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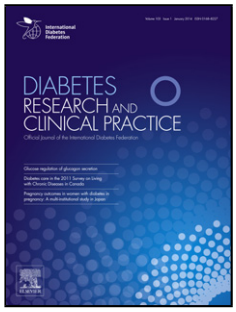
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Poor glycemic control in type 2 diabetes in the South of the Sahara: the issue of limited access to an HbA1c test.

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Abstract

Background: - Management of type 2 diabetes remains a challenge in Africa. The objective of this study was to evaluate the prevalence and predictors of poor glycemic control in patients with type 2 diabetes living in sub-Saharan.

Patients and methods: - This was a cross-sectional study involving 1267 people (61% women) with type 2 diabetes (mean age 58 years) recruited across health facilities in Cameroon and Guinea. Predictors of poor glycemic control (HbA1c ≥7.0% (53 mmol/mol)) were investigated via logistic regressions.

Results: - The mean body mass index was 27.4 ± 5.8 kg/m^2, and 74% of patients had poor glycemic control. Predictors of poor glycemic control in multivariable regression models were recruitment in Guinea [odd ratio: 2.91 (95% confidence interval 2.07 to 4.11)], age <65 years [1.40 (1.04 to 1.88)], diabetes duration ≥3 years [2.36 (1.74 to 3.21)], treatment with: oral glucose control agents [3.46 (2.28 to 5.26)], insulin alone or with oral glucose control agents [7.74 (4.70 to 12.74)] and absence of a previous HbA1c measurement in Guinea [2.96 (1.30 to 6.75)].

Conclusion: - Poor control of blood glucose is common in patients with type 2 diabetes in these two countries. Limited access to HbA1c appears to be a key factor associated with poor glycemic control in Guinea, and should be addressed by health policies targeting improvement in the outcomes of diabetes care.

Keywords: Type 2 diabetes, glycemic control, sub-Saharan Africa

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1. Introduction

Type 2 diabetes is a common and rapidly growing chronic non-communicable disease worldwide [1], including in sub-Saharan Africa [2]. The long-term microvascular and macrovascular complications of diabetes are responsible for significant morbidity and mortality. The growing population of people in need of care for diabetes is a challenge for low-income countries where non-communicable diseases are adding to the burden of communicable diseases [3].

Several large clinical trials have demonstrated the beneficial effect of glycemic control on the development of long-term complications of diabetes [4]. Despite this evidence, a high proportion of patients with diabetes remains poorly controlled [5]. This is the case in Africa where a large number of people with diabetes do not reach the recommended HbA1c targets [6]. The difficulties to achieve an appropriate glycemic control in developing countries are likely due to a limited access to adequate health services, poor education level, reduced access to medical education and a lack of monitoring of glucose control. The magnitude of poor glycemic control in patients with type 2 diabetes in Africa has not been extensively investigated, nor have the predictors of poor glycemic control received greater attention in this setting.

The main aim of this study was to determine the prevalence and investigate the predictors of poor glycemic control in patients with type 2 diabetes across outpatient diabetes clinics in Cameroon and Guinea. We specifically investigated whether prior measures of HbA1c affect subsequent glycemic control.

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2. Population and methods

2.1 Source of data

Patients with type 2 diabetes included in the current study were recruited and examined as part of the baseline evaluation of the project "Improving access to HbA1c in sub-Saharan Africa", which has been described previously [7]. In brief, data were collected over a one year period between 2009 and 2010 and included demographics, history of diabetes, blood pressure and anthropometric measurements, fasting blood glucose and glycated haemoglobin (HbA1c).

2.2 Study sites and population

Patients were recruited in 10 diabetes management centers including six regional centers in Cameroon (a Central African country with 18 million inhabitants) and four regional centers in Guinea (a West African country with 10 million inhabitants). The centres were either university hospitals (UH) where patients were seen by endocrinologists or regional hospitals (RH) where patients were seen by general physicians or diabetologists. Prior to the study "Improving access to HbA1c in sub-Saharan Africa", these centers monitored metabolic control of patients with fasting capillary blood glucose. The study protocol was approved by the Ethics Committees of the Ministries of Public Health in Cameroon and Guinea. Participants were informed of the purpose of the study and signed an informed consent. Between August 2009 and October 2010, 1349 patients with type 1 or type 2 diabetes were selected at outpatient visits. The inclusion criteria were: being diagnosed with diabetes since at least one year and being 16 years of age or older. For the current analyses, patients with missing data on the duration of diabetes and age were excluded (n = 17), as well as those with type 1 diabetes (n = 65). Thus, data from 1267 patients with type 2 diabetes were analysed.

