Self-Monitoring of Blood Glucose

Language and financial barriers in a managed care population with diabetes

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OBJECTIVE — Self-monitoring of blood glucose (SMBG) is a cornerstone of diabetes care, but little is known about barriers to this self-care practice.

RESEARCH DESIGN AND METHODS — This cross-sectional study examines SMBG practice patterns and barriers in 44,181 adults with pharmacologically treated diabetes from the Kaiser Permanente Northern California Region who responded to a health survey (83% response rate). The primary outcome is self-reported frequency of SMBG.

RESULTS — Although most patients reported some level of SMBG monitoring, 60% of those with type 1 diabetes and 67% of those with type 2 diabetes reported practicing SMBG less frequently than recommended by the American Diabetes Association (three to four times daily for type 1 diabetes, and once daily for type 2 diabetes treated pharmacologically). Significant independent predictors of nonadherent practice of SMBG included longer time since diagnosis, less intensive therapy, male sex, age, belonging to an ethnic minority, having a lower education and neighborhood income, difficulty communicating in English, higher out-of-pocket costs for glucometer strips (especially for subjects with lower incomes), smoking, and excessive alcohol consumption.

CONCLUSIONS — Considerable gaps persist between actual and recommended SMBG practices in this large managed care organization. A somewhat reduced SMBG frequency in subjects with linguistic barriers, some ethnic minorities, and subjects with lower education levels suggests the potential for targeted, culturally sensitive, multilingual health education. The somewhat lower frequency of SMBG among subjects paying higher out-of-pocket expenditures for strips suggests that removal of financial barriers by providing more comprehensive coverage for these costs may enhance adherence to recommendations for SMBG.

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Self-monitoring of blood glucose (SMBG) is considered one of the cornerstones of diabetes care and is widely recommended (1) despite the lack of evidence regarding the effectiveness of SMBG in improving glycemic control (2,3). Proponents consider SMBG useful for achieving and maintaining near-normal blood glucose levels, providing feedback to the health care provider and the patient regarding therapeutic effectiveness, helping patients adjust insulin dosages and diet and exercise regimens, and aiding in the detection and prevention of asymptomatic hypoglycemia and extreme hyperglycemia (1,4). Given the growing clinical consensus that SMBG is an important component of care, the American Diabetes Association (ADA) Provider Recognition Program (cosponsored by the National Committee for Quality Assurance) now recognizes the proportion of patients who perform SMBG to be a performance measure when assessing the quality of managed care plans.

However, the practice is costly for patients and providers. For type 1 diabetic patients who are practicing SMBG as recommended, the price of test strips alone can exceed $850 annually (4 strips/day × $0.60/strip × 365 days). In 1997, use of glucometer blood glucose monitoring strips represented the fourth largest outpatient pharmacy expenditure in the Kaiser Permanente Northern California Region (KP) (a health maintenance organization), amounting to 2% of total outpatient pharmacy expenditures.

Despite its relevance to diabetes self-management and the significant health care costs associated with SMBG, relatively little is known about current practice patterns and barriers associated with SMBG. The 1997 ADA Clinical Practice Recommendations suggested monitoring three to four times a day for individuals with type 1 diabetes and once daily for individuals with pharmacologically treated type 2 diabetes but did not specify a frequency for diet-controlled type 2 diabetic patients (5). Previous studies suggested the persistence of low levels of adherence to these recommended levels of practice (6). Potential barriers include the high cost of strips, language barriers, inadequate education about the practice and its benefits, and patient discomfort and inconvenience (7).

We studied SMBG use and potential demographic, behavioral, and clinical determinants of nonadherence to ADA recommended levels of practice with a special focus on financial and language barriers. The study population included 44,181 adult patients with pharmacologically treated diabetes who were members of KP, a large group model not-for-profit health maintenance organization, during 1994–1997. Our population's size, ethnic diversity, and similar access to health care make this study of SMBG unique.

