 (0.1)
Congestive heart failure	15 (0.9)
Missing	2 (0.1)
Atrial fibrillation	10 (0.6)
Missing	1 (0.1)
Any recorded renal complication	393 (24.1)
Missing	3 (0.2)
Microalbuminuria	343 (21.0)
Missing	67 (4.1)
Gross proteinuria	183 (11.2)
Missing	55 (3.4)
End-stage renal disease	26 (1.6)
Missing	3 (0.2)
Dialysis	5 (0.3)
Missing	3 (0.2)
Any recorded foot complications	103 (6.3)
Missing	1 (0.1)
Healed ulcer	82 (5.0)
Missing	2 (0.1)
Ulcer infection	51 (3.1)
Missing	1 (0.1)

Table 4 (continued)

Complication, <i>N</i> (%)	All subjects (<i>N</i> = 1631)
Active ulcer	22 (1.3)
Missing	1 (0.1)
History of amputation	14 (0.9)
Missing	1 (0.1)

^a Dyslipidemia: (i) LDL cholesterol > 2.6 mmol/l or (ii) HDL cholesterol < 1.0 mmol/l in males and < 1.3 mmol/l in females, or (iii) TG > 1.7 mmol/l or currently taking medication for dyslipidemia

^b Hypertension: (i) currently taking medication for hypertension, or (ii) systolic blood pressure \geq 140 mmHg, or diastolic blood pressure \geq 90 mmHg

^c Based on the total number of male patients (*n* = 671). Diabetes-related complication data were collected from medical records. Patients with missing observations were assumed not to have the complication in question

HDL, high-density lipoprotein; *LDL*, low-density lipoprotein; *TG*, triglycerides

1.93, respectively), diabetic nephropathy (OR, 1.94 and 1.67, respectively), and eye complications (OR, 1.70 and 1.27, respectively). HbA1c was associated with cardiovascular complications (OR, 1.07), peripheral vascular disease (OR, 1.09), and eye complications (OR, 1.06).

Hypoglycemic episodes

Symptoms of mild, moderate, severe, and nocturnal hypoglycemia within the previous 3 months were reported by 39.7%, 2.8%, 1.3%, and 8.2% of patients, respectively (Supplementary Table 2). Among patients who had experienced hypoglycemia, most (88.6%) did not check their blood glucose or only checked it occasionally, and only 10.6% of patients always measured their blood glucose when a hypoglycemic event occurred. Most patients (97.1%) who had experienced hypoglycemia did not visit or only occasionally visited a hospital during an event. Following a hypoglycemic episode, 88.8% snacked between meals and 8.2% of patients skipped or reduced their diabetes medications. Most patients (59.8%) indicated that they were not worried about hypoglycemia.

EQ-5D VAS and health status questionnaire

Patients reported a healthy state of overall well-being on the EQ-5D visual analogue scale (VAS), with a mean (\pm SD) score of 71.3 ± 16.9 (on a scale of 0–100). However, in the EQ-5D health status questionnaire, many patients reported moderate pain or discomfort (32.6%), and moderate anxiety or depression (26.8%; Supplementary Table 3).

Discussion

This study provides an overview of the status of diabetes care in patients with T2DM treated in various hospital care settings in Vietnam in 2015. With regard to the primary endpoint, 36.1% of patients had HbA1c < 7.0% (< 53 mmol/mol) and the mean HbA1c was 7.9% (63 mmol/mol). This study was similar in design to the DiabCare Asia 1998 study, which also recruited all eligible patients with T2DM treated at hospital or referral clinics in Vietnam. The DiabCare Asia 1998 study group reported that 18% of patients in Vietnam had HbA1c < 7.0% (< 53 mmol/mol) and a mean HbA1c of 8.9% (74 mmol/mol) [15]. Thus, the current data indicate that glycemic control has improved from 1998 to the present day and suggest an improvement in the standard of care for patients with T2DM in Vietnam.

