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Self-monitoring of blood glucose, practices, and determinants in type 2 diabetics

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Abstract

Background: Self-Monitoring of Blood Glucose is an approach whereby people with diabetes measure their blood sugar themselves using a glycemic reader device (glucose meter). Based on the reading, they can adjust or check the effect of their treatment (diet, exercise, insulin, antidiabetics) or consult their physician.

Objectives: To assess the practice and determinants of self-monitoring of blood glucose in type2 Diabetic patients.

Patients and method: A cross- sectional study, carried at the endocrine and diabetes center in Al-Sadr Hospital in Al-Najaf governorate in Iraq at the period from the 1st of July to the end of Dec 2020. A Convenient sample included type 2 diabetes mellitus patients with age 18 years and above by direct interview using structured questionnaire.

Results: About (73.8%) were currently using a glucometer, (79.4%) said they changed their device, and only 170 (44.3%) calibrate the device with laboratory, on the other hand, most of the glucometer users, (89.9%), changed the lancet at each test but unfortunately (10.2%) did not. About (61.2%) patients had good and (38.8%) had poor self-monitoring of blood glucose.

Conclusion: Less than 2/3rd of patients had good practice levels. A significant association was found with age, marital state, occupation, education, and disease duration.

Introduction

Diabetes is a chronic condition in which blood glucose levels are chronically elevated to equal or more than 126 mg/dl in fasting plasma glucose test. Diabetes is one of the most important public health problems of the 21st century. The prevalence of diabetes has increased due to changes in lifestyle and an increased life expectancy. According to the International Diabetes Federation, 8.8% of adults aged 20–79 years were estimated to have diabetes in 2017, and the number of people with diabetes in that year reached 425 million people worldwide. The number of people with diabetes increases to 451 million if the age range is expanded to 18–99 years. Should these trends continue, by 2045, 693 million people aged 18–99 years, or 629 million people aged 20–79 years, will have diabetes [1,2].

Glycemic control is necessary to reduce morbidity and mortality of DM through the prevention and/or delay of these complications [3]. Optimum glycemic control can be achieved only when the patients are adherent to self-management behaviors such as healthy diet, physical activity, monitoring of blood glucose, taking medications, reducing the risk factors, ability to resolve diabetes problems, and healthy coping [3-7].

Therefore, the American Diabetes Association announced that each diabetic patient should participate in a diabetes self-management educational (DSME) program. Unfortunately, DSME programs are lacking in Iraq [8].

Impractical to directly adopt a validated DSME program [9-11] because they were already validated in communities with different health beliefs and cultures from Iraqi patients [12].

Hence, the development of a culturally specific DSME program is mandatory. The first step in developing such a program is to know specifically the self-management behaviors among Iraqi patients [13].

Type 2 diabetes mellitus (T2DM) is the major type of diabetes around the world. It is caused by the body's ineffective use of insulin added to a slowly progressive loss of pancreatic β-cells [14].

Both types of diabetes may have the same symptoms, but in T2DM they are often less marked or absent. Subsequently, it may be a silent disease without manifestation for a long time, until complications occur [15].

For many years, this type of diabetes was observed only in adults, but based on recent World Health Organization (WHO) data, it is also increasingly manifesting in children. For the past 30 years, the world has experienced a continuous rise in the prevalence of diabetes particularly in low- and middle-income countries which marks the most rapid growth. The earlier onset of T2DM is described in children, potentially due to the modernization of lifestyle [16].

The prevalence of diabetes worldwide in 2017, is estimated to be 8.8% (425 million people) among the adult population as presented by

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the International Diabetes Federation (IDF). Among IDF regions, the Middle East and North Africa (MENA) region have the second-highest rate of diabetes and 9.2% prevalence. Between 2017 and 2045, it is estimated that diabetes prevalence will increase by 110% in the MENA region and will reach 629 million worldwide in 2045 [17].

