

Macrovascular and Microvascular Complications of Diabetic Patients: Study form in Gatak Primary Health Care, Sukoharjo, Indonesia

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Abstract

Background: Diabetes is a major global health problem, and Indonesia being one of the countries with high prevalence. Fasting plasma glucose (FPG) and HbA1c are the main biomarkers used to assess glycaemic control. Screening for macrovascular and microvascular complications is necessary for early intervention to prevent permanent disability. This study aimed to determine the incidence of macrovascular and microvascular complications in diabetic patients in primary health care.

Methods: A descriptive cross-sectional study was conducted from July to September 2022 among patients with diabetes who routinely attended Gatak Primary Health Care. Screening for macrovascular complications included PAD with Ankle-Brachial Index assessment; whereas the microvascular complications using monofilament testing for neuropathy, eye examination for retinopathy, and microalbuminuria for nephropathy.

Result: Among 65 patients with diabetes, most were female (83.1%), with a mean age of 62.43±9.47 years. The mean fasting plasma glucose (FPG) was 192.62±86.92 mg/dl, and the mean HbA1c was 12.55±3.59%. Both macrovascular complication (PAD 32.3%) and microvascular complications (retinopathy 57.1%, neuropathy 44.9%, nephropathy 49.2%) were identified, demonstrating the burden of diabetes-related outcomes in primary care.

Conclusion: Macrovascular and microvascular complications were highly prevalent among patients with diabetes in primary care, with microvascular complications occurring more frequently. These findings indicate that inadequate glycaemic control contributes substantially to complication rates.

Keywords: Diabetes mellitus, macrovascular complications, microvascular complications, primary health care

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Introduction

Diabetes mellitus (DM) is the ninth leading cause of death in the world. Globally, there are 463 million people, and approximately 1 in 11 adults suffers from type 2 diabetes mellitus (T2DM) with Asia is the first rank in the global epidemic of T2DM.¹ Indonesia is among the 10 countries with the highest number

of individuals with diabetes worldwide. Approximately 10.7 million Indonesians aged over 20 years are living with diabetes mellitus. In Central Java Province, the prevalence of diabetes is 2.1%, corresponding to an estimated 96,794 cases.²

It is estimated that 45.8% of diabetes cases in adults remain undiagnosed. Individuals with undiagnosed and untreated diabetes face

a higher risk of complications compared to those receiving treatment. These long-term complications increase illness, death rates, and reduce quality of life. Main complications include macrovascular issues (e.g., stroke, coronary heart disease, and peripheral arterial disease) and microvascular problems (e.g., kidney disease, nerve damage, and vision disorders like retinopathy).^{3,4} Diabetes mellitus is also recognized as a comorbid condition associated with increased disease severity among patients with coronavirus disease 2019 (COVID-19)³ Therefore, screening for diabetic complications in outpatient settings is essential, particularly for primary and secondary prevention, to enable early intervention before irreversible complications develop.

Maintaining glycemic control is of paramount concern in the effective management of DM as evidenced by the direct correlation between elevated HbA1C levels and an augmented risk of diabetic complications, such as microvascular and cardiovascular sequelae.⁴ Centre of Disease Control and Prevention (CDC) data and studies have shown that these chronic complications are related to HbA1c levels. A 1% decrease in HbA1c can reduce the risk of developing macrovascular and microvascular complications by up to 40%.⁵⁻⁶ Other important related parameters include blood glucose profile (fasting and two hours after eating), lipid profile, body mass index (BMI), and smoking status.⁶ This study aimed to determine the incidence of macro and micro complications in diabetic patients treated at the Gatak Primary Health Care in Sukoharjo, Central Java, Indonesia.

Methods

This descriptive observational study with a cross-sectional design was conducted from July to September 2022 at Gatak Primary Health Care, Sukoharjo, Central Java, Indonesia. The study included patients with diabetes mellitus aged >20 years who routinely attended follow-up visits. To minimize bias from pre-existing conditions, individuals with a history of amputation, acute coronary syndrome (ACS), stroke with lasting effects (sequelae), or impaired renal function (creatinine >1.5 mg/dL) prior to diabetes diagnosis were excluded. Ethical clearance has been obtained from the Ethical Clearance Committee of the Faculty of Medicine, Muhammadiyah University, Surakarta (No. 3044/B.2/KEPKFKUMS/IX/2022).

