

# Barriers to Blood Glucose Monitoring in a Multiethnic Community

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**OBJECTIVE** — We studied a multiethnic community to determine factors associated with blood glucose monitoring (BGM) and to determine the independent association between barriers to diabetes care and BGM.

**RESEARCH DESIGN AND METHODS** — A total of 323 participants (35.6% European, 32.2% Maori, and 32.2% Pacific Islander) from the South Auckland Diabetes Project (free of major complications by self-report) completed a qualitative survey to determine barriers to diabetes care. Five barriers to diabetes care categories were generated including internal psychological (self efficacy/health beliefs), external psychological (psychosocial environment), internal physical (comorbidities/side effects of treatment), external physical (finance/access to care), and educational (knowledge of diabetes/services) barriers.

**RESULTS** — Characteristics associated with BGM greater than or equal to twice weekly were female sex, HbA<sub>1c</sub> >8%, higher diabetes knowledge scores, and insulin use. Multivariate analyses demonstrated that those reporting external physical barriers (OR 0.47, 95% CI 0.26–0.84), external psychological barriers (0.55, 0.30–1.0), and internal psychological barriers (0.56, 0.32–1.0) were less likely to perform BGM independent of ethnicity, insulin use, age, sex, diabetes knowledge, and glycemic control. Further multivariate analyses demonstrated that those reporting external physical barriers, particularly related to personal finance, were less likely to perform BGM.

**CONCLUSIONS** — These data demonstrate that patient-reported barriers to diabetes care are associated with BGM, particularly in relation to financial, psychosocial, and self-efficacy issues. Understanding these barriers and overcoming them within the context of the patient's ethnic environment may lead to increased participation in self-care.

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Clinical trials, including the Diabetes Control and Complications Trial (DCCT) (1) and the U.K. Prospective Diabetes Study (UKPDS) (2), have demonstrated that improving glycemic control can reduce the risk of microvascular complications in people with diabetes. Self-monitoring of blood glucose levels is an integral part of the intensive management required to optimize glucose control (3). Other factors instrumental to the success of achieving better

glycemic control include psychosocial support (4), health beliefs (5), socioeconomic status (6), access to care (6), and type of care (7).

Previous studies have demonstrated lower use of self-monitoring in ethnic minorities (8,9), in those of lower socioeconomic status (6,8), and in those with lower diabetes knowledge (10). This is of concern as these groups are also more likely to suffer from the long-term consequences of diabetes (11).

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**Abbreviations:** BGM, blood glucose monitoring.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Few data are available assessing the barriers to diabetes care that are most likely to impede self-management from the patient perspective, particularly in population-based cohorts. It was our objective in a multiethnic population-based cohort of patients with diabetes to determine factors associated with blood glucose monitoring (BGM) and to determine the independent association between barriers to diabetes care and BGM.

## RESEARCH DESIGN AND METHODS

Inner-urban South Auckland includes some of the most disadvantaged communities in New Zealand, with high rates of unemployment and low income. The population consists of Europeans, Maori, Pacific Islanders, and smaller numbers of other ethnic groups (12). Polynesians (Maori and Pacific Islanders) experience high rates of gestational diabetes (13), diabetes (12), undiagnosed diabetes (14), and diabetes complications (15). General practitioners, who can refer patients to a hospital clinic or a community-based clinic, deliver much of the care to these patients.

## The South Auckland Diabetes Project

Between April 1992 and August 1995, a locally recruited multiethnic team from the South Auckland Diabetes Project visited 27,419 households in inner-urban South Auckland of which 25,039 (91%) participated in surveys (16). Concurrently, a survey was administered to known diabetic patients (16). Presence of known diabetes for each patient was confirmed by comparison with general practitioners, diabetes clinics, and diabetes research databases (17). A total of 1,739 diabetic subjects of European, Maori, or Pacific Islander descent were identified. A survey was administered to these subjects asking for demographic and diabetes history information including presence of complications, self-care behaviors, barriers to diabetes care, and diabetes knowledge.

BGM was determined by asking participants how they tested their blood glucose level and how often they tested per

**Table 1—Barriers to diabetes care (adapted from Simmons et al. [16])**

Barrier category	Description
Internal psychological	Health beliefs Self factors (motivation)/self-efficacy Priorities/time
Educational	Low diabetes knowledge Low knowledge of services
Internal physical	Other health conditions Physical effects of treatment (side effects, pain associated with self-monitoring)
External physical	Personal finance Physical access Limited range of services/community-based services Physician appointment system/staffing
External psychological	Unsatisfactory/inappropriate diabetes care Prejudice/discrimination due to having diabetes Lack of support (family, friends, community) Communication/inappropriate cultural messages

month. Diabetes knowledge was assessed by four open-ended questions as has been previously described (18): 1) What is diabetes? 2) What symptoms can you get with a high sugar level? 3) What damage can diabetes cause? and 4) How is diabetes treated? Type 1 diabetes was defined as age at diagnosis <20 years and exclusive treatment with insulin. To determine barriers to diabetes care, participants responded to three standardized open-ended questions enumerating whether and why they were worried about their diabetes, how they would improve local diabetes services, and what they believed prevented themselves or others from properly taking care of their diabetes. Each barrier to diabetes care response was then given a code to facilitate analyses (a maximum of three responses was coded). Validation of the survey is described elsewhere (16). Briefly, a detailed qualitative study among 50 diabetic subjects and diabetes care workers generated ~30 barrier groups. The 458 individual codes generated from the household survey were then mapped onto the 30 slightly amended barrier codes. The mapping was undertaken requiring unanimous agreement among three coders (a physician, an anthropologist, and a psychologist). Again by unanimous agreement, these response codes were then grouped into five barrier categories described in Table 1.

### Study population

A random sample of 733 subjects representing Europeans, Maori, and Pacific Is-

landers were invited to participate in physical exams during 1994 and 1995, including the measurement of height, weight, and blood pressure and routine laboratory tests. Of those invited, 486 participated (a 66% response rate). There was no difference in response rate across ethnic groups. Within ethnic groups there were no differences between participants and nonparticipants with regard to age, diabetes duration, diabetes knowledge scores, insulin use, presence of major complications, or the proportion with type 1 diabetes. Within Europeans, nonresponders were significantly more likely to be women.

Because having severe complications may influence self-care, subsequent analyses included 323 participants free of major complications (laser treatment, blindness due to diabetes, foot amputations or ulcers, kidney failure, and acute cardiovascular events, e.g., stroke or acute myocardial infarction) by self-report.

### Lab methods

Glycated hemoglobin was measured using cation exchange high performance liquid chromatography (Biorad Diamat; Biorad) (upper limit of reference range 6.2%).

### Analyses

BGM twice per week and each of the five barriers to diabetes care categories were analyzed as dichotomous variables (yes/no or presence/absence, respective-

ly). Univariate associations were conducted using ANOVA, generalized linear models, or  $\chi^2$ . Adjustment of discrete variables for ethnicity was undertaken using Mantel Haentzel  $\chi^2$ . Five separate logistic regression models were used to examine the independent association between each barrier to diabetes care category and the outcome variable, self-monitoring blood glucose at least twice per week. The barrier, insulin therapy (yes/no), age in tertiles (18 to  $\leq$ 43, 43 to  $\leq$ 68, and  $>$ 68 years), sex (female versus male), HbA<sub>1c</sub> ( $\leq$ 8 vs.  $>$ 8%), and diabetes knowledge score in tertiles (7 to  $\leq$ 35.7%, 35.7 to  $\leq$ 64.4%, and  $>$ 64.4%) were forced into the model as explanatory variables. Dummy variables were created for the three ethnic groups with Europeans as the reference. Socioeconomic status was determined using the Elley-Irving Socioeconomic Scale (19). Data were analyzed using SAS version 8 (SAS Institute, Cary, NC). Univariate results are presented by ethnic group. *P* values  $\leq$ 0.05 were considered significant. The local ethics committees approved all surveys.

## RESULTS

### Study population

Characteristics of the 323 people with diabetes and no significant complications are shown in Table 2. Ethnic groups were significantly different in age, proportion with secondary education, diabetes knowledge scores, BGM daily and twice weekly, and glycemic control. Interestingly, despite these differences, there were no significant differences between ethnic groups in the frequency of self-reported barriers to diabetes care.

### Associations with self-monitoring

Characteristics associated with BGM within and across ethnic groups are presented in Table 3. Across ethnic groups, BGM twice weekly was more likely among women, those having an HbA<sub>1c</sub>  $>$ 8%, those having higher diabetes knowledge scores, and those using insulin. For both European and Maori participants, those with postsecondary education were less likely to self-monitor, although this relationship did not reach statistical significance. There were no significant differences by ethnicity with regard to age, duration, and glycemic control. There were no significant differences in

Table 2—Population characteristics

	European	Maori	Pacific Islander	P
n	115	104	104	
Age (years)	62.7 ± 12.7	51.8 ± 10.3	55.4 ± 10.4	<0.0001
Duration (years)	8.4 ± 10.2	7.5 ± 8.2	7.2 ± 10.0	0.67
Sex (% male)	49.6	42.3	50.0	0.45
Post secondary education (%)	34.8	31.7	18.3	0.02
HbA <sub>1c</sub> (mean)	7.4 ± 1.7	9.6 ± 2.6	9.2 ± 2.6	<0.0001
Receiving insulin treatment (%)	12.7	11.8	9.2	0.71
BGM daily (%)	21.9	9.0	10.7	0.01
BGM twice weekly (%)	57.9	28.0	37.9	<0.0001
Type 1 diabetes (%)	5.5	2.2	3.1	0.43
Diabetes knowledge score (mean %)	54.5 ± 20.0	40.3 ± 20.3	33.2 ± 19.5	<0.0001
Personal barriers to diabetes care				
Internal physical (%)	7.8	8.7	6.7	0.87
Knowledge (%)	11.3	16.4	10.6	0.39
External physical (%)	36.5	47.1	50.0	0.10
Internal psychological (%)	55.7	51.0	52.3	0.78
External psychological (%)	34.8	30.8	33.7	0.81
Any barrier (%)	67.8	75.0	74.0	0.43

Data are means ± SD unless otherwise indicated. Comparisons were made using the  $\chi^2$  or ANOVA procedure.

univariate analyses with regard to BGM twice weekly and barriers to diabetes care.

**Multivariate analyses**

Results of multiple logistic regression models are shown in Fig. 1. Multivariate models with all covariates (age, sex, diabetes knowledge score, ethnicity, insulin use, and glycemic control) forced into the model demonstrated that external physi-

cal barriers were significantly and independently associated with BGM twice weekly, with those reporting the barrier approximately half as likely to perform BGM (OR 0.47, 95% CI 0.26–0.84). There was a trend for those reporting internal and external psychological barriers to be half as likely to perform BGM at least twice weekly, although this relationship was of borderline significance (0.56,

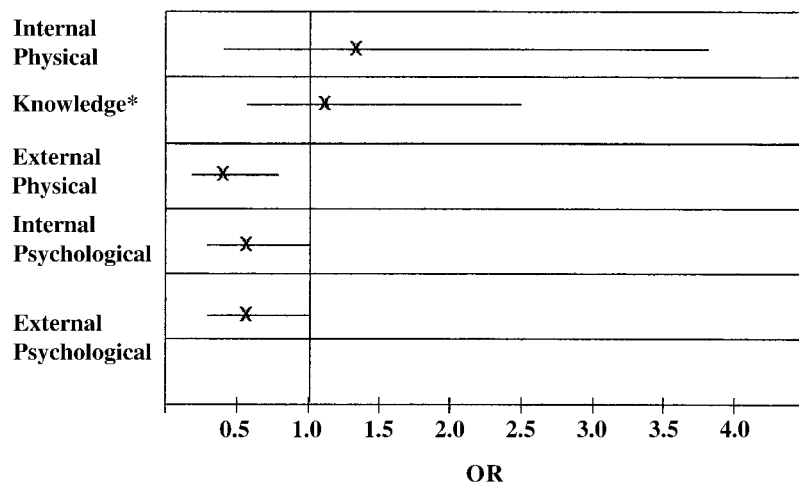
0.32–1.0 and 0.55, 0.30–1.0, respectively). After accounting for self-reported barriers, Maori were approximately one-third as likely to perform BGM as Europeans. Insulin treatment, diabetes knowledge, and being female were associated with greater likelihood of performing BGM after entry of the barriers to self-care.

Models were also run with all barriers

Table 3—Characteristics associated with BGM at least twice weekly

BGM	European		Maori		Pacific Islander		¶P
	No	Yes	No	Yes	No	Yes	
Population characteristics							
Age (years)	62.5	62.7	52.0	51.0	57.1	52.8*	0.21
Duration (years)	7.2	9.1	7.8	7.2	6.7	7.9	0.41
Sex (% male)	60.4	40.9*	43.1	32.1	50.0	48.7	0.06
Post secondary education (%)	41.7	28.8	33.3	17.9	17.2	18.0	0.08
HbA <sub>1c</sub> (mean)	7.3	7.4	9.7	9.5	8.9	9.6	0.37
HbA <sub>1c</sub> >8% (%)	25.6	35.0	64.4	76.9	54.9	73.5	0.03
Receiving insulin treatment (%)	14.0	12.1	6.5	21.4*	1.7	20.5†	0.01
Type 1 diabetes (%)	4.7	6.1	1.6	3.4	0.0	7.7	0.11
Diabetes knowledge score (mean)	52.3	55.6	38.2	44.8	30.5	37.0	0.04
Personal barriers to diabetes care							
Internal physical (%)	10.4	6.1	6.9	10.7	3.1	12.8	0.40
Knowledge (%)	8.3	13.6	15.3	17.9	12.5	7.7	0.77
External physical (%)	43.8	30.3	48.6	46.4	50.0	48.7	0.29
Internal psychological (%)	62.5	50.0	51.4	53.6	48.4	61.5	0.97
External psychological (%)	39.6	30.3	31.9	28.6	34.4	30.8	0.30
Any barrier (%)	75.0	62.1	73.6	82.1	68.8	82.1	0.72