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Abbreviations: ADA, American Diabetes Association; ANOVA, analysis of variance; BRFSS, Behavioral Risk Factor Surveillance System; CATI, computer-assisted telephone interview; KP, Kaiser Permanente Northern California Region; NHIS, National Health Interview Survey; OHA, oral hypoglycemic agent; OR, odds ratio; SMBG, self-monitoring of blood glucose.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

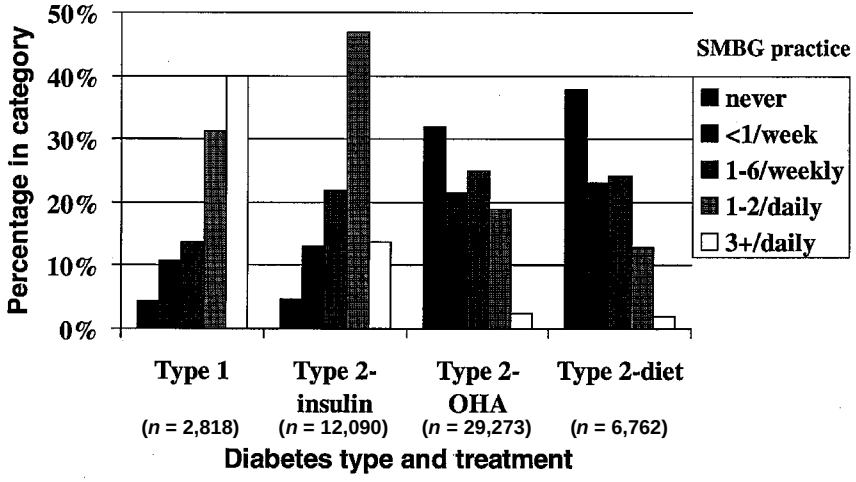

Figure 1—*Self-reported SMBG practice among 50,943 patients with diabetes who were ≥19 years of age by type of diabetes and treatment: the KP Diabetes Registry 1995–1997. Note that the 1997 ADA Clinical Practice Recommendations (5) are three to four times daily for type 1 diabetes and at least daily for pharmacologically treated type 2 diabetes (insulin or OHAs).*

RESEARCH DESIGN AND METHODS

Study participants and data resources

The KP Diabetes Registry was initiated in 1993, when the authors identified all KP health plan members with diabetes by using administrative data from KP pharmacies (prescriptions for diabetes medications or supplies); laboratories (HbA_{1c} value >6.7%); and outpatient, emergency department, and hospitalization records listing a diagnosis of diabetes. The study subjects were all included in this registry. The methods used have been described in detail previously (8–10).

From 1994 to 1997, all registry members ≥19 years of age (n = 94,024) received a health survey that included questions about the frequency of SMBG ("If you check your blood sugar at home, how often do you check it?") as well as other behavioral, demographic, and clinical data. After this initial self-administered questionnaire, a shorter questionnaire (without SMBG questions) was sent to the nonrespondents, and finally a computer-assisted telephone interview (CATI), which also included SMBG questions, was administered to nonrespondents to either version of the self-administered questionnaire. Participants were assured that participation (or lack thereof) would not affect their membership in the health plan and that the information would be strictly confidential (i.e., it would not be included in their medical records).

A total of 83% (n = 77,726) of the eligible KP members with diabetes responded to the survey overall; however, 6,605 of the written surveys did not include the question about SMBG. Analysis was restricted to the 44,181 respondents who answered the questions about SMBG, reported having diabetes, provided sufficient information to assign a type of diabetes, were taking medications for their diabetes, and did not have diabetes during gestation only. We excluded patients with type 2 diabetes whose disease was controlled solely by diet and exercise (13% of the registry) given the lack of ADA recommendations for SMBG practice among this group. For patients currently receiving insulin, type of diabetes was determined by a decision algorithm based on age at diagnosis, length of time between initial diagnosis and the start of insulin treatment, the history of insulin "holidays" (i.e., intervals of 3 months or longer of not taking insulin after initiation of insulin therapy), and the presence of obesity based on BMI (>27.8 kg/m^2 in men and >27.3 kg/m^2 in women) at diagnosis. The algorithm is available from the authors on request. A total of 6% of subjects were classified as having type 1 diabetes, and 81% had pharmacologically treated type 2 diabetes (24% were using insulin including combination therapy, and 57% were using oral hypoglycemic agents [OHAs] only). In addition to survey-derived data, we obtained measures of neighborhood socioeconomic status by geocoding each member's address and mapping it to its 1990 U.S. Census block group and the associated average annual per capita income in that block group.

