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ORIGINAL ARTICLE

Knowledge, attitude, and practice: cross-sectional study of pseudo-hyperglycemia and effects of unwashed hands among people with type 2 diabetes mellitus, in Riyadh, Saudi Arabia

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ABSTRACT

Background: Saudi Arabia is ranked the second highest, in the Middle East, for the prevalence of diabetes. People carry out blood glucose self-monitoring with diabetes to measure their blood sugar using a glycemic reader. Still, the accuracy could be affected by few factors, such as unwashed hands. The present study aimed at assessing the knowledge, attitude, and practice of pseudo-hyperglycemia effects of unwashed hands among type 2 diabetes patients in Saudi Arabia.

Methodology: This cross-sectional study assessed the knowledge, attitude, and practice of pseudo-hyperglycemia effects of unwashed hands among 394 participants with type 2 diabetes mellitus aged 40 and older in King Salman bin Abdulaziz Hospital, Riyadh, Saudi Arabia. The data were analyzed by Statistical Package for the Social Sciences software, 2017. Chi-squared test was used to attain a *p*-value between categorical data, both dependent and independent, to estimate the association where *p*-value ≤ 0.05 was considered significant.

Results: Among the studied subjects, 58.4% (*n* = 230) of the participants had knowledge about the pseudo-hyperglycemia effect of unwashed hands, 68.8% (*n* = 271) always washed their hands. Regarding attitude, 71.1% (*n* = 280) agreed that there was a relationship between unwashed hands and wrong reading. The only significant factor that could increase the risk of pseudo-hyperglycemia effect of unwashed hands was gender (*p* = 0.037). And the characteristics that could be associated with adequate knowledge are age (*p* = 0.049), gender (*p* = 0.011), and nationality (*p* = 0.016).

Conclusion: The study deduces the importance of washing hands before using a blood glucose meter to prevent pseudo-hyperglycemia, despite using alcohol swabs. Therefore, we recommend all people with type 2 diabetes to wash hands before using a glucose meter.

Keywords: Diabetes, glucose meter, hand washing, pseudo-hyperglycemia, self-monitoring of blood glucose.

Introduction

Saudi Arabia ranked the second highest, in the Middle East, for the prevalence of diabetes. It was calculated that around three million of the population have diabetes [1]. Diabetes is a disease in which the blood glucose level is not regulated in the usual manner [2]. Glucose comes from eaten food, and insulin is the hormone that introduces glucose to the cells to have energy at the end of some biological cycles [2]. Without insulin, glucose remains in the blood and affects daily life. There are many types of diabetes, commonly type 1 and type 2 diabetes [2]. The differences between them are that in type 1, there is no insulin production from beta cells of the pancreas, while in type 2 there is insulin insufficiency [2]. Other types are diabetes insipidus and gestational diabetes [3]. There are ways where people with diabetes

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can measure their blood glucose level, one of which is pricking the finger's tip and dropping the blood into a specific strip of a glucose meter and waiting for seconds to show the result [4]. Glycemic reader (glucose meter) is a device that measures the concentration of glucose in the blood, which patients generally utilize in different settings, and it is the key element of self-monitoring of blood glucose in patients with diabetes [4]. The correct use of glucose meter helps manage blood glucose levels and tracks its variation throughout the day, which can help reduce complications in the long term [5]. Factors and errors which were ignored and deficiently understood by patients affected glucose monitoring. Sources of glucose monitoring errors fall under four categories: strip factors, physical factors, patient factors, and pharmacological factors [6]. Some glucose strips have small individual reaction wells (23 mm), and a well-size variation of 50 μm leads to a 3% error [6]. High temperature/humidity or open vial shortens the strips' life, and different strip brands react differently to high temperature [6]. Some brands underestimate the glucose readings, whereas others overestimate it [6]. In both cases, the error is large. In physical factors, the most common factors that affect glucose monitoring are temperature and attitude. Still, the effect of temperature is less expected since glucose meters sense low temperature and report an error [6]. Hand washing has always been an issue in glucose monitoring, and the insignificant amount of contaminant can highly alter the accuracy of a blood glucose meter [6]. Other naturally occurring substances in the body affect the readings of glucose values as well [6]. In 2011, the study about glucose monitoring after fruit peeling showed that blood glucose levels estimated after peeling any of the fruits, followed by washing hands, were like the control subjects (no fruit handling); however, the groups after fruit peeling, followed by no washing, were abnormally and significantly high, even when the fingertip was cleaned once or multiple times with an alcohol swab before blood sampling [4].