\*P < 0.05, †P < 0.01 within ethnic group comparison; ¶P value comparison is across ethnic groups using the Mantel Haentzel  $\chi^2$  or the generalized linear model procedure adjusting for ethnicity.



**Figure 1**—Multiple logistic regression results for BGM at least twice weekly. All models were adjusted for ethnicity, age, sex, insulin treatment, diabetes knowledge, and insulin treatment. Diabetes knowledge and age were divided into tertiles for entry into the model. Glycemic control was dichotomized as  $\leq 8$  vs.  $> 8\%$ . Insulin treatment was entered as “yes” or “no,” and ethnicity was adjusted using three dummy variables with Europeans as the reference. \*The model used to assess the association between knowledge barriers and BGM did not include diabetes knowledge score. X indicates the OR, and the line represents the 95% CI.

in the model and controlling for all potentially confounding variables. The barrier significantly associated with BGM at least twice weekly was the external physical barrier (OR 0.48, 95% CI 0.25–0.92). Further, the components of the external physical barrier (personal finance, physical access to care, range of services, community-based services, appointment system and staffing levels, and unhelpful health provider in the past) were entered into the model controlling for other confounding variables. Results demonstrated that those reporting barriers related to personal finance were significantly less likely to perform BGM at least twice weekly (0.38, 0.17–0.86). Other external physical barriers were not significantly associated with BGM at least twice weekly.

Models were further adjusted for socioeconomic status with no change in the estimates for the models. When subjects with type 1 diabetes were removed from the analyses, the ORs were slightly attenuated for internal and external psychological barriers (0.57–0.60 and 0.55–0.57, respectively); however, the findings remained unchanged for external physical barriers.

**CONCLUSIONS**— In a multiethnic population-based cohort of patients with diabetes, our findings demonstrate that those reporting personal barriers to dia-

betes care, particularly those relating to finance and access (external physical barriers), community and family support (external psychological barriers), and self-efficacy, motivation, and health beliefs (internal psychological barriers) were less likely to perform BGM twice weekly. These relationships existed despite patient age, sex, level of diabetes knowledge, ethnic group, or glycemic control. Whereas previous studies have focused on clinic attendees, managed care settings (6), or aggregate data (8) to demonstrate associations between barriers to care and self-care, our data add to currently available evidence based on reports from a population-based sample.

The strongest relationship was between the “external physical” barriers to diabetes care and BGM and provides evidence that the manner in which diabetes care is structured, delivered, and financed may affect the ability of patients to care for their diabetes. As personal finance was independently associated with BGM after adjusting for other barriers and ethnicity, insulin use, age, sex, glycemic control, and diabetes knowledge, particular attention should be paid to this aspect of diabetes care, with self-management recommendations made by health care providers. Previous work in this population found finances to be particularly problematic for the Maori and Pacific Is-

landers, whereas costs of care were associated with stopping both self-monitoring and insulin therapy (20). We have previously shown that Maori and Pacific Islanders, when asked about barriers to care, ranked barriers regarding physical access and personal costs of care much higher than those of European descent (16,20). As  $> 66\%$  of this population subgroup was unemployed (18), this finding is not surprising. Cost of self-care as a barrier was demonstrated by Karter et al. (6), where higher out-of-pocket costs were associated with poor (less than daily) adherence to self-monitoring. Similarly, a cross-sectional study of the diabetes database in Tayside, Scotland, found a lower use of test strips in the less affluent (21). These results are in contrast to those of Harris et al. (9), where socioeconomic status was not associated with self-monitoring. However, in that report, the effect of income on self-monitoring was different in Mexicans (8), indicating that socioeconomic factors may have differential effects across ethnic groups.

There was also a borderline association between external psychological barriers to diabetes care and BGM. These barriers include external support systems such as family, cultural appropriateness, satisfaction with care, and public awareness of diabetes. Studies have shown that social (22) and familial support (4) can affect self-care. Additionally, cultural sensitivity from the health care providers, including use of interpreters, development of community-based programs, and adapting educational materials to the ethnic group concerned (5), may increase participation in self-management practices.