Members having difficulties communicating in English and preferring languages other than English were identified by having requested a survey or health education materials in a non-English language, by using a Spanish-speaking interviewer for the CATI, or by the CATI interviewer assessing the respondent as lacking fluency in English. The cover letter accompanying the initial survey mailing included text in Spanish, Chinese, Vietnamese, and Tagolog to allow for requests for surveys in other languages, thus maximizing the inclusion of linguistically isolated members with diabetes.

To evaluate whether the out-of-pocket cost of strips represented a barrier to the practice of SMBG, we derived a three-level categorical variable ($0.00–3.00 [reference group], $5.00–10.00, and $18.00–30.00) for the out-of-pocket cost of strip prescriptions dispensed at the KP pharmacy. For those members with a drug benefit, the cost of each strip prescription equals their copayment amount (27% pay $0.00, $1.00, $2.00, or $3.00; 55% pay $5.00, $7.00, or $10.00; and 10% pay $18.00). The 8% of the members lacking a drug benefit incur the full cost of SMBG strips, which is approximately $30 for 50 strips.

Data quality validation

To assess the validity of self-reported SMBG frequency, we compared self-reports with actual KP pharmacy orders for glucose monitoring strips for the 12,630 members who had continuous membership during the year before their survey date with drug plan coverage and at least one pharmacy purchase for strips during this period. We excluded members without a KP drug benefit to minimize misclassification associated with strip purchases in non-KP pharmacies. The average number of strips purchased correlated with the self-reported SMBG frequency (Spearman's correlation coefficient 0.6; P = 0.0001), which suggests that self-reported SMBG frequency provides a valid measure of actual practice.

Assessment of SMBG practice patterns and barriers

SMBG frequency and appropriateness vary by treatment regimen and type of diabetes. Because no SMBG practice guidelines were in place for KP before 1998, we assumed that the widely disseminated ADA recommendations represented the most prevalent source of guidelines for patients and

providers at the time of the survey. We structured analyses so that we could ascertain prevalence and predictors of nonadherent behavior relative to the guidelines detailed in the 1997 ADA Clinical Practice Recommendations (5) (i.e., three to four times daily for type 1 diabetes and at least once daily for pharmacologically treated type 2 diabetes). Although nonadherence includes both underutilization (a public health concern) and inappropriate overutilization of SMBG (a health economics concern), we focused on the former in this report.

Descriptive statistics (percentages, means ± SD) and associated *P* values were calculated for all subject characteristics by type of diabetes. χ^2 statistics were used to analyze the discrete data, analysis of variance (ANOVA) was used for normally distributed continuous variables, and the Kruskal-Wallis test was used for non-normally distributed continuous variables.

Multivariate logistical regression analysis (LOGIST procedure; SAS Institute, Cary, NC) was used to assess the association between strip use and two barriers (language and cost) after adjusting for a host of potentially confounding demographic, behavioral, and clinical variables and after identifying other independent predictors of nonadherent behavior. For subjects with type 1 diabetes, we modeled the practice of SMBG less than three times daily (yes/no) as the dependent variable, whereas for pharmacologically treated type 2 diabetic subjects, less-than-daily SMBG practice (yes/no) was the outcome. Given that the outcome was not a common event (a violation of the rare disease assumption), the logistical regression results should be used to identify significant predictors of the outcome rather than to interpret the magnitude of the odds ratios (ORs) as measures of effect size (11,12). Because the potential for financial barriers may be greatest in economically disadvantaged patients, we tested the statistical interaction between out-of-pocket expenditures for strips and tertiles of census block group per capita income (less than $13,959/year, $13,960–18,628/year, and greater than $18,629/year) and between expenditures and education.

