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Adherence to Screening Recommendations for Diabetic Nephropathy in Lebanese Patients with Diabetes

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ABSTRACT

Background

Diabetic Nephropathy (DN) is a debilitating microvascular complication of diabetes mellitus that often progresses before becoming symptomatic, highlighting the importance of screening during comprehensive diabetes management. Therefore, we captured the incidence snapshot of DN screening in a country caught in the whirlwind of a pandemic and a severe economic crisis, limiting access to healthcare facilities and adherence to screening schedules.

Methods

We conducted a retrospective longitudinal cross-sectional study to assess the adherence of 258 Lebanese patients with diabetes to the recommended DN screening guidelines in a tertiary medical center. Medical records were analyzed for patient demographics, medication profile, and laboratory indicators of glycemic control, e.g. glycated hemoglobin (HbA1c), and kidney function.

Results

Less than half of the patients in our cohort screened for DN with almost two-thirds recording abnormal markers of kidney function. Only half of the screened cohort underwent follow-up testing. Multivariate analysis revealed that lower HbA1c, lower age, outpatient status, and year of first abnormal HbA1c were independently associated with DN screening.

Conclusion

National-scale interventions through funding an annual screening and awareness campaign, while institutional-level interventions by implementing a quality improvement process to detect and address gaps in practice, are needed to increase adherence to screening recommendations.

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INTRODUCTION

Diabetic Nephropathy (DN) is one of the most common and debilitating complications of diabetes mellitus (DM), affecting approximately 20-40% of patients with DM [1]. DN is defined as increased urinary albumin excretion in the absence of any other renal disease. It is a chronic condition characterized sequentially by glomerular hypertrophy, transient hyperfiltration, proteinuria, renal fibrosis, and ultimately a decrease in glomerular filtration rate and albuminuria. DN can result in end-stage renal disease, eventually necessitating renal replacement therapy [2].

According to the American Diabetes Association (ADA), patients with type I DM should be screened for DN yearly starting five years after the diagnosis, whereas patients with type II DM should be screened at diagnosis and yearly afterwards [3]. Recommended initial DN workup involves measurement of albumin in a spot sample of urine [3]. Twenty-four-hour urine collection is also possible, but less practical for patients and less accurate compared to spot urine samples [3]. Measured albumin values can be presented as urinary albumin concentrations or urinary albumin-to-creatinine ratio (ACR) [4]. Abnormal albumin values should be followed by two other sample collections within three to six months [3]. Alternatively, proteinuria can be assessed via protein-to-creatinine ratio (PCR) [5].

DN may progress long before symptoms become evident, accounting for its increased associated mortality, reaching as high as 31.1% of DN cases [6]. Therefore, early detection and intervention are key, since these have been shown to improve prognosis [7]. Nonetheless, despite clear screening recommendations, DN remains substantially underdiagnosed and/or sub-optimally followed up [8]. One of the reasons is the lack of proper provider adherence to screening guidelines [9]. In Lebanon, there have been no national DN screening or awareness campaigns. Additionally, no prior study has attempted to quantify the frequency of DN and adherence to DN screening guidelines. Given the proven cost-effectiveness of population-based screening measures in reducing disease burden [10], it has become imperative to draw a baseline for DN frequency and screening practices. Such data will help highlight the public health significance of DN, and guide the development of targeted interventions to address existing gaps, with the goal of reducing costs of treatment for end-stage renal disease. Financially smart preventive measures are now critical more than ever, in light of Lebanon's financial crisis, that ranked among the highest in the world [11].

Therefore, we attempted to quantify the frequency of DN, and adherence to DN screening and follow-up testing in patients with DM over a period of three years. We were also interested in understanding the factors that affected DN screening practices. This study is the first to depict the frequency of DN, and attempts to establish a baseline for understanding DN screening practices in a country crippled by a severe economic crisis that has limited access to proper preventive medicine. This crisis further contributed to a shift in priorities away from preventive health maintenance and towards combating a pandemic, which, in turn, has also restricted access to healthcare facilities for non-urgent care.