Subjects and Methods

A quantitative, observational, and cross-sectional study was carried out to examine the knowledge, attitude, and practice of pseudo-hyperglycemia effects of unwashed hands. The study was conducted from August to October 2019 among people with type 2 diabetes mellitus 2 at King Salman bin Abdulaziz Hospital, Riyadh. It adhered to the tenets of the Declaration of Helsinki 2013. All the participants were informed about the study's objectives and procedures in the participant's consent form, and they signed it before starting the interview. King Salman bin Abdulaziz Hospital is a large governmental hospital in western Riyadh. It serves 3 million patients annually. The interview was conducted in the waiting areas of the outpatient clinics of internal medicine and endocrine departments. The sampling technique of this study was non-probability convenience sampling. It was carried out in the waiting areas of outpatient clinics and laboratory departments. The completion of the interview was dependent on the response of the participants. According to the sample size calculation [n = ((1.96)^(2) × 0.5 (1−0.5))/(0.05)^2 = 384], 384 subjects were recruited by interviewing 420 participants with type 2 diabetes aged 40 and older, where z = 1.96 for a confidence level (α) of 95% = 1.96, p = proportion (expressed as a decimal) = 0.5, and e margin of error = 0.05. Individuals with type 2 diabetes mellitus aged 40 years and above were included and individuals with type 1 diabetes mellitus, and anyone aged less than 40 were excluded, because most diabetic patients have type 2 diabetes and their ages are 40 and older [1]. An interview containing four main parts, demography, knowledge, attitude, and practice was carried out. Knowledge means learning data, and by comprehension, learning background and recognizing the examining advancements that implies the capacity of pressing together and utilizing knowledge [7]. Attitude is a frame of mind that shows the consequence of making responses by means of specific routes in particular explanations, and watches and clarifies dependent on the after effect of responses or joins into perspective attitude [7]. Practice demonstrates what learning and propensity cooperate into practice [7]. The interview questionnaire was modified from similar previous studies' questionnaires. It was pre-tested and validated by an expert in health education, which was tested on a small group of people with type 2 diabetes mellitus before distributing it. The knowledge, attitude, and practice questions are based on a 3-point Likert scale (agree, unsure, and disagree). The interviews were carried out in the waiting areas, and an Arabic questionnaire was used for the patients. The researchers collected data by a tablet using Google Forms. Statistical Package for the Social Sciences software 2017 was used to analyze the data. The data are presented as frequency and are presented in tables. All categorical variables are presented as frequencies and percentages, while continuous variables are presented as means and standard deviations. Chi-squares and analysis of variance tests were used to attain a p-value between categorical data, both dependent and independent, to estimate the association where p-value ≤ 0.05 is considered as significant. The study was Institutional Review Board (IRB) approved, and written informed consent was obtained from all individual participants included in the study, which is in the study's index. Before starting the interview, data confidentiality was maintained and only used for the purposes described in the study objectives.

Results

The study consisted of 394 participants. The socio-demographic characteristics of the study participants are shown in Table 1. Mean age of the study sample was 57.73 years; 24.4% (n = 96) were of in the age category between 56 and 60 years, and more than half of the participants (n = 247, 65.7%) were females. Almost 72% (n = 282) had elementary school education or more and the rest 28.4% (n = 121) were uneducated; 93.1% (n = 367) were from Saudi Arabia and 61.2% (n = 241) were housewives. Table 2 shows the knowledge of people on

Table 1. *Demographic data: age, gender, education, nationality, and job.*

Demographic data	Count	%	Mean	SD
Age				
40-45	42	10.7	57.7335	10.05241
46-50	67	17.0		
51-55	58	14.7		
56-60	96	24.4		
61-65	60	15.2		
66-70	32	8.1		
Older than 70	39	9.9		
Gender				
Male	147	37.3		
Female	247	62.7		
Education level				
Uneducated	112	28.4		
Elementary School	79	20.1		
Middle School	57	14.5		
High School	72	18.3		
University	52	13.2		
Higher than University	3	0.8		
Other	19	4.8		
Nationality				
Saudi	367	93.1		
Other	27	6.9		
Job				
Housewife	241	61.2		
Solider	11	2.8		
Teacher	36	9.1		
Health Employee	8	2.0		
Private job	26	6.6		
Retired	50	12.7		
Other	22	5.6		