2.3 Measurements and operational definition

In this study, HbA1c was measured in a capillary blood sample by spectrophotometry using the Biorad ® IN2IT devices [8,9]. A good glycemic control was defined as HbA1c <7.0% (<53 mmol/mol) [10].

The following data were collected: country of recruitment, health facility (University or Regional hospital), gender (Female or Male), age (dichotomized into <65 or ≥65 years), marital status (married, single), level of education (Illiterate, ≤ High school, >High school), employment (employed or unemployed), duration of diabetes (grouped as 1-2 and ≥3 years),

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treatment of diabetes (categorized as diet only, oral glucose control agents alone, insulin alone or with oral glucose control agents), self-monitoring of blood glucose (yes or no), waist and hip circumferences. Among the 350 subjects who were treated with insulin, information about the number of injections per day was available for 262 patients who were grouped as 1 and 2-3 injections per day. The socioeconomic status was based on the employment status and level of education. The body mass index (BMI) was calculated using Quetelet's index (weight / height^2) and expressed in kilograms per meters square (kg/m^2) and was further dichotomized into <25 and ≥25 kg/m².

The American Diabetes Association definition of hypertension was applied: i.e. systolic/diastolic blood pressure ≥ 130/80 mmHg or antihypertensive treatment [10]. The patients were classified for hypertension status as normal, unknown hypertension, known hypertension with treatment and known hypertension without treatment.

2.4 Statistical analysis

Data are presented as mean ± SD or as [median (quartile 1, quartile 3)] for continuous variables and as count (%) for categorical variables. The Pearson correlation coefficient was used to measure the continuous association between HbA1c and fasting glucose. Patients from Cameroon and Guinea were combined for the analysis the predictors of poor glycemic control.

Predictors with $p \leq 0.30$ in univariable analysis were entered into a multivariable logistic regression models, and factors associated with poor glycemic control retained from backward selections. Interaction terms were tested and those significant at $p < 0.10$ were added to the final model. Odds ratios and 95% confidence intervals were calculated and a value of $p < 0.05$ was considered statistically significant. The quality of the final model was verified by the Hosmer and Lemeshow fit test and the area under receiver operating characteristic curve. Analyses used SAS software (version 9.3, SAS Institute, Cary, NC).

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3. Results

3.1 Characteristics of the study population

The characteristics of the 1267 patients with type 2 diabetes included in the study are presented in Table 1; 60% were from Cameroon; 54% were followed in university hospitals; 30% were illiterate. The mean duration of diabetes was 7.6 ± 6.3 years [median 6 years (25^{th}-75^{th} percentiles: 3-10)]. The mean age was 58.4 ± 10.5 years [median 58 years (52- 65)]. They were mostly treated with an oral oral glucose control agents alone (62% overall, 66% in Cameroon and 56% in Guinea). Among patients who were receiving insulin, the information of number of injections per day was available for 262. Most of them (90.1%) had two or three injections per day. In all 39% of patients reported that they self-monitored their blood glucose, more frequently in Guinea (42%) than in Cameroon (38%). Only 21% had had a previous determination of HbA1c prior to the study. The mean body mass index (BMI) was 27.4 ± 5.8 kg/m², which was significantly higher in Cameroon (28.6 ± 6.2 kg/m²) than in Guinea (25.5 ± 4.7 kg/m²); p <0.001. Among the 962 subjects (76%) with hypertension, only 42% were on antihypertensive therapy at inclusion.