KEY MESSAGES

- **What is already known on this topic–** Diabetic Nephropathy (DN) is a rapidly progressive condition often detected at late stages, due to limited screening practices. Screening for DN has never been investigated in Lebanon, and the impact of the country's multifaceted crisis on regular check-ups and screening practices remains unaddressed.
- **What this study adds –** This study is the first to describe DN screening practices in Lebanon across times of crisis.
- **How this study might affect research, practice or policy-** Both national campaigns and institutional quality improvement interventions are required to increase adherence to DN screening guidelines.

METHODS

We conducted a retrospective longitudinal study, since we collected pre-existing data to look back from a defined starting point i.e., first abnormal glycated hemoglobin (HbA1c), and examined data over time e.g., time to first DN screening and follow-up. Although our data was collected from a static database, the temporal structure and statistical methods reflect a longitudinal design. The study did not involve direct contact with patients and carried minimal risk to patients, hence waiver of informed consent was provided by the Institutional Review Board after it approved this study. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines [12].

Study Design

A retrospective study was performed to assess the rate of adherence to DN screening and follow-up testing among a sample of Lebanese patients with DM from a tertiary university medical center.

The patient population was selected by looking at laboratory results of HbA1c measurements taken between January 2019 and June 2021. Inclusion criteria

were: age > 18 years, and HbA1c ≥ 6.5% as per the 2021 ADA guidelines [13]. Patients were further stratified into three groups, based on the degree of DM control: <8% (Group 1), eight – 10% (Group 2), and >10% (Group 3). Other parameters indicative of DM control (i.e., fasting blood sugar (FBS) at the date of first abnormal HbA1c and a random blood glucose measurement) were also collected.

The dataset was further divided into three groups based on the year of the first abnormal HbA1c: 2019, 2020, and 2021.

Primary outcomes

Nephropathy screening upon the first abnormal HbA1c after 2019 was the primary outcome we sought in this study. To determine nephropathy screening status, patients' laboratory data were followed longitudinally until December 20, 2022. The first laboratory testing after the first abnormal HbA1c post-2019 was considered as initial DN screening. Sequential testing was a DN screening follow-up. Dates of DN screening and up to four follow-up testings – along with those of the first abnormal HbA1c post-2019 – were recorded and time intervals were calculated in days. Those whose time interval between first abnormal HbA1c and DN screening was zero were considered to be patients with a prior diagnosis of DN. Using medical records and clinical archives, we checked whether patients were tested for albumin in spot urine (cut-off: <2 mg/dL), ACR (cut-off: <30 mg/g creatinine), 24-hour urine protein (cut-off: <150 mg/24hrs), and/or PCR (cut-off: <200 mg/g). Abnormal lab values were noted and corresponding two follow-up testings were categorized into expected (< six months) and late (> six months).

Covariables

Risk factors as well as protective factors for DM and DN were chosen a priori as covariables. Information was retrieved from medical records and included: age, gender, in/outpatient status, smoking history, and comorbidities such as hypertension and dyslipidemia. Medication profiles were collected and grouped into four categories: antihyperglycemic agents (insulin, metformin, sodium-glucose transport protein 2 (SGLT2) inhibitors, sulfonylureas, dipeptidyl peptidase-4 (DPP-4) inhibitors, glucagon-like peptide-1 receptor agonists (GLP1-RA), meglitinides), antihypertensives (angiotensin-converting enzyme (ACE) inhibitors, angiotensin II receptor blockers (ARBs), beta blockers, calcium channel blockers, diuretics), antilipidemic (statins, fenofibrates), renoprotective medications (ACE inhibitors/ARBs, SGLT2 inhibitors and GLP1-RA). [14–16] Medications with renoprotective properties work to optimally maintain kidney function [17].

Study Size and Patient Involvement

Given the proportion of type-two DM in our population – 11.2% in 2019 based on the International Diabetes Federation (IDF) [18], the sample size was calculated using the single population proportion formula:

$$n = \frac{Z^2 . p . (1 - p)}{d^2}$$

where n is the sample size, Z is the Z-score for a 95% confidence level (1.96), p is the estimated prevalence (0.112), and d is the margin of error (0.05). A minimum of 239 patients should be included in this study.

We randomly selected a total of 298 patients with abnormal HbA1c ≥ 6.5% between January 2019 and June 2021, from our laboratory archives. A total of 40 patients were excluded from the study due to the following: 34 were duplicates and six were <18 years old. Our final cohort comprised 258 patients with DM. Patients with DM were not involved in study design, implementation, reporting, or dissemination plans of our work.