Borderline associations between internal psychological barriers to diabetes care and BGM were also found. These barriers include health beliefs, motivation and self-efficacy, and emotional issues. Although logical, little quantitative evidence has previously existed linking psychological status with self-care. Aalto et al. (23) found that self-efficacy was positively associated with BGM in patients with type 1 diabetes. Glasgow et al. (24) found that an intervention targeting social learning variables, particularly problem-solving skills and self-efficacy, increased the frequency of BGM in patients with type 2 diabetes. Thus, interventions aimed at improving self-efficacy may

prove beneficial for increasing participation in BGM.

We did not find an association between internal physical barriers (comorbid conditions, side effects of medication, and pain associated with blood glucose monitoring) and BGM. This may be due to the selection of the study population, where those included in the analyses were complication-free by definition and therefore not as severely ill as those already damaged by diabetes. The study was also possibly too small to identify a relationship between BGM and side effects of medication (e.g., insulin therapy) or self-monitoring. The chance of finding such events in a cross sectional study would be low.

That we did not find an association between BGM and those reporting that they knew too little about diabetes and diabetes care services was not surprising. The importance of actual diabetes knowledge rather than perceived need was reflected by the continued relationship between the diabetes knowledge score and BGM after adjustment for barriers to care. Peveler et al. (10) found a similar pattern where those higher diabetes knowledge scores were correlated with frequency of blood glucose testing.

One rather curious finding was the positive association between BGM and HbA<sub>1c</sub>, where those with the higher HbA<sub>1c</sub> levels were more likely to perform BGM. Similar findings were reported by Harris et al. (9,25). This finding should not imply that less monitoring is associated with better glycemic control. It may be that these subjects were aware of their elevated glucose levels and were taking steps to improve glycemic control, thus increasing their frequency of self-monitoring. Additionally, providers may have recommended an increased frequency of monitoring due to concern over elevated glucose levels. However, due to the cross-sectional nature of these analyses, no cause-effect relationship can be determined.

### Limitations

There are certain limitations to these analyses that should be considered when interpreting results. The barriers to diabetes care questions were open-ended and prone to under-reporting (26). Additionally, because only three responses were coded, it is possible that barriers may have been under-recorded. However, it was

felt that issues reported by individuals were likely to be those most important to the study participants, and external validity was provided by the highest number of answers being obtained from those with the greatest number of barriers: Maori and Pacific Islanders (16). It is therefore likely that they have expressed their major concerns. Additionally, multilingual teams were used to overcome language barriers that may have been inherent in administration of an open-ended survey to a multiethnic population. (16). Regarding validity of the barriers survey, three coders were used to develop the barriers to diabetes care categories. Unanimous agreement was required for the code, and no adjudication was necessary (16), indicating high inter-rater reliability. The external validity and reproducibility of the barriers has been previously described (16).

Although the response rate for clinical exams was moderate, participants were not significantly different from non-participants, thus results are not likely affected by the response rate. There was a 1- to 2-year time lag between the assessment of barriers and physical exams as a result of the funding process. While associations between glycemic control and barriers to diabetes care may be over- or underestimated because of this, it is unlikely that barriers changed over time. This study did not collect data on provider practice patterns or patient adherence to provider recommendations, thus it is difficult to assess which (if any) patients should be monitoring more regularly.

These analyses include patients with both type 1 and type 2 diabetes, as BGM is recommended for all patients with diabetes. Although there is stronger evidence supporting its role for type 1 diabetic patients (3), we felt it was important to include all patients in these analyses. However, we relaxed the criteria from daily monitoring to twice weekly monitoring to account for the large majority of subjects having type 2 diabetes. When the analysis was repeated excluding type 1 diabetic subjects, there was little change in the associations observed, demonstrating that inclusion of type 1 diabetic subjects in the analyses had little impact on the overall interpretation of results.

While the evidence supporting the utility of BGM and long-term glycemic control is not sufficiently strong, there is evidence to support patients monitoring

their blood glucose to avoid hyper- and hypoglycemic episodes (3). Additionally, evidence suggests that processes involved in intensive therapy do not substantially interfere with patients' quality of life (27,28). These data have quantified, from a patient perspective, what barriers to BGM are important. Overcoming barriers to diabetes care to enhance participation in self-management requires a range of strategies targeted at individual need. Substantial efforts aimed at identifying individual barriers to care using clinically relevant tools (29) should be developed to overcome these barriers and to improve self-care and outcomes. Due to the cross-sectional nature of studies addressing barriers to diabetes care and self-monitoring, future research should include a randomized clinical trial addressing methods to overcome all or some of these barriers to diabetes care while encouraging self-care practices.

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