Barriers and Behaviors in Blood Glucose Monitoring

a report by
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"The relatively infrequent and uneven inclusion of behavioral and social science principles in diabetes care has limited the effective use of new knowledge gained from biomedical clinical trials. A focus on biomedical intervention without integration of behavior and social science principles into clinical care severely limits the impact of biotechnology and biomedicine."[1]

As this quotation suggests, the integration of blood glucose monitoring into overall patient care occurs at the intersection of biomedicine and behavior, and requires considerable behavioral medicine expertise on the part of diabetes care providers. Accordingly, we should discuss what is known about patient adherence to blood glucose monitoring, characteristics of adherent and non-adherent patients, the controversial relationship between blood glucose monitoring and glycemic control, and behavioral medicine interventions to promote adherent self-monitoring of blood glucose (SMBG) and improved glycemic control.

Levels of Adherence to Self-monitoring Blood Glucose

We derive considerable encouragement from the recently reported findings from the Centers for Disease Control and Prevention (CDC), which indicate a substantial and steady increase from 1997 to the present day of the number of US citizens with diabetes who self-monitor their blood glucose at least once a day.[2] According to this report, the SMBG objectives of 'Healthy People 2010' have already been achieved. However, while the CDC findings appear to provide evidence of important gains in SMBG adherence, we observe that adherence to SMBG measured as an absolute frequency—e.g. once a day, as in the case in the CDC report—may result in estimates that are not always related to the actual SMBG requirements of patients with diabetes.

Vicenze et al.,[3] among others, have pointed out that an adherence to SMBG measured in terms of the proportion of the recommended SMBG frequency (absolute frequency ÷ healthcare provider stipulated frequency) may provide the most meaningful assessment of SMBG adequacy and result in lower estimates of adherence. Measured in relation to the proportion of patients adhering to the SMBG frequency recommended by the American Diabetes Association (ADA), in a sample of 44,181 respondents and with an 83% response rate[4] it was stated that 60% of those with type 1 diabetes and 67% of those with type 2 diabetes reported SMBG frequencies lower than recommendations. At this juncture, we note that the prevalence of SMBG appears to be improving in the US over time, that SMBG adherence adequacy may be most meaningfully evaluated in relation to recommended—not absolute—frequency of monitoring, and that whatever population trends may develop, in terms of the physician–patient encounter SMBG adherence is individually variable and differs within individuals across time and circumstance, and should be continuously monitored in relation to the patient's health status.

Factors Influencing Self-monitoring Blood Glucose

A multiplicity of studies have identified the determinants of SMBG frequency. For example, the recent CDC report[2] presents multivariate findings to indicate that less well-educated patients, those without health insurance, those whose therapy is less intensive, and males have a substantially reduced likelihood of performing daily SMBG. Other research echoes this pattern of findings[4] and indicates that for those with type 1 diabetes, male sex, ethnic minority status, low income level, smoking, and being <65 years of age are independent predictors of less-frequent SMBG. For those with type 2 diabetes, male sex, ethnic minority status, lesser education, language barriers, higher cost of out-of-pocket strip expenditures, longer duration of diabetes diagnosis, smoking, and excessive alcohol consumption are independent predictors of lower-frequency SMBG.

In addition, research has identified psychological factors that are related to lower-frequency SMBG, including lower levels of self-esteem, self-efficacy, and competence, and higher levels of anxiety, depression, and perceived painfulness of monitoring procedures.[3,5–9] Environmental factors associated with SMBG infrequency, including lifestyle interference and inconvenience of SMBG, lack of parental involvement (for SMBG frequency for adolescents with type 1 diabetes), and lack of family support (for SMBG frequency for adults with type 2 diabetes), have also been identified.[3,10,11]

In summary, adherence to SMBG appears to be meaningfully linked to a number of patient characteristics, ranging from time since diagnosis to

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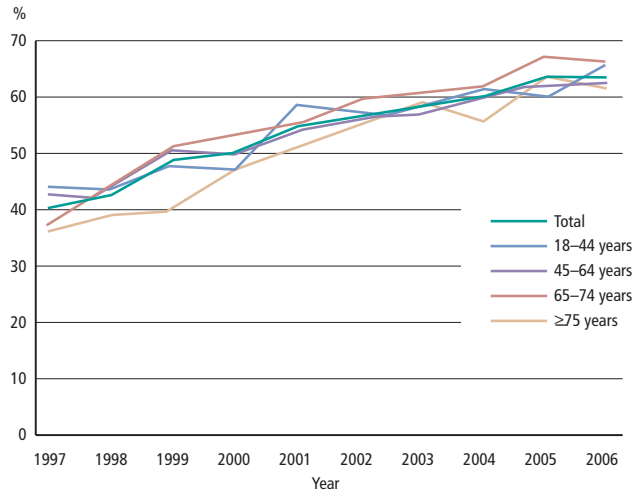
Figure 1: Estimated Basic Rate of Daily Self-monitoring of Blood Glucose Among Adults with Diabetes



Figures adapted from the US age group–behavioral risk factor surveillance system, 1997–2006.[2]

Table 1: Continuing Support for Maintenance of Intervention and Behavioral Change

Behavior change interventions should involve:

- well-validated behavioral science intervention models;
- collaborative identification of the self-care challenge;
- collaborative goal-setting for achievable outcomes;
- collaborative problem-solving;
- contracting for change;
- rewarding success; and
- continuing support for maintenance of interventional and behavior change.

Emotional support interventions should include:

- screening for diabetes-related emotional distress;
- providing ongoing informal emotional support; and
- referring treatment of significant emotional difficulties.

Source: Fisher and Glasgow, 2007.[1]

depression to family support, which may present in the clinical setting. A systematic assessment of patient adherence to SMBG and patient characteristics robustly linked with adherence levels in the research literature, coupled with targeted intervention support to address challenges to adherence, may be explored as means for promoting SMBG at an appropriate frequency.