In 2017, the mortality rate due to diabetes reached 10.7% in adult patients (20-79 years). In MENA Region, diabetes accounts for 373 557 deaths (21 countries and territories including Iraq) and an estimate of 51.8% of deaths are due to diabetes in patients aged below 60; this puts the region in the highest second level among IDF regions [17]. Despite the high prevalence of diabetes in the MENA region, data on diabetes progression and complications are scarce and only 2.9% of total global spending on diabetes is invested in the region [18].

Around 1.4 million Iraqis have diabetes. Reported T2DM prevalence in Iraq ranges from 8.5% (IDF—age-adjusted) to 13.9%. A local study including more than 5400 people in the city of Basrah, Southern Iraq, reported a 19.7% age-adjusted prevalence of diabetes in subjects aged 19 to 94 years [19].

In Iraq, there are insufficient epidemiological studies and randomized controlled trials (RCTs) related to diabetes; therefore, it remains difficult to fully understand the prevalence of diabetes in Iraq and the most effective therapies for the Iraqi population [19].

Self-monitoring of blood glucose

Self-Monitoring of Blood Glucose is an approach whereby people with diabetes measure their blood sugar themselves using a glycemic reader (glucose meter). Based on the reading, they can adjust or check the effect of their treatment (diet, exercise, insulin, antidiabetics, stress management). Within the wider context of diabetes self-management, self-monitoring supports the maintenance of blood glucose (sugar) at levels as close as possible to target values [20].

Approximately half of the patients with diabetes are reported to have suboptimal or poor glycemic control, both at the national level and the global level. Uncontrolled diabetes represents the major factor for diabetes-related morbidity. Notably, cardiovascular complications increase the number of hospitalizations and related health expenditures [21-25].

The level of hemoglobin A1c (HbA1c) is linearly associated with coronary heart disease (CHD) hospitalization. Uncontrolled diabetes was associated with 13.6% all-cause mortality, 17.9% for CHD, and 2.7% for stroke hospitalization [26].

A study estimated that each unit increase inHbA1c level is independently associated with a 40% and 11% increase in the odds of microvascular and macrovascular complications, respectively [27]. Over the last two decades, self-management has become an integral part of management in patients with diabetes in combination with pharmacological treatments. It consists of empowering patients to perform a set of activities to achieve target lifestyle and behavioral standards in different dimensions such as diet, exercise, and blood glucose monitoring [28-30]. This strategy demonstrated high efficacy in improving diabetes control and is increasingly recommended as a standard of care in diabetes [29,31].

The day-to-day management of diabetes mellitus is a complex and consistent challenge for patients and healthcare providers alike. Established patient self-management tools, such as self-monitoring of blood glucose (SMBG), are now being used in tandem with information technology and telecommunications to provide more integrated management of the disease [32].

The benefits of intensive glycemic control have long been established both in type 1and type 2 diabetes, and include reduced rates of microvascular complications, with SMBG providing the means to monitor progress and avoid hypoglycemia. Although SMBG is well supported for frequent use in insulin-dependent diabetes, there is controversy over self-testing in non-insulin-dependent type 2 diabetes and a lack of research on the importance of testing frequency on clinical outcomes. One line of reasoning as to why SMBG cannot consistently be shown to demonstrate an effect in non-insulin-dependent diabetes lies in the variability of decision-making because of SMBG [32].

With the advent of online communications, the Internet-based Blood Glucose Monitoring System (IBGMS) is a technology that is used to augment SMBG by giving patients the means to communicate their blood glucose levels to their healthcare provider for actionable feedback. This technology has been shown to reduce A1C in several randomized controlled trials for type1 and type 2 diabetes [33,34].

Objectives:

To assess practice and determinants of blood glucose self-monitoring in type 2 diabetic patients.

Patients and method

A cross-sectional study. the study was conducted at the endocrine and diabetes center in Al-Sadr Hospital in Al-Najaf governorate in Iraq. A convenient sample that included type 2 diabetic patients aged 18 years and above that attend the diabetic center and by direct interview using a modified questionnaire (Tables 1-9).

