

Understanding Self-Monitoring of Blood Glucose Among Individuals With Type 1 and Type 2 Diabetes

An Information–Motivation–Behavioral Skills Analysis

Purpose

To evaluate self-monitoring of blood glucose (SMBG) information deficits, motivational obstacles, and behavioral skills limitations in individuals with type 1 and type 2 diabetes, and to assess the relationship of these deficits with SMBG frequency.

Methods

Individuals with type 1 ($n = 208$; 103 male, 105 female) and type 2 ($n = 218$; 107 male, 111 female) diabetes participated in an online survey assessing SMBG information, motivation, behavioral skills, and behavior.

Results

A substantial proportion of participants scored as SMBG uninformed, unmotivated, and unskilled on specific assessment items. SMBG information, motivation, and behavioral skills deficits were significantly correlated with SMBG frequency, such that individuals with type 1 or type 2 diabetes, who were less informed, less motivated, and less behaviorally skilled, reported lower frequency of SMBG.

William A. Fisher, PhD

Taylor Kohut, MSc

Holly Schachner, MD

Patricia Stenger, RN, CDE

From the Department of Psychology, Department of Obstetrics and Gynecology, University of Western Ontario, London, Ontario, Canada (Dr Fisher); the Department of Psychology, University of Western Ontario, London, Ontario, Canada (Mr Kohut); and Bayer HealthCare LLC, Diabetes Care, Tarrytown, New York (Dr Schachner, Ms Stenger).

Correspondence to William A. Fisher, PhD, the Department of Psychology, Social Science Centre, Room 7428, University of Western Ontario, London, Ontario, Canada, N6A 5C2 (fisher@uwo.ca).

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Conclusion

Common and consequential SMBG information, motivation, and behavioral skills deficits were present, and patients with these gaps were less likely to test frequently. Clinical education focusing on relevant SMBG information, motivation to act, and behavioral skills for acting effectively may be a priority.

Self-monitoring of blood glucose (SMBG) has the potential to be an effective self-management tool that may be instrumental in achieving glycemic control among adults with type 1^{1,2} and type 2^{3,4} diabetes. Although research support for the association between SMBG and glycemic control among individuals with type 2 diabetes has been mixed,^{5,6} recent meta-analyses of randomized controlled trials^{3,4} (see also Guerci and colleagues' large, individual randomized trial⁷) have concluded that SMBG can contribute to significant improvement in glycemic control among noninsulin-using individuals with type 2 diabetes. Recent critiques have also emphasized that cross-sectional studies of the relation between SMBG and glycemic control among individuals with diabetes may be inherently methodologically confounded.^{8,9} It has been noted as well that whether persons with diabetes have been taught appropriate self-management actions to take on the basis of SMBG results, and whether they undertake such actions, is pivotal to the relationship between SMBG and glycemic control.^{2,6}

Interest in the potential contribution of SMBG to achievement of glycemic control has stimulated epidemiologic studies concerning the prevalence and frequency of SMBG among individuals with type 1 and type 2 diabetes as well as intervention research to identify effective methods for promoting the practice of SMBG.

With respect to SMBG prevalence, the US Centers for Disease Control and Prevention^{2,6,10} has reported a substantial and steady increase, from 1997 to 2006, in the proportion of US citizens with diabetes who report daily or more frequent testing. According to these reports, some 63% of noninsulin-using individuals with diabetes and some 87% of insulin-using individuals with diabetes practice SMBG at least once daily. While these findings

suggest optimism concerning SMBG utilization in the United States, the measure of SMBG as "once daily or more often" is a relatively crude one that does not provide information about adherence to recommended frequency of monitoring. In this connection, Karter et al¹¹ (see also Vincze¹²) surveyed a sample of 44 181 individuals with diabetes and found that 60% of individuals with type 1 diabetes and 87% of individuals with type 2 diabetes reported SMBG frequencies that fell below those recommended by the American Diabetes Association. While acknowledging positive trends in some indicators of SMBG utilization across time, there remains a need to focus on adherence to recommended patterns and frequency of SMBG as opposed to dichotomous daily/not daily frequency of testing measures.