Statistical Analysis

The data was analyzed using SPSS (Statistical Package for Social Sciences) software, version 28.0. For descriptive analysis, frequency and percentage were used for categorical variables. Mean and standard deviation were employed for quantitative variables. The distribution of these variables was considered normal using visual inspection of the histogram while the skewness and kurtosis were lower than one.

For the bivariate analysis of continuous variables, the Student's T-test was used to compare the means between two groups and ANOVA to compare between three groups or more, after checking for homogeneity of variances using Levene's test. In case the variances are not homogenous, the corrected T-Test and the Kruskal-Wallis test were used, respectively. Moreover, a univariate Cox regression was conducted to take into account time to screening. As for the multivariate analysis, a multiple Cox regression analysis was conducted, and adjusted Hazard Ratio were calculated as exponential betas. Independent variables introduced in the models were sociodemographic, and other independent variables of clinical importance. In all cases, a p-value lower than .05 was considered significant.

Given having missing data inherent to the retrospective data collection from health records, we did not perform missing values replacement. However, we conducted two models for multivariate analysis: one without variables that had missing values (Model one) and the other with these variables (Model two), which could be considered as a sensitivity analysis.

RESULTS

Our sample comprised 258 patients with a mean age of 67.64 (± 12.9) years, and reflected a male predominance (n=163; 63.2%). At the time of abnormal HbA1c detection, 78 patients (30.2%) were admitted to the hospital, while the remainder of our sample (n=180; 69.8%) consisted of outpatients. The average HbA1c was 7.98 ± 1.49 % with 172 (66.7%) patients having an HbA1c below eight %, 61 (23.6%) patients between eight %-10%, and 25 (9.7%) patients greater than 10%. Other measures of glycemic control assessed were FBS (171.78 ± 76.24 mg/dL) and point of care blood glucose (195.13 ± 94.74mg/dL) for inpatients. More than half of patients were taking antihyperglycemic medications (n=146, 56.6%). It is difficult to determine whether the remaining 43.4% of patients were diet treated, or were taking no medication at all. Approximately 70% of patients (n=181; 73.3%) had a history of hypertension, with more than half (n=145, 56.2%) taking antihypertensive medications. Dyslipidemia was another comorbid condition present in 147 (59.5%) patients, and of those, 40.3% (n=104) were taking lipid lowering medications. Around one third of patients were taking a renoprotective medication (n=85, 32.9%). The majority of patients did not smoke (n=161; 62.4%) **(Table 1)**.

A total of 113 (43.8%) patients were screened for DN, out of which almost 40% had elevated albumin or protein in urine (n=44). Follow-up testing for DN was conducted in more than half of tested patients (n=64; 56.6%). Among those with abnormal DN screening who attempted follow-up testing, nine out of 44 patients (20.45%) were tested again in the expected first six months after the abnormal reading. The tests ordered for DN screening and follow-up testing included urine microalbumin spot (n=167; 54.2%), ACR (n=104; 33.8%), PCR (n=22; 7.1%), and 24-hour urine protein (n=15; 4.9%). The patients who screened for DN were younger (64.72 ± 13.95 years) and had lower HbA1c levels (7.77 ± 1.23 %) than those who did not undergo screening (P < .05) **(Table 2)**. Hospitalization status was also significantly associated with DN screening, whereby outpatients at the time of their abnormal HbA1c had a higher likelihood of pursuing DN screening (χ^2 11.044; P, .001) **(Table 3)**. Nonetheless, there was no significant difference in FBS levels and point of care glucose values between patients who underwent DN screening and those who did not (P > .05) (Table 2). Similarly, sex, comorbid conditions (i.e., hypertension and dyslipidemia), smoking status, HbA1c levels, and medication profile were not significantly associated with DN screening (P > .05) **(Table 3)**.