The questionnaires were divided into 3 parts and included the following data:

1. Part I (6 questions): sociodemographic criteria of the patients (age, gender, marital status, occupation, and level of education)
2. Part II (7 questions): about the diabetes mellitus history (duration, type of treatment, diet, medications, follow-up of their health, presence or absence of comorbidity, and family history of DM)
3. Part III (22 questions): all about the self-monitoring of the blood glucose.

On starting an interview, the researcher explained the purpose, importance of the study, and how to respond correctly.

Ethical approval and permission:

The current study was approved by the Iraqi board council of family medicine. The agreements were obtained from the participants and all of them informed that the information in this study will be secrete and not used for other purposes.

Statistical analysis

Data of the study participants were checked for errors or inconsistency, then entered and analyzed using the statistical package for social sciences (SPSS) version 26, IBM, US, 2019. Descriptive statistics of variables presented as frequencies, proportion (%) mean, and standard deviation according to the type of

variables.

The produced SMBG score was tested for statistical normal distribution, and it did follow the normal distribution. The impact of independent variables (Age, gender, marital status, occupation, level of education, presence of comorbidities Family history of DM, duration

of DM, treatment, and use of a glucometer) were cross- tabulated against the level of SMBG as a dependent variable. The significance of association between independent and dependent variables was assessed using Chi-square test. Level of significance (P. value) of 0.05 or less was considered significant. Finally, results and findings presented in tables with an explanatory paragraph for each, using the Microsoft Word and Excel Software version 2019.

Table 1. Socio-demographic characteristics of the studied group(N=428).

Variable		No.	%
Age (year)	18-29	89	20.8
	30 - 39	92	21.5
	40 - 49	84	19.6
	50-59	88	20.6
	≥60	75	17.5
Gender	Male	192	44.9
	Female	236	55.1
Marital state	Married	354	82.7
	Unmarried	61	14.3
	Divorced/Widow	13	3.0
Occupation	Employed	144	33.6
	Unemployed	284	66.4
Education	Illiterate	38	8.9
	Primary	96	22.4
	Secondary	131	30.6
	College	108	25.2
	Higher	55	12.9
Comorbidities	Hypertension	50	11.7
	Heart disease	18	4.2
	Others	21	4.9
	None	339	79.2
Family history of DM*	Yes	170	39.7
	No	258	60.3
Duration of DM (years)	3 - 5	171	40.0
	6 - 10	165	38.6
	> 10	92	21.5
Treatment	OHG*	383	89.5
	OHG +Insulin	45	10.5
Total		428	100.0

DM: diabetes mellitus, OHG: oral hypoglycemic agent

Table 2. Diabetes Management and follow-up related variable of the studied group(N=428).

Variable		No.	%
Follow a diabetes diet	Yes	315	73.6
	No	113	26.4
Take medication regularly	Yes	361	84.3
	No	67	15.7
Follow up health conditions regarding diabetes with a doctor	Yes	351	82.0
	No	77	18.0
Total		428	100.0

Table 3. Distribution of the studied group according to the use of Glucometerdevice and times.

Variable	Category	No.	%
Use a glucometer	Currently use	316	73.8
	Previously use	68	15.9
	No	44	10.3
	Total	428	100.0
How often do you usethe device	More than Once/day	33	8.6
	Daily	29	7.6
	2-4 times weekly	89	23.2
	Weekly	89	23.2
	Irregular	144	37.5
	Total	384	100.0

Table 4. Practices of the glucometer users (N=384).

Variable	Category	No.	%
Changing the device	Yes	305	79.4
	No	79	20.6
Calibrate the device with the laboratory	Yes	170	44.3
	No	214	55.7
Change the lancet	At each test	345	89.8
	Frequently/on each other testing	39	10.2
Sharing the device with someone else	Yes	20	5.2
	No	364	94.8
Total		384	100.0

Table 5. Distribution of sample according to the instructors and reason ofglucometer use (N=384).

