FEATURE ARTICLE

When Less Is More: Identifying Patients With Type 2 Diabetes Engaging in Unnecessary Blood Glucose Monitoring

Marcella H. Boynton,[1,2] Katrina E. Donahue,[3,4] Erica Richman,[4] Asia Johnson,[4] Jennifer Leeman,[5] Maihan B. Vu,[6] Jennifer Rees,[2] and Laura A. Young[7]

This study examined whether certain patient characteristics are associated with the prescribing of self-monitoring of blood glucose for patients with type 2 diabetes who are not using insulin and have well-controlled blood glucose. Against recommendations, one-third of the patient sample from a large health network in North Carolina ($N = 9,338$) received a prescription for testing supplies (i.e., strips or lancets) within the prior 18 months. Women, African Americans, individuals prescribed an oral medication, nonsmokers, and those who were underweight or normal weight all had greater odds of receiving such a prescription. These results indicate that providers may have prescribing tendencies that are potentially biased against more vulnerable patient groups and contrary to guidelines.

Over the past two decades, with the advancement of glucose monitoring technology, self-monitoring of blood glucose (SMBG) has become a mainstay of diabetes self-management (1). Increasingly sophisticated glucose monitoring systems that are minimally invasive, convenient, and comparatively affordable have helped to make SMBG a ubiquitous element of diabetes self-care. For people with diabetes who use insulin, SMBG is vital to maintaining stable blood glucose values. However, for people with diabetes who do not use insulin, the utility of daily SMBG is less clear (2–4). Times when SMBG may be useful for people with diabetes who do not use insulin include during changes to antihyperglycemic therapy, acute illness, periods of concern about hypoglycemia, and when glycemic control is not optimal (5). However, for patients who are meeting glycemic goals and not using insulin, SMBG may be of limited clinical value (1,2).

Because emerging evidence has shown that SMBG likely has minimal clinical benefits for people with type 2 diabetes who are not on insulin, several major professional medical groups, including the American Diabetes Association (ADA), no longer recommend universal daily SMBG for these patients (6,7). Despite this change in guidelines, many health care providers continue to prescribe glucose testing supplies for people with diabetes who are not using insulin. For de-implementation of SMBG to be successful, large shifts in practice habits must occur; however, to date, these changes have been piecemeal, with some providers and diabetes educators hesitant to discourage SMBG in people with diabetes who are not using insulin therapy.

It is unclear what systematic differences, if any, determine whether providers counsel their patients who are not taking insulin to use SMBG. The purpose of this study was to leverage electronic health record data to empirically examine whether certain patient characteristics are associated with SMBG prescribing (i.e., prescription of lancets or blood glucose strips). Identifying factors associated with these prescribing practices could help sharpen the content of provider education efforts and provide insights into which types of patients and providers are most likely to unnecessarily use SMBG.

[1]Department of Medicine, Division of General Medicine & Clinical Epidemiology, University of North Carolina at Chapel Hill, Chapel Hill, NC; [2]North Carolina Translational and Clinical Sciences Institute, University of North Carolina at Chapel Hill, Chapel Hill, NC; [3]Department of Family Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC; [4]Cecil G. Sheps Center for Health Services Research, University of North Carolina at Chapel Hill, Chapel Hill, NC; [5]School of Nursing, University of North Carolina at Chapel Hill, Chapel Hill, NC; Department of Medicine, Division of Endocrinology and Metabolism, University of North Carolina at Chapel Hill, Chapel Hill, NC; [6]Department of Health Behavior, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC; [7]Department of Medicine, Division of Endocrinology and Metabolism, University of North Carolina at Chapel Hill, Chapel Hill, NC

Corresponding author: Marcella H. Boynton, mhb23@unc.edu

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Research Design and Methods

Participants

The Carolina Data Warehouse for Health curates electronic medical record data for the University of North Carolina UNC Physicians Network (UNCPN) and a small group of affiliated practices and comprises data on ~3.6 million North Carolina patients at any given time. A previously validated phenotype for type 2 diabetes was used to identify patients with diabetes not requiring SMBG (8). To be eligible for inclusion in the analytic dataset, an individual must have been seen as a patient at a UNCPN practice at least twice in the prior 18 months, have a diagnosis of type 2 diabetes, be ≥18 years of age, and have at least one A1C test result. Patients prescribed insulin or a continuous glucose monitoring system or who had at least one A1C test result >9.5 mg/dL in the past 18 months were excluded. These criteria resulted in a sample of 9,338 adults seen as patients by 733 providers between 1 April 2018 and 17 December 2019.