While these data indicate that the proportion of patients with T2DM in Vietnam achieving recommended glycemic targets has increased over time, the majority of the cohort (i.e., around 63%) had HbA1c > 7.0% (> 53 mmol/mol), with a notable minority (12%) of patients presenting with HbA1c \geq 10.0% (\geq 86 mmol/mol). Several possible reasons may underlie this suboptimal glycemic control. Firstly, the frequency of testing was lower than that recommended by the ADA [26], with many patients not monitoring their blood glucose levels at all in the past year. This lack of testing may be attributable to public health factors such as no local provision for testing and a lack of health insurance cover; health insurance was only introduced in Vietnam in the last two decades and is still not universal [27]. Secondly, a high proportion of patients did not adhere to treatment-related advice and a substantial proportion did not adhere to their prescribed treatment regimens. Thirdly, about half of the patient cohort led a sedentary lifestyle with no exercise. Finally, the prevalence of diabetes in Vietnam is increasing due to an aging population, and changes in lifestyle and dietary patterns, resulting in a significant public health burden [6].

The Vietnamese government has unveiled a national strategy for non-communicable diseases for 2015–2025 that explicitly includes the control and prevention of diabetes. In order for this goal to be achieved, the current data indicate that more work is required within diabetes treatment services in Vietnam. In particular, these findings emphasize the need to promote frequent HbA1c testing and improve patient adherence to lifestyle modification and medication. To improve the quality of care, the ADA advocates that diabetes services should follow the chronic care model [27]. Moreover, recruitment of specialist staff such as nutritionists and diabetes specialist nurses may be needed in Vietnam. Educational programs delivered by diabetes educators would also likely improve outcomes in Vietnamese patients diagnosed with T2DM.

Patients with T2DM are predisposed to developing hypertension and dyslipidemia, which are known to increase the risk of late complications such as end-stage renal failure and cardiovascular events [28–31]. In this study, the high proportion of patients

Table 5 Risk factors for diabetes complications using univariate and multivariate logistic regression analysis