Variable	Category	No.	%
Advisor to use thedevice	Doctor	92	24.0
	Family member	179	46.6
	Someone else	113	29.4
Taughtor to use the device	Doctor	148	38.5
	Family member	156	40.6
	Someone else	80	20.8
Reason to do thetest	Before taking insulin	23	6.0
	To find out the level of diabetes	166	43.2
	To monitor my sugar levels	164	42.7
	At the doctor's direction	31	8.1
Total		384	100.0

Table 6. Distribution of sample according to doing and reading results ofglucometer (N=384).

Variable	Category	No.	%
Doing the test him/herself	Yes	288	75.0
	No	96	25.0
If did not do the test him/herself, who would do it?	Family member	77	80.2
	Someone else	19	19.8
Reading the results	His/herself	281	73.2
	Family member	84	21.9
	Someone else	19	4.9
Total		384	100.0

Table 7. Distribution of sample according to the timing, follow updoctor advices and confidence in results of the test (N=384).

Variable	Category	No.	%
Having a specific time to take the test	Yes	134	33.7
	No	264	66.3
Doing a test only when feel symptoms	Yes	238	62.0
	No	146	38.0
Follow the doctor's advice whenmaking the test	Yes	138	35.9
	No	246	64.1
Confidence in the results of the test	Yes	351	91.4
	No	33	8.6
Total		384	100.0

Table 8. Distribution of sample according to their attitude toward the glucometer test (N=384).

Variable	Yes		No	
	No.	%	No.	%
Feel the test is Painful	48	12.5	336	87.5
Getting tested in front of others is embarrassing	70	17.9	320	82.1
Test strips financially expensive	119	31.0	265	69.0
Follow the user guide instructions for the device	324	84.4	60	15.6

Table 9. Actions taken by sample on getting abnormal or error in testresults (N=384).

Variable	Category	No.	%
Action taken when theresults are abnormal (very high / very low)	Recheck	195	50.8
	Examine in the laboratory	82	21.4
	Stop / repeat treatment	43	11.2
	Go to the hospital	24	6.3
	See a doctor	23	6.0
	Call a doctor	12	3.1
	I'm not doing anything	5	1.3
Action taken on seeing an error in reading (No result appears)	Recheck	322	83.9
	Examine in the laboratory	47	12.2
	Not doing anything	15	3.9
Total		384	100.0

Table 10. Descriptive statistics of blood glucose self-monitoring (BGSM) score ofthe study participants (N=428).

Statistics	BGSM score
Mean	10.2
Standard Deviation	3.3
Median	11
Interquartile range (IQR)	9 - 12
Minimum	1
Maximum	15

Level of SMBG and scoring system:

To assess the level of SMBG, responses of study participants towards 18 items that related to their practice and adherence with SMBG were scored.

These 18 items included: -

The good practice response scored "1" while poor or not performed scored "0" the total score for each participant ranged 0 – 18 by summation of scores of all items, the lower score indicated poor practice and adherence. Study participants then categorized according to their scores to be a poor or good level of SMBG, However, the levels of SMBG were evaluated according to Bloom's criteria; The original Bloom's cut-off points, 80.0–100.0%, 60.0–79.0%, and ≤59.0% were adapted and modified, hence, participants with good response for 60% or more of the items considered to have good SMBG] while those with < 60% good response considered to have poor SMBG.

Results:

A total of 428 diabetic patients were enrolled in this study aged 18-67 years, moreover, most of the patients were at age of thirty or older.

Females were Slightly dominant represented 55.1% of the study participants with a female to male ratio of 1.23 to one.

According to the practices of study participants for blood glucose self-monitoring (BGSM), descriptive statistics of their BGSM score are shown in (Table 10) where the mean BGSM score was 10.2 ± 3.3, the median was 11, and range of 1-15.