Measures

Basic demographic characteristics that included sex, age, and race/ethnicity were included in the dataset. Sex was coded as either male (0) or female (1). Race was coded as either White; Black or African American; Asian; American Indian, Native Alaskan, or Pacific Islander; or other, which included individuals identifying as mixed race. Latino ethnicity was coded as present (1) or absent (0). Smoking status was classified as current smoker, never-smoker, former smoker, passive smoker, or unknown smoking status. Use and type of oral diabetes medication was also noted. A1C values were a continuous score ranging between 4.0 and 9.5%. A comprehensive list of diabetes test strip and lancet national drug codes was used to identify patients with type 2 diabetes who were not using insulin, had well-controlled diabetes, and who had received a prescription for blood glucose testing supplies (i.e., glucose test strips or lancets) in the past 18 months.

Statistical Analysis

We estimated means and proportions for the variables in the dataset, stratified by receipt of a blood glucose testing prescription. Using multilevel logistic regression analyses, with patients (Level 1) nested within provider (Level 2), we examined how certain patient factors predicted the prescription of blood glucose test strips or lancets at least once during the study period. The provider was assigned based on who last ordered an A1C for a patient. All analyses were adjusted for key factors (Table 1) and conducted using Stata 15 statistical software. All procedures were approved by the UNC Institutional Review Board (#18-3319).

Results

The sample was approximately half female (52.8%) and the majority were White (67.7%), non-Latino (95.4%), and prescribed an oral diabetes medication in the past 18 months (79.1%) (Table 1). The mean age was 67.2 years (SD 12.0 years), and mean A1C at the most recent time point during the 18-month period was 6.81% (SD 0.89%). Roughly one-third (34.2%) were prescribed test strips or lancets in the past 18 months. Age was a strong predictor of odds of a testing supplies prescription; for every 1-year increase in age, there was a corresponding 18% increased odds of receiving a testing supplies prescription (odds ratio [OR] 1.18, 95% CI 1.13–1.23) (Table 2). For every 1-point increase in A1C, there was a 7% increase in odds of a prescription (OR 1.07, 95% CI 1.10–1.12).

Women (OR 1.17, 95% CI 1.06–1.28) and African American patients (compared with White patients, OR 1.18, 95% CI 1.06–1.32) had greater odds of a prescription. Compared with smokers, nonsmokers (OR 1.34, 95% CI 1.14–1.57) and former smokers (OR 1.33, 95% CI 1.13–1.56) had greater odds of receiving a prescription. Those who were underweight or normal weight (OR 1.28, 95% CI 1.12–1.46) or overweight (OR 1.18, 95% CI 1.07–1.30) also had greater odds of prescription receipt compared with those who were obese. Compared with those without an oral diabetes medication prescription, those receiving a sulfonylurea or glinide (OR 2.67, 95% CI 2.28–3.14); a glucagon-like peptide 1 (GLP-1) receptor agonist, sodium–glucose cotransporter 2 (SGLT2) inhibitor, or dipeptidyl peptidase 4 (DPP-4) inhibitor (OR 2.86, 95% CI 2.43–3.67); or some other medication, including metformin (OR 2.16, 95% CI 1.89–2.46), were all associated with more than two times greater odds of a prescription for SMBG supplies compared with those not taking any oral medications.

Discussion

Evidence suggests that people not using insulin who have relatively well-controlled type 2 diabetes gain minimal clinical or psychological benefit from SMBG (2). The limited value of SMBG for this population is an important message that has yet to be fully embraced by many providers and patients. In this analysis, we examined factors that predict unnecessary prescription of

TABLE 1 Participant Demographics (*N* = 9,338)