Note: SD = standard deviation

unwashed hands could affect glucose reading. 58.4% of the patients (n = 230) agreed to this statement. The patients who thought that peeling fruits could affect glucose reading were 40.9% (n = 161). Concerning the false glucose, the task could be preventable; 55.8% of the participants (n = 220) were certain that it could be preventable. Moreover, most people with type 2 diabetes mellitus (58.4%) (n = 230) think that their glucose meter should be tested from time to time to make sure it works correctly. Finally, regarding their thoughts on which of the following fruits, if it was contacted with hands, will affect the blood glucose reading, many thought that apples did not affect the reading (n = 367, 93.1%). However, numerous patients thought that dates affected glucose meter reading w (n = 102, 25.9%). In Table 3, 71.1% (n = 280) of the people with type 2 diabetes

Table 2. *Participants' knowledge.*

Do you think that unwashed hands could affect glucose reading		Count	%
	Agree	230	58.4
	Unsure	102	25.9
	Disagree	62	15.7
Do you think that peeling fruit could affect glucose reading			
	Yes	161	40.9
	No	233	59.1
Do you think that false glucose reading is preventable			
	Yes	220	55.8
	No	36	9.1
	I don't know	138	35.0
Do you think your blood glucose meter should be tested every time to make sure it is correct			
	Yes	230	58.4
	No	94	23.9
	Not sure	70	17.8
Do you know which of the following fruit if contacted with hands it may affect blood sugar reading ?			
Apple	Yes	27	6.9
	No	367	93.1
Orange	Yes	56	14.2
	No	338	85.8
Banana	Yes	46	11.7
	No	348	88.3
Watermelon	Yes	78	19.8
	No	316	80.2
Pawpaw	Yes	26	6.6
	No	368	93.4
Dates	Yes	102	25.9
	No	292	74.1
All of the above	Yes	87	22.1
	No	307	77.9
None of the above	Yes	147	37.3
	No	247	62.7

Table 3. *Participants' attitude.*

	Count	%
Relationship between unwashed hands and wrong reading		
Agree	280	71.1
Unsure	66	16.8
Disagree	48	12.2
Relationship between peeling fruit and wrong reading		
Agree	191	48.5
Unsure	127	32.2
Disagree	76	19.3

mellitus agreed that there is a relationship between unwashed hands and wrong reading, while 12.2% (n = 48) disagreed. Also, most of the participants, (n = 191, 48.5%) were certain that there is a relationship between peeling fruits and wrong reading. However, 19.3% (n = 76) disagreed, and 32.2% (n = 127) were unsure. Table 4 represents the practice, where 68.8% (n = 271) of the sample always washed their hands before measuring the blood glucose and 10.7% (n = 42) never washed their hands. Regarding how they washed their hands, the majority (39.3%, n = 155) used the alcohol swab and the minority (n = 5, 1.3%) used hand sensitizer (Gel). 87.1% of the sample (n = 343) are using glucose meters, while 12.9% (n = 51) are not. The meter itself has been tested in the lab for 32% of the samples (n = 126) and has not been tested in 68% (n = 268). Table 5 demonstrates the association between washing hands and average blood glucose reading after meals (p = 0.010), (SD ± 1.64566). Out of the 330 answers, 113 of the participants reported that their post-prandial blood glucose reading was less than 190 (mean 1.6549, SD ± 1.380), 83 said the reading ranged from 191 to 230 (mean 1.927, SD ± 1.56), and 95 reported a reading from 231 to 300 (mean 2.2947, SD ± 1.78572); however, only 39 participants had a blood glucose reading more than 300 (mean 2.4615, SD ± 1.97146). Table 6 represents the association between the knowledge, attitude, and practice of unwashed hands on the blood glucose reading among the participants and their different demographic characteristics. The only significant factor that is associated with good knowledge is gender (p = 0.037). Females were more aware; 152 of the female patients agreed that unwashed hands could cause pseudo-hypoglycemia, while for attitude and practice, none of the demographic data showed significant results.