According to the level of BGSM of participants, 262 (61.2%) patients had good and 166 (38.8%) had poor BGSM, (Table 11).

Further analysis was performed to assess the relationship between BGSM and patient's characteristics; Spearman's bivariate correlation test was used to assess this correlation, where BGSM score was used as a dependent variable and other variables as independent (determinant) variables; results of this analysis demonstrated in (Table 12). A significant positive correlation was found with age indicated that BGSM is better with advancing age, a significant correlation was found between BGSM score and each of marital state, occupation, education and use of a glucometer, in all comparisons, P. value < 0.005.

No significant association was found with other variables, (P>0.05)

Discussion

Diabetes mellitus, like many other chronic degenerative diseases, has progressively increased incidence and prevalence throughout the world and remains a major problem for global public health because the number of patients is increasing day by day [35-37].

Self-monitoring of blood glucose is part of the treatment in patients with type 2 (DM2) treated with or without insulin. Several randomized trials have questioned the clinical utility and cost-effectiveness of routine self-monitoring of blood glucose in these patients. Therefore, the present study aimed to assess the practice and determinants of Iraqi patients in blood glucose self-monitoring (SMBG) using glucometer devices, hence the study included 428 adult diabetic patients aged 18-67 years and most of them at 30 years or older, the age distribution in this study consistent with the epidemiological characteristics of T2DM where previous literatures mentioned that age and gender among the important risk factors for the development of DM [35,36].

The demographic characteristics of the studied group almost close to that of T2DM Iraqi population which reflects the homogeneity of the selected sample and its ability to be representative to the total population and generalization of findings of the study [37-39].

In the study, 73.6% of patients following a diabetes diet, and 84.3% of them claimed that they take medications regularly, these findings were higher than that reported in the United Arab Emirates where only 10% did follow and adhere to recommended special diet for Diabetes. A

Table 11. Distribution of the study participants according to the level of BGSM level (N=428)

BGSM	No.	%
Good	262	61.2
Poor	166	38.8
Total	428	100.0

Table 12. Results of Bivariate correlation analysis between BGSM score and othervariables of the studied group (N = 428).

	Indices of correlation with BGSM score	
	R	P. value
Age	**0.217**	**0.0001***
Male gender	0.026	0.592
Marital state	**0.361**	**0.0001***
Occupation	**0.097**	**0.046**
Education	**0.096**	**0.047***
Comorbidities	-0.037	0.439
Family history of DM	-0.025	0.606
Duration	**0.168**	**0.0001***
Treatment	-0.075	0.122
Use a glucometer	**0.665**	**0.0001***

*significant correlation
Spearman's test was applied.

higher proportion, 59.9%, of patients following a special recommended diet and almost 90% used medication regularly, the differences among different studies attributed to the cultural nature of different populations among these countries. In Iraq, unhealthy diet and physical inactivity represented a real challenge in the management and control of many chronic diseases. It is well-known that unhealthy diet and lifestyle are an important risk factors for poor diabetic control and management, hence knowledge and practice of patients play an essential role in the management of DM [38-41].

The present study found that (89.5%) patients used an oral hypoglycemic agents while (10.5%) used a combination of OHGAs and insulin, this was not unexpected because in the management of T2DM particularly those who had the disease for longer duration Insulin needed for the optimization of glycemic control [42].

Regarding the use of glucometer by the patients in the present study, 73.8 of the respondents measures their glucose by glucometer, which is in agreement found in Norway, where 72% of patients used glucometer in their SMBG. Which close to that reported in a recent Iranian study conducted in 2020 by Babaniamansour et al. who found that 78.6% used a glucometer. Lower rate of glucometer usage was reported in an Earlier Pakistani study where Farhan et al. found that the prevalence of home usage of glucometer was only 59% [43-49].

The variation in the usage of glucometer among different studies could be attributed to the availability of glucometer, cost of the device, and its strips in addition to knowledge and experience of patients regarding using the device [50-53].