Variables	Age	Gender	Duration of diabetes	BMI	Receiving insulin therapy	Use of multiple OADs	HbA1c	SMBG testing	Hypertension	FPG
Univariate analysis										
Cardiovascular complications	1.03 (1.02;1.04)***	0.92 (0.74;1.13)	1.04 (1.02;1.06)***	1.01 (0.98;1.04)	2.01 (1.63;2.48)***	0.77 (0.60;0.98)*	1.09 (1.03;1.16)**	0.99 (0.80;1.22)	3.63 (2.65; 4.97)***	1.03 (0.99;1.07)
Peripheral vascular disease	1.03 (1.01;1.05)***	1.27 (0.94;1.72)	1.05 (1.03;1.08)***	0.95 (0.91;1.00)*	3.26 (2.37;4.49)***	0.64 (0.44;0.92)*	1.13 (1.05;1.22)**	1.05 (0.77;1.42)	2.38 (1.49;3.81)***	1.01 (0.96;1.07)
Diabetic nephropathy	1.04 (1.03;1.05)***	0.98 (0.77;1.23)	1.10 (1.08;1.12)***	1.00 (0.97;1.03)	2.99 (2.37;3.78)***	0.87 (0.66;1.14)	1.11 (1.04;1.18)***	1.34 (1.07;1.69)*	2.50 (1.79;3.48)***	1.08 (1.04;1.13)***
Eye complications	1.07 (1.06;1.08)***	0.89 (0.73;1.09)	1.10 (1.08;1.12)***	0.96 (0.93;0.99)**	2.40 (1.96;2.95)***	0.80 (0.63;1.02)	1.11 (1.05;1.17)***	1.54 (1.26;1.88)***	2.34 (1.79;3.05)***	1.03 (0.99;1.07)
Dyslipidemia	0.99 (0.98;1.00)	0.74 (0.57;0.95)*	0.99 (0.97;1.01)	1.03 (0.99;1.07)	0.74 (0.58;0.95)*	0.72 (0.52;0.99)*	1.00 (0.94;1.08)	1.04 (0.81;1.33)	0.90 (0.66;1.22)	1.02 (0.98;1.08)
Hypertension	1.08 (1.06;1.09)***	0.71 (0.56;0.91)**	1.08 (1.05;1.10)***	1.15 (1.10;1.19)***	2.07 (1.60;2.68)***	0.99 (0.75;1.31)	1.04 (0.97;1.12)	1.27 (1.00;1.61)*	–	1.01 (0.97;1.06)
Multivariate analysis										
Cardiovascular complications	1.01 (1.00;1.02)**	1.15 (0.96;1.38)	1.00 (0.99;1.02)	–	1.46 (1.19;1.81)***	–	1.07 (1.02;1.14)*	0.80 (0.67;0.95)*	2.88 (2.22;3.74)***	–
Peripheral vascular disease	1.01 (0.99;1.02)	1.57 (1.19;2.06)**	1.03 (1.01;1.05)*	0.92 (0.89;0.97)***	2.28 (1.68;3.09)***	–	1.09 (1.01;1.18)*	–	1.93 (1.28;2.92)***	–
Diabetic nephropathy	1.04 (1.02;1.05)***	1.17 (0.95;1.43)	1.05 (1.03;1.07)***	–	1.94 (1.56;2.41)***	–	–	–	1.67 (1.25;2.23)***	1.08 (1.05;1.13)***
Eye complications	1.06 (1.05;1.07)***	1.01 (0.84;1.22)	1.06 (1.04;1.08)***	0.96 (0.94;0.99)**	1.70 (1.37;2.11)***	–	1.06 (1.00;1.12)*	1.24 (1.04;1.48)*	1.27 (1.00;1.62)*	–
Dyslipidemia	1.01 (1.00;1.02)*	1.33 (1.08;1.65)**	1.01 (1.00;1.03)	–	–	–	–	–	–	0.95 (0.91;0.99)*
Hypertension	0.92(0.91;0.93)***	0.99 (0.81;1.22)	0.99 (0.97;1.01)	0.85 (0.83;0.88)***	0.37 (0.28;0.50)***	0.71 (0.53;0.95)*	–	–	–	–

Hypertension: (i) currently taking medication for hypertension, or (ii) systolic blood pressure \geq 140 mmHg, or diastolic blood pressure \geq 90 mmHg. Dyslipidemia: (i) LDL cholesterol $>$ 2.6 mmol/l or (ii) HDL cholesterol $<$ 1.0 mmol/l in males and $<$ 1.3 mmol/l in females, or (iii) TG $>$ 1.7 mmol/l or currently taking medication for dyslipidemia

BMI, body mass index; CI, confidence interval; FPG, fasting plasma glucose; OAD, oral antidiabetic drug; SMBG, self-measured blood glucose; TG, triglyceride

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Data are presented as odds ratios (95% CI)

with dyslipidemia (81.2%) and hypertension (78.4%) irrespective of treatment for these conditions is a cause for concern. Indeed, the prevalence of hypertension was higher in the current study (78.4%) than reported in DiabCare Asia 1998 (61.0%) [15]. Interestingly, it was found that treatment with multiple OADs, current use of insulin therapy, BMI, and age were associated with hypertension in the patient cohort. This corroborates previous research indicating that older age and OAD use is associated with poor blood pressure control in patients with diabetes [32]. The relationship between insulin and hypertension may require further analysis, as insulin use can indicate late-phase diabetes in which hypertension may be more common compared with earlier stages in the disease pathway [33]. Age, male gender, and FPG were significantly associated with dyslipidemia. The lack of a significant association between HbA1c and dyslipidemia was perhaps surprising based on previous research [34–36].