Table 4. *Participants' practice.*

	Count	%
Wash Hands		
Always	271	68.8
Sometimes	81	20.6
Never	42	10.7
Practice		
Washing hands with water only	51	12.9
Washing hands with soap	128	32.5
Washing hands using antiseptic hand wash (like dettol soap)	11	2.8
Using alcohol swab	155	39.3
Using hand sanitizer (Gel)	5	1.3
Washing hands with soap + alcohol swab	4	1.0
Don't wash hands	31	7.9
Don't have glucose meter	9	2.3
Use Glucose meter		
Yes	343	87.1
No	51	12.9
Tested glucose meter in lab		
Yes	126	32.0
No	268	68.0

Discussion

The study concludes the significance of washing hands before using a blood glucose meter to avoid the pseudo-hyperglycemia impact result of sugar residues. In this way, we request all people with type 2 diabetes mellitus to wash their hands with water and dry their hands appropriately before utilizing a glucose meter. This study shows the knowledge of people with type 2 diabetes mellitus about the pseudo-hyperglycemia effect of unwashed hands is 58.4% (n = 230), 68.8% (n = 271) always washed their hands, and 71.1% (n = 280) agreed that there is a relationship between unwashed hands and wrong reading. Also, a risk factor that increases the pseudo-hyperglycemia effect of unwashed hands is gender (p = 0.037). Also, the characteristics of the participants associated with adequate knowledge are age (p = 0.049), gender (p = 0.011), and nationality (p = 0.016). A descriptive study carried out to assess the knowledge, attitude, and practices of blood glucose monitoring among people with type 2 diabetes mellitus, at a tertiary care hospital, Karad, has shown the level of knowledge was good in 21 (21%), average in 70 (70%), and poor in 9 (9%) diabetic patients [8]. However, Table 2 shows the level of people with type 2 diabetes mellitus knowledge suppose that unwashed hands may affect blood glucose reading was 58.4% of the patients (n = 230) who agreed. In comparison, 25.9% of the members (n = 102) were unsure and 15.7% of the people (n = 62) disagreed. According to a study carried out in a tertiary care hospital, Karad, demonstrated a level of

Table 5. *Cross-table association between do you wash hands and average reading after meals.*

		N	Mean	SD	SE	*p*-value
Average reading	Less than 190	113	1.6549	1.38080	0.12989	0.010*
	191-230	83	1.9277	1.56004	0.17124	
	231-300	95	2.2947	1.78572	0.18321	
	More than 300	39	2.4615	1.97146	0.31569	
	Total	330	2.0030	1.64566	0.09059	

N = number of participants; SE = standard error; * = significant.

Table 6. *Cross-table between knowledge, attitude, and practice of the effect of unwashed hands and socio-demographic data.*

			Agree	Unsure	Disagree	Total	*p*-value
Age							
	40-45	Count	23	11	8	42	0.280
	46-50	Count	47	12	8	67	
	51-55	Count	37	13	8	58	
	56-60	Count	53	30	13	96	
	61-65	Count	36	11	13	60	
	66-70	Count	15	13	4	32	
	Older than 70	Count	19	12	8	39	
Total		Count	230	102	62	394	
Gender							
	Male	Count	78	37	32	147	0.037*
	Female	Count	152	65	30	247	
Cross-section between attitude toward the effect of unwashed hands on blood glucose readings and demographic data							
	Age		31	Yes	No	Total	*p*-value
	40-45	Count	48	6	5	42	0.693
	46-50	Count	45	10	9	67	
	51-55	Count	69	6	7	58	
	56-60	Count	41	18	9	96	
	61-65	Count	19	9	10	60	
	66-70	Count	27	10	3	32	
	Older than 70	Count	280	7	5	39	
Total		Count		66	48	394	
Gender							
	Male	Count	103	20	24	147	0.094
	Female	Count	177	46	24	247	
Total		Count	280	66	48	394	
Cross-table association between practice of washing hands and demographic data							
Age				Yes	No	Total	*p*-value
	40-45	Count	37	5	42		
	46-50	Count	54	13	67		
	51-55	Count	45	13	58		
	56-60	Count	80	16	96		
	61-65	Count	51	9	60		
	66-70	Count	25	7	32		
	Older than 70	Count	36	3	39		
Total		Count	328	66	394		0.493
Gender							
	Male	Count	117	30	147		
	Female	Count	211	36	247		
Total		Count	328	66	394		0.134

attitude regarding blood glucose monitoring indicating that 66 samples (66%) were having a positive attitude, while 34 (34%) participants had a negative attitude [8]. Table 3 shows a relationship between unwashed hands and inaccurate reading, where 71.1% (n = 280) of the participants agreed, while 12.2% (n = 48) disagreed. Krishnan, V. And Thirunavukkarasu, J show that only 37 (24.1%) (20 males and 17 females) patients were aware and have been following self-blood glucose monitoring appropriately [9]. Nonetheless, Table 4 shows that 87.1% of the sample (n = 343) use glucose meters, while 12.9% (n = 51) do not. A clinical trial was carried out to examine

whether peeling fruits is related to pseudo-hyperglycemia [10]. Although the capillary blood samples were collected from ten healthy participants, the results were worth mentioning. The participants had peeled orange, grape, or kiwi for 1 hour prior to collecting capillary blood with no hand washing or hand sanitizing after peeling fruits [10]. The results showed no difference in blood glucose reading between subjects who washed hands with water after peeling fruits, and the control subjects. But there was a significant increase in the reading of the blood glucose in issues who did not wash hands after peeling fruits, whether they had used alcohol swab or not [10]. The study concluded that hand washing is important after peeling fruits to avoid pseudo-hyperglycemia [10]. A study examined the influence of handling food on blood glucose reading [11]. The participants (n = 21) included patients with type 2 diabetes mellitus (n = 1) and healthy individuals (n = 20). The blood glucose measurements were carried out among participants after they had touched food and did not wash hands, after washing hands, after handling, and peeling fruits including banana, orange, pineapple, strawberry, and apple [11]. The results showed a significant increase of blood glucose readings in the first drop of blood in the subjects compared to control (p = 0.01), but no significant increase of the blood glucose readings in the second drop (p = 0.05) [11]. The highest significant reading was seen in subjects who peeled fruits. The study suggested washing hands before using a blood glucose meter [11].

Another study tested the hypothesis of a falsely elevated blood glucose reading after peeling fruits [12]. The samples (n = 50) included were healthy participants, and their age ranged from 19 to 37 years. The participants' blood glucose measurement was conducted after 1 hour of peeling fruits, including orange, watermelon, apple, banana, and pawpaw, using the first, and the second drops of blood [12]. The results showed a marked increase in participants' blood glucose reading after peeling fruits without washing their hands or using alcohol swab compared to control subjects. Among all the mentioned fruits, handling pawpaw had the highest reading of blood glucose [12]. There was no significant increase in blood glucose reading in participants who handled fruits and washed their hands compared to control subjects. The study demonstrated the need to wash hands after handling fruit due to pseudo-hyperglycemia [12]. Although the previously mentioned studies were experimental, their results were similar to our observational study, which showed an association (p = 0.010), (SD 1.645) between the average blood glucose reading after meals and washing hands. The high blood glucose readings after meals in Table 6 may be due to inadequate diet for people with type 2 diabetes mellitus or using the first drop of blood, which may be contaminated with glucose and fructose of the fruits [10,11]. There was no significant association between demographic data and the increased risk of pseudo-hyperglycemia effects of unwashed hands, due to the confined age group in the study sample. Males are more prone to underestimate the consequences of not washing their hands. 20.4% (n = 30) of male patients do not wash their hands; on the contrary, female patients who do not wash their hands were 14.5% (n = 36). However, unexpectedly, as the patients got older in the study sample, they were more attentive to washing their hands before measuring the glucose level. With regard to the education level, evidently, the higher the education level the better practice of washing hands before blood glucose reading. Uneducated patients do not know how important it is for them to wash their hands before they measure their glucose level. Also, they probably do not have a companion to help them wash their hands and educate them. 21.4% (n = 24) of uneducated patients do not wash their hands, unlike patients with bachelor's degrees; only 15.3% (n = 8) did not wash their hands. Most of the study sample were housewives, and they showed the better practice of washing their hands, and only 16.4% (n = 34) did not wash their hands, compared with the other jobs (n = 32, 20.9%). Our study showed no significant association between the knowledge of the effect of unwashed hands on blood glucose reading and most demographic variables except for gender as shown in Table 5. 152 female out of the 247 female participants answered agree, and only 78 male out of 147 male participants answered agree (p = 0.037). However, there is a significant association between age, gender, and nationality of the participant and the knowledge of peeling fruits on blood glucose reading. The majority of the older participants aged 56 and above answered no to the association between peeling fruits and inaccurate blood glucose reading. Regarding gender, most male participants answered no, and the difference was less significant in female participants. In addition, there was a significant association between nationality and knowledge in contrast to other nationalities, and more than half of the Saudi participants answered no. There was no significant association between the demographic data and attitude toward the effect of unwashed hands on blood glucose. Table 6 shows that there is no association between the demographic data and the participants' attitude toward peeling fruits would cause wrong reading except for the age (p = 0.009) and gender (p < 0.001). However, female participants wash their hands more than males (85.4% and 79.5% respectively), and that may be due to many of the females involved in our study are uneducated and with no job or housewives, so their presence in the home would facilitate washing hands more than the male who spend less time in the house. Moreover, there is no relationship between job and washing hands (p = 0.131). For age, gender, educational level, nationality, job, and how washing hands affect the reading, the study reveals no association between them with extreme significant levels for educational status (p = 0.067) and for the nationality (p = 0.862). First of all, Prince Sultan Military Medical City demands a fee for every research conducted in their departments. Moreover, there is a 4-6 weeks waiting period for the IRB to be provided. In addition, Prince Sultan Military Medical City hospital only allows researchers to conduct their

research if they have an IRB supplied by the hospital itself. Some of King Salman Hospital patients are not very welcoming, especially men, besides the difficulty of communicating with the patients due to them not understanding the question. Also, most of them had a hearing problem which was a restriction from collecting more data. Finally, there was a small number of patients.

In this study, we aimed to evaluate the knowledge, attitude, and practice of pseudo-hyperglycemia effect of unwashed hands among type 2 diabetes patients aged 40 and older in King Salman Hospital in Riyadh, Saudi Arabia, to determine the characteristics associated with adequate knowledge, attitude, and practice, and to determine the risk factors that probably increase the risk of pseudo-hyperglycemia effect of unwashed hands. We found that 58.4% of the patients (n = 230) know that pseudo-hyperglycemia is an effect of unwashed hands and 68.8% (n = 271) of the sample had a good practice of always washing their hands before measuring their blood glucose. Regarding attitude, 71.1% (n = 280) of the participants agreed that there is a relationship between unwashed hands and wrong glucose meter readings. Also, there is a significant risk between male and pseudo-hyperglycemia effect of unwashed hands (p = 0.037). Finally, the characteristics of people with type 2 diabetes mellitus with good knowledge can be associated with age (p = 0.049), gender (p = 0.011), and nationality (p = 0.016). In addition, there was a significant relationship between age and attitude of participants who ascertained that there is a relationship between peeling fruits and if it could cause inaccurate reading (p = 0.009), and the cross-association between gender and attitude of samples ponder that there is a relationship between peeling fruits and wrong blood glucose reading (p < 0.001). However, the practice is not associated with any significant factor. This study concludes the importance of washing hands before using the blood glucose meter for people with diabetes. Unwashed hands cause pseudo-hyperglycemia because hands are contaminated by the glucose and fructose of fruits, or contaminated by dirt, even after using alcohol swabs. Using the blood glucose meter is a basic routine for diabetic patients. Counting on the readings to get adequate knowledge about their blood glucose stability will be misleading and may be worse and more challenging to maintain blood glucose.

Conclusion

The present study suggests all people with type 2 diabetes mellitus to wash their hands, either by water alone, or with soap, and dry their hands well before using the blood glucose meter. During data collection, we noted the low educational level among the elderly patients in King Salman Hospital and the lack of awareness regarding hand hygiene, especially the male participants and the proper use of glucose meters. Some participants confessed that they did not often recall what the health education unit has taught them since they claimed they visited the health education office only once they are diagnosed. We recommend regular visits to the health education office to provide patients with the proper guidance they need. We also noted that there are not enough infographics and banners that target the diabetes clinic patients, so we suggest using multimedia materials that are direct and easy to understand, preferably in the Arabic language.

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Conflict of interest
The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent to participate
Written informed consent was obtained from all the participants.

Ethical approval
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