After informed consent was obtained primary data were collected through structured interviews, including demographic information. Diabetes diagnosis was confirmed using venous blood sampling which were fasting plasma glucose (FPG) and HbA1C level. Glucose status was designated as normal (FPG <100 mg/dL) and prediabetes/diabetes (≥ 100 mg/dL); whereas glycemic control was grouped as controlled (HbA1c <7%) and uncontrolled (HbA1c $\geq 7\%$).

Diabetic subsequently evaluated. Peripheral arterial disease (PAD) was assessed using the ankle-brachial index (ABI ≤ 0.90) measured by Doppler duplex ultrasonography. Diabetic retinopathy was evaluated by ophthalmologists using direct ophthalmoscopy to identify nonproliferative findings, including microaneurysms, hard exudates, and hemorrhages, or proliferative findings characterized by abnormal blood vessel proliferation. Diabetic neuropathy was assessed, according to the criteria of the American Academy of Neurology using at least two of five indicators, including symptoms, clinical signs, and monofilament sensation testing with a 10-g filament. Results were categorized as positive or negative.⁷

Anthropometric and clinical parameters included body mass index (BMI), calculated as kg/m^2 and classified as normal (18.5–24.9) or overweight (25.0–29.9) based on WHO standards. Blood pressure categorized into normotension (<120/80 mmHg), prehypertension (120–139/80–89 mmHg), or hypertension ($\geq 140/90$ mmHg). Waist circumference was measured with WHO thresholds for male ≤ 102 cm and for female ≤ 88 cm).⁸

Data were analyzed using the Statistical Package for Social Science (SPSS) software version 25.0. Univariate analysis was conducted to assess the distribution of data on anthropometric and clinical parameters as well as laboratory data and complications that occurred.

Results

A total of 65 diabetes patients were included in this study, predominantly women (83.1%) with an average age of 62.43 ± 9.47 years as shown in Table 1.

Only 20% of participants achieved the glycemic target (HbA1c <7%), and most of these patients were aged ≥ 60 years. Normal fasting plasma glucose levels were observed in only 27.7% of participants. Most patients

Table 1 Demography of Diabetic Patients Attending Gatak Primary Health Care In Sukoharjo, Central Jawa, Indonesia (n=65)

Variable	Mean±SD	n	%
Gender			
Male		11	16.9
Female		54	83.1
Age (years)	62.43±9.47		
<60		28	43.1
≥60		37	56.9

Note: SD=standard deviation

(79%) had normal body mass index values, whereas neuropathy was identified in 43.1% of patients (Table 2).

Laboratory findings revealed poor glycemic control (HbA1c ≥7%) in 52 patients (80%) and elevated fasting glucose in 47 patients (72.3%). The present study found that 53 patients (82.5%) exhibited abnormal blood pressure, with a mean systolic pressure of 148.24±19.44 mmHg and a mean diastolic pressure of 87.11±17.18 mmHg. A normal BMI was observed in 51 patients (79%). With regard to the occurrence of complications, diabetic retinopathy was identified in 37 patients (57.1%), while cataracts were observed in

Table 2 Clinical and Laboratory Characteristics of Patients with Diabetes Mellitus Attending Gatak Primary Health Care, Sukoharjo, Central Jawa, Indonesia (n= 65)

Variable	Mean ± SD	n	%
Blood Pressure (mmHg)			
Systolic	148.24±19.44		
Diastolic	87.11±17.18		
Normotension*		12	17.5
Elevated blood pressure**		53	82.5
Body mass index (kg/m ²)			
Normal (18.5–24.9)		51	79
Overweight (25.0–29.9)		14	21
Waist Circumference			
Acceptable (male ≤102 cm; female ≤88 cm))		30	47.3
Elevated (male >102 cm; female >88 cm)		35	52.7
Fasting plasma glucose (mg/dL)	192.62±86.92		
Normal (<100)		18	27.7
Elevated (≥100)		47	72.3
HbA1c (%)	12.55±3.59		
Controlled (<7)		13	20
Uncontrolled (≥7)		52	80
Microalbuminuria			
<30 mg/dL		33	50.8
≥30 mg/dL		32	49.2
Diabetic retinopathy			
No Retinopathy		24	36.9
Diabetic Retinopathy		37	57.1
Cataract		4	6
Neuropathy (monofilament test)			
Yes		28	43.1