Table 1—*Sociodemographic and clinical characteristics of patients (≥19 years of age) with diabetes by type of diabetes: KP Diabetes Registry, 1995–1997*

	Type 1 diabetes	Type 2 diabetes treated with insulin and/or OHAs	*P*
n	2,818	41,363	
Age (years)	39.8 ± 13.0	60.5 ± 11.8	0.0001*
Women	48.3	46.6	0.092
Race/ethnicity			
Non-Hispanic caucasian	77.3	55.9	0.001
African-American	7.5	13.3	
Hispanic	7.7	14.7	
Asian/Pacific Islander	3.9	12.0	
American Indian	2.8	3.1	
Other	0.9	1.0	
Educational attainment			
High school or less	29.1	46.3	0.001
Some college	36.2	30.8	
College graduate	34.7	22.9	
Prefer to communicate in non-English language	2.1	7.3	0.001
Census block group annual 1989 income (U.S. $)	18,943 ± 7,697	17,235 ± 7,064	0.0001†
Mean duration of diabetes			
0–9 years	19.9	63.2	0.001
10+ years	80.1	36.8	
BMI at survey	24.5 ± 3.8	30.4 ± 6.5	0.0001*
Daily injections			
1/day	10.4	26.6	0.001
2/day	52.3	63.8	
3/day or pump	37.0	9.7	
Excessive alcohol intake (>21 drinks/week)	2.4	2.0	0.149
Current smokers	16.1	11.6	0.001
No drug benefit coverage	13.0	8.1	0.001

Data are *n*, means ± SD, or %. * *P* value derived from ANOVA; † *P* value derived from Kruskal-Wallis test. *P* values for comparisons of discrete data were calculated by using a χ^2 statistic, whereas ANOVA was used for normally distributed continuous variables, and the Kruskal-Wallis test was used for non-normally distributed continuous variables.

RESULTS — Patients treated with insulin (both type 1 and type 2 diabetes) were more likely to practice frequent SMBG (Fig. 1). Although most patients reported some level of SMBG monitoring, 60% percent of those with type 1 diabetes and 67% of those with pharmacologically treated type 2 diabetes reported practicing SMBG less frequently than recommended by the ADA. Compared with subjects with type 2 diabetes, subjects with type 1 diabetes were younger, included fewer minority ethnic groups, were better educated, had a longer duration of diabetes, had a lower BMI, and were more likely to be current smokers (Table 1).

Language barriers and SMBG

Among Hispanics and Asian/Pacific Islanders, 26 and 30%, respectively, were identified as having difficulties communicating in English or as preferring languages other than English. However, only 1% of non-Hispanic Caucasian and African-American members with diabetes had language difficulties. In most cases, those patients with language difficulties were less likely to practice SMBG at recommended levels compared with subjects who were fluent in English (Table 2). Particularly among type 1 patients of both ethnicities, subjects with language difficulties were markedly less likely to practice SMBG daily. Although in the expected direction and statistically significant, somewhat smaller disparities were noted in the proportion reporting daily SMBG practice among pharmacologically treated type 2 diabetic patients. In multivariate models that include all ethnicities, having language difficulties was a significant independent predictor of less-than-daily practice among type 2 diabetic patients treated pharmacologically after controlling for a

Table 2—*Self-reported practice of SMBG (percentage practicing SMBG at least daily and at least three times daily) among Asian/Pacific Islanders and Hispanics who had difficulty communicating in English compared with subjects who were fluent in English*

		Type 1 diabetic subjects*			Pharmacologically treated type 2 diabetic subjects†		
	n	Not fluent	Fluent	*P*	Not fluent	Fluent	*P*
Asian/Pacific Islander	4,289						
≥1 time daily SMBG (%)		36	66	0.053	20	26	0.001
≥3 times daily SMBG (%)		9	27	0.201	2	3	0.008
Hispanic	5,406						
≥1 time daily SMBG (%)		40	69	0.025	25	31	0.001
≥3 times daily SMBG (%)		33	33	0.989	3	6	0.001

Data are *n* or %. *Asian/Pacific Islanders, *n* = 97; Hispanic subjects, *n* = 202; †Asian/Pacific Islanders, *n* = 4,192; Hispanic subjects, *n* = 5,204. *P* values for comparisons were calculated by using a χ^2 statistic.