Patient Characteristics	Total (*N* = 9,338)	No Strips/Lancets (*n* = 6,145)	Strips/Lancets (*n* = 3,193)	*P*
Age, years	67.18 ± 12.03 (range 20–103)	66.41 ± 12.14 (range 20–103)	68.67 ± 11.66 (range 21–99)	<0.001
Gender, male	4,403 (47.2)	2,980 (48.5)	1,423 (44.6)	<0.001
Race				0.40
White	6,318 (67.7)	4,174 (67.9)	2,144 (67.1)	
Black or African American	2,358 (25.3)	1,535 (25.0)	823 (25.8)	
Asian	197 (1.9)	123 (2.0)	74 (2.3)	
AI, AN, NH, or PI	32 (0.3)	18 (0.3)	14 (0.4)	
Other or unknown	433 (4.6)	295 (4.8)	138 (4.6)	
Ethnicity, Latino/Hispanic	274 (2.9)	185 (3.0)	89 (2.8)	0.56
Cigarette exposure status				
Current smoker	1,050 (11.2)	769 (12.5)	281 (8.8)	<0.001
Former smoker	3,620 (38.8)	2,360 (38.4)	1,260 (39.5)	0.325
Never-smoker	4,619 (49.5)	2,983 (48.5)	1,636 (51.2)	0.014
Passive smoker (secondhand smoke)	38 (0.4)	24 (0.4)	14 (0.4)	0.734
Unknown smoking status	11 (0.1)	9 (0.1)	2 (0.1)	0.351
A1C, most recent, %	6.81 ± 0.89	6.78 ± 0.89	6.86 ± 0.88	<0.001
Most recent A1C <7%	3,605 (38.6)	2,285 (37.2)	1,320 (41.3)	<0.001
BMI, kg/m^2				<0.001
Underweight	45 (0.5)	26 (0.4)	19 (0.6)	
Normal weight	1,151 (12.3)	715 (11.6)	436 (13.7)	
Overweight	2,746 (29.4)	1,754 (28.5)	992 (31.1)	
Obese	5,396 (57.8)	3,650 (59.4)	1,746 (54.7)	
Oral medication prescription in past 18 months				<0.001
Sulfonylurea or glinide	1,392 (14.9)	809 (13.2)	583 (18.3)	
GLP-1 RA, SGLT2 inhibitor, or DPP-4 inhibitor	1,422 (15.2)	819 (13.3)	603 (18.9)	
Some other oral medication	4,571 (49.0)	2,962 (48.2)	1,609 (50.4)	
No oral medication	1,953 (20.9)	1,555 (25.3)	398 (12.5)	
Prescribed a test strip or lancets in the past 18 months	3,193 (34.2)	–	–	–

Data are *n* (%) or mean ± SD unless otherwise indicated. Eligible patients had to have at least one reported A1C and BMI during the 18-month study period, could not have an A1C ≥9.5% during that time, and could not be prescribed a continuous glucose monitoring system. AI, American Indian; AN, Alaska Native; NH, Native Hawaiian; PI, Pacific Islander, RA, receptor agonist.

glucose testing supplies. With this information in hand, we can identify low-cost, high-yield opportunities to educate providers on common prescribing biases and patient populations most likely to be inappropriately encouraged to conduct SMBG.

Compared with White patients in our sample, Black patients were more likely to have a prescription for testing supplies. The causes underlying this difference are unclear. It is possible that the increased likelihood of being counseled to perform SMBG stems from a well-intentioned desire to reduce documented racial health disparities with respect to diabetes outcomes (9,10). However, the potentially high financial and time burden of SMBG is amplified for those with low capital and could exacerbate health disparities because of the added allostatic load incurred with glucose testing. That is, the clinical value of SMBG for a given patient population must be considered in concert with the potential burdens it imposes. The goal in contemporary diabetes management should be to achieve optimal glycemic control in the simplest, most economical means possible, while also minimizing interruptions to daily routines and emphasizing a focus on proven diabetes

TABLE 2 Multilevel Logistic Regression Model Predicting Receipt of Glucose Test Strips or Lancets (*N* = 9,338)

	Unadjusted OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Age, decades	1.17 (1.13–1.21)	<0.001	1.18 (1.13–1.23)	<0.001
Gender, female	1.17 (1.07–1.28)	0.001	1.17 (1.06–1.28)	0.001
Race				
White (ref)	–	–	–	–
Black or African American	1.07 (0.97–1.19)	0.186	1.18 (1.06–1.32)	0.002
Asian	1.21 (0.89–1.65)	0.217	1.15 (0.84–1.58)	0.371
AI, AN, NH, or PI Islander	1.54 (0.75–3.18)	0.239	1.85 (0.89–3.88)	0.101
Other or unknown	0.94 (0.76–1.17)	0.580	0.99 (0.79–1.24)	0.937
Ethnicity, Latino/Hispanic	0.91 (0.75–1.09)	0.302	–	–
Tobacco use				
Current smoker (ref)	–	–	–	–
Former smoker	1.46 (1.25–1.71)	<0.001	1.33 (1.13–1.56)	0.001
Never-smoker	1.51 (1.29–1.76)	<0.001	1.34 (1.14–1.57)	<0.001
Passive smoker (secondhand smoke)	1.73 (0.87–3.44)	0.012	1.34 (0.67–2.70)	0.406
Unknown smoking status	0.70 (0.15–3.37)	0.660	0.56 (0.12–2.70)	0.470
BMI				
Underweight or normal weight	1.28 (1.12–1.46)	<0.001	1,21 (1.05–1.40)	0.008
Overweight	1.18 (1.07–1.30)	0.001	1.12 (1.01–1.25)	0.026
Obese (ref)	–	–		
A1C, most recent, %	1.11 (1.06–1.17)	<0.001	1.07 (1.01–1.12)	0.008
Oral medication prescription in past 18 months				
Sulfonylurea or glinide	2.76 (2.36–3.23)	<0.001	2.67 (2.28–3.14)	<0.001
GLP-1 RA, SGLT2 inhibitor, or DPP-4 inhibitor	2.78 (2.38–3.25)	<0.001	2.86 (2.43–3.67)	<0.001
Some other oral medication	2.10 (1.84–2.39)	<0.001	2.16 (1.89–2.46)	<0.001
No oral medication (ref)	–	–	–	–