Time between the first abnormal HbA1c and DN screening was significantly shorter for patients with abnormal DN workup (Mean, 48.43; SD, 173.37 days) compared to those with normal DN workup (Mean, 193.41; SD, 295.09 days) (Effect size, .073; P, .004) **(Table 4)**. As such, abnormality in DN workup was a significant risk factor for initiation of DN screening (HR, 1.566; 95% CI, 1.051 to 2.333; P, .027) **(Table 5)**. Subsequent time intervals between DN screening and follow-up testing did not significantly differ between those with normal versus abnormal DN screening results (P > .05) **(Table 4)**. Patients who had their first abnormal HbA1c detected in 2020 and 2021 were less likely to screen for DN compared to those whose abnormal HbA1c was detected in 2019 (χ^2 34.235; P, < .001 / 2019 vs 2020: HR, .568; 95% CI, .354 to .911; P, .019 / 2019 vs 2021: HR, .289; 95% CI, .181 to .460; P, < .001). Conversely, HbA1c level did not affect the cumulative probability of DN screening (P > .05) **(Table 5)**.

In multivariate model one, lower HbA1c (HR, .768; 95% CI, .619 to .952; P, .016), younger age (HR, .950; 95% CI, .927 to .974; P, < .001), outpatient status (HR, .513; 95% CI, .267 to .985; P, .045) and year of first abnormal HbA1c (2019 vs 2021: HR, 8.387; 95% CI, 4.127 to 17.043; P, < .001 / 2020 vs 2021: HR, 2.763; 95% CI, 1.300 to .875; P, .008) were independently associated with DN screening. Patterns of associations with DN screening were not preserved when variables with missing values were included in multivariate model two, wherein screening for DN remained independently associated with the year at which the first abnormal HbA1c was recorded (2019 vs 2021: HR, 9.441; 95% CI, 3.056 to 28.982; P, < .001 / 2020 vs 2021: HR, 3.428; 95% CI, 1.017 to 11.554; P, .047), while a significant negative association was revealed in hyperlipidemic patients (HR, .331; 95% CI, .120 to .909; P, .032) **(Table 6)**.

DISCUSSION

In this study, we sought to determine the frequency of screening for DN amongst patients in a university tertiary medical center. We found that less than half of the patients in our sample were screened for DN, with nearly 40% of them having abnormal markers of kidney function. Patients with lower HbA1c levels presenting to our hospital for outpatient laboratory testing were more likely to undergo DN screening, especially if their first abnormal HbA1c was in 2019 compared to later years. Conversely, patients with comorbid dyslipidemia were less likely to screen for DN.

The DN screening rate observed in this study falls within the values reported in the literature that ranged from 11 to 86 % **[19–21]**. Amidst the scarcity of data on DN screening in our country, comparable data on low to middle income countries in 2019 reveals underscreening in our sample, with around 44 % of patients undergoing screening versus 86% in other cohorts **[20]**. The male predominance in our sample is explained by the increased age-standardized prevalence of DM (18+ years) among Lebanese males compared to females in 2022 **[22]**. Patients who had lower HbA1c levels were more likely to be

screened, suggesting that these patients were more closely monitored, and generally more likely to meet glycemic targets. Individuals who visit our laboratories as outpatients are more likely to undergo screening than those admitted to the hospital. Evidently, patients who are admitted are dealing with more urgent issues, however given the paucity of outpatient screening, this may be a missed opportunity to improve the care of these patients. Unfortunately, current insurance policies in our country do not cover DN screening during inpatient services, which drives patients to do these tests as outpatient. Patients with co-morbid dyslipidemia were less likely to undergo DN screening, despite their increased risk of developing nephropathy [23]. This questions our DN screening practices as evidence from a retrospective observational study on 15,362 patients with DM from the database of the Italian Association of Clinical Diabetologists showed decreased high-density lipoprotein concentration and elevated triglycerides to be independent predictors of DN development [24]. The clinical correlation of this observation raises concern for potential underscreening of these patients. Notably, patients who screened for DN had increased use of antilipidemic medications – albeit statistically insignificant due to low event rate – reflecting closer control of comorbid health issues which could justify fewer screening efforts.

Conversely, the co-presence of hypertension did not significantly impact DN screening, even though hypertension is associated with an increased risk of DN and albuminuria [23]. More than half of our patients were taking anti-hypertensive medication; however, little information was available about the duration and control of their hypertension. Despite not reaching statistical significance for the aforementioned reasons, the magnitude and direction of effect size suggests a meaningful clinical impact wherein patients with comorbid hypertension are at higher risk for DN and screen more closely.