Diabetes-related complications were prevalent, with the most common (excluding hypertension and dyslipidemia) being eye complications and peripheral neuropathy—both of which, encouragingly, were screened for in a relatively high proportion of patients (e.g., 62.0% of patients had been screened for eye complications). The previous DiabCare Asia 1998 study reported the most common complications in patients with T2DM were cataract, neuropathy, and retinopathy [15]. Neuropathy was only slightly more common in the current study compared with DiabCare Asia 1998, occurring in 37.9% and 35.0% of patients, respectively [15]. Eye complications were significantly associated with the most common risk factors observed in the current study (age, diabetes duration, BMI, current insulin therapy, HbA1c, and hypertension). Microalbuminuria occurred in 21% of patients in the current study compared with 45% of patients in DiabCare Asia 1998. This finding could be explained by the increased use of medications that reduce albuminuria, such as inhibitors of the renin-angiotensin-aldosterone system. These findings emphasize the importance of early identification of patients at risk of developing diabetes-related complications and implementing more effective preventative efforts—primarily targeted at improving overall glycemic and metabolic control—in Vietnam [12, 13, 37].

It is now well recognized that hypoglycemia can have deleterious physical and psychological consequences that can significantly impact the functioning of patients with diabetes [38, 39]. In the current study, patient responses to the hypoglycemia questionnaire showed that the majority did not check or only occasionally checked their blood glucose during a hypoglycemic event. Furthermore, around one-third of patients skipped or reduced their diabetes medications following an episode. These findings call for strategies to increase patients' awareness of the benefits of diabetes treatment, and for the development of measures to avoid and/or mitigate the impact of hypoglycemia in patients with T2DM in Vietnam.

There are several limitations to the current study. Due to the cross-sectional, observational design of the study, it was not possible to draw conclusions on the cause-and-effect relationship between risk factors and dyslipidemia, hypertension, and various diabetes-related complications. As all centers offered specialized diabetes care services, patients attending these centers who were eligible for study enrollment may not be representative of the Vietnamese T2DM patient population. The relatively high prevalence of CVD may reflect that patients attending these centers had more advanced disease than the general Vietnamese T2DM population. Treatment adherence, hypoglycemia, and EQ-5D were self-reported and, consequently, the estimates may have been subject to recall and/or desirability bias. Also, due to the retrospective collection of laboratory findings (aside from HbA1c), it was not possible to fully assess the glycemic control and lipid control status in the entire study cohort. Some important aspects of diabetes management, including patient literacy, were also not assessed, and it would have been interesting to ascertain the number of HCPs adhering to national guidelines on diabetes care. Lastly, the patient sample size was smaller than planned due to administration delays and financial constraints; nevertheless, the relatively large number of patients allow for valid observations to be drawn.

Conclusion

While glycemic control in patients with T2DM has improved in Vietnam from 1998 to the present day, most patients still have unsatisfactory glycemic and metabolic control, with a high prevalence of diabetes-related complications and suboptimal treatment adherence. Improvements in diabetes services are likely needed to better these outcomes. Finally, future studies are needed to continue to monitor diabetes care in Vietnam and to direct and improve diabetes management.

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Data accessibility The subject level analysis data sets for the research presented in the publication are available from the corresponding author on reasonable request.

Author contributions KTN revised the protocol before disseminating it to the sites and followed up all the data collecting process of the study in all sites before the analysis. All authors contributed to subject recruitment, data collection, review and discussion of the trial report, and review and discussion of the manuscript.

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Compliance with ethical standards

Ethical approval The study was conducted in accordance with the Declaration of Helsinki [40] and the Guidelines for Good Pharmacoepidemiology Practice (GPP) [41].

Informed consent Before any study-related activity, eligible patients were provided with oral and written study information, and their informed consent was obtained.

Conflict of interest Dr. KTN has received honoraria for lectures and meeting chairs from Abbott, Astra Zeneca, Aventis, Boehringer Ingelheim, MSD, Novo Nordisk, Sanofi, and Servier. Dr. BTDD, Dr. VKDN, Dr. HVL, Dr. KQT and Dr. NQT have nothing to disclose.

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