Intraclass correlation = 0.043. AI, American Indian; AN, Alaska Native; PI, Pacific Islander, RA, receptor agonist.

care interventions (e.g., dietary changes and regular exercise). Encouraging unnecessary self-care, such as SMBG when it is not indicated, does not align with these goals, and health care providers should be encouraged to reassess their patients' need to monitor glucose values on an ongoing basis during clinic visits.

The findings with respect to sex, smoking status, and BMI were unexpected. We did not hypothesize a sex difference, and we assumed that those at higher risk from diabetes complications, including smokers and patients with obesity, would be *more* likely to receive a prescription for diabetes testing supplies, not less. Our post hoc assessment is that providers might be less likely to prescribe supplies if they believe that a patient is less likely to follow through on diabetes testing. Indeed, there is evidence to suggest that patients at higher risk of diabetes complications are less likely to perform SMBG, although the causes underlying this difference are unclear (11). However, these conclusions are speculative and merit further study.

According to the ADA's *Standards of Medical Care in Diabetes* (7), routine SMBG is not necessary for patients who are not using insulin and who are meeting glycemic targets. In our cohort of patients, mean A1C was 6.81% (SD 0.89%), and the mean highest A1C over 18 months was 7.33% (SD 0.96%), suggesting that the majority of patients enjoyed outstanding glycemic control. Notably, as A1C levels increased, the odds of a prescription receipt also modestly increased (OR 1.07). Contrary to ADA recommendations, approximately one-third of our sample received a prescription for testing supplies (i.e., glucose test strips or lancets) in the prior 18 months. These findings indicate that providers should work closely with patients to rethink the need for routine SMBG as a daily self-care practice if it is not medically indicated.

The argument to encourage SMBG in patients who are using noninsulin therapies that might promote hypoglycemia is understandable, especially given the increased morbidity and mortality associated with this condition (12,13). In our cohort, compared with patients who were not using any medications, those using sulfonylureas, which carry a relatively high risk of hypoglycemia as a side effect, had more than two times the odds of receipt of a prescription for glucose testing supplies. Some of the newer noninsulin agents such as GLP-1 receptor agonists and SGLT2 inhibitors do not increase patients' risk of hypoglycemia; however, patients using these therapies also had greater than two times the odds of receiving a glucose test supply prescription compared with those not taking a noninsulin therapy. In addition to glycemic lowering, these agents have been shown to provide cardiovascular and renal benefits in patients with diabetes (14,15). Although these newer agents offer multiple medical benefits, they are expensive. Patients should be supported in their efforts to access these costly medications. One way to promote greater access to newer oral diabetes medications is to eliminate the expectation of daily SMBG. Funds saved on glucose testing supplies can be shifted to support the purchase of these highly efficacious, but more costly, diabetes medications.

It is important to point out that our data are limited in that the analyses are a retrospective examination of a sample of type 2 diabetes patients not taking insulin in North Carolina. Our demographic categories are also limited. For example, patients are only able to select a binary sex identification and are unable to indicate membership to more than one race category. There was also underrepresentation of Latinos in the sample. These limitations are offset by multiple strengths: a large number of patients and providers, a rich set of medical and demographic variables, and a modeling approach that accounts for data nonindependence by provider.

In conclusion, many patients with noninsulin-treated type 2 diabetes received testing supplies, despite having well-controlled diabetes. Funds saved on testing supplies could be shifted to other aspects of diabetes care that have the potential for greater benefit such as newer but more costly diabetes medications, a more diabetes-friendly diet, and behavioral intervention care.

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DUALITY OF INTEREST

No potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

M.H.B. co-developed the idea, conducted analyses, and drafted sections of the manuscript. K.E.D. contributed to the analysis and writing, as well as reviewed and edited the manuscript. E.R., A.J., J.L., M.B.V., and J.R. reviewed and edited the manuscript. L.A.Y. co-developed the idea and drafted sections of the manuscript. M.H.B. and L.A.Y. are the guarantors of this work and, as such, had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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