3.2 Glycemic and blood pressure control

Among the 1267 patients, 939 (74%) had an HbA1c ≥7.0% (≥53 mmol/mol) of whom 388 (41%) had an HbA1c ≥10.0% (≥86 mmol/mol) (Table 2). The frequency of poor glycemic control was 74% overall and significantly higher in Guinea (84%) than in Cameroon (68%); p <0.001. The average HbA1c was 8.9 ± 2.5% (74 ± 4 mmol/mol) and fasting glucose averaged 9.4 ± 4.3 mmol/L. HbA1c and fasting glucose were significantly and positively correlated with each other (r = 0.68, p <0.001). A blood pressure below 130 / 80 mmHg was observed in only 250 subjects (20%) and only 75 (6%) patients had both glycemia and blood pressure values below the recommended thresholds.

3.3 Univariable predictors of poor glycemic control

Demographic factors significantly associated with poor glycemic control were: recruitment in Guinea [odds ratio: 2.52 (95% confidence interval: 1.89 to 3.34)] and age under 65 years [1.33 (1.01 to 1.75)]. Diabetes was more likely to be poorly controlled among those with little education [1.53 (1.13 to 2.07)] (Table 2). Compared to the patients with <high school, those with ≥high school were the most likely to have poor glycemic control even though this did not reach statistical significance. Clinical and behavioural factors

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associated with poor glycemic control were the presence of high diastolic blood pressure [1.39 (1.07 to 1.80)], absence of previous measures of HbA1c [1.68 (1.25 to 2.25)], diabetes duration ≥3 years [2.61 (1.97 to 3.47)], treatment with oral glucose control agents [2.55 (1.75 to 3.72)], insulin alone or with oral glucose control agents [6.25 (3.94 to 9.91)]. Those who had two or more insulin injections per day had a significantly higher odds ratio of having a poor glycemic control [OR: 2.98; 95% CI: (1.14 to 7.75)] than those with one injection per day. Normal weight (BMI <25 kg/m²) was also associated with poor glycemic control [1.43 (1.09 to 1.88)].

3.4 Multivariable predictors poor glycemic control

The variables significantly associated with poor glycemic control based on a threshold of p <0.30 in univariate models, were entered altogether in the same multivariable model. Then backward selection procedures were applied to retain the final predictors (Table 3). Of all the interactions terms tested, only the interaction between country and previous measurement of HbA1c (p = 0.06) was significant and was therefore added to the final model which included: recruitment in Guinea [2.91 (2.07 to 4.11)], age <65 years [1.40 (1.04 to 1.88)], diabetes duration ≥3 years [2.36 (1.74 to 3.20)], treatment with oral glucose control agents alone [3.46 (2.28 to 5.26)], insulin alone or with oral glucose control agents [7.74 (4.70 to 12.74)] and no previous measurement of HbA1c in Guinea [2.96 (1.30 to 6.75)]. The level of education, the body mass index, the diastolic blood pressure and the number of insulin injections were not significantly related to the glycemic control in the multivariate model.

The Hosmer and Lemeshow chi-square statistic for the final multivariable model was 1.50 (p = 0.98); and the area under the ROC curve was 73%.

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4. Discussion

This study has revealed that three out of four patients with type 2 diabetes in the participating centres in two Sub-Sarahan African countries (Cameroon and Guinea), had poor glycemic control and only 6% were at target control levels for glycemia and blood pressure values. On average, the diagnosed duration of diabetes was eight years at enrolment in the study. Recruitment in Guinea, younger age, longer duration of diabetes, treatment with oral glucose control agents with or without insulin, and lack of previous HbA1c measures were the main predictors of poor glycemic control.

High frequencies of poor glycemic control for type 2 diabetes, defined by HbA1c thresholds of 6.5% (48 mmol/mol) or 7.0% (53 mmol/mol), have been reported across regions around the world. In "The International Diabetes Mellitus Practice Study" (IDMPS) [11], conducted in low-income countries, the frequency of poor glycemic control in type 2 diabetes ranged from 63% in Asia to 64% in Eastern Europe and Latin America. In the" Diabcare Africa study" [6] conducted across six African countries, the prevalence of HbA1c ≥6.5% (≥48 mmol/mol) was 71%.

After adjusting for the others variables the level of education was not associated with poor glycemic control. Our result in terms of level of education was similar to that reported in Michigan [12]. However, a low level of education was associated with poor glycemic control in Jordan [13] and in Mexican Americas in the United States [14].