Table 2 Continued

Variable	Mean ± SD	n	%
No		37	56.9
Ankle-brachial index	1.006±0.28		
Normal		39	60
Peripheral arterial disease		21	32.3
Arteriosclerosis		5	7.7

Note: SD, Standard Deviation; FPG, Fasting Plasma luucose; PAD, peripheral artery disease. * Normotension: systolic blood pressure <120 mmHg and diastolic blood pressure <80 mmHg. ** Elevated blood pressure includes prehypertension (systolic 120–139 mmHg or diastolic 80–89 mmHg) and hypertension (systolic ≥140 mmHg or diastolic ≥90 mmHg)

4 patients (6%), and no retinopathy was detected in 24 patients (36.9%). Peripheral artery disease (PAD) was detected in 21 patients (32.3%), and arteriosclerosis in 5 patients (7.7%) (Table 2). As shown in Table 3, comparisons between age groups (<60 years vs. ≥60 years) and between genders (male vs. female) revealed no statistically significant differences across almost all assessed parameters. No significant associations were identified between age group or sex and the presence of neuropathy, HbA1c levels, FPG, diabetic retinopathy, BMI, blood pressure, PAD, or microalbuminuria. However, a significant difference was observed between sexes regarding waist circumference ($p=0.004$).

Furthermore, the study revealed that there were more females than male with normotension, while 82.5% presented with hypertension (systolic >140 mmHg and/or diastolic >90 mmHg) for the age groups between <60 years old and ≥60 years old ($p=0.379$ and $p=0.820$, respectively). The ophthalmoscopic evaluation of patients by certified ophthalmologists revealed diabetic retinopathy in 57.1%; meanwhile, the gender comparison between male and female was also not significant ($p=0.246$). Doppler duplex ultrasound screenings demonstrated peripheral arterial disease (ABI ≤0.90) in 32.3% and atherosclerotic lesions in 7.7%

Waist circumference measurements based on World Health Organization criteria showed that 47.3% of participants were within acceptable thresholds, whereas 52.7% exceeded the recommended limits. Interestingly, the comparison of waist circumference by gender demonstrated a significant difference ($p=0.004$) between the acceptable and unacceptable thresholds. In contrast to the findings related to BMI, the groups with normal and overweight BMI, stratified by age and gender, did not show

significant differences, whether by age (<60 years and >60 years) or sex ($p=0.360$ and $p=0.245$, respectively). The findings revealed no statistically significant differences in the prevalence of neuropathy based on age or gender ($p=0.206$ and $p=0.399$, respectively).

Discussion

A substantial prevalence of macrovascular and microvascular complications was identified among patients with diabetes mellitus (DM) within primary healthcare settings. Diabetic retinopathy was the most demonstrating the considerable burden of diabetes-related morbidity in this population.

Previous studies conducted in other primary health care setting in Indonesia have identified several factors contributing to poor glycemic control, including limited knowledge regarding diabetes management, nonadherence to dietary recommendations, insufficient physical activity, and poor adherence to prescribed medication regimens.⁹ Therefore, implementation of professional continuous glucose monitoring (P-CGM), which has been shown to improve glycemic control and reduce diabetes-related complications, may be beneficial.¹⁰

Prolonged diabetes duration emerged as a significant risk factor for complication development, including microvascular complications.¹¹ Conversely, other area may have different distribution, such as a predominantly high prevalence of macrovascular complications.¹² Macrovascular complications have additionally been reported to show stronger association with geriatric syndrome comorbidities than microvascular complications.¹³

Another risk factor that causes the high incidence of macro as well as micro complication is that the target of therapy