Table 3—*Multiple logistic regression models* of SMBG practice*

	SMBG practice and type of diabetes	
	Less than three times daily (vs. three or more times daily) in type l diabetic subjects	Less than daily (vs. at least daily) in type 2 diabetic subjects treated with OHAs or insulin
Sex		
Female (reference group)	1.0	1.0
Male	1.3 (1.1–1.6)†	1.3 (1.2–1.3)†
Age (years)		
18–39 (reference group)	1.0	1.0
40–64	1.0 (0.8–1.2)	1.2 (1.1–1.4)†
≥65	0.5 (0.3–1.0)†	1.3 (1.1–1.5)†
Race/ethnicity		
Caucasian (reference group)	1.0	1.0
African-American	1.5 (0.9–2.2)	1.2 (1.1–1.3)†
Hispanics	1.2 (0.8–1.7)	1.2 (1.1–1.3)†
Asian/Pacific Islander	1.8 (1.0–3.3)†	1.5 (1.4–1.6)†
American Indian	0.8 (0.4–1.4)	1.1 (0.9–1.3)
Education		
High school or less	0.9 (0.7–1.2)	1.1 (1.0–1.2)†
Some college	1.0 (0.8–1.3)	1.0 (0.9–1.1)
College graduate (reference group)	1.0	1.0
Tertile of census block group mean annual 1989 income		
Less than $13,959	1.5 (1.2–2.0)†	1.0 (0.9–1.1)
$13,960–18,628	1.1 (0.8–1.4)	1.0 (0.9–1.1)
More than $18,629 (reference group)	1.0	1.0
English language difficulty?		
Yes	0.6 (0.3–1.4)	1.3 (1.2–1.5)†
No (reference group)	1.0	1.0
Out-of-pocket expenditure for glucometer strips		
$0.00, $1.00, $2.00, or $3.00 (reference group)	1.0	1.0
$5.00, $7.00, or $10.00	1.0 (0.8–1.3)	1.0 (1.0–1.1)
$18.00 or $30.00	1.4 (1.0–1.9)	1.4 (1.3–1.5)†

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host of relevant factors including education, income, and ethnicity (Table 3).

Financial barriers and SMBG

The prevalence of adherent monitoring was somewhat lower in subjects with the highest expenditures for strips (Table 4). In multivariate models, expenditure for strips was a significant independent predictor of less-than-daily SMBG for patients with pharmacologically treated type 2 diabetes and was borderline significant for type 1 diabetic patients (Table 3). Additionally, a significant interaction was evident between out-of-pocket costs and tertile of census block group income for subjects with type 2 diabetes ($P = 0.02$ for interaction); the largest decrease in the frequency of SMBG practice with increasing strip cost was observed in subjects from neighborhoods with the lowest average annual incomes. The ORs for practicing SMBG less than daily among subjects paying $18.00–30.00 for 50 strips relative to subjects paying $0.00–3.00 were 1.5 ($P = 0.0001$), 1.4 ($P = 0.0001$), and 1.3 ($P = 0.001$) across tertiles of neighborhood incomes. The differences were even more marked when analyzing only insulin-treated type 2 diabetic subjects (Fig. 2). In this subgroup, we observed a pronounced and graded sensitivity to strip cost in the first (i.e., most economically disadvantaged) two tertiles but no sensitivity in the third (i.e., wealthiest) tertile. No significant interactions were evident regarding education and out-of-pocket costs.

Independent predictors of nonadherent SMBG practice

In the multivariate models, the independent predictors of monitoring less frequently than recommended by the ADA varied somewhat by diabetes type (Table 3). Among subjects with type 1 diabetes, male sex, Asian/Pacific Islander ancestry, living in the most impoverished neighborhoods (<$13,959 average annual income), taking fewer daily insulin injections, and smoking were associated with significantly increased odds of monitoring less than three times daily, while being ≥65 years of age was associated with decreased odds. Among subjects with type 2 diabetes treated with insulin or OHAs, significant predictors of monitoring less than daily included male sex, age ≥40 years, belonging to a noncaucasian minority group except for American Indians, having a high school or lower education level, having language difficulties, paying the highest

out-of-pocket strip expenditures, having a duration of diabetes ≥10 years, taking OHAs or less than three daily injections of insulin, being a current smoker, and excessive alcohol consumption.