Is Self-monitoring Blood Glucose Linked with Glycemic Control?

A demonstration of the relationship of SMBG frequency with glycemic control is an obvious and controversial matter for the promotion of SMBG as an important element in diabetes management. On the one hand, observational studies often show no relationship of SMBG with glycated hemoglobin (HbA_{1c}) levels, especially for non-insulin-treated diabetes patient populations,[12–14] and some research suggests that high-frequency SMBG added to the scenario may be related to distress, worry, and depression for non-insulin-treated diabetes patients,[13] although other studies show that SMBG is associated with increased wellbeing and reduced depression.[15]

However, from a critical perspective it is extremely important to note that observational studies of the relationship between SMBG frequency and glycemic control may be problematic from the methodological and statistical points of view. Specifically, it seems quite plausible that, in observational research, diabetes patients with poor glycemic control may monitor frequently (as a consequence of their poor glycemic control and in an effort to remedy this situation), and it seems equally valid that diabetes patients with poor glycemic control may monitor infrequently (which contributes to their poor glycemic control). Similarly, it seems credible that diabetes patients with good glycemic control may monitor frequently (and thereby achieve good glycemic control) or infrequently (as they do not perceive a need to do so). Accordingly, observational studies may show no relationship between SMBG and glycemic control because SMBG frequency may be related to both good and poor glycemic control.

Given the problematic nature of observational studies of the relationship between SMBG and glycemic control, we may seek clearer evidence concerning the causal link between SMBG frequency and glycemic control in intervention studies, which successfully improve SMBG frequency and that consistently show improved HbA_{1c} levels.

Welschen et al.[16] carried out a systematic review of six randomized, controlled trials conducted to evaluate the effect of SMBG in type 2 diabetes patients not using insulin. "The overall effect of SMBG was a statistically significant decrease of 0.39 in HbA_{1c} compared with control groups. This is considered clinically relevant … expected to reduce risk of microvascular complications by ~14%."[16,17]

At this point, it would seem prudent to exercise caution in interpreting observational studies showing no relation between SMBG and glycemic control, and to carefully consider the results of randomized controlled trials showing that improved SMBG may be causally related to improved glycemic control. At the same time, implicit in the analysis of the findings concerning SMBG and glycemic control, it would be sensible to emphasize the role of patient education concerning actions to be taken when SMBG results show high blood glucose levels in an attempt to exploit the full value of SMBG for glycemic control.

Can Interventions Improve Self-monitoring Blood Glucose?

Given evidence that SMBG may result in improved glycemic control, and that SMBG levels are often suboptimal, convincing evidence that clinical interventions may result in improved SMBG is exceedingly important. To this end, it is encouraging to note that meta-analytic reviews as well as a multiplicity of individual intervention studies demonstrate success in improving SMBG frequency. For example, a meta-analysis of self-management training trials by Norris et al.[18] showed positive effects of interventions on knowledge, frequency, and accuracy of SMBG, as well as on dietary habits and glycemic control, at six-month follow-up intervals.

However, at the same time evidence for maintenance of change beyond six months was inconsistent and thought to be related to regular reinforcement and collaborative intervention approaches, as opposed to a top-down didactic approach. We note that numerous individual intervention trials have demonstrated success, including research showing that counseling and SMBG device introduction improved HbA_{1c} over a six-month follow-up.[19] Other observations include:

- automated telephone reminders and nurse follow-up of problems increased SMBG, self-care (foot, weight), and dietary adherence, and lowered HbA_{1c} over a 12-month follow-up;[20]
- provision of a blood glucose 'Owners Manual' increased SMBG and improved HbA_{1c} over a six-month follow-up;[21]
- a Stages of Change model-based intervention improved SMBG compared with usual care;[22]
- a motivational interviewing intervention improved SMBG, dietary adherence, and glycemic control over a four-month follow-up;[23,24] and
- an computer-based patient education study showed improved HbA_{1c} and increased physician adherence to treatment guidelines.[25,26]

According to Fisher and Glasgow,[1] successful interventions to improve diabetes self-management should involve both behavioral interventions (to teach effective self-care strategies) and emotional interventions (to address problems such as depression, which may interfere with self-care). Suggested elements of behavior- and emotion-focused interventions are featured in *Table 1*.[1] In addition, it is clear that interventions to stimulate the initiation of self-care must be augmented by attention to maintenance of initial intervention-induced gains: "The assumptions that once learned, major lifestyle changes can be easily maintained and that new challenges posed by diabetes over time do not require new knowledge and new techniques for problem resolution are contradicted by a long line of behavioral research."[1,27,28] It is suggested that maintenance of intervention gains may be facilitated by continuous monitoring and reinforcement of patient health status gains, and by periodic review, revision, and reinforcement of clinician behavioral management strategies.

We close this article on SMBG behaviors and barriers by asserting that we need to follow through with the implementation of already well-validated self-management interventions—not breakthroughs *per se*—in SMBG adherence promotion in diabetes care. A wide range of empirically supported self-management interventions that promote SMBG and are effective in achieving improved glycemic control currently exist in the literature. Implementation of self-management interventions remains to be accomplished, however, via relatively seamless and relatively low-cost integration into the ecology of clinical care and via alignment of intervention efforts with current clinical care approaches and priorities.

In addition, maintenance of intervention gains must be a planned-for focus in any intervention implementation program. We concur strongly with the view that "… all members of the diabetes care team need to be behavioral experts … The use of well-documented behavioral practices can improve clinical outcomes when they are applied systematically, conscientiously, and uniformly; when they are applied by all diabetes health professionals; and when they are considered part of each clinical team member's skill set."[1] ■

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