Table 3 Comparing Various Factors Based on Age and Gender

Variable	Age (years)				p-value	Gender				p-value
	<60	%	≥60	%		Male	%	Female	%	
Neuropathy (Monofilament test)										
Yes	14	50	14	38	0.206	6	55	22	41	0.399
No	14	50	23	62		5	45	32	59	
HbA1c (%)										
Controlled (<7)	4	14	12	32	0.097	4	36	12	22	0.822
Not Controlled (≥7)	24	86	25	68		7	64	42	78	
FPG (mg/dL)										
Normal (<100)	2	7	9	24	0.164	2	18	9	17	0.930
Abnormal (≥100)	26	93	28	76		9	82	45	83	
Diabetic Retinopathy										
No Retinopathy	12	44	12	32	0.206	3	27	21	39	0.246
Diabetic Retinopathy	13	48	24	63		8	73	29	54	
Cataract	2	7	2	5		-		4	7	
Waist Circumference										
Acceptable (M≤102 cm and F ≤88 cm)	-	-	-	-	0.238	7	64	23	43	0.004
Unacceptable (M>102 cm and F >88 cm)	-	-	-	-		4	36	31	57	
BMI (kg/m ³)										
Normal (18,5–24,9)	10	36	17	46	0.360	7	64	20	37	0.245
Overweight (25,0–29,9)	18	64	20	54		4	36	34	63	
Blood Pressure (mmHg)										
Normal blood pressure*	5	18	7	19	0.820	1	9	11	20	0.379
Abnormal blood pressure**	23	82	30	81		10	91	43	80	
PADs										
Normal	11	39	28	76	0.476	10	91	29	54	0.787
PAD	13	46	8	22		-		21	39	
Arteriosklerosis	4	14	1	3		1	91	4	7	
Microalbuminuria										
<30 mg/dL	14	50	19	51	0.718	6	55	27	50	0.349
≥30 mg/dL	14	50	18	49		5	45	27	50	

Notes: SD = standard deviation; FPG = fasting plasma glucose; M = male; F = female; BMI = body mass index; PAD = peripheral artery disease.*Normal blood pressure was defined as systolic blood pressure <120 mmHg and diastolic blood pressure <80 mmHg.** Abnormal blood pressure was defined as prehypertension, systolic blood pressure 120–139 mmHg or diastolic blood pressure 80–89 mmHg, or hypertension, systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg

that has not been achieved. These targets extend beyond the glycemic control (HbA1c and blood glucose profiles) that need to be included such as lipid profiles, body weight, waist circumference, and blood pressure.¹⁴ Additional patient characteristics associated with long-term complications include hypertension, elevated body mass index, and dyslipidemia which are elevated triglyceride and low-density lipoprotein (LDL) levels.

A study in China shows that inpatients with diabetes in tertiary hospitals capture the prevalence of microvascular and macrovascular complications and need to improve the health management level of patients with diabetes and drive optimization of the healthcare system.¹⁵ Therefore, all of these factors must also be controlled as part of the target therapy for diabetic patients in primary health care.¹⁶

Hyperglycemia is associated with increased risk of diabetes-related complications.⁵ In the present study, most patients had HbA1c levels $\geq 7\%$, indicating poor glycemic control and increased risk of both macrovascular and microvascular complications. These findings suggest that a substantial proportion of the cohort exhibited suboptimal glycemic control, indicative of elevated risks for both macrovascular and microvascular complications. However, further longitudinal investigations are warranted to establish definitive causal relationships between specific glycemic parameters (e.g., HbA1c, FPG) and individual complications through targeted analytical methodologies.

