

A1C Testing and its Sociodemographic Predictors: Implications for Diabetes Self-management Programs

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Abstract

Background: One of the Healthy People (2020) goals related to the glycated hemoglobin (HbA1C) test is to increase the percentage of adults (aged 18 years and older) with diabetes who have had an HbA1C test at least twice in the past 12 months from 64.6% percent in 2008 to 71.1% by 2020. However, Texas has historically trailed behind several other states in achieving this goal. Targeted interventions for demographic subgroups of population could be a strategy to increase testing. However, little is known about the sociodemographic predictors of A1C test.

Method: Texas Behavioral Risk Factor Surveillance System (BRFSS) data (2011 and 2012) were used to identify socio-demographic predictors of having had at least one A1C test in the past 12 months among diabetic patients. The sociodemographic predictors examined included age, sex, race/ethnicity, marital status, educational attainment, insurance status, whether or not the respondents had a primary care physician, and age when diabetes was diagnosed. A logistic model was developed to predict the membership.

Results: Multivariate logistic regression indicated that insurance status and educational attainment are predictors of adherence to an annual A1C test. Those with insurance were nearly 3 times more likely than those without insurance to report adherence to annual A1C test (odds ratio [OR] = 2.82, 95% confidence interval [CI], 1.47-5.42, $P = .002$), when controlled for all other sociodemographic variables. Likewise, those with more than college-level education were also nearly 3 times more likely than those with less than high school level education to report adherence (OR = 2.74, 95% CI, 1.27-5.89, $P = .010$).

Conclusion: Population-based diabetes management programs should consider educational attainment level and insurance status of individuals when developing interventions to increase the rate of adherence to A1C testing recommendation among diabetic patients. Targeting interventions toward individuals with less than high school education and ensuring that diabetic individuals have some form of health insurance coverage may be helpful.

Keywords

A1C, diabetes, Texas, self-management, demographics

Background

Growing evidences suggest that type 2 diabetes is becoming a more critical public health concern in the recent years. According to Centers for Disease Control and Prevention (CDC), diabetes affects 8.3% of the US population, which equates to 18.8 million of diagnosed and about 7 million undiagnosed cases. According to the American Diabetes Association, individuals with >126 mg/dL fasting plasma glucose level or with a glycated hemoglobin (HbA1C; hereafter referred to as A1C) of $\geq 6.5\%$ are called diabetic patients.¹ In addition, it is estimated that there are 79 million individuals aged 20 or older in the United States, who are prediabetic. Individuals with ≥ 100 to

125 mg/dL of fasting plasma glucose or with an HbA1C of 5.7% to 6.4% are called prediabetics.¹ In year 2010 alone, there were 1.9 million new cases diagnosed in the country.²

In Texas, the overall prevalence of diagnosed diabetes among individuals aged 18 years or older has been increasing

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almost every year since 1994, with an estimate of 9.7% in 2010² and 10.6% in 2012 (Texas Department of Health and Human Services. Texas BRFSS data 2012. 2014). Likewise, the percentage of adults with diabetes who had one or more A1C tests conducted within the past year, among users of health maintenance organizations (HMOs) in 2011, was lower in Texas (85.6%) than the national average (89.9%). In addition, among the HMO users, the percentage of adults with poorly managed diabetes (A1C > 9%) was nearly double in Texas (49.8%) as compared with national average of 27.3%.

A1C test is a measure of how well one is managing the sugar level in his or her body. However, recent data indicate that a large proportion of diabetic patients have never taken the A1C test. According to CDC, about 13% of diabetics in the United States had poorly managed diabetes with A1C levels > 9% during 2003 to 2006.³ The Healthy People (2020) goal is to increase the proportion of adults with diabetes who have had the A1C test at least twice in the past 12 months from 64.6% (the baseline of 2008) to 71.1% by 2020.⁴ Achieving this goal requires multifaceted interventions targeted on those diabetic patients who are less likely to get tested on a regular basis and are likely to have poorly managed diabetes. However, little is known about the sociodemographic determinants of A1C test. Few studies have documented the impact of sociodemographics on A1C control. One recent study noted that patient sociodemographics along with perceptions of care and diabetes distress account for about 14% of variances in the A1C level.⁵ Other studies have documented sociodemographic disparities in glycemic control.^{6,7}

Given this backdrop, determining who is actually taking the A1C test in Texas once they are diagnosed with diabetes is an important task. This information will be useful to prioritize the awareness-building efforts to target the individuals who are not managing their disease well in the given similar demographic areas. Thus, this study's main research question is "what are the primary sociodemographic factors associated with A1C test in Texas?"