We noticed the absence of a significant difference in medication profile between those who were screened for DN and those who were not. As such, medications profiles do not seem to reflect the complexity of the clinical status of screening patients. This finding was also reported in a cross-sectional sample of 378 non-insulin dependent patients with DM, which concluded that aggressive treatment measures did not affect DN screening [25]. Compared with cross-sectional real-world data on more than 80,000 patients from both high- and low-income Asian countries between 2007 and 2012, patients in this study were less likely to be taking antihypertensive (56.2% vs 90%) and antilipidemic (40.3% vs 77%) medications [26], both of which were linked with decreased progression of diabetic kidney disease [16, 27]. Further weakening the strength of medication profiles as a variable reflective of disease severity and quality of patient follow-up.

The time interval between the first abnormal HbA1c and DN screening is shorter in those who eventually had abnormal DN values, potentially indicating that first evidence of DN prompted patients to undergo screening before the annual checkup milestone. Clinically, this suggests that DN screening in Lebanon often follows clinical suspicion of disease progression rather than primary screening, which highlights the lack of current preventive measures. Additionally, screening figures showed a decreasing trend over the years (from 2019 to 2021) in which the first abnormal HbA1c was detected, which could be attributed to the soaring economic crisis that is considered one of the most severe crises since the mid-nineteenth century [28]. In the study of Parikh et al. (2014), responses of 11,274 participants from the Centers for Disease Control Behavioral Risk Factor Surveillance Survey in the United States revealed financial barriers to be linked with fewer medical check-ups, HbA1c measurements, ophthalmologic and diabetic foot exams, and more vascular morbidity [29]. As such, restricting the effects of financial hurdles on the application of optimal medical care can help reduce the rate of diabetic complications through interventions targeted towards financially challenged groups [25]. Another factor that likely contributed to decreased DN screening is the Covid pandemic, whereas decreased outpatient clinic visits were reported during this period, and the routine, non-urgent care of patients suffered greatly [30]. Park et al. (2022) studied 51,471 patients with diabetes from the Korea Community Health Survey and found that the degree of exposure to Covid was negatively associated with screening for complications of DM [31]. In Lebanon, one fifth of patients with DM could not maintain regular follow-up with their physicians because of the compounded effects of the economic crisis and Covid pandemic [32], ultimately affecting DN screening. The main obstacles to screening were the predominance of expensive private health institutions in care delivery, and high costs of private insurance [33], amidst inability of the Ministry of Public Health to cover care costs due to budget cuts [34].

Current trends of DN screening highlight the need for additional measures to improve adherence with screening guidelines, while keeping careful consideration for the underserved socioeconomic context of the country. As such, a funded national screening campaign can be organized yearly to diagnose DN earlier, which offers a monetary advantage that relies on low-cost interventions to circumvent the need for high-cost national expenditure on treatment of advanced kidney disease [35, 36]. Campaigns can also provide awareness on the importance of controlling risk factors for kidney disease, including blood pressure and glycemic control which were linked with decreased morbidity in the literature [37, 38]. Based on our findings, interventions should target young patients at an early stage of their DM course, ideally before DN progresses.

At the institutional level, a quality improvement process, involving interprofessional cooperation, can greatly increase compliance with screening guidelines for kidney disease [39]. This process involves reflection over gaps in medical practice in order to formulate actionable goals to improve DN screening [39].

Both the incidence of DN in our cohort and scarcity of screening in Lebanon bolster the importance of applying ADA clinical practice guidelines for DN screening. The financial interference in our findings imparts economic considerations on these practice guidelines, i.e., stringent application of guidelines should apply to high-risk patients with more lenience on low-risk groups. Based on our findings, patients with higher HbA1c, dyslipidemia, and of older age are high-risk groups. As such, healthcare providers should give greater attention to these patients. Moreover, institutions can optimize DN screening cards/checklists for patients with diabetes, especially given siloed care delivery in Lebanon amidst decentralized and inconsistent initiation of care by primary care physicians [40].

LIMITATIONS

Our medical center is an academic health center with relatively expensive pricing of laboratory tests, which may make it less appealing for routine workups. As a result, we may not have a comprehensive view of DN screening rates if patients who previously underwent testing at our center have shifted to other centers due to the ongoing financial crisis and Covid pandemic. This could lead to an underestimation of DN screening rates and challenge the external validity of our study to the entire population. Furthermore, our data was solely obtained retrospectively from our center's medical records, which could have been incomplete, inaccurate, or inconsistently recorded, since we did not have access to physicians' paper charts that could have included more detailed information on DN screening status and other factors related to DM control. Access to this information via electronic medical records could have enhanced our analysis. Selection bias is another limitation in this study due to the possible loss of follow-up of some patients. Moreover, residual confounding is a potential limitation since we could not take account of all potential confounders in our analysis. Finally, male predominance in our cohort is another potential confounder, however - despite no statistical significance - we have no explanation why men were more likely to be screened than women beyond increased DM frequencies in males.

CONCLUSION

This retrospective longitudinal study aimed to assess the rate of adherence to DN screening and follow-up testing among a sample of patients with DM from a university medical center. We demonstrated that less than 50% of patients with DM were screened for nephropathy, which is less than in countries of equivalent income, with numbers further declining throughout the years likely due to the financial crisis and the impact of the Covid pandemic on quality of outpatient care.

We suggest the establishment of a national screening and awareness campaign to favor those suffering from the financial crisis, as screening would be more cost-effective than treatment once DN has been established. Factors found to be associated with better DN screening include lower HbA1c, younger age, hospitalization, and year of first abnormal HbA1c. On the other hand, no link was found between medication profile and the tendency to screen for DN.

Keywords
Diabetic Nephropathies, Mass Screening, Compliance, Diabetes Mellitus

TABLE 1 - Sample characteristics.

Variable		Patients (n=258)
Age (years)		67.64 ± 12.95
Sex	Male	163 (63.2%)
	Female	95 (36.8%)
Hospitalization Status	Inpatient	78 (30.2%)
	Outpatient	180 (69.8%)
Weight (Kg)		79.62 ± 17.50
HbA1c (%)		7.98 ± 1.49
	<8	172 (66.7%)
	8 - 10	61 (23.6%)
	>10	25 (9.7%)

Fasting Blood Sugar (mg/dL)		171.78 ± 76.24[a]
Blood Glucose Measurement (mg/dL)		195.13 ± 94.74[a]
Nephropathy Screening	Yes	113 (43.8%)
	No	145 (56.2%)
Abnormal Screening	Yes	44 (38.9%)
	No	69 (61.1%)
Nephropathy Follow-up	Yes	64 (56.6%)
	No	49 (43.3%)
Hypertension	Yes	181 (73.3%)
	No	66 (26.7%)
Hyperlipidemia	Yes	147 (59.5%)
	No	100 (40.5%)
Smoking	Yes	86 (34.8%)
	No	161 (65.2%)

[a] 64 and 84 missing values, respectively

TABLE 2 - Sample descriptives using t-test for equality of means.

Variable	Nephropathy Screening, Mean (SD)		P-value
	Yes	No	
Age (years)	64.72 (13.95)	69.91 (11.67)	.001*
HbA1c (%)	7.77 (1.23)	8.15 (1.64)	.045*
Fasting Blood Sugar (mg/dL)	175.08 (75.16)	168.04 (77.69)	.524
Blood Glucose Measurement (mg/dL)	187.39 (94.59)	200.85 (94.92)	.356

* Significant result ($p < .05$)

TABLE 3 - Chi-square test for DN screening.

Variable		Nephropathy Screening, No.(%)		Chi-square Value	P-value
		Yes	No		
Hospitalization Status	Inpatient	22 (28.2%)	56 (71.8%)	11.044	.001*
	Outpatient	91 (50.6%)	89 (49.4%)		
Sex	Female	40 (42.1%)	55 (57.9%)	.175	.676
	Male	73 (44.8%)	90 (55.2%)		
Follow-up Testing	Yes	64 (100.0%)	0 (0.0%)	109.216	<.001*
	No	49 (25.3%)	145 (74.7%)		
Hypertension	Yes	78 (43.1%)	103 (56.9%)	.094	.759
	No	27 (40.9%)	39 (59.1%)		
Hyperlipidemia	Yes	62 (42.2%)	85 (57.8%)	.016	.898
	No	43 (43.0%)	57 (57.0%)		

Smoking	Yes	39 (45.3%)	47 (54.7%)	.435	.510
	No	66 (41.0%)	95 (59.0%)		
HbA1c (%)	<8	81 (47.1%)	91 (52.9%)	2.664	.264
	8.01 - 10	24 (39.3%)	37 (60.7%)		
	>10.01	8 (32.0%)	17 (68.0%)		
Medications					
Antihyperglycemic	Yes	67 (45.9%)	79 (54.1%)	.598	.439
	No	46 (41.1%)	66 (58.9%)		
Antihypertensive	Yes	61 (42.1%)	84 (57.9%)	.402	.526
	No	52 (46.0%)	61 (54.0%)		
Antilipidemic	Yes	50 (48.1%)	54 (51.9%)	1.296	.255
	No	63 (40.9%)	91 (59.1%)		
Renoprotective	Yes	41 (48.2%)	44 (51.8%)	1.014	.314
	No	72 (41.6%)	101 (58.4%)		
Year of first abnormal HbA1c	2019	64 (66.0%)	33 (34.0%)	34.235	<.001*
	2020	24 (39.3%)	37 (60.7%)		
	2021	25 (25.0%)	75 (75.0%)		

* Significant result (p < .05)

TABLE 4 - ANOVAs based on DN screening result.

Time Interval, days	DN Screening, Mean days (SD)		P-value	Effect Size
	Normal	Abnormal		
Abnormal HbA1c – DN Screening	193.41 (295.09)	48.43 (173.37)	.004*	.073
DN Screening – Follow-up 1	427.90 (255.31)	321.21 (255.89)	.113	.041
Follow-up 1 – Follow-up 2	324.70 (204.21)	308.69 (144.61)	.805	.002
Follow-up 2 – Follow-up 3	182.87 (71.81)	213.43 (124.77)	.564	0.26

* Significant result (p < .05)

TABLE 5 - Univariate Cox regression for cumulative probability of DN screening after first abnormal HbA1c post-2019.

Variable		HR (95% CI)	P-value
Result of DN Workup		1.566 (1.051 – 2.333)	.027*
Year of First Abnormal HbA1c	2019 vs 2020	.568 (.354 – .911)	.019*
	2019 vs 2021	.289 (.181 – .460)	<.001*
HbA1c (%)	<8	.782 (.494 – 1.237)	.293
	8.01 - 10	.534 (.256 – 1.117)	.096

* Significant result (p < .05)

TABLE 6 - Multivariate analysis models of features associated with DN screening.

Variable	Model 1		Model 2	
	HR (95% CI)	P-value	HR (95% CI)	P-value
HbA1c	.768 (.619 χ952)	.016*	.741 (.539 χ1.017)	.063
Hospitalization	.513 (.267 χ985)	.045*	.840 (.319 χ2.214)	.724
Status				
Age	.950 (.927 χ974)	< .001*	.985 (.952 χ1.019)	.383
Sex	.818 (.451 χ486)	.510	.521 (.223 χ1.220)	.133
Year of First Abnormal HbA1c				
2019 vs 2021	8.387 (4.127 χ17.043)	< .001*	9.411 (3.056 χ28.982)	<.001*
2020 vs 2021	2.763 (1.300 χ875)	.008*	3.428 (1.017 χ1.554)	.047*
Hypertension			1.441 (.463 χ4.484)	.528
Hyperlipidemia			.338 (.124 χ923)	.034*
Smoking			2.074 (.805 χ5.346)	.131
Medications				
Antihyperglycemic			1.292 (.545 χ3.061)	.560
Antihypertensive			.563 (.220 χ1.445)	.232
Antilipidemic			1.937 (.775 χ4.840)	.157
Renoprotective			1.086 (.413 χ2.857)	.867
Fasting Blood			1.000 (.994 χ1.005)	.871
Sugar				
Blood Glucose			.999 (.994 χ1.005)	.748
Measurement				

* Significant result (p < .05)

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All authors contributed equally and validated the final version of record.

Declarations

Conflicts Of Interests

The Authors declare that there is no conflict of interest.

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Data availability statement

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

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Ethical approval for this study was not required.

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