Our study confirmed that a longer duration of diabetes is significantly associated with poor glycemic control [15,16], as observed in the natural history of the disease. Furthermore, among patients with longstanding diabetes, those with normal BMI were more likely to have poor glycemic control, possibly reflecting the effect of weight loss in the context of poor glycemic control [17]. We also found young age to be associated with poor glycemic control, in line with some reports in the literature [18–20] but not all [15,21]. Treatment with oral glucose lowering agents or insulin was associated with poorer glycemic control, most likely reflecting the phenomenon of reverse causality, i.e. more intensive treatment being required by the presence of elevated glycaemia. A poor glycemic control was more frequently observed among patients who were treated with drugs (oral agents and / or insulin), but more so in those who were treated with insulin (alone or in combination with oral drugs). Some studies [22,23] have reported a link between poor glycemic control and treatment with a combination of oral glucose lowering agents and insulin. These results may reflect a delay in the introduction of insulin in the treatment of patients with poor glycemic control [4,24] but also to the intensification of insulin therapy with insufficient insulin doses.

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Affordable access to HbA1c measurements for people with diabetes remain a challenge in developing countries [25], which may affect the quality of care and explain the correlation found in our study lack of access to HbA1c and poor glycemic control in Guinea. Indeed, HbA1c measurement is the cornerstone in strategies for initiating and intensifying treatments for people with diabetes [26]. Availability of HbA1c has been associated with improved glycemic control [27], both by positively affecting the attitude of healthcare providers [28], and improving adherence to treatments in patients.

The cross-sectional nature of this study limits inferences about causality of relationships between the predictors identified in the study and poor diabetes control in our sample. This study is also limited by the lack of information on physical activity, psychological status, and compliance to treatment, other factors that may influence glycemic control and the outcomes of diabetes care.

In conclusion, the percentage of patients with poor glycemic control is as high in Cameroon and Guinea as has been reported in a number of other countries. Limited access to HbA1c monitoring appears to be a contributing factor. These findings suggest that increased access to an HbA1c test could be an important step in health policies to improve glycemic control in patients with type 2 diabetes from Sub Sahara Africa.

Conflict of interest statement

None

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Table 1: Characteristic (mean ± SD or n (%)) of the 1267 type 2 diabetes patients from Cameroon and Guinea.

	Total (N=1267)		Cameroon (n=766)		Guinea (n=501)	
Age (years)	58.4	(±10.5)	58.7	(±10.7)	57.8	(±10.1)
Monitoring site: University Hospital	688	(54%)	380	(50%)	308	(61%)
Women	775	(61%)	461	(60%)	314	(63%)
Married	881	(70%)	499	(65%)	382	(76%)
Unemployed	612	(48%)	383	(50%)	229	(46%)
Level of education						
Illiterate	378	(30%)	162	(21%)	216	(43%)
≤High school	678	(53%)	500	(65%)	178	(36%)
>High school	211	(17%)	104	(14%)	107	(21%)
Treatment of diabetes						
Diet only	130	(10%)	53	(7%)	77	(15%)
oral glucose control agents alone	787	(62%)	509	(66%)	278	(56%)
insulin alone or with oral glucose control agents	350	(28%)	204	(27%)	146	(29%)
Number insulin injections per day (n=262)	1.9	(±0.3)	1.9	(±0.4)	1.9	(±0.3)
Diabetes duration (years)	7.6	(±6.3)	7.5	(±6.5)	7.8	(±5.9)
Previous measurement of HbA1c	266	(21%)	232	(30%)	34	(7%)
Self-monitoring of blood glucose	498	(39%)	289	(38%)	209	(42%)
Known hypertension	962	(76%)	534	(70%)	428	(85%)
Hip (cm)	101	(±11.4)	102	(±11.8)	99.6	(±10.7)
Waist (cm)	94.8	(±13)	96.2	(±14.1)	92.7	(±10.6)
Body mass index (kg/m²)	27.4	(±5.8)	28.6	(±6.2)	25.6	(±4.7)

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Table 2: Odds ratios for factors associated with poor diabetes control (HbA1c ≥7%) in type 2 diabetes patients in Cameroon and Guinea