Methods

Texas Behavioral Risk Factor Surveillance System (BRFSS) data (2011 and 2012) were used for this study. Texas BRFSS is a cross-sectional, random digit dialed telephone survey conducted annually by the CDC that collects behavioral health-related information from noninstitutionalized adults (18 years and older) in the United States.⁸ Most of the questions used in BRFSS have high reliability and validity.^{8,9} The dependent variable of interest was A1C test, which was assessed among those who reported that they had diabetes (N = 2102) by asking "A test for 'A one C' measures the average level of blood sugar over the past 3 months. About how many times in the past 12 months has a doctor, nurse, or other health professional checked you for 'A one C'?" The response options were discrete integers, *Don't know/Not sure*, *None*, *Never heard of A1C*, and *Refused*. A dichotomous variable with options *Yes* referring to at least 1 and a maximum of 4 A1C tests that the

patient had taken in the past 12 months and *No* referring to no tests and never heard of was computed. When a respondent answer was "Number of tests greater than 4 in the last 12 months," these were treated as *don't know* because the standard clinical guidelines recommend getting the A1C test every 3 months, thus those numbers were implausible.

Sociodemographic variables, age, sex, race/ethnicity, marital status, educational attainment, insurance status, has a primary care physician (PCP) or not, and age when diabetes was diagnosed, were used as the independent variables. Age of the respondent and age at diagnosis of diabetes were continuous variables and the other variables were categorical. Univariate analysis using the survey data analysis approach, entailing population weight and strata, was used to determine the independent relationship of predictor variables to the outcome. Mean age and age when the diabetes was diagnosed were calculated for both groups, namely the group who had taken A1C test and those who had not taken the test. A logistic model was developed to predict the membership. The Logistic model is appropriate for binary outcomes¹⁰ such as one used in this study. Significant variables in the univariate analysis were included in the logistic model with all variables being entered into the model at once.

Hosmer and Lemeshow's goodness-of-fit test was conducted to examine the model fit because pseudo R^2 is not applicable to survey data because with survey data the assumption that the observations are independently and identically distributed is not met, which is a required assumption for maximum likelihood estimation and associated computation of pseudo R^2 . Predictive margins of the probability of A1C test for the levels of education and insurance status were calculated. In addition, average marginal effects were calculated to be able to describe the difference in the probability of those with higher educational level and those with insurance having A1C test as compared with the lower educational level and those without insurance, respectively, while adjusting for all other covariates in the model. Analyses were conducted using Stata 13.0 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP). Missing data were handled using listwise deletion. Two-tailed tests with $P < .05$ were considered significant.

Results

Analysis suggests that in Texas the proportion of diabetic patients who completed A1C test at least twice in the past 12 months per the guidelines in the Healthy People 2020 objectives was only 51.8% and 54.8% during 2011 and 2012, respectively. Proportions of those diabetic individuals who reported never having heard of A1C test was also notable (8.6% in 2011 and 4.5% in 2012). The mean age of those who had completed A1C test at least once in the last 12 months (58.7 years) was significantly different (adjusted Wald test $F_{1, 2058} = 17.03$, $P = .0000$) from the mean age of the respondents (51.3 years) who had not completed the test (Table 1). Likewise, the mean age of the respondents at the time of diagnosis of diabetes, who had completed A1C test, was higher than that of those

Table 1. Mean Age and Age at Diagnosis of Diabetes.^a

A1C	Mean Age	Standard Error	95% Confidence Interval
Mean age of the participants			
No	51.32	1.71	47.97-54.67
Yes	58.72	0.48	57.79-9.66
Mean age of diagnosis of diabetes			
No	43.05	1.72	39.68-46.42
Yes	49.71	0.64	48.46-50.96

^aN = 2102.

who had not completed any test (49.7 vs 43.1 years), with adjusted Wald test $F_{1,2063} = 13.03, P = .0003$.

Univariate analyses indicated (Table 2) that race/ethnicity, level of educational attainment, marital status, insurance status, and PCP status were independently associated with A1C test. A gradient effect of education was where the increase in educational attainment level the percentage of those who reported that they had completed A1C test in the past 12 months increased. Respondents of other race/ethnicity category reported highest percentage of A1C test completion, while the rate of A1C test completion was lowest among Hispanics. Higher proportions of married individuals than unmarried individuals had completed A1C test. A large difference was noted by insurance status, with 92.1% reporting completion of A1C test among insured as compared to 68.6% among uninsured. An even higher gap in A1C test was noted between those who reported having a PCP (91.9%) than those reporting not having a PCP (55.5%).

Logistical regression indicated that educational attainment and insurance status could be associated with adherence to A1C test guidelines among the diabetic patients. Respondents with college plus level of education were nearly 3 times more likely than those with less than high school level of education (odds ratio [OR] = 2.7, 95% confidence interval [CI] = 1.3-5.9) to report that they had completed A1C test in the past 12 months, when controlled for rest of the sociodemographic factors. Likewise, those who reported having a health insurance were also nearly 3 times more likely than uninsured respondents to report that they had completed A1C test (OR = 2.8, 95% CI = 1.5-5.4; Table 3).