Diabetes-related complications and their underlying pathophysiological mechanisms arise from chronic hyperglycemia, resulting in dysregulation of carbohydrate, lipid, protein, and electrolyte metabolism.¹⁷ This metabolic dysregulation induces systemic vascular dysfunction, characterized by structural damage to capillary endothelial cells in critical tissues such as the retinal vasculature, renal glomeruli, and both central and peripheral nervous systems.¹⁷ Concurrent pathogenic processes include excessive generation of reactive oxygen species (ROS) coupled with diminished antioxidant defense mechanisms, further exacerbating cellular and vascular injury.¹⁸

An intensive primary care based program may serve as an effective secondary prevention strategy for those with asymptomatic complications. The recommended management strategy¹⁹ is summarized as follows: 1) Reduction of vascular risk: It is

essential to reduce vascular risk, in addition, to controlling other CVA risk factors. It is also recommended that each patient receive periodic nutritional consultations and smoking cessation education for those who are still smoking; 2) Reduction of the risk of retinopathy. Visual and fundoscopic examinations with dilated pupils must be conducted annually. Furthermore, the family physician routinely inquires about visual complaints from their patients; 3) Nephropathy risk reduction. Individuals with hypertension, hyperglycemia, and/or dyslipidemia must be monitored for the presence of microalbuminuria periodically. Additionally, creatinine levels, the aluminum/creatinine ratio, and the estimated glomerular filtration rate (eGFR) calculation must be monitored regularly; 4) Neuropathy risk reduction: Physicians should assess the presence or absence of postural hypotension, numbness, and decreased sensation of taste and vibration with a monofilament in each patient. They should also evaluate the presence of dry feet, calluses, and pulsation of the dorsalis pedis and posterior tibial arteries.¹⁹

The clinical benefits of structured diabetes screening and management programs highlight the importance of sustained implementation and expansion of these interventions, particularly among high-risk populations with comorbid hypertension, smoking history, obesity, and dyslipidemia. Standardized monitoring and evaluation of diagnostic tools, including the Ankle-Brachial Index (ABI), monofilament testing, and diabetic retinopathy screenings—are essential to assess progress in diabetes management and ensure alignment with promotive and preventive objectives. Achieving these targets holds significant potential to elevate patient quality of life, thereby mitigating the burden of chronic diabetes-related complications.²⁰ Furthermore, integrating behavior change frameworks into primary care strategies may enhance the efficacy of health promotion and disease prevention initiatives.²¹⁻²²

Several limitations in this study should be acknowledged. First, the data collection methodology restricts the ability to stratify the sample into distinct cohorts of patients with controlled versus uncontrolled diabetes, owing to the absence of longitudinal data on anti-diabetic medication duration within these subgroups. Second, the cross-sectional design inherently limits temporal assessment, preventing definitive conclusions about whether the HbA1c profiles reflect short-term

glycemic fluctuations or sustained therapeutic outcomes. Despite these constraints, the study identifies a clinically significant proportion of participants (80%, n=52) with HbA1c levels $\geq 7\%$, indicative of suboptimal glycemic control. These findings highlight the necessity for future investigations employing longitudinal designs, granular treatment duration metrics, and rigorously defined patient cohorts to elucidate temporal relationships between glycemic management and complication risks. Such advancements could refine clinical strategies for diabetes care.

In conclusion, microvascular complications specifically neuropathy, retinopathy, and nephropathy represent the most prevalent chronic manifestations of diabetes mellitus (DM). Achievement of therapeutic targets, including glycemic control (HbA1c $< 7\%$), blood pressure regulation, and lipid profile optimization, is essential to reduce long-term morbidity. However, a comprehensive epidemiological assessment of chronic complications among Indonesian DM patients requires multi-center, population-based cohorts with larger sample sizes. Such studies should incorporate longitudinal designs, standardized diagnostic criteria, and stratified analyses to account for regional and demographic variability. These efforts will generate reliable evidence to inform public health strategies and clinical guidelines adapted to Indonesia's unique diabetes burden and the study's findings should be particularly relevant to healthcare practitioners managing patients with chronic diseases, such as diabetes mellitus, that frequently result in microvascular complications so that it can contribute to a reduction in the prevalence of microvascular complications in patients with diabetes mellitus and an enhancement in their quality of life.

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Authors' Contributions

I.N.N.M. contributed to the study conception. I.N.N.M., M.P., S.E., and S.S. contributed to data collection, data interpretation, and manuscript drafting. R.C.S. contributed to supervision, administrative support, critical revision of the

manuscript, and final approval. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Generative AI Disclosure Statement

The authors declare that no generative artificial intelligence tools were used in data analysis, manuscript preparation, or any part of the research process.

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