CONCLUSIONS — This large-scale study identifies patient characteristics associated with less-than-optimal practice of SMBG and demonstrates how limited English language fluency and out-of-pocket expenditures may impose barriers to this self-care practice, even in a large managed care organization in which patients presumably have similar access to care. The crude prevalence of subjects with diabetes practicing SMBG observed in our population (75%) was similar to the 78% reported in the 1994 Behavioral Risk Factor Surveillance System (BRFSS) assessments from 22 states (13), although the time frames differ to some extent. Although most KP patients with diabetes report practicing SMBG, considerable gaps persist between actual and recommended care practices (13). Although only 4 of 100 KP members with type 1 diabetes reported not practicing SMBG, more than 60% failed to adhere to current ADA guidelines (more than three tests a day for patients with type 1 diabetes [1]). Similarly, only 5 and 32% of members with insulin-treated and OHA-treated type 2 diabetes, respectively, reported not practicing SMBG, whereas 40 and 77%, respectively, failed to adhere to the ADA recommendation of at least daily SMBG for this group. This low level of adherence to ADA guidelines is most likely typical of managed care populations.

The two most comprehensive studies of the practice patterns of SMBG in the U.S. are population-based samples (self-reported as having diabetes) of respondents to the 1989 National Health Interview Survey (NHIS) (n = 2,405) (14) and the aforementioned 1994 BRFSS study (n = 2,056) (13). Subsequent to the Diabetes Control and Complications Trial, the intensified focus on near normalization of glucose has substantially increased the practice of SMBG (13,15), which probably explains the higher reported prevalence of SMBG in the more recent of the two studies. However, the characteristics associated with adherence should be more stable over time. The NHIS study demonstrated marked ethnic, educational, and age differences in the proportion practicing SMBG at least once daily among subjects with insulin-treated type 2 diabetes. These sociodemographic differences may be partially accounted for by variation in access to and quality of health care in the general population. However, in this managed care population, we also observed less adherence to recommended monitoring practices among subjects belonging to ethnic minorities, men, and subjects who had lower education levels, lived in poorer neighborhoods, were linguistically isolated, paid the highest out-of-pocket costs for glucometer strips, received the least intensive pharmacological treatment, and reported smoking or excessive alcohol consumption. Note that

Table 3—*continued*

	SMBG practice and type of diabetes	
	Less than three times daily (vs. three or more times daily) in type l diabetic subjects	Less than daily (vs. at least daily) in type 2 diabetic subjects treated with OHAs or insulin
Years since diagnosis		
0–9 (reference group)	1.0	1.0
≥10	1.2 (0.9–1.6)	1.1 (1.1–1.2)†
Treatment regimen‡		
OHAs only	N/A	17.0 (14.0–20.6)†
1 insulin injection/day	N/A	4.3 (3.5–5.3)†
2 insulin injections/day	N/A	2.9 (2.4–3.6)†
≥3 insulin injections/day or pump (reference group)	N/A	1.0
Daily insulin injections§		
1 injection/day	14.5 (9.2–23.0)†	N/A
2 injections/day	7.3 (5.8–9.0)†	N/A
≥3 injections/day or pump (reference group)	1.0	N/A
Excessive alcohol consumption		
Yes (>21 drinks/week)	1.4 (0.6–3.1)	1.5 (1.2–1.8)†
No (reference group)	1.0	1.0
Current smoking status		
Smoker	1.6 (1.2–2.2)†	1.2 (1.1–1.3)†
Nonsmoker (reference group)	1.0	1.0

Data are ORs (95% CIs). *ORs (95% CIs) from two separate logistic regression models applied to mutually exclusive groups defined by type of diabetes and treatment. Each model outcome reflects nonadherent practice based on ADA recommendations for SMBG frequency specified for the two groups. †ORs that are significant at the $P < 0.05$ level. Model outcomes include the following: *1*) less than three times daily (relative to three or more times daily) in subjects with type 1 diabetes, and *2*) less than daily (relative to daily) SMBG in subjects with type 2 diabetes treated with OHAs or insulin. Models for subjects with type 1 diabetes include sex, ethnicity, age, education, census block annual income (1990 U.S. Census), presence of a language barrier, copayment amount, duration of diabetes, number of daily insulin injections(§), current smoking status, and reported excessive drinking behavior (>21 drinks/week). Models for subjects with type 2 diabetes treated with medications include the same variables; however, to avoid matrix dependency, a class variable for treatment regimen(‡) includes both the number of insulin injections and OHA use.