As for the Practices and experience of the glucometer users with their device, majorities (79.4%) of the patients said they changed their device, less than half (44.3%) of them calibrate the device with laboratory, on the other hand, 79.4 of the glucometer users, changed the lancet at each test. Only (5.2%) sharing their devices with others. These findings agreed reported in previous studies conducted in Iran. A study in Norway found that 18% of patients change their devices [50,51].

Among the glucometer users, less than fourth (24%) of the patients get advice about the use of a device from the doctor, and about half (46.6%) get their advice from a family member and more than a fourth from someone else. From another point of view, the Taughtor to use the devices was the doctor in 38.5% of the patients.

There is wide variation in the information and instruction received by the patients about the use of glucometer among different studies due to the variation in the population studied, health facilities, and health systems in different countries. For instance, Tenderich reported that 41% of patients did not obtain information from anyone and they claimed that they learned the use of glucometer by themselves, 38% informed by nurses, and only 5% instructed by the doctors which are lower than the reported rate in the current study. Almost similar findings were also reported by Cordts S et al. in 2013 and Polonsky et al. in 2013. A Saudi study, Alhaiti et al, found that 80.1% of the patients got advises from healthcare providers [49-52].

Among the glucometer users, only (24%) get advice about the use of the device from the doctor. Only (6%) did the test before breakfast, (43.2%) to find their diabetes level, patients (42.7%) to monitor their blood sugar levels, and only (8.1%) patients did the test according to doctor instructions.

The interesting finding in the present study was only (6%) did the test before breakfast. On the other hand, about 33.7% of the patients having a specific time to take the test, while 62% doing a test only when feeling symptoms. These findings indicate poor adherence to the instruction and timing of testing. These findings were relatively consistent with that reported by Alhaiti et al. from Saudi Arabia. However, SMBG is neither uniform nor identical among all patients and settings, it is mainly subjective intervention and not like the use of medication. Timing and frequency of tests vary significantly according to the experience and satisfaction of patients about the use in addition to their knowledge, hence, some patients well and the others poorly used their devices and SMBG [52-58].

In general, the level of SMBG of participants was good in 61.2% of patients, which consistent with the findings of an earlier Iraqi study in Najaf where Mohammed-Ali and Hamza [54] found a rate of 60.2%. On the other hand, this rate was higher than that in Saudi Arabia by Alhaiti et al. [51] where only 42% of the patients had good SMBG. Tenderich A [48] found a rate of 60% [49,52,53]

Regarding following the doctor's advice when making the test 35.9% followed the doctor's instructions when taking the test, and 91.4% of patients were confident in the obtained results. Previous studies reported different rates and this variation could be attributed to the variation in the populations, study designs, and samples [53].

Among the barriers of SMBG to use, 12.5 % of the patients feel that the test is painful, 17.9% considered it embarrassing to do the test in front of others, cost of the strips is another factor that contribute to a negative attitude, and 15.6% did not follow the user guide instructions for the device. Almost similar findings were reported by Ong et al. who found that cost of that strip, stigma, perception of that SMBG for only insulin dose optimization, fear of pain, inadequate knowledge among the barriers of SMBG [58].

Further analysis was performed to assess the relationship between SMBG and patients' characteristics. A significant positive correlation was found with age indicated that SMBG is better with advancing age, a significant correlation was found between SMBG score and each of marital state, occupation, education and use of glucometer. In previous studies various determinant related to SMBG among diabetic patients; Gomes et al. in Brazil [55] found that female gender, younger age, and high social status significant determinants of good SMBG. Raoufi et al. found that higher education level, residence, family income was a significant determinant of SMBG [1]. Scorpiglione et al. found that age below 50 years, treated at a diabetes clinic, and incidence of hypoglycemic attacks were significant motivations for self-monitoring of blood glucose [57] Sadiq and salih [58].

Conclusion

1. Less than 2/3rd of patients had good practice levels.
2. A significant association was found with age, marital state, occupation, education, and disease duration.

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