Post-estimation analyses suggested that there was no evidence of lack of model fit as indicated by the nonsignificant Hosmer and Lemeshow's goodness-of-fit test ($F_{9,2007} = 1.12, Prob > F = .3418$). Examination of predictive margins suggested that there is a sizable difference in the completion of A1C test between individuals with less than high school and those with college graduates, with the marginal probability of A1C test for less than high school graduates being 83.1% and that for college graduates being 92.3%, as shown in Table 4. Likewise, it was noted that there is a sizable difference in marginal probability of A1C test between those who have (90.1%) health insurance and those who do not (78.4%).

Examination of average marginal effects (risk difference) indicated that the risk difference between those with less than high school education and those with more than college education is about 9.3%. Likewise, the risk difference between

those who do not have insurance and those who do is 12.4% in this population. Both results were significant as shown in Table 5.

Discussion

The prevalence of having completed the A1C test at least twice in the past 12 months (an indicator used in Healthy People 2020 objectives), is lower in Texas relative to the national average of 64.6%. Given the large proportion of diabetic individuals who have not completed an A1C test even once in the past 12 months, the public health priority should be to focus on those who are unaware about how their body is managing sugar. Lack of access to primary care physicians due to the lack of insurance may explain the lower rate of completion of A1C test in Texas. Those with health insurance are likely to see physicians, thus increasing the chances of being recommended for A1C test. The impact of health insurance on increased visits to physicians is more pronounced among minority groups.¹¹ Patient-physician communication is associated with better glycemic control,¹² and A1C test taking is one of the important behaviors for glycemic control that is helpful in disease management. The finding that uninsured are less likely to take A1C test is in conformity to other studies, for example.¹³ Per the recent statistics from small area health insurance estimates, more than a quarter (25.2%) of the population under 65 years was uninsured in Texas during 2012, which is the highest rate of uninsurance in the country.¹⁴ Thus, the recent efforts to enroll as many individuals as possible in the federal health exchange marketplace as part of Affordable Care Act may improve some of the health outcomes in the intermediate and long run.

As evident in the analysis, educational attainment is another crucial determinant of A1C test. First, an awareness of the need and importance of A1C test for self-management would be needed among diabetic individuals to want to take the A1C test. Individuals with higher education are likely to have higher health literacy,¹⁵ thus are more likely to take the test. It is also noted that diabetes-related numeracy is associated with poor glycemic control.¹⁶ We speculate that the diabetes-related numeracy could be a function of educational attainment among several other factors. In addition, the A1C test taking behavior is related to improved metabolic control and improved A1C outcome.¹⁷ Health literacy indirectly affects A1C outcome via increased social support.¹⁶ It is noteworthy here that the literature is not consistent in regard to the association between health literacy and A1C outcome.¹⁸ Other potential mechanisms whereby education may impact A1C test taking behavior include self-efficacy.¹⁸ Education not only brings health awareness, it also contributes indirectly by increasing the income and employment opportunities, which is likely to increase the chances of being insured, thus increasing the likelihood of adherence to testing guidelines, as discussed subsequently.

Disease management programs may educate their diabetic clients about the importance of regular A1C testing. As there exists a huge gap in the proportion of diabetic individuals who reported taking just 1 test in the past 12 months and those who conducted 2 or more tests in the past 12 months, it is an

Table 2. Association of Sociodemographic Factors With A1C Test.

Variables	Sample N ^a	% who had done A1C test in past 12 months?	Uncorrected χ^2	Design-based <i>F</i>	Significance (<i>P</i> value)
Gender					
Male	887	85.2	6.52	$F_{1,2063} = 2.1$	0.1476
Female	1215	88.9			
Race/ethnicity					
White	1292	91.8	47.44	$F_{2,68,5454.41} = 4.7$	0.0041
Black	185	85.8			
Hispanic	544	81			
Other	54	93.9			
Education					
Less than HS	342	76.5	71.26	$F_{2,53,5191.48} = 8.4$.0000
High school	562	87.9			
Some college	580	88.1			
College plus	608	95.1			
Marital status					
Married	1067	90.4	24.44	$F_{1,2056} = 7.8$.0054
Unmarried	1028	83.1			
Insurance status					
Uninsured	273	68.6	173.10	$F_{1,2058} = 50.9$.0000
Insured	1824	92.1			
Have a PCP?					
No	169	55.5	284.60	$F_{1,2052} = 77.1$.0000
Yes	1922	91.9			

^aThe sum of cells does not always add up to 2102, which is the total sample that responded to A1C question, because of missing data in other covariates.

Table 3. Odds Ratio and 95% Confidence Intervals.

A1C	Odds Ratio	Standard Error	<i>t</i>	<i>P</i> Value	LB ^a	UB ^b
Age	1.01	0.02	0.72	.471	0.98	1.05
White (Reference)						
Black	0.85	0.32	-0.42	.675	0.41	1.79
Hispanic	0.73	0.23	-1	.316	0.40	1.34
Others	1.25	0.93	0.29	.769	0.29	5.41
Less than high school (reference)						
High school	1.44	0.48	1.1	.272	0.75	2.76
Some college	1.51	0.50	1.25	.211	0.79	2.89
College plus	2.74	1.07	2.59	.01 ^c	1.28	5.89
Unmