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Predictive Score of Prolonged Poor Glycemic Control in Type 2 Diabetic Patients Followed in Hospital in Burkina Faso

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Abstract: *Introduction*: Achieving and maintaining optimal glycemic targets can be difficult because of several factors that make uncontrolled diabetes a public health problem. The objective of this study was to propose a predictive score for prolonged poor glycemic control in the type 2 diabetes cohort. *Methodology*: This was a secondary data analysis of a cross-sectional study. The dependent variable was prolonged poor glycemic control. The modality of the variable with the lowest adjusted OR in the model was assigned a point. The points of the other modalities were weighted proportionally to this variable. Logistic regression was performed and tested by a ROC curve. *Results*: 270 patients were included in the study. In multivariate analysis, low educational level (OR=8.34, CI95% [1.97-35.22]); family support for diabetes management (OR=0.65, CI95% [0.45-0.94]); abdominal obesity (OR=2.27, CI 95% [1.08-4.77]); a history of hospitalization (OR=7.39, CI95% [2.97-18.39]); poor adherence to treatment (OR=2.97, CI 95% [1.42-6.18]); and microangiopathy (OR=5.05, CI 95% [2.36-10.81]) were factors independently associated with prolonged poor diabetes control. A score greater than or equal to 45 was found in this study. The sensitivity and the specificity in our study were respectively 78.89% and of 84.51% with a good performance (AUC= 0.87). *Conclusion*: The Predictive score is made up of a triad of patient, family and caregiver factors. All of these components are modifiable factors.

Keywords: Predictive Score, Prolonged Poor Glycemic Control, Type 2 Diabetes, Ouagadougou

1. Introduction

One of the goals of diabetes management is to achieve good glycemic control in order to prevent micro and macrovascular complications. On the African continent, the proportions of type 2 diabetic patients (T2DM) with poor glycemic control are estimated to vary between 68.3% and 83.3% [1-6]. Achieving and maintaining optimal glycemic targets can be difficult due to several factors [7-10] making

uncontrolles diabetes a public health problem.

Several factors associated with poor glycemic control have been described in studies including demographic, anthropometric, behavioral, diabetes-related and environmental factors [11-17]. In Burkina Faso, a recent study concluded that the factors associated with prolonged poor glycemic control were similar to those reported in the literature [18].

The objective of this study was to propose a composite predictive score for prolonged poor glycemic control in the T2DM cohort in light of the results of the previous study on associated factors.

2. Patients and Methods

2.1. Setting of the Study

The study took place in the internal medicine department of the Yalgado OUEDRAOGO University Hospital (CHU-YO).

2.2. Type and Population of Study

This was a secondary data analysis of a cross-sectional analytical study combining retrospective data collection of the last year of patient follow-up and prospective data collection of missing information in the patient's medical record [18]. The study population consisted of the cohort of diabetic patients, aged at least 18 years, followed and treated in the internal medicine department of the CHU-YO between January 1, 2010 and December 31, 2018.

2.3. Data Extraction

Data from all patients who had been included in the previous study were retained [18]. Compliance with drug treatment was determined from the items of the Morisky assessment questionnaire [19]. The score was calculated from the associated variables in multivariate analysis.

2.4. Proposal of a Predictive Score for Prolonged Poor Glycemic Control in T2DM Patients

Score Variables and Point Allocation:

The dependent variable was prolonged poor glycemic control. Based on the variables retained in the final model of the article on factors associated with imbalance [18], we developed a score of prolonged poor glycemic control in the T2DM patient cohort.

The variable modality with the lowest adjusted OR in the model was assigned a point. The points of the other modalities were weighted proportionally to this variable.

From the created score variable a logistic regression was performed and then tested by Receiver Operating Characteristic (ROC). The area under the ROC curve was defined as excellent (Area Under Curve=0.9-1), very good (AUC=0.8-0.9), good (AUC=0.7-0.8), fairly good (AUC=0.6-0.7), poor (AUC=0.5-0.6) and not applicable (AUC<0.5) [20].

2.5. Ethical Considerations

Confidentiality of participants data was maintained.

3. Results

3.1. General Characteristics of the Study Population

A total of 270 patients were included in this study. Poor glycemic control of diabetes was observed in 73.70% or about two-thirds of the patients in the cohort.

The mean age of the patients was 55.97 years (standard deviation: 11.52 years) and the sex ratio was 0.6. More than half of the population was educated (59.26%). More than two-thirds (85.19%) of the participants were supported by their family in the management of their diabetes. The average expenditure for diabetes care was 47 USD (Standard deviation: 23 USD) per month. One out of two patients (55.92%) was overweight and/or obese. More than one out of two patients (67.04%) had at least one medical history. Arterial hypertension was the most common medical history (41.85%).

The mean duration of diabetes was 5.85 years (standard deviation: 5.15 years). At least one complication of diabetes was found in more than half (68.15%) of the population. Almost all (94.81%) of the patients in the study were taking medications. The average number of tablets taken was 2.94 (standard deviation: 1.56) per patient.

3.2. Multivariate Analysis of Factors Associated with Prolonged Poor Glycemic Control in T2DM

In multivariate analysis with logistic regression, six factors were independently associated with prolonged poor diabetes control. These were low level of education (OR=8.34, CI 95% [1.97-35.22]; p=0.00); family support for diabetes management (OR=0.65, CI 95% [0.45-0.94]; p=0.02); presence of abdominal obesity (OR=2.27, CI 95% [1.08-4.77]; p=0.03); the positive history of hospitalization (OR=7.39, CI 95% [2.97-18.39]; p=0.00); poor compliance with diabetes therapy (OR=2.97, CI 95% [1.42-6.18]; p=0.00); the presence of microangiopathy (OR=5.05, CI 95% [2.36-10.81]; p=0.00). Table 1 shows the factors that are independently associated with poor long-term control of T2DM.

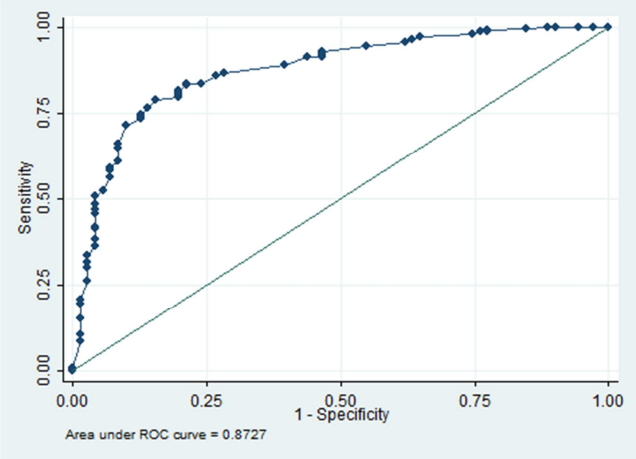

Figure 1. *Sensitivity and specificity of variables associated with prolonged poor glycemic control in T2DM.*

Table 1. *Factors independently associated with prolonged poor control of T2DM, multivariate analysis (N = 270).*

	Prolonged poor Multivariate analysis glycemic control				
	Yes n (%)	**No n (%)**	**Odds-ratio OR**	**CI 95%**	**p value**
Education status					0,01
No formal education	87 (79.09)	23 (20.91)	8.34	1.97; 35.22	*<0.01*
Primary	57 (71.25)	23 (28.75)	4.93	1.19; 20.32	0.02
Secondary	46 (76.67)	14 (23.33)	5.28	1.20; 23.10	0.02
Tertiary	9 (45.00)	11 (55.00)	-	1	-
Family support in diabetes mellitus management					0.02
Never	34 (85.00)	6 (15.00)	1	-	-
Little	32 (80.00)	8 (20.00)	0.87	0.20; 3.74	0.86
Often	53 (71.62)	21 (28.38)	0.42	0.12; 1.49	0.18
Always	80 (68.97)	36 (31.03)	0.31	0.09; 1.04	0.05
Abdominal obesity					
Yes	133 (77.78)	38 (22.22)	2.27	1.08; 4.77	0.03
No	66 (66.67)	33 (33.33)		1	
History of hospitalization for a diabetes mellitus-related event					
Yes	123 (94.62)	7 (5.38)	7.39	2.97; 18.39	*<0.01*
No	76 (54.29)	64 (45.71)			
Quality of compliance according to Morisky					
Good	75 (59.06)	52 (40.94)			
Bad	124 (86.71)	19 (13.29)	2.97	1.42; 6.18	*<0.01*
Microangiopathy					
Yes	140 (90.32)	15 (9.68)	5.05	2.36; 10.81	*<0.01*
No	59 (51.30)	56 (48.70)			

3.3. Validity of the Score and Choice of a Threshold

The specification of the score was verified using the ROC (Receiver Operating Characteristic) statistical method.

The area under the ROC curve was 0.87 [0.8 - 0.9]. Table 2 evaluates the sensitivity and specificity of variables associated with prolonged poor glycemic control in T2DM according to the different weights.

A score ≥ 45 well predicts the probability of prolonged poor glycemic control in 80.37% with a sensitivity of 78.89% and specificity of 84.51%.

Table 2. *Sensitivity and specificity of model variables associated with prolonged poor glycemic control in T2DM.*

Threshold	**Sensitivity (Se)**	**Specificity (Sp)**	**Se + Sp**	**Classification**
≥ 4	100.00%	0.00%	100.00%	73.70%
≥ 6	100.00%	2.80%	102.80%	74.44%
≥ 11	100.00%	5.63%	105.63%	75.19%
≥ 13	100.00%	9.86%	109.86%	76.30%
≥ 17	100.00%	11.27%	111.27%	76.67%
≥ 18	99.50%	15.49%	114.99%	77.41%
≥ 19	98.99%	22.54%	121.53%	78.89%
≥ 20	98.49%	22.54%	121.03%	78.52%
≥ 23	98.49%	23.94%	122.43%	78.89%
≥ 24	97.99%	25.35%	123.34%	78.89%
≥ 25	96.98%	35.21%	132.19%	80.74%
≥ 26	96.48%	36.62%	133.10%	80.74%
≥ 27	95.48%	38.03%	133.51%	80.37%
≥ 28	94.47%	45.07%	139.54%	81.48%
≥ 29	92.96%	53.52%	146.48%	82.59%
≥ 30	92.46%	53.52%	145.98%	82.22%
≥ 32	91.96%	53.52%	145.48%	81.85%
≥ 33	91.46%	53.52%	144.98%	81.46%
≥ 34	91.46%	56.34%	147.80%	82.22%
≥ 35	88.94%	60.56%	149.50%	81.48%
≥ 36	86.43%	71.83%	158.26%	82.59%
≥ 37	85.93%	73.24%	159.17%	82.59%
≥ 38	83.42%	76.06%	159.68%	81.48%
≥ 39	83.42%	78.87%	162.29%	82.22%
≥ 40	82.91%	78.87%	161.78%	81.85%
≥ 41	81.41%	80.28%	161.69%	81.11%
≥ 42	80.90%	80.28%	161.18%	80.74%
≥ 43	80.40%	80.28%	160.68%	80.37%
≥ 44	79.40%	80.28%	159.68%	79.63%

Threshold	Sensitivity (Se)	Specificity (Sp)	Se + Sp	Classification
≥ 45	78.89%	84.51%	163.40%	80.37%
≥ 47	76.38%	85.92%	162.30%	78.89%
≥ 48	74.37%	87.32%	161.69%	77.78%
≥ 49	73.87%	87.32%	161.19%	77.41%
≥ 50	73.37%	87.32%	160.69%	77.04%
≥ 51	71.36%	90.14%	161.50%	76.30
≥ 52	65.83%	91.55%	157.38%	72.59%
≥ 53	64.82%	91.55%	156.37%	71.85%
≥ 54	60.80%	91.55%	152.35%	68.89%
≥ 57	58.79%	92.96%	151.75%	67.78%
≥ 58	58.29%	92.96%	151.25%	67.41%
≥ 59	56.28%	92.96%	149.24%	65.93%
≥ 60	52.26%	94.37%	146.63%	63.33%
≥ 61	50.75%	95.77%	146.52%	62.59%
≥ 62	48.24%	95.77%	144.01%	60.74%
≥ 63	46.73%	95.77%	142.50	59.63%
≥ 64	45.73%	95.77%	141.5%	58.89%
≥ 65	41.71%	95.77%	137.48%	55.93%
≥ 67	41.21%	95.77%	136.98%	55.56%
≥ 68	38.19%	95.77%	133.96%	53.33%
≥ 69	36.18%	95.77%	131.95%	51.85%
≥ 70	33.67%	97.18%	130.85%	50.37%
≥ 71	31.66%	97.18%	128.84%	48.89%
≥ 74	30.15%	97.18%	127.33%	47.78%
≥ 75	26.13%	97.18%	123.31%	44.81%
≥ 76	20.60%	98.59%	119.19%	41.11%
≥ 77	19.60%	98.59%	118.19%	40.37%
≥ 78	15.08%	98.59%	113.67%	37.04%
≥ 80	10.55%	98.59%	109.14%	33.70%
≥ 85	8.54%	98.59%	107.13%	32.22
≥ 87	1.01%	100.00%	101.01%	27.04%
> 87	0.00%	100.00%	100.00%	26.30%

3.4. Proposal of a Predictive Score for Prolonged Poor Glycemic Control

Family support was the variable with the lowest OR with the modality: "patients always benefits from the family for the management of their disease" associated in multivariate analysis with poor prolonged control of T2DM. As well as the points of the other variables associated with poor long-term control of T2DM were assigned as shown in the table below (Table 3).

Table 3. *Variables in the model of the predictive score for poor long-term glycemic control of T2DM and their points.*

Variables independently associated with poor glycemic control in T2DM	Points
Education status	63
No formal education	27
Primary	16
Secondary	17
Tertiary	3
Family support in diabetes mellitus management	8
Never	3
Little	3
Often	1
Always	1
Abdominal obesity presence	7
History of hospitalization for a diabetes mellitus-related event	24
Bad quality of compliance according to Morisky	10
Microangiopathy presence	16
Total	128

4. Discussion

In this study including T2DM patients, aged at least 18 years, during their last year of follow-up, the prevalence of prolonged poor glycemic control was high (73.70%). In the model using variables including low education level, family support for diabetes management, presence of abdominal obesity, history of hospitalization for a diabetes-related event, presence of microangiopathy and poor compliance with

medication, a score greater than or equal to 45 predicted the probability of prolonged poor glycemic control in 80.37% of cases with a sensitivity of 78.89% and specificity of 84.51%. This predictive score showed good performance (Area Under Curve [AUC]= 0.87).

4.1. Interaction Between Composite Factors Associated with Prolonged Poor Glycemic Control

Patients with family support were protected from poor diabetes control in our study (OR=0.65, CI95% [0.45-0.94]; p=0.02). The role of the family is also important in chronic disease management. The close family supports T2DM patients by motivating them in the fight against diabetes, in improving their diet and in adherence to treatment [21]. However, this family environment could influence obesity.

Patients with abdominal obesity had poor glycemic control in our study (OR=1.76, CI95% [1.00-3.84]; p=0.04). Indeed, abdominal obesity is associated with insulin resistance. Patients with insulin resistance are more difficult to treat because they require a higher dose of insulin for insulin therapy.

Low educational attainment was associated with uncontrolled diabetes, (OR=8.34, CI95% [1.97-35.22]; p=0.00). Educational level may also be a barrier to patient management. The negative influence of low level of education on glycemic control could be explained by the difficulty that health workers may have in conducting therapeutic education, which relies on approaches or strategies adapted to the socio-cultural and educational level of our patients. It is therefore necessary to take this into account in the sensitization and education directed towards the different sub-populations. Moreover, therapeutic education creates conditions to improve patient compliance and follow-up.

In our study, poor adherence to medication significantly increased the risk of prolonged poor diabetes control (OR=2.97, 95% CI [1.42-6.18]; p=0.00). Both the patient and the practitioner are responsible for non-compliance with diabetes medication. Indeed, frequent therapeutic interruptions due to denial of the notion of chronicity of the disease are related to the patient, while the physician's workload could influence the physician-patient trust relationship. According to the results of a meta-analysis, the consultation time of physicians in developing countries was less than 5 minutes in 18 of the 67 countries included in the study [22]. The needs and concerns of the patient cannot be addressed in this time frame. Hospitalization would then be used to compensate for these shortcomings in the doctor-patient relationship.

In our study, patients with a history of hospitalization for an acute diabetes-related event had a higher risk of prolonged poor diabetes control (OR=14.79, CI95% [6.44-33.96]; p=0.00). Indeed, these hospitalizations would occur in generally non-compliant patients with already complicated diabetes [23]. In the literature, poor control of diabetes resulting in hospitalization is a condition for the progression of the disease to complications.

These six factors were independently associated with prolonged poor control of diabetes constitutes a composite triad that associates the caregiver (history of hospitalization, presence of microangiopathy), the patient (level of education, presence of abdominal obesity, poor compliance with medication) and the environment (family support). The patient is at the center of these interactions with the physician or environment independently. It is important to note that all of these factors are modifiable.

4.2. Threshold Score Predictive of Prolonged Poor Glycemic Control

A score ≥ 45 better predicts the probability of uncontrolled T2DM in 80.37% with a sensitivity of 78.89% and specificity of 84.51%. This composite score made of the triad of caregiver, patient and family environment is a call to unity of action for efficient management of diabetes.

In the literature review, scores were also developed to predict diabetes control. The first score concerned type 1 diabetic patients (T1DM) with three variables: measurement of glycated hemoglobin at the beginning of the observation period, age and the ratio of the duration of the disease to age [24]. The second score, this time in a population of T2DM patients [25], also included three variables including body mass index, HbA1c measurement and triglyceride measurement. The third score came from "The Discover study" in which the authors developed a score to predict durable glycemic control in T2DM patients after metformin failure. This score included several variables including age, gender, ethnicity, income by country, baseline glycated hemoglobin value, being on second-line diabetes therapy, duration of diabetes progression, type of insurance, glomerular filtration rate measurement and self-monitoring of blood glucose [26]. The fourth score was developed in T2DM patients and included age, fasting plasma glucose, waist-to-hip ratio and systolic blood pressure [4].

4.3. Interest of the Developed Score

Medicine is full of measurement tools. Every day, doctors use scores in their practice. These scores are often medical decision support tools. These scores sometimes make use of clinical and biochemical data that may require expenses that are not affordable for patients in Burkina Faso. The clinical score we developed in a local context is a reliable, easy-to-use, accessible, non-invasive, non-expensive, reproducible, and cost-effective screening tool that does not include any paraclinical elements.

4.4. Limitations of the Study

This study developed a predictive score for prolonged poor glycemic control. However, it had limitations and biases that must be taken into account when interpreting the results. Indeed, for the purposes of this study, we limited ourselves to the internal validation stage of our clinical score for the purpose of popularization. Before using the scores in clinical practice, it is imperative to verify that they have been

developed and validated in populations similar to the one in which they are to be used.

5. Conclusion

The components of the triad of this predictive score, notably those related to the patient, his or her entourage or caregivers, are all modifiable factors. They can be managed to achieve optimal glycemic control and avoid or delay the onset of diabetes complications. So it is all about therapeutic patient education which would be benefit from being more developed in our countries.

However, a score alone will never replace the clinical approach, but can support an assessment and possibly avoid unnecessary investigations.

In addition, prospective studies could better inform this score and help practitioners make decisions.

Conflict of Interest

The authors declare no conflict of interests in relation to this manuscript.

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