The Open Diabetes Journal

Content list available at: https://opendiabetesjournal.com

RESEARCH ARTICLE

Impact of Self-monitoring of Blood Glucose on Glycaemic Control in Type 2 Diabetic Nigerians who Reside in Lagos

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Abstract:

Background:

Self-Monitoring of Blood Glucose (SMBG) is a vital constituent of diabetes care. The aim of this study was to document the practice, determinants and effects of SMBG in our setting.

Methods:

A cross-sectional study was carried out on 249 adult type 2 diabetic subjects who attended the diabetes clinic of the Lagos State University Teaching Hospital Ikeja. The statistical analysis was done with independent t-test and logistic regression. A *P*-value of less than 0.05 was taken as significant.

Results:

The age of the study subjects ranged from 28 years to 87 years. The mean + S.D age is 62 + 11 years. The mean + S.D BMI of the study subjects is 27.79 + 4.73 Kgm2. 159 (64%) of the patients practised SMBG while 90 (36%) patients did not. Twenty-two (14%) of the patients have been practising SMBG for less than 12 months, 71 (46%) patients for 12 - 36 months, while 60 (39%) of them for more than 36 months. 36 (23%) of the patients did SMBG daily, 58 (37%) patients twice weekly, 48 (30%) patients weekly, 11 (7%) patients monthly, 5 (3%) patients did it for unspecified time period while 1 (1%) patient was unable to report the time period. SMBG practice was associated with better short term glycemic control *P*= < 0.001, OR= 0.399 and 95% CI 0.229-0.693. Predictors of SMBG were male sex, higher socioeconomic status and insulin therapy. More male patients (72.7%) practice SMBG compared to female patients (59.9%) *p*-value 0.051. The detection of chronic complications of DM was comparable between those who practice SMBG and those who do not.

Conclusion:

SMBG practice is significantly associated with better short term glycaemic control.

Keywords: Self-monitoring, Blood glucose, Glycaemic control, Complications, Type 2 diabetes mellitus, Triglyceride.

Article History	Received: December 28, 2018	Revised: March 16, 2019	Accepted: April 02, 2019

1. INTRODUCTION

The rising global prevalence of Type 2 Diabetes Mellitus (T2DM) requires concerted efforts at identifying and promoting measures that can mitigate the burden. Self-monitoring of Blood Glucose (SMBG) has been identified to be an effective self-management tool in non-insulin-treated diabetic subjects [1]. The usefulness of SMBG includes the provision of support to enhance diabetes care programme, nurture inclusiveness and share decision taking between healthcare providers and patients as well as help to provide individually tailored advice about blood glucose lowering medication [1]. The impact of SMBG on glycaemic control and the presence of complications in non-insulin treated study subjects were debatable [2 - 4]. Nonetheless, some studies have demonstrated the positive impact of structured SMBG on glycaemic control [5, 6]. The current guidelines recommend SMBG prescription as part of the broad educational program. This may, however, be hampered by cost, especially in a resource challenged setting. The few available observational studies on SMBG in Nigeria suggest that about half of the population of diabetic patients

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have less practiced SMBG [7 - 10]. If the practice of SMBG would result in better glycaemic control in type 2 diabetic patients in Nigeria, it remains to be established. Beyond this assertion, does SMBG impact chronic diabetic complications among our patients? Thus, the aims of our study are to, **1**) Document the percentage of study subjects who practice SMBG, **2**) Identify the impact of SMBG practice on glycaemic control using the glycosylated haemoglobin (HbA1c) values and Fasting blood glucose, **3**) Document the predictors of SMBG and **4**) Document the relationship between SMBG practice and the presence of chronic diabetic complications.

2. METHODS

Study design and Participants: The study was designed as a cross-sectional observational study, which was carried out at the Diabetes Clinic of the Lagos State University Teaching Hospital (LASUTH), located in the cosmopolitan city of Lagos, Nigeria, from January to June 2016. An average of eighty type 2 diabetic patients are seen on each clinic day, which runs twice a week.