Table 4—*Self-reported practice of SMBG (percentage practicing SMBG at least daily and at least three times daily) for subjects paying $0.00–10.00 versus subjects paying $18.00–30.00 for each glucometer strip prescription*

	Out-of-pocket expenditure for strip prescriptions					
	Type 1 diabetes			Pharmacologically treated type 2 diabetes		
	$0.00–10.00	$18.00–30.00	*P*	$0.00–10.00	$18.00–30.00	*P*
n	2,302	446	—	33,353	7,496	—
≥1 time daily SMBG (%)	72	68	0.068	34	29	0.001
≥3 times daily SMBG (%)	41	36	0.064	6	4	0.001

Data are *n* or %. *P* values for comparisons were calculated by using a χ^2 statistic.

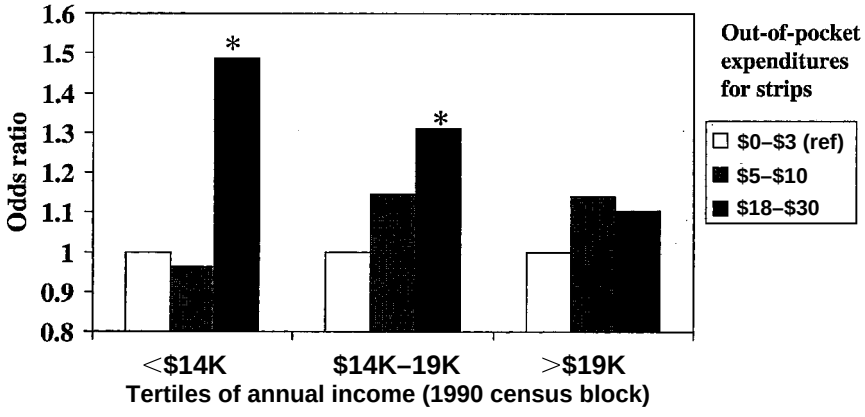

Figure 2—*Prevalence ORs for less-than-daily practice of SMBG according to out-of-pocket cost of glucometer strips across tertiles of annual incomes (based on census block group averages) in type 2 diabetic patients treated with insulin. The interaction between strip cost and annual income was significant (P = 0.02). *Prevalence OR significantly greater than the reference group. $14K, $14,000; $14K–19K, $14,000–19,000; $19K, $19,000.*

these same variables predicted which diet-controlled patients with type 2 diabetes reported that they were not current SMBG users (data not shown).

The somewhat lower frequency of SMBG observed among subjects with language difficulties is consistent with other studies, which indicates a substantially reduced use of preventive services in patients with poor English language skills (16–19). Among Hispanics, the lack of English language fluency appears to be more important as a health care access factor, and cultural factors (acculturation) play a much smaller role in health behavior (16,17). Language difficulties can create various barriers to access; patients affected by language barriers generally cannot benefit from English language diabetes health care literature and may have more difficulty negotiating the automated telephone systems associated with large health care systems. Our study population included substantial proportions of Hispanics and Asian/Pacific Islanders with poor English language skills (23 and 33%, respectively among survey respondents). Similar to other large managed care organizations, KP has historically attempted to provide informal counseling in languages other than English. However, at the time of our survey, only the KP facilities with the highest concentration of Hispanic members had instituted a culturally competent diabetes education program in Spanish ("La Diabetes Y Su Salud" or "Diabetes and Your Health"), but no KP facilities offered formal classes in Asian languages. After completing the six-session Spanish language series, the proportion of subjects who reported practicing SMBG at least weekly relative to baseline nearly doubled (from 23 to 41%) (Laurie Doyle, MPH, unpublished study). For patients with poor English skills, more persistent outreach, one-on-one interventions, and culturally competent programs (i.e., cultural adaptation, not merely language translation) are necessary to raise SMBG adherence to the level of patients who are fluent in English.

We also observed that SMBG practice patterns may be sensitive to out-of-pocket expenditures for glucometer strips. Even with insurance coverage, direct costs to the patient can be substantial, depending on the extent of their prescription coverage. In this population, we observed modest reductions in the frequency of SMBG practice among subjects with the highest out-of-pocket expenditures for glucometer strips overall. However, among members with pharmacologically treated type 2 diabetes, this sensitivity to cost was heightened in the most economically disadvantaged individuals. These findings are consistent with several previous studies. In the 1994 BRFSS study, SMBG was reported significantly more often among subjects with health insurance coverage than by subjects who were uninsured (73 vs. 50%; $P < 0.05$) (13). Lower rates of SMBG have been reported among children with type 1 diabetes in families lacking health insurance (20). Individuals with type 1 diabetes with lower household incomes reported practicing SMBG significantly less often and spending a larger proportion of their income on medical supplies (21). In an interview study of Mexican Americans with diabetes (22), the cost of blood glucose monitoring strips has been shown to be a major burden for patients with limited economic resources. Subjects in that study reported reserving the practice of SMBG to when they were feeling ill or when they were not complying with therapy. Our findings differed from those reported by the NHIS (14), which suggests that financial barriers associated with income and health insurance did not influence the practice of SMBG.

Several limitations must be noted. As in all cross-sectional studies, the associations reported may have no causal basis, and a potential for selection bias (e.g., response bias) exists. This study excludes survey nonrespondents whose characteristics and SMBG practices may differ from survey respondents. Nonrespondents were slightly younger, less likely to be treated with insulin or OHAs, and more likely to belong to an ethnic minority. A potential misclassification bias may result from a failure of those surveyed to correctly state their SMBG frequency. Reports from previous studies regarding the accuracy of self-reported frequency of SMBG when using memory meters were contradictory and reported both overestimation (23) and highly reliable reporting (24). In our validation study, the self-reported values correlated well with pharmacy purchase data for the year before the survey. That estimate of correlation should be conservative given the potential for change in monitoring behavior during the year subsequent to the survey. A potential limitation of our assessment of language barriers is that we did not formally validate our categorization of "language difficulties." However, we suspect minimal misclassification given that the only subjective criteria in the categorization were based on the CATI interviewer assessment of English fluency. In all other cases, patients were self-identified as having language barriers by requesting the survey in another language or by speaking Spanish with the interviewer.

This study has a number of strengths relative to previous research. The large sample size, high response rate, and adequate statistical power allow us to assess the epidemiology of SMBG by type of diabetes in an ethnically diverse population. The presumably similar access to

and quality of health care, with the exception of variability in copayment or language services, make this a unique study population. We have shown previously that the 2.8 million members of this KP region are representative of the surrounding geographical region's population (25–27), and thus findings should be generalizable to insured individuals with diabetes.

Given that community-based educational programs have been shown to be effective in increasing the proportion of patients practicing SMBG (4,28), targeting health education efforts toward patients who do not adhere to guidelines while minimizing barriers may reduce underutilization. Also, given the widespread use and substantial cost of this practice, quantifying overall practice patterns is important for health economic planning and may have policy implications.

In managed care, cost sharing is generally intended to reduce inappropriate or excessive health care utilization (e.g., multiple daily testing among nonpregnant diet-controlled patients). In our study, patients who paid the highest out-of-pocket expenses for strips were less likely to monitor inappropriately than subjects who paid less. But cost sharing is a "double-edged sword"; although it reduced inappropriate use, we observed an unintended effect, a modest overall reduction in desirable use (sensitivity to cost). Furthermore, evidence showed that this sensitivity to cost was greatest in the poorest segment of the population. We suggest that SMBG practice patterns may improve if cost-sharing policies are rationalized by reducing or eliminating financial barriers for poorer patients and patients for whom more frequent monitoring is desirable. However, the increased cost of such changes must be carefully weighed against the potential gains in adherence. Assessing the effect of the new mandated coverage of glucometer strips (California Senate Bill 64: California Health and Safety Code, section 1367.51) as well as other managed care benefit changes on SMBG practice patterns will be valuable. Additionally, the persistence of reduced SMBG frequency in patients who have language barriers, who belong to select ethnic minorities, and who have lower education levels suggests the need for increased emphasis on targeted and multilingual diabetes health education.

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