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The relationship between self-monitoring of blood glucose and glycaemic control among patients attending an urban diabetes clinic in Nigeria

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Abstract

Background/Objective: Self-monitoring of blood glucose (SMBG) is a component of modern diabetes mellitus (DM) self-management. Its value is discussed controversially, and its impact in resource poor settings has been infrequently studied. The aim of this report is to determine the pattern of SMBG and its relationship with glycemic control amongst type 2 DM (T2DM) patients attending an urban DM clinic in Lagos, Nigeria. **Methods:** Data were collected from patients with T2DM in a cross-sectional study, using systematic random sampling, with an interviewer-administered questionnaire investigating demographic data, DM history and SMBG practice. Weight, height, fasting plasma glucose (FPG) and glycated hemoglobin (HbA1c) were measured. **Results:** One hundred patients were studied consisted of 62 (62%) females and 38 (38%) males. The mean age, body mass index and HbA1c of the study population were 59.9 (9.5)

years, 26.2 (5.6) kg/m^2 and 7.9 (2.2%). The median (interquartile range [IQR]) FPG and duration of DM were 107.0 (82.0–142.0) and 8.5 (5.0–15.0) years respectively. SMBG was practiced by 40 (40.0%) patients with a median (IQR) of 6 (4–15) times/month. SMBG was performed more frequently by persons with tertiary level of education ($P = 0.04$) and DM duration ≥8.5 years ($P = 0.04$). The mean HbA1c in the group who practiced SMBG was lower though not statistically significant compared to the group that did not (7.8% vs. 8.0%, $P = 0.61$) practiced. The Spearman's rank correlation coefficient between the frequency of SMBG and HbA1c was –0.025, and $P = 0.81$ among the entire T2DM patients. **Conclusion:** There was no statistically significant relationship between SMBG and glycemic control. There is a need for larger studies to be carried out in order to justify the value of SMBG in resource poor settings.

Abstract in French

Résumé
Contexte/objectif: Autosurveillance glycémique (ASG) est un composant de l'autogestion du diabète moderne (DM). Sa valeur est discutée de façon controversée, et son impact dans les milieux pauvres a été rarement étudiée. Ce rapport vise à déterminer le modèle d'ASG et sa relation avec le contrôle de la glycémie chez les patients de type DM 2 (T2DM) fréquentant une clinique DM urbaine à Lagos, au Nigeria.
Méthodes: Données ont été recueillies auprès de patients atteints T2DM dans une étude transversale, à l'aide d'un échantillonnage aléatoire systématique, grâce à un questionnaire de l'intervieweur enquêter sur les données démographiques, DM histoire et pratique de l'ASG. Poids, hauteur, jeûne de glucose plasmatique (FPG) et l'hémoglobine glyquée (HbA1c) ont été mesurées.
Résultats: Cent patients ont été étudiés se composait de 62 femmes (62 %) et 38 (38 %) étaient des hommes. L'âge moyen, indice de masse corporelle et HbA1c de la population de l'étude étaient 59,9 (9.5) années, 26,2 (5,6) kg/m^2 et 7,9 (2,2 %). La médiane (intervalle interquartile [ei]) FPG et durée de DM ont été 107.0 (82,0–142,0) et 8,5 ans (5.0–15,0) respectivement. ASG a été pratiquée par 40 (40,0 %) patients avec une médiane (IQR) de 6 (4-15) fois / mois. ASG a été effectuée plus fréquemment par des personnes ayant un niveau supérieur de l'éducation ($P = 0,04$) et DM Durée ≥8.5 ans ($P = 0,04$). La moyenne HbA1c dans le groupe qui a pratiqué l'autosurveillance glycémique est plus faible, bien que non statistiquement significatif par rapport au groupe qui n'a pas (7,8 % comparativement à 8,0 %, $P = 0,61$) pratiqué. Coefficient de corrélation de Spearman rang entre la fréquence d'ASG et HbA1c était –0.025 et $P = 0,81$ parmi les patients T2DM entiers.
Conclusion: Il y n'a aucune relation statistiquement significative entre le contrôle glycémique et glycémique. On a besoin de grandes études à mener afin de justifier la valeur d'ASG dans les milieux pauvres.
Mots-clés: Le diabète sucré, le contrôle glycémique, Nigeria, relation, auto-surveillance

Keywords: Diabetes mellitus, glycemic control, Nigeria, relationship, self-monitoring

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Introduction

In 2013, there were 382 million people with diabetes mellitus (DM) globally with a projected increase to 570 million persons by 2030,[1] majority of which will occur among low- and middle-income countries.[2] DM is linked with a myriad of long-term complications, resulting in increased morbidity and mortality amongst affected persons. Improved glycemic control is associated with a reduced risk for almost all diabetes-related endpoints, diabetes-related deaths, and all-cause mortality in patients with DM.[3],[4]

Self-monitoring of blood glucose (SMBG) has enhanced DM management, especially for individuals with type 1 DM and those with type 2 DM (T2DM) using insulin.[5] It provides instant information about blood glucose (BG) and allows detection of hypo-glycemia or hyper-glycemia, which can enable individuals with DM to achieve glycemic targets by making safe and appropriate adjustment in diet, exercise and/or treatment.[6] SMBG is undertaken with the aid of a glucometer. The value of routine SMBG, especially in patients not on insulin, has come into question in the developed world, due to uncertain or modest benefits [7] and significant costs.[6],[8],[9],[10] An association of SMBG with depression [11] and lower quality of life [12] has also been described.

According to the 2013 International Diabetes Federation (IDF) Atlas, Nigeria accounts for the largest number of people living with DM in Africa, with 3.9 million persons affected.[13] The financial burden of DM is immense in terms of the direct and indirect costs of monitoring and control of BG and managing DM-related complications. Moreover, in Nigeria, health insurance is not widespread [14] and majority still live below the poverty line. There are few studies on the practice of SMBG [15],[16] and/or its impact on glycemic control among persons with DM in Nigeria and other resource poor settings.[17],[18] The aim of this study was to determine the relationship of SMBG with glycemic control among patients with T2DM attending an outpatient's clinic of an urban tertiary Nigerian hospital. We also explored the factors associated

with SMBG among the study participants.

Methodology

Study location and design

A cross-sectional study was carried out at the DM clinic of the Lagos University Teaching Hospital (LUTH), which is one of the largest tertiary hospitals in Nigeria. The DM clinic holds once every week with an average clinic attendance of 60–80 patients per clinic.

Study population, sampling method and sample size

Systematic sampling was used to select the study participants. Every third patient with T2DM and who had been attending the clinic for at least 1-year were recruited for the study until the desired sample size was attained. The sample size was calculated using the formula: $n = (a^2 + b^2) \times (z\,\text{crit} + z\,\text{pwr})^2/(\mu_1 - \mu_2)^2$

Where,

n = Desired sample size,

a = Standard deviation of glycated hemoglobin (HbA1c) of 1.3% amongst T2DM patients who perform SMBG once a week or more,

b = Standard deviation of HbA1c of 1.2% among T2DM patients who do not perform SMBG,

μ_1 = Mean HbA1c of 6.9% T2DM patients who perform SMBG once a week or more,

μ_2 = Mean HbA1c of 6.6% T2DM patients who perform SMBG once a week or more,

z crit = Standard normal deviation set at 1.96 corresponding to 0.05 (5%) significance level

z pwr = Standard normal deviation set at 0.84 corresponding to 80% statistical power.

The minimum calculated sample size was 50. However, 100 study participants were recruited.

Ethical approval and informed consent

Approval for the study was obtained from LUTH Health Research and Ethics Committee. Written informed consent was also obtained from the study participants.

Data collection

A structured interviewer-administered questionnaire was used to obtain the following information: Age, gender, duration of LUTH DM clinic attendance, DM history (duration, type of DM, medication history), possession of glucometer, SMBG practices, frequency of BG tests with the glucometer. The case notes of the patients were also reviewed.

Anthropometric indices such as the weight and height were measured using standard methods.

The patients also had blood drawn for fasting plasma glucose (FPG) and HbA1c, which was performed with a point of care device (in2it™ , Bio-Rad Laboratories Inc., CA, USA) which utilizes the boronate affinity method for HbA1c determination.

Predictor and outcome variables

The outcome variable for this study was glycemic control measured by FPG and HBA1c. The predictor variable was (SMBG) with a glucometer. SMBG was defined as self-measurement of BG with the aid of a glucometer.[19] In order to explore the factors associated with SMBG, the predictor variables were age group, gender, educational level, DM duration and type of glucose lowering agent used.

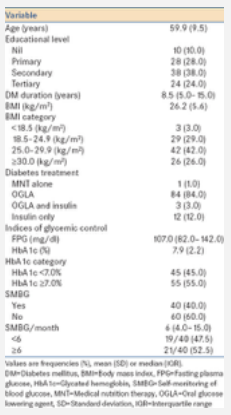
Data management and statistical analysis

The data were entered into Excel worksheet for cleaning before importation into Statistical Package for Social Sciences (SPSS) statistical software version 21 (IBM SPSS Inc. Chicago, Illinois). For the purpose of analysis, some variables were categorized. The age and duration of DM were dichotomized based on the mean age and the median duration of DM respectively among the study participants. The type of glucose lowering agent used was categorized into two. Patients who used medical nutrition therapy alone or oral glucose lowering agents (OGLAs) were placed in one category while those who used insulin alone or in combination with OGLAs were placed in another category. Educational level was categorized into three:

No/primary school, secondary and tertiary. Among those who performed SMBG, the frequency of SMBG/month was dichotomized based on the median frequency of SMBG. Continuous variables were expressed as means and standard deviation or median with an interquartile range if the data was not normally distributed while categorical variables were expressed as frequencies with accompanying percentages in paracentesis. Differences between groups were compared using the Chi-square or Fishers exact test for categorical data. The unpaired independent *t*-test was used to compare means of data that were normally distributed while the Mann–Whitney U-test was used to compare variables with skewed distribution. The Spearman's rank correlation coefficient was used to determine the relationship between the frequency of SMBG and HbA1c. T2DM patients, who did not perform SMBG were assigned a frequency of 0 for SMBG. A $P < 0.05$ was considered as significant.

Results

One hundred patients with T2DM were recruited for the study, consisting of 62 (62.0%) females and 38 (38.0%) males. The mean age and HbA1c of the patients was 59.9 (9.5) years and 7.9 (2.2%) respectively. The median duration of DM was 8.5 (5.0–15.0) years. Other demographic and clinical characteristics of the patients are presented in [Table 1].



Variable	
Age (years)	59.9 (9.5)
Educational level	
Nil	10 (10.0)
Primary	28 (28.0)
Secondary	38 (38.0)
Tertiary	24 (24.0)
DM duration (years)	8.5 (5.0–15.0)
BMI (kg/m²)	26.2 (5.6)
BMI category	
<18.5 (kg/m²)	3 (3.0)
18.5–24.9 (kg/m²)	29 (29.0)
25.0–29.9 (kg/m²)	42 (42.0)
≥30.0 (kg/m²)	26 (26.0)
Diabetes treatment	
MNT alone	1 (1.0)
OGLA	84 (84.0)
OGLA and insulin	3 (3.0)
Insulin only	12 (12.0)
Indices of glycemic control	
FPG (mg/dl)	107.0 (82.0–142.0)
HbA1c (%)	7.9 (2.2)
HbA1c category	
HbA1c <7.0%	45 (45.0)
HbA1c ≥7.0%	55 (55.0)
SMBG	
Yes	40 (40.0)
No	60 (60.0)
SMBG/month	6 (4.0–15.0)
<6	19/40 (47.5)
≥6	21/40 (52.5)

Values are frequencies (%), mean (SD) or median (IQR).
DM=Diabetes mellitus, BMI=Body mass index, FPG=Fasting plasma glucose, HbA1c=Glycated hemoglobin, SMBG=Self-monitoring of blood glucose, MNT=Medical nutrition therapy, OGLA=Oral glucose lowering agent, SD=Standard deviation, IQR=Interquartile range

Table 1: Clinical characteristics and glucose monitoring practices of the study participants

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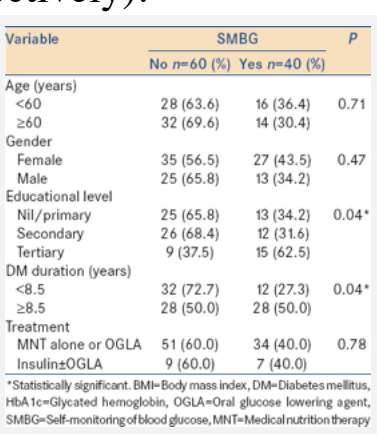
The frequency and pattern of glucose monitoring are summarized in [Table 1]. Although 42 (42.0%) persons possessed glucometers, SMBG was performed by 40 (40.0%). The median number of times SMBG was performed/month was 6 (4–15) times. Out of the 40 persons who performed SMBG, 21 (52.5%) did it ≥6 times/month. Only 3 (7.5%) persons checked their blood sugar at least once a day (not shown in the table). Two of these three patients who performed SMBG at least once a day were on insulin therapy while 1 was on OGLA alone.

[Table 2] shows the association between SMBG and other variables. Educational level and DM duration were the variables significantly associated with SMBG. Patients with tertiary (62.5%) compared with no/primary (34.2%) and secondary (31.6%) level of education and DM duration ≥8 years compared to DM duration <8 years were more likely to perform SMBG (odds ratio [OR] = 3.4, confidence interval [CI] 1.31–8.84, $P = 0.01$ and OR = 2.7, CI 1.1–6.2, $P = 0.03$ respectively).



Variable	SMBG		*P*
	No *n*=60 (%)	Yes *n*=40 (%)	
Age (years)			
<60	28 (63.6)	16 (36.4)	0.71
≥60	32 (69.6)	14 (30.4)	
Gender			
Female	35 (56.5)	27 (43.5)	0.47
Male	25 (65.8)	13 (34.2)	
Educational level			
Nil/primary	25 (65.8)	13 (34.2)	0.04*
Secondary	26 (68.4)	12 (31.6)	
Tertiary	9 (37.5)	15 (62.5)	
DM duration (years)			
<8.5	32 (72.7)	12 (27.3)	0.04*
≥8.5	28 (50.0)	28 (50.0)	
Treatment			
MNT alone or OGLA	51 (60.0)	34 (40.0)	0.78
Insulin±OGLA	9 (60.0)	7 (40.0)	

*Statistically significant. BMI=Body mass index, DM=Diabetes mellitus, HbA1c=Glycated hemoglobin, OGLA=Oral glucose lowering agent, SMBG=Self-monitoring of blood glucose, MNT=Medical nutrition therapy

Table 2: Association between sociodemographic variables and SMBG

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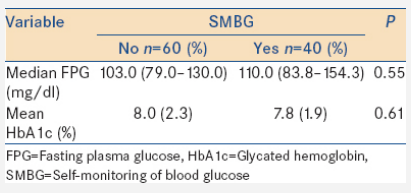
[Table 3] shows the comparison of HbA1c and FPG with SMBG. The median FPG was similar in the two groups ($P = 0.55$). The mean HbA1c in the group who practiced SMBG was lower (7.8% vs. 8.0%) but did not reach statistical significance compared to the group that did not practice SMBG ($P = 0.61$).



Variable	SMBG		*P*
	No *n*=60 (%)	Yes *n*=40 (%)	
Median FPG (mg/dl)	103.0 (79.0–130.0)	110.0 (83.8–154.3)	0.55
Mean HbA1c (%)	8.0 (2.3)	7.8 (1.9)	0.61

FPG=Fasting plasma glucose, HbA1c=Glycated hemoglobin, SMBG=Self-monitoring of blood glucose

Table 3: Comparison of HbA1c and FPG with SMBG

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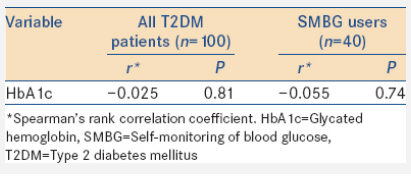
[Table 4] shows the correlation between the frequency of SMBG/month and HbA1c. Among the entire T2DM patients studied, the Spearman's rank correlation (*r*) between the frequency of SMBG and HbA1c was –0.025, $P = 0.81$. Among those who performed SMBG, the Spearman's rank correlation (*r*) between the frequency of SMBG and HbA1c was –0.055, $P = 0.74$.



Variable	All T2DM patients (*n*= 100)		SMBG users (*n*=40)	
	*r**	*P*	*r**	*P*
HbA1c	−0.025	0.81	−0.055	0.74

*Spearman's rank correlation coefficient. HbA1c=Glycated hemoglobin, SMBG=Self-monitoring of blood glucose, T2DM=Type 2 diabetes mellitus

Table 4: Correlation between the frequency of SMBG per month and HbA1c

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Discussion

In the quest for desired optimal glycemic control in patients with T2DM, SMBG has been suggested as a beneficial adjunctive management strategy. There is thus the need for evidence to justify the time and cost needed for SMBG by these categories of patients with T2DM, as these resources may be better utilized in well-proven interventions to improve glycemic control and indeed management outcomes.

In this study, only 40% of the patients practiced SMBG. The proportion of patients who performed SMBG in our study was much lower than 70–80% reported by workers in developed countries.[20],[21] Likewise, in the study carried out in a specialist DM clinic of a University Teaching Hospital in Jamaica, 60% performed SMBG.[18] The issue of cost as a possible barrier to SMBG amongst Nigerians with DM, where medical expenses are mostly borne out-of-pocket,[14] is a thrust for further research.

It is generally recommended that the frequency of SMBG should be determined on a case by case basis, depending on the type of DM, treatment of DM, as well as the willingness and ability of the patient and healthcare provider to use the information from SMBG to adjust their medication or modify their behavior. The IDF has several recommendations in its guidelines on SMBG among patients with T2DM.[22] One of these is that "SMBG protocols (intensity and frequency) should be individualized to address each individual's specific educational/behavioral/clinical requirements (to identify/prevent/manage acute hyper- and hypo-glycaemia) and provider requirements for data on glycemic patterns and to monitor impact of therapeutic decision making."[22] In this study, the median number of times SMBG performed per month was 6 times. We found no relationship between the number of times SMBG was performed and HbA1c, as reported by other Meier *et al*.[23] In their study, the recommended frequency of SMBG among stable T2DM patients controlled on oral agents or diet therapy was at least twice weekly. In line with the IDF recommendations for SMBG it would be interesting to evaluate the knowledge, skill and willingness of Nigerian T2DM patients to use the information derived from SMBG in their diabetes care plan.

This study also aimed to explore other factors associated with SMBG. In our study, persons with a longer duration of DM and tertiary educational level were more likely to practice SMBG. Age, gender and type of glucose lowering agent used were not associated with SMBG. Francis *et al*.,[18] and Yacoub *et al*.,[24] also found that attainment of a higher educational level was linked to practicing SMBG. It is plausible that persons with a higher educational level are more motivated and empowered to perform SMBG as well as use the information in making adjustments to their care.

Insulin use either alone or in combination with OGLAs was not associated with SMBG in this study, as other workers have reported,[20],[24] although we did not subdivide our insulin-treated patients by injection types, dose or frequency because of relatively few patients on insulin. Insulin use was found to be associated with SMBG by some workers.[18], [20]

In this study, there was no statistically significant relationship between SMBG and glycemic control as determined by the HbA1c. This finding is consistent with other studies that did not find a relationship between SMBG and HbA1c.[11],[24], [25] Evans *et al*.[26] found that SMBG was associated with glycemic control in type 1 but not T2DM patients. On the other hand, a recently published study amongst Jamaican patients with DM,[18] and a meta-analysis of 2552 individual patients from randomized controlled trials (RCTs) found that SMBG was associated with a small (0.25%) but significant reduction in HbA1c amongst noninsulin treated T2DM patients.[27] The study involved a much larger sample size compared to ours, and the study design was also different (RCT vs. cross-sectional). The differences in clinical characteristics including the frequency of SMBG, as well the ability to use the information derived from the SMBG, could account for the difference observed between our study and theirs. In this study, there was a lower mean HbA1c level (7.8%) amongst the patients who practiced SMBG compared to those who did not practice SMBG (8.0%), which did not reach statistical significance. Nonetheless, the clinical significance of the lower trend of HbA1c amongst Nigerian T2DM patients who practiced SMBG needs further investigation.

The limitations of this study include the cross-sectional study design, which is unable to establish causality. Larger studies on SMBG, its cost effectiveness and impact amongst T2DM in resource poor settings are also necessary. There is also a need for more evidence that SMBG amongst patients with T2DM in resource constrained settings can give feedback on lifestyle and treatment and thus have a positive impact on the outcome.

Conclusion

There was no relationship between SMBG and glycemic control. Less than half of the patients in this study performed SMBG, and the majority that did so performed it less than once a day. Longer duration of DM and higher education level were associated with SMBG. There is the need for larger studies to be carried out in this area, in order to justify the need for SMBG, especially among T2DM patients not on insulin therapy in resource constrained settings.

Source of Support:

Nil

Conflict of Interest:

None declared.

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Tables

[Table 1], [Table 2], [Table 3], [Table 4]

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