The research protocol and procedures were approved by the LASUTH Health Research and Ethics Committee. Two hundred and sixty (260) type 2 diabetic patients who gave their informed consent in writing were recruited by systematic random sampling on each day of the clinic. We excluded people with serious comorbidities, such as cancer, people with renal replacement therapy, sickle cell disease and pregnant women. However, 249 had complete information in the case records.

2.1. Measurements and Data Collection

Demographic information and participants' diabetes history were obtained by questionnaires administered by the interviewer; the practice of SMBG, including the frequency of monitoring, was sought, while other relevant clinical information was obtained from participants' case records. The evidence of chronic complications was extracted from case records.

2.2. Laboratory Investigations

10 millilitres of fasting blood samples were collected from participants on arrival at the clinic and sent to the laboratory within LASUTH where analysis for glucose (using glucose oxidase method) and lipids was carried out on the same day. Total cholesterol assay was done using a modified method of Liebermann-Burchard. The high-density lipoprotein was estimated by precipitation method. Low-density lipoprotein calculation was done using Friedwald's formula. Triglyceride (TG) with a kit was estimated with a kit using enzymatic hydrolysis of TG with lipases. Glycosylated hemoglobin was assayed using a fully automated boronate affinity assay for the determination of the percentage of hemoglobin A1C (HbA1c %) in whole blood.

Data collated was analyzed using *SPSS* version 22.0. Descriptive statistics which include frequency and percentages were used to summarize categorical variables while means and standard deviations were obtained for continuous variables. Associations between categorical variables were done using logistic regression while the means of continuous variables were compared using *t*-test. Results were presented in tables and charts. A *P*-value less than 0.05 was considered to be statistically significant, *i.e.* confidence level was set at 95%.

2.3. Definitions

SMBG refers to any subject who possessed a glucometer and utilizes it to monitor his or her blood glucose. The frequency of SMBG was categorized as daily, twice weekly, once weekly, once/month and infrequently. The duration of SMBG refers to when the individual began to practice SMBG and categorised as **i)** less than 12 months **ii)** 12-36 months and **iii)** above 36 months. The normal HbA1c is 7% or less. Chronic DM complications sought for, evidence of Retinopathy, Nephropathy, Neuropathy, Transient Ischemic attack, stroke, cardiovascular disease, peripheral vascular di-sease and foot ulceration.

3. RESULTS

The age of the study subjects ranged from 28 years to 87 years. The mean ± S.D age is 62 ± 11 years (Table **1**). The mean ± S.D BMI of the study subjects is 27.79 ± 4.73 Kgm^2. 25 (10%) of the patients had no formal education, 61 (25%) patients were educated up to primary level, 68 (27%) up to secondary level, 93 (37%) up to tertiary level, while 2 (1%) patients had post-graduate education. 132 (53%) were currently unemployed. The mean ± S.D duration of DM is 9.28 ± 7.66 years. 8 (3%) of the patients have had diabetes for less than 1 year, 96 (39%) patients; 1-5 years, 56 (23%) patients; 6-10 years, 48 (19%) patients; 11-15 years, 26 (10%) patients; 16-20 years while 15 (6%) patients have had diabetes for 21 years and above. More than three-quarters (192, 77%) of the patients treated their diabetes with Oral Antidiabetic Drugs (OADSs), 8 (3%) patients; insulin, 47 (19%) patients; insulin and OADs, while 2 (1%) patients treated their diabetes with diet only.

159 (64%) of the patients practised SMBG while 90 (36%) patients did not (Fig. **1** and Table **2**).

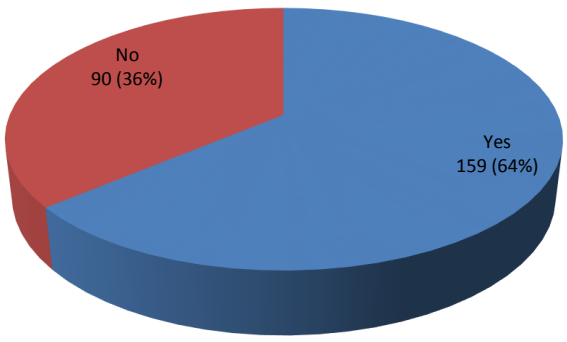

Fig. (1). Shows the proportion of those who practice SMBG and those who did not.

Twenty-two (14%) of the patients have been practising SMBG for less than 12 months, 71 (46%) patients for 12-36 months, while 60 (39%) of them for more than 36 months. 36

Table 1. Demographic characteristics of the study subjects.

–	Frequency	Percent
Age group	***Mean ± SD = 61.60 ± 10.77***	–
25 - 34	6	2.4
35 - 44	7	2.8
45 - 54	42	**16.9**
55 - 64	87	34.9
65 - 74	78	31.3
≥75	29	11.6
Sex	–	–
Male	77	30.9
Female	172	69.1
Occupation	–	–
Civil servant	36	14.5
Artisan	23	9.2
Business/Trader	50	20.1
Farmer	3	1.2
Housewife	9	3.6
Teacher	6	2.4
Unemployed	28	11.2
Retired	94	37.8
Level of education	–	–
No formal	25	10.0
Primary	61	24.5
Secondary	68	27.3
Tertiary	95	38.2

(23%) of the patients did SMBG daily, 58 (37%) patients twice weekly, 48 (30%) patients weekly, 11 (7%) patients monthly, 5 (3%) patients did it for unspecified time period while 1 (1%) patient was unable to specify the time period .

A higher proportion of those who practised SMBG had a longer duration of DM which was however insignificant *p*-0.14.

There was no association between age and SMBG practice. More male patients (72.7%) practice SMBG compared to female patients (59.9%) *p*-value 0.051.

Table **3** above shows that subjects with primary or no formal education were less likely to practice SMBG than those with higher level of education (post secondary), ($P < 0.001$, OR = 0.254, 95% C.I = 0.146 - 0.442). Similarly patients that use insulin/insulin+OHA were 2 times more likely to practice SMBG than those that use Diet/diet+OHA ($P = 0.031$, OR = 2.126, 95% C.I = 1.071 - 4.219).

Table 2. Comparison of clinical parameters between patients who practice SMBG and those who do not.

–	PRACTICE SMBG		Do not PRACTICE SMBG		–			
	Mean	**Std. Dev**	**Mean**	**Std. Dev**	**Mean Difference**	**T**	**df**	***P*-value**
Duration of Diabetes	9.81	7.66	8.34	7.62	1.461	1.448	247	0.149
FBG	130.66	62.68	157.44	67.52	-26.781	-2.967	155.7	0.003
2-HPP	169.25	72.00	200.89	66.33	-31.639	-2.524	124	0.013
RBS	121.60	47.45	157.43	74.64	-35.829	-0.939	10	0.370
HbA1C (%)	7.43	1.86	8.24	2.28	-0.818	-2.898	156.8	0.004
Total Cholesterol	194.92	47.52	204.52	45.02	-9.59	-1.529	236	0.128
HDL	59.86	18.58	59.48	15.76	0.378	0.160	236	0.873
LDL	112.55	39.24	118.67	36.27	-6.117	-1.190	236	0.235
Triglyceride	112.91	64.84	122.46	58.21	-9.545	-1.135	236	0.258
Uric acid	6.14	1.88	5.96	1.59	0.172	.694	214	0.488

HDL - high-density lipoprotein, LDL - low-density lipoprotein, VLDL - Very low-density lipoprotein, 2-HPP - 2 hours postprandial glucose.

Table 3. Association between some demographic factors and SMBG practice.

–	SMBG Practice		–	–	–
–	**Yes n (%)**	**No n (%)**	***P*-value**	**OR**	**95% C.I for OR**
Age	–	–	–	–	–
≤50	24 (68.6)	11 (31.4)	0.532	1.277	0.594 – 2.746
>50	135 (63.1)	79 (36.9)	–	–	–
Gender	–	–	–	–	–
Male	56 (72.7)	21 (27.3)	0.053	1.786	0.993 – 3.213
Female	103 (59.9)	69 (40.1)	–	–	–
Level of education	–	–	–	–	–
None/Primary	37 (43.0)	49 (57.0)	< 0.001	0.254	0.146 – 0.442
Post primary	122 (74.8)	41 (25.2)	–	–	–
Duration of DM	–	–	–	–	–
≤ 10	99 (61.9)	61 (38.1)	0.384	0.784	0.454 – 1.354
>10	60 (67.4)	29 (32.6)	–	–	–
Family history of DM		–	–	–	–
Yes	70 (64.8)	38 (35.2)	0.783	1.076	0.638 – 1.815
No	89 (63.1)	52 (36.9)	–	–	–
Treatment of DM	–	–	–	–	–
Insulin+OHA	42 (76.4)	13 (23.6)	0.031	2.126	1.071 – 4.219
Diet+OHA	117 (60.3)	77 (39.7)	–	–	–

OHA- Oral hypoglycaemic agents

Table **4** above shows that SMBG practice was not significantly associated with HbA1c, an index of long term glycaemic control ($P = 0.118$, OR = 1.519, 95% C.I = 0.900 - 2.565). However, normal FBG was significantly associated with the practice of SMBG. Subjects who practice SMBG were less likely to have abnormal FBG than those who do not practice ($P = 0.001$, OR = 0.399, 95% C.I = 0.229 - 0.693).

The detection of chronic complications of DM was comparable between those who practice SMBG and those who do not as shown in Tables **5** and **6**. There was no significant association between SMBG practice and chronic diabetic complications ($P > 0.05$).

Table 4. Association between SMBG practice and glycaemic control.

–	SMBG Practice		–	–	–
–	**Yes n (%)**	**No n (%)**	***P*-value**	**OR**	**95% C.I for OR**
Glycemic control HbA1c	–	–	–	–	–
Good	80 (50.3)	36 (40.0)	0.118	1.519	0.900 – 2.565
Poor	79 (49.7)	54 (60.0)	–	–	–
FBG	–	–	–	–	–
Abnormal	48 (31.6)	44 (53.7)	0.001	0.399	0.229 – 0.693
Normal	104 (68.4)	38 (46.3)	–	–	–

HbA1c - Glycosylated haemoglobin, FBG - Fasting blood glucose

Table 5. Association between SMBG practice and the presence of chronic diabetic complications.

–	SMBG Practice		–	–	–
–	**Yes n (%)**	**No n (%)**	***P*-value**	**OR**	**95% C.I for OR**
Retinopathy	–	–	–	–	–
Present	49(39.2)	24(33.3)	0.412	1.289	0.702 – 2.367
Absent	76(60.8)	48(66.7)	–	–	–
Foot ulcer	–	–	–	–	–
Yes	5 (3.1)	4 (4.4)	0.599	0.698	0.183 – 2.669
No	154 (96.9)	86 (95.6)	–	–	–

(Table 5) contd.....

–	SMBG Practice		–	–	–
–	**Yes n (%)**	**No n (%)**	***P*-value**	**OR**	**95% C.I for OR**
Stroke	–	–	–	–	–
Yes	6 (3.8)	2 (2.2)	0.510	1.725	0.341 – 8.733
No	153 (96.2)	88 (97.8)	–	–	–
History of dialysis	–	–	–	–	–
Yes	1 (0.6)	0 (0.0)	NA	NA	NA
No	158 (99.4)	90 (100.0)	–	–	–
Neuropathy	–	–	–	–	–
≤ 10	59 (37.1)	29 (32.2)	0.439	1.241	0.718 – 2.144
>10	100 (62.9)	61 (67.8)	–	–	–

*NA = Not applicable

Table 6. - The Relationship between Frequency of SMBG and Glycosylated Haemoglobin.

–		HbA1c (%)		Total
		Normal	**Abnormal**	
Frequency of SMBG	Daily	16 (45.7%)	19 (54.3%)	35
	Twc weekly	29 (50%)	29 (50%)	58
	Weekly	16 (33.3%)	32 (66.7%)	48
	Monthly	8 (72.7%)	3 (27.3%)	11
Total		69 (45.4%)	83 (54.6%)	152

Twc - twice χ^2 (3) = 6.630, *p*-value =0.085 (two-tailed)

4. DISCUSSION

SMBG prescribed as part of an educational programme to the diabetic individual helps to guide treatment decisions and self-management [7]. It also provides patients with the knowledge of the effects of their lifestyle, food choices and physical activities on their blood glucose levels. We demonstrated in this study that 64% of our study population practice SMBG, this is similar to the report by Ugwu *et al*. [7], but contrasts with observations of Iwuala et al. and Raimi *et al*., [8, 9]. Low prevalence of SMBG was also observed in other developing countries like Bangladesh (8.6%) [10] and Western Kenya(34%) [11]. The sample size in this study is similar to that in the study by Ugwu *et al*. [7], which may explain the higher prevalence of those who practised SMBG.

We observed in this study that, despite the number of people who practised SMBG, the majority did not do it daily in accordance with clinical practice guidelines. This observation is similar to the findings in Pakistan, where, despite the high prevalence of SMBG, most did so infrequently [12]. The prohibitive cost of test strips and out of pocket payment for health care service by the majority of our patients may be some of the reasons for this observation.

A comparison between those who did SMBG and those who did not, in this study, revealed that short term glycaemic control was significantly better in those who did SMBG. This observation agrees with the findings of the aforementioned Pakistani study. Similarly, Hou Yun Ying *et al*., [13] reported a positive association between SMBG practice and glycaemic control. We observed that only the index of short term glycaemic control (FBG) was better among those who did SMBG.

The predictors of SMBG in this study were; a higher level of education, male gender and treatment with insulin. A higher level of education may confer a better understanding of the disease and awareness of complications on the individual. Wijesinha *et al*., Farhan *et al.,* and Parsons *et al*., [14 - 16], also remarked a positive association between SMBG and higher socioeconomic status. In contrast to our observation in this study, Andrew Carter *et al*., [17] reported that a long time since the diagnosis of DM predicted the non-adherent practice of SMBG. The observation in this study of a positive association between SMBG and insulin use is not surprising, as self-management education by healthcare providers may be skewed in favor of patients on insulin to prevent hypoglycemia in these patients. However, in a real-world study of the use of SMBG among type 2 diabetics, Rossi *et al*., [18] observed that SMBG were underutilized both in patients on OADs as well as insulin treated.

Relatively more men did SMBG in this study, which can be explained by better socioeconomic empowerment in men. Women still make up a large proportion of the population living in poverty in Nigeria [19].

The presence of chronic diabetes complications was, however comparable between the two groups in this study, although we demonstrated an insignificant lower frequency of complications among those who did SMBG daily. Ezenwaka *et al*., [20] suggested in a recent trial that the use of SMBG may provide an improvement in calculated coronary heart

disease risk scores. The Rosso study also found that SMBG was associated with a lower incidence of micro and macrovascular events and all-cause mortality, regardless of insulin use [21].

The limitations of this study are the relatively small sample size which may hamper generalisation of the findings; the possibility of recall bias on the part of participants in terms of frequency of SMBG could also be entertained. We also did not obtain information on the initial education received on SMBG that could have influenced the practice.

A suggested area of research from this study is a longitudinal assessment of the effect of SMBG on newly diagnosed Type 2 diabetics without evidence of chronic complications.

CONCLUSION

SMBG practice is significantly associated with good short term glycaemic control and may prevent the development of chronic DM complications; therefore, provision of glucose meters should be prioritized in the allocation of resources to diabetes care at all levels of healthcare service provision.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The research protocol and procedures were approved by the LASUTH Health Research and Ethics Committee.

HUMAN AND ANIMAL RIGHTS

No Animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

AVAILABILITY OF DATA AND MATERIALS

The dataset analyzed can be obtained from the corresponding author on request.

FUNDING

The authors received no funding.

AUTHORS' CONTRIBUTIONS

OOA conceived and designed the study, collected data, scrutinized for intellectual content. AOO critically reviewed the manuscript and did statistical analysis. ETU analyzed and interpreted data. AB performed the experiments.

All authors read and approved the manuscript.

CONSENT FOR PUBLICATION

All study subjects gave informed written consent to participate and for results to be published.

CONFLICTS OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

We acknowledge the assistance provided by Mr. Joshua Ogungbemi with data collation.

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