	HbA1c < 7% (n=328)		HbA1c ≥ 7% (n=939)		OR non adjusted (95% CI)	
Country						
Cameroon	248	(32%)	518	(68%)	Ref	-
Guinea	80	(16%)	421	(84%)	2.52	1.89-3.34
Monitoring site						
University Hospital	171	(25%)	517	(75%)	Ref	-
Regional Hospital	157	(27%)	422	(73%)	0.89	0.69-1.14
Age						
≥ 65 years	102	(30.0%)	238	(70.0%)	Ref	-
< 65 years	226	(24.4%)	701	(75.6%)	1.33	1.01-1.75
Sex						
Man	138	(28%)	355	(72%)	Ref	-
Woman	190	(24%)	584	(75%)	1.19	0.93-1.54
Marital status (Married)						
No	101	(26%)	285	(74%)	Ref	-
Yes	227	(26%)	654	(74%)	1.02	0.78-1.34
Employment						
Unemployed	169	(28%)	443	(72%)	Ref	-
Employed	159	(24%)	496	(76%)	1.19	0.92-1.53
Level of education						
Illiterate	78	(20.6%)	300	(79.4%)	1.53	1.13-2.07
≤High school	193	(28.5%)	485	(71.5%)	Ref	-
>High school	57	(27.0%)	154	(73.0%)	1.07	0.76-1.52
Treatment of diabetes						
Diet only	64	(49.2%)	66	(50.8%)	Ref	-
oral glucose control agents alone	217	(27.6%)	570	(72.4%)	2.55	1.75- 3.72
insulin alone or with oral glucose control agents	47	(13.4%)	303	(86.6%)	6.25	3.94-9.91
Number injections per day (n=262)						
1	7	(26.9%)	19	(73.1%)	Ref	-
2-3	26	(11.0%)	210	(89.0%)	2.98	1.14 - 7.75
Duration of diabetes						
<1-3 years	114	(41.8%)	159	(58.2%)	Ref	-
≥3 years	214	(21.5%)	780	(78.5%)	2.61	1.97-3.47
Previous measurement of HbA1c						
Yes	91	(34.2%)	175	(65.8%)	Ref	-
No	237	(23.7%)	764	(76.3%)	1.68	1.25-2.25
Self-monitoring of blood glucose						
Yes	132	(26.5%)	366	(73.5%)	Ref	-
No	196	(25.5%)	573	(74.5%)	1.05	0.82-1.36
Body mass index						
≥25 kg/m²	231	(28.3%)	586	(71.7%)	Ref	-
<25 kg/m²	97	(21.6%)	353	(78.4%)	1.43	1.09-1.88
Hypertension						
unknown hypertension	86	(28.2%)	219	(71.8%)	Ref	-
known hypertension treated	103	(25.6%)	300	(74.4%)	1.14	0.82-1.59
known hypertension without treatment	139	(24.9%)	420	(75.1%)	1.19	0.87-1.63
Blood pressure systolic ≥130 mmHg						
No	100	(28.3%)	254	(71.7%)	Ref	-
Yes	228	(25.0%)	685	(75.0%)	1.18	0.89-1.56
Blood pressure diastolic ≥80 mmHg						
No	135	(30.1%)	314	(69.9%)	Ref	-
Yes	193	(23.6%)	625	(76.4%)	1.39	1.07-1.80

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Table 3: Odds ratios (95% confidence intervals) of factors associated independently with poor glycemic control (HbA1c≥7%) in type 2 diabetes patients in Cameroon and Guinea

	OR (95% CI) without interaction term	OR (95% CI) with interaction term
Country (Guinea)	2.62 (1.90 -3.61)	2.91 (2.07 - 4.11)
Age (<65 years)	1.39 (1.03 -1.88)	1.40 (1.04 - 1.88)
Duration of diabetes (≥3 years)	2.36 (1.74 -3.20)	2.36 (1.74 - 3.21)
Treatment of diabetes		
oral glucose control agents alone	3.38 (2.23 -5.12)	3.46 (2.28 - 5.26)
insulin alone or with oral glucose control agents	7.60 (4.62 -12.48)	7.74 (4.70 - 12.74)
Previous measurement of HbA1c (none)	1.43 (1.04 -1.98)	
No previous measurement of HbA1c in Guinea		2.96 (1.30 - 6.75)
No previous measurement of HbA1c in Cameroon		1.28 (0.91 - 1.81)

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