With respect to the promotion of SMBG, a substantial amount of intervention research has been carried out to identify effective methods for improving SMBG practice. Meta-analytic research indicates that a variety of interventions have positive effects on knowledge, frequency, and accuracy of SMBG,¹³ although maintenance of change 6 months after intervention appears to be variable and may depend on the use of collaborative as opposed to didactic intervention techniques as well as regular reinforcement of change. Individual intervention trials of methods as diverse as counseling and provision of an SMBG device,¹⁴ provision of a blood glucose "owner's manual,"¹⁵ and motivational interviewing^{16,17} and stages of change interventions,¹⁸ have all shown positive effects on SMBG frequency and often on levels of hemoglobin A1C as well.

Despite the potential benefits of SMBG and substantial interest in the prevalence and promotion of this practice, few efforts to apply validated behavioral science theory to identify basic social and psychosocial factors that influence SMBG appear in the literature. Although there is a significant amount of conceptually unintegrated observations concerning correlates of SMBG frequency—we know that length of time since diagnosis, age, sex, ethnicity, and socioeconomic status,¹¹ as well as self-esteem, self-efficacy, anxiety, and depression^{12,19-22} may all be associated with SMBG frequency—well-integrated behavioral science models of factors that influence SMBG have yet to be extensively tested or reported. The current research applies the Information–Motivation–Behavioral Skills (IMB) model of health behavior,²³⁻²⁵ a well-researched model of factors that are conceptually and empirically related to health behavior performance,

in an organized effort to systematically identify basic social and psychosocial factors that may be related to SMBG utilization in samples of individuals with type 1 and type 2 diabetes.

According to the IMB model, *information that is relevant to SMBG practice*, including information about recommended frequency and patterns of testing, interpretation of blood sugar results, and self-management actions based on results, constitutes a fundamental prerequisite of adherent and effective SMBG. *Motivation to engage in SMBG at the recommended frequency* is a second fundamental determinant of whether even well-informed individuals will be inclined to act on what they know and practice SMBG at the recommended frequency. Motivation to practice SMBG is a function of an individual's attitudes toward personally performing SMBG and his or her perceptions of social support from significant others for this practice. Finally, *behavioral skills for engaging in SMBG effectively* include the following: objective and perceived abilities to self-cue SMBG; ability to engage in this practice discreetly, nondisruptively, and painlessly; and ability to engage in effective self-management actions based on blood glucose readings. Behavioral skills are a third pivotal determinant of whether even well-informed and well-motivated individuals will be capable of practicing SMBG effectively and at the recommended frequency. According to the IMB model, well-informed, well-motivated, behaviorally skilled individuals with type 1 and type 2 diabetes will be inclined to practice SMBG adherently and to engage in appropriate self-management actions based on SMBG results. In contrast, from the perspective of the IMB model, individuals with significant SMBG information gaps, motivational obstacles, and behavioral skills deficits will be unlikely to adhere to SMBG regimens or to undertake appropriate self-management actions based on blood sugar results.

According to the IMB model (Figure 1), SMBG information and SMBG motivation will influence the application of SMBG behavioral skills and result in SMBG adherence over time. The objective and subjective health outcomes of SMBG will form a feedback loop that will strengthen or weaken SMBG information, motivation, and behavioral skills, depending on the positive or negative nature of the health outcome. Finally, moderating factors, ranging from states of clinical depression to employment interference to financial distress, will affect the ability of even well-informed, well-motivated, and behaviorally skilled individuals to engage in SMBG.

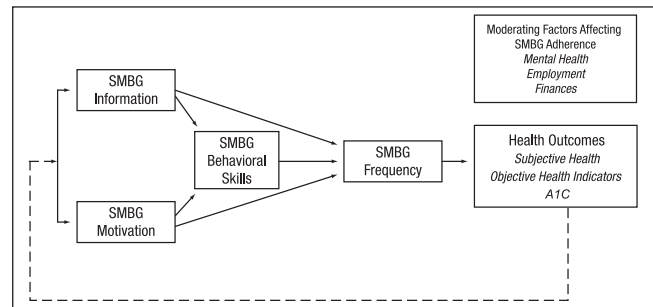


Figure 1. An Information–Motivation–Behavioral Skills (IMB) model of social and psychological factors that influence self-monitoring of blood glucose (SMBG).^{24,25}

The current research, guided by the IMB model, represents an initial attempt to map out SMBG information deficits, SMBG motivational obstacles, and SMBG behavioral skills limitations in individuals with type 1 and type 2 diabetes, and to assess the relationship of SMBG information, SMBG motivation, and SMBG behavioral skills with SMBG frequency in these individuals.

Research Design/Methodology

Data Collection Procedures

Individuals with type 1 ($n = 208$; 103 male, 105 female) and type 2 ($n = 218$; 107 male, 111 female) diabetes who were enrolled in the Chronic Illness Panel of Harris Interactive were recruited for participation in this research. Chronic Illness Panel members are US citizens from across regions of the country, who have been diagnosed with type 1 or type 2 diabetes, and have consented to be approached to participate in condition-related research. Respondents were contacted via customized email invitations that provided a link to an online survey platform used to collect data for this research, and received a nominal incentive for taking part in this study. Sample characteristics including age, ethnicity, education, time since diagnosis, and self-reported A1C levels are described in the Results section. All research procedures were reviewed and approved by the Western Institutional Review Board.

Measure Development

Assessing SMBG Information, Motivation, and Behavioral Skills

A research team consisting of a senior diabetes educator, an endocrinologist experienced in diabetes management,

and a health psychologist experienced in research tests of the IMB model created new self-report measures of SMBG information, motivation, and behavioral skills for the purposes of this research. First, definitions of the IMB model constructs of SMBG information, motivation, and behavioral skills, described earlier, were specified. Second, sets of items assessing SMBG information, motivation, and behavioral skills were written, reviewed by the research team, edited for clarity and consistency with construct definitions, and reviewed by persons with diabetes. Third, these items were administered to a research panel of individuals with type 1 or type 2 diabetes.

The proportion of participants whose responses indicated that they were SMBG uninformed, unmotivated, or unskilled with respect to each information, motivation, and behavioral skills item was calculated and is reported. Summed SMBG information, motivation, and behavioral skills scales, capturing individuals' overall SMBG information, motivation, and behavioral skills, were also created. For this purpose, item-selection procedures, based on significant item-total score correlations within the SMBG information, motivation, and behavioral skills item pools, were carried out to obtain internally consistent summed measures of the SMBG information, motivation, and behavioral skills constructs at focus. Scales assessing SMBG information (35 items, Cronbach alpha = 0.93), SMBG personal motivation (25 items, Cronbach alpha = 0.90), SMBG social support (7 items, Cronbach alpha = 0.84), and SMBG behavioral skills (34 items, Cronbach alpha = 0.94) were formed on the basis of this item-selection process, and summed SMBG information, motivation, and behavioral skills scale scores were calculated.

Scoring SMBG Information

Participants responded to SMBG information items on 5-point strongly disagree to strongly agree scales. Those who indicated strong disagreement, disagreement, or a neutral response to a correct SMBG information item were scored as "SMBG uninformed" for that item, because their response indicated that they lacked relevant SMBG information. For example, individuals who responded to the item "I know how often to test my blood sugar" with strong disagreement, disagreement, or a neutral response, and did not respond with any degree of agreement that they knew how often to test their blood sugar, were coded as "SMBG uninformed" for this item. Similarly, those who indicated strong agreement,

agreement, or a neutral response to an incorrect SMBG information item were also scored as "SMBG uninformed." For example, individuals who responded to the item "My doctor does not need to know my daily blood sugars because he or she has my A1C value" with strong agreement, agreement, or a neutral response, and did not respond with any degree of disagreement with the statement, were coded as "SMBG uninformed" for this item.

Scoring SMBG Motivation

Participants responded to SMBG motivation items assessing attitudes toward personally performing SMBG on 5-point and 7-point scales anchored with positive and negative evaluations. Those who responded on the negative side of the scale midpoint were coded as "SMBG unmotivated" because they indicated a negative attitude to SMBG. For example, individuals who responded to the item "Testing my blood sugar as often as recommended by my health care provider would be 1 = *awful* to 7 = *nice*," on scale points 1, 2, or 3 would be scored as "SMBG unmotivated" because they expressed a negative attitude to engaging in SMBG.

Participants responded to SMBG motivation items assessing perceived social support for SMBG on 5-point "strongly disagree" to "strongly agree" scales. Those who indicated any degree of disagreement or a neutral response to items assessing perceived social support for SMBG were coded as "SMBG unmotivated" because they did not perceive social support for this practice. For example, individuals who responded to the item "My family thinks I should test my blood sugar as often as recommended by my health care provider" with any degree of disagreement or with a neutral response were scored as "SMBG unmotivated" because they did not perceive social support from their families for monitoring their blood sugar.

Scoring SMBG Behavioral Skills

Participants responded to SMBG behavioral skills items on 5-point scales anchored at each end with "very easy" and "very difficult." Those who responded on the "very difficult" side of the scale midpoint were coded as "SMBG unskilled" because they indicated that the SMBG practice in question was difficult for them. For example, individuals who responded to the item "Testing my blood sugar level without too much pain is 1 = *very difficult* to 5 = *very easy*," on scale points 1 or 2 would be

scored as “SMBG unskilled” because they indicated that a particular SMBG-related behavior was difficult for them to accomplish.

Scoring SMBG Frequency

Average frequency of SMBG was assessed by aggregating responses to two self-report items and dividing by two. The items read, “Yesterday, I tested my blood sugar” and “The day before yesterday, I tested my blood sugar,” with response options on a 9-point scale ranging from “I did not test my blood sugar yesterday (2 days ago)” to “I tested my blood sugar 1, 2, 3, 4, 5, 6, 7 times, or 8 or more times.”

Results

Sample Characteristics

Participants’ average age was 46 years (range, 21-75 years); 90% self-identified as white, 2% as African American, and 2% as Hispanic, and the remainder (6%) self-identified with other racial or ethnic groups. A total of 13% of the participants had completed high school or less; 67% had completed some or all of college, and 19% had completed some or all of a graduate education. Respondents with type 1 diabetes self-reported SMBG a median of 4 times per day during the past 2 days (range, 0-7.5 times); mean self-reported adherence to their health care provider’s recommended SMBG frequency was 96% (range, 0%-200% of the recommended frequency), and mean self-reported A1C level was approximately 7.3. Median length of time since diagnosis of diabetes for those with type 1 diabetes was more than 10 years (range, 7 months to more than 10 years). Respondents with type 2 diabetes self-reported a median SMBG frequency of 2 times per day during the past 2 days (response range, 0-5.5 times); mean adherence to recommended SMBG frequency was 90% (range, 0%-200% of the recommended frequency), and mean A1C level was approximately 7.0. The median length of time since diagnosis of diabetes for those with type 2 diabetes was 5 to 10 years (range, 7 months to more than 10 years).

SMBG Information, Motivation, and Behavioral Skills Responses

Table 1 shows that a substantial proportion of those with type 1 and type 2 diabetes scored as “SMBG

uninformed,” “SMBG unmotivated,” and “SMBG unskilled” on specific assessment items.

With respect to SMBG information, approximately 75% of respondents with type 1 and type 2 diabetes did not disagree with the statement that “My body tells me without testing if my blood sugar is low or high.” Similarly, 39% of those with type 1 diabetes and 47% of those with type 2 diabetes did not disagree that “It is my body—not testing, diet, or exercise—that really affects my blood sugar levels,” and more than one quarter of respondents with type 1 and type 2 diabetes did not disagree with the statement that “My doctor does not need to know my daily blood sugars because he or she has my A1C value.” Moreover, roughly half of those with type 1 and type 2 diabetes failed to agree that “I should test my blood sugar after meals,” and 21% of those with type 1 diabetes and 40% of those with type 2 diabetes did not agree that “I know how to look for patterns in my blood sugar readings.”

With respect to SMBG motivation, a substantial proportion of individuals with type 1 and type 2 diabetes reported that testing their blood sugar as often as recommended would be expensive (62% and 48%, respectively), constantly remind them they had diabetes (45%, 53%), be painful (34%, 35%), let everyone know they have diabetes (31%, 22%), would be unpleasant (28%, 30%) and frustrating (26%, 25%), and would require a huge time commitment (25%, 25%). Moreover, a substantial proportion of individuals with type 1 and type 2 diabetes did not agree that the people they work with (60% and 67%, respectively) or their children (57%, 57%), spouses (34%, 45%), or friends (43%, 47%) thought that they should test their blood sugar as often as recommended.

With respect to SMBG behavioral skills, individuals with type 1 and type 2 diabetes reported that it was difficult to pay for their testing supplies (41%, 37%), to test their blood sugar without other people knowing they were testing (28%, 20%), to test their blood sugar without too much pain (21%, 22%), to remember to test their blood sugar (17%, 27%), and to keep their blood sugar meters available when needed (19%, 18%). Individuals with type 1 and type 2 diabetes also reported difficulty downloading blood sugar information to their home computer (26%, 24%) and indicated that they frequently run out of blood sugar testing supplies (14%, 20%), among other behavioral skills limitations.

Table 1

Self-Monitoring of Blood Glucose (SMBG) Information, Motivation, and Behavioral Skills Deficits Among Individuals With Type 1 and Type 2 Diabetes

	Percentage Uninformed, Unmotivated, or Unskilled	
	Type 1	Type 2
SMBG information		
1. My body tells me without testing if my blood sugar is low or high.	76.0	73.9
2. I should test my blood sugar after meals.	45.7	52.8
3. Meal planning is more important than blood sugar testing.	44.7	68.3
4. When my blood sugar is low I need to eat protein.	44.7	63.3
5. It is my body—not testing, diet, or exercise—that really affects my blood sugar levels.	38.5	47.2
6. If my blood sugar is high, I could increase my exercise.	38.5	30.7
7. I do not believe that keeping a record of blood sugar levels is that important.	29.3	33.0
8. My doctor does not need to know my daily blood sugars because he or she has my A1C value.	26.4	31.7
9. Activity is more important than blood sugar testing.	24.0	53.2
10. If I often have low blood sugar, I should test more frequently.	22.6	42.2
11. I know how to look for patterns in my blood sugar readings.	20.7	39.9
12. If I often have high blood sugars, I should test more frequently.	19.7	28.4
13. I know when to contact my health care provider if my blood sugar is out of target.	16.3	21.6
14. If my blood sugar is low, I could increase my carbohydrates.	15.9	38.1
15. I know how to fill out my record book (log book).	15.9	20.2
16. If I follow my management plan, I do not have to be too concerned about testing my blood sugar levels.	13.9	37.2
17. I know what to do about adjusting my diabetes management plan based on my blood sugars.	12.0	31.7
18. If my blood sugar is high, I could increase my insulin.	11.5	64.7
19. If my blood sugar is OK in the morning, I do not have to test again that day.	11.5	33.5
20. If I frequently have low blood sugar levels, I do not have to be too concerned about testing my blood sugar.	9.6	21.6
21. I have a clear understanding of what my blood sugar readings mean.	9.1	18.8
22. I should test my blood sugar before meals.	8.7	33.9
23. If my blood sugar is low, I could increase my exercise.	8.7	32.6
24. I know what my target blood sugar range is.	8.7	12.8
25. I do not understand the benefit of monitoring.	8.7	17.9
26. I know when to test my blood sugar.	7.2	14.7
27. I know what to do if I have a low blood sugar reading.	7.2	14.7
28. I know what to do if I have a high blood sugar reading.	7.2	20.6
29. I do not believe that food or exercise have that much of an effect on blood sugar.	7.2	14.7
30. If my blood sugar is high, I could increase my carbohydrates.	7.2	24.8
31. I know how often to test my blood sugar.	6.7	13.3
32. I don't need to check my blood sugar because I get an A1C.	6.7	18.3
33. Blood sugar usually does not change during the day.	6.3	17.9
34. If I frequently have high blood sugar levels, I do not have to be too concerned about testing my blood sugar.	5.3	15.6
35. It is bad for my health to have high blood sugar.	5.3	8.7
SMBG motivation: attitudes		
1. Testing my blood sugar as often as recommended would be expensive.	62.0	48.2
2. Testing my blood sugar as often as recommended would constantly remind me that I have diabetes.	45.2	52.8
3. Testing my blood sugar as often as recommended would be painful.	33.7	34.9

(continued)

Table 1 (continued)

	Percentage Uninformed, Unmotivated, or Unskilled	
	Type 1	Type 2
5. Testing my blood sugar as often as recommended by my health care provider would be unpleasant.	27.9	30.3
6. Testing my blood sugar as often as recommended would make me less anxious.	27.4	25.2
7. Testing my blood sugar as often as recommended would be frustrating.	25.5	24.8
8. Testing my blood sugar as often as recommended would be a huge time commitment.	24.5	24.8
9. Testing my blood sugar as often as recommended would help me stick to my meal plan.	15.4	15.6
10. Testing my blood sugar as often as recommended would interfere with many aspects of my life.	13.9	15.1
11. Testing my blood sugar as often as recommended would interfere with many things I like to do.	13.9	16.5
12. Testing my blood sugar as often as recommended would make me more anxious.	13.5	16.5
13. Testing my blood sugar as often as recommended by my health care provider would be awful.	12.5	12.4
14. Testing my blood sugar as often as recommended by my health care provider would be unnecessary.	9.1	6.4
15. Testing my blood sugar as often as recommended would cause problems at work.	9.1	8.3
16. Testing my blood sugar as often as recommended would help me adjust my activity.	8.2	8.3
17. Testing my blood sugar as often as recommended by my health care provider would be foolish.	7.7	5.5
18. Testing as often as recommended would not be necessary because I know what my blood sugar is by the way I feel.	7.2	14.2
19. Testing my blood sugar as often as recommended would help me work with my health care team (doctor or nurse).	3.4	3.7
20. Testing my blood sugar as often as recommended would help me avoid complications.	2.9	5.0
21. Testing my blood sugar as often as recommended would help me control my diabetes.	2.4	2.3
22. Testing my blood sugar as often as recommended would help my health care team care for me.	2.4	3.2
23. Testing my blood sugar as often as recommended by my health care provider would be bad.	1.4	2.3
24. Testing my blood sugar as often as recommended would help me adjust my medication.	1.4	9.6
25. Testing my blood sugar as often as recommended would cause friction with my spouse or significant other.	1.4	3.7
SMBG motivation: social support		
1. The people I work with think I should test my blood sugar as often as recommended by my health care provider.	60.1	67.0
2. My children think I should test my blood sugar as often as recommended by my health care provider.	57.2	56.9
3. My friends think I should test my blood sugar as often as recommended by my health care provider.	43.3	46.8
4. My diabetes educator thinks I should test my blood sugar as often as recommended by my doctor.	34.1	44.0
5. My husband or wife thinks I should test my blood sugar as often as recommended by my health care provider.	33.7	44.5
6. My family thinks I should test my blood sugar as often as recommended by my health care provider.	24.0	33.5
7. My doctor thinks I should test my blood sugar as often as he or she recommends.	7.7	15.6
SMBG behavioral skills		
1. Paying for my blood sugar meter and testing supplies is very difficult.	41.3	36.7
2. Testing my blood sugar level without other people knowing I'm testing is very difficult.	28.4	20.2
3. I can download information from my blood sugar meter to my home computer.	26.0	23.9
4. I can check my blood sugar reading without other people noticing.	22.6	16.1
5. I know how to get insurance coverage to pay for my blood sugar testing supplies.	22.1	21.1
6. Testing my blood sugar level without too much pain is very difficult.	20.7	22.0
7. Keeping my blood sugar meter available so I can use it when I need to is very difficult.	19.2	17.9
8. Remembering to test my blood sugar level is very difficult.	17.3	27.1
9. I find it easy to talk to my friends about having diabetes.	14.4	9.3
10. I find it easy to talk to my coworkers about having diabetes.	14.4	14.7

(continued)

Table 1 (continued)

	Percentage Uninformed, Unmotivated, or Unskilled	
	Type 1	Type 2
12. I know how to ask for support from friends and family for monitoring my blood sugar.	13.5	8.3
13. I often run out of blood sugar level testing supplies.	13.5	19.7
14. I am able to keep extra blood sugar level testing supplies on hand.	12.5	17.9
15. I can get an adequate drop of blood for testing.	10.6	6.9
16. I know how to use my lancing device so that blood sugar level testing is not so painful.	10.6	11.9
17. I find it easy to talk to my family members about having diabetes.	10.1	9.6
18. I feel comfortable talking with my health care provider about my blood sugar records.	9.6	3.2
19. I can set the date and time on my blood sugar meter.	9.1	9.6
20. I can use all of the features on my blood sugar meter.	8.7	9.6
21. I know how to get the averages on my blood sugar meter.	8.2	11.5
22. I know how to remind myself to take a blood sugar reading at the frequency recommended by my health care provider.	8.2	17.0
23. I know how to talk to my health care provider about my blood sugar.	5.8	3.2
24. Testing my blood sugar levels is very difficult.	5.3	8.7
25. I know how to remind myself when it is time to get new blood sugar testing supplies.	4.8	4.6
26. I know how to talk to my health care provider about my blood sugar level records or log book, even when my health care provider doesn't ask.	4.8	4.6
27. I know what blood sugar my health care provider wants to see.	4.8	4.1
28. I can use some of the features on my blood sugar meter.	4.3	5.0
29. I can apply the drop of blood to the test strip on my blood sugar meter.	3.8	2.8
30. I know how to ask for support from my health care providers for monitoring my blood sugar.	3.8	6.4
31. I know what meter information to bring to my health care provider.	3.4	4.1
32. I can turn my blood sugar meter on.	0.0	0.0
33. I can insert a test strip or disk into my blood sugar meter.	0.0	1.4
34. I can insert the lancet into the lancing device for my blood sugar meter.	0.0	1.4

Abbreviation: SMBG, self-monitoring of blood glucose.

Correlational Analyses

Correlational analyses assessed the relationship of SMBG information, SMBG motivation, and SMBG behavioral skills, with average frequency of SMBG during the past 2 days, within the samples of individuals with type 1 and type 2 diabetes, employing the summed SMBG information, motivation, behavioral skills, and behavior measures described earlier. For those with type 1 diabetes, SMBG information ($r = 0.45$), SMBG motivation (attitudes; $r = 0.38$), and SMBG behavioral skills ($r = 0.28$), were significantly correlated (all $P < .05$) with SMBG average frequency. Individuals with type 1 diabetes who reported lower levels of SMBG information,

motivation, and behavioral skills reported lower frequencies of SMBG, and the magnitude of these relationships ranged from medium to large according to accepted principles of behavioral science research.²⁶ The multiple correlation of SMBG information, SMBG motivation, and SMBG behavioral skills with SMBG average frequency was $R_{\text{mult}} = 0.49$, $P < .05$, indicating a strong relationship.²⁶ SMBG information, SMBG motivation (attitudes), and SMBG behavioral skills together accounted for approximately 25% of the variation in SMBG frequency among individuals with type 1 diabetes. For those with type 2 diabetes, SMBG information ($r = 0.28$), SMBG motivation (perceived social support; $r = 0.18$), and SMBG behavioral skills ($r = 0.19$), were all significantly

correlated ($P < .05$) with SMBG average frequency. Individuals with type 2 diabetes who reported lower levels of SMBG information, social motivation, and behavioral skills reported lower frequencies of SMBG, and the magnitude of these relationships ranged from small to medium according to accepted principles of behavioral science research.²⁶ The multiple correlation of SMBG information, motivation, and behavioral skills with SMBG average frequency for those with type 2 diabetes was $R_{\text{mult}} = 0.30$, $P < .05$, indicating a medium strength relationship.²⁶ SMBG information, SMBG motivation (social support), and SMBG behavioral skills together accounted for 9% of the variance in SMBG average frequency among those with type 2 diabetes.

Conclusions

The current research applied the IMB model of health behavior²³⁻²⁵ in an effort to explore social and psychological factors that may influence SMBG frequency. Guided by the model, we identified significant SMBG information gaps, motivational obstacles, and behavioral skills limitations among individuals with type 1 and type 2 diabetes. The majority of these individuals did not disagree with the view that blood sugar testing is unnecessary because their body tells them without testing if their blood sugar is low or high, and a substantial proportion were unaware that their health care provider needs to know their blood sugar testing results, and indicated that they did not know how to detect patterns in their blood sugar readings. Moreover, a considerable proportion of those with type 1 and type 2 diabetes viewed SMBG as expensive, painful, unpleasant, a huge time commitment, a constant reminder that they have diabetes, and likely to let others know they have diabetes, and they did not perceive social support from significant others for their practice of SMBG. Finally, a significant number of individuals with type 1 and type 2 diabetes reported potentially crucial SMBG behavioral skills limitations and found it difficult to pay for blood sugar testing, to remember to test, to keep their blood sugar meter accessible, to test without too much pain, to test so that others do not know they are testing, and to download blood sugar results to their home computer.

Assessments of SMBG information, motivation, and behavioral skills deficits were significantly correlated with average frequency of SMBG for both individuals with type 1 and type 2 diabetes. Stronger relationships among these

measures were observed for those with type 1 diabetes than for those with type 2 diabetes. SMBG information, motivation, and behavioral skills accounted for a respectable 25% of the variability in SMBG frequency among individuals with type 1 diabetes and for a more modest 9% of the variance in SMBG frequency among individuals with type 2 diabetes. Further research on information, motivation, and behavioral skills correlates of SMBG remains to be accomplished beyond this initial study, particularly with respect to understanding factors that influence SMBG frequency among individuals with type 2 diabetes.

Limitations of this research include the fact that the current study was both correlational and cross-sectional, and prospective research in this area remains to be accomplished. The current samples of respondents with type 1 or type 2 diabetes included individuals across a wide range of ages, education, and geographic locations in the United States and had variable levels of SMBG frequency and glycemic control. At the same time, the current samples of respondents were, on average, relatively well educated, computer literate, and under relatively good glycemic control. As is the case with all research in this area, the study of SMBG information, motivation, and behavioral skills deficits, and their relationship to SMBG frequency, could benefit from additional research with diverse samples of individuals with diabetes.

Implications/Relevance for Diabetes Educators

The current research has a number of clinical practice implications. From the clinical perspective, there appear to be common and consequential SMBG information, motivation, and behavioral skills gaps in patients in whom we may wish to encourage SMBG practice. On the basis of the present findings, it would appear to be essential to clarify that patients possess information that is directly relevant to the practice of SMBG and that they do not endorse common beliefs that tend to deter SMBG. It would seem to be equally essential to explore whether patients are motivated or unmotivated to practice SMBG and to verify that they possess the specific behavioral skills required for maintaining the adherent and effective practice of SMBG over time. As the current findings indicate, a substantial proportion of individuals with type 1 and type 2 diabetes are unconvinced that they need to test. They find testing painful, time consuming, and a constant reminder to themselves and others that they

have diabetes, and they have difficulty remembering to test, keeping their meter accessible, testing without too much pain, and testing discreetly. Individuals with limited SMBG information, motivation, and behavioral skills were also less likely, overall, to test frequently. It follows from these findings that clinical education with a focus on easy-to-enact SMBG information, psychoeducational efforts to defuse negative motivation to testing, and focused rehearsal and refinement of behavioral skills for remembering to test, for doing so relatively painlessly, and for undertaking appropriate self-management actions on the basis of blood sugar results, may be a priority for diabetes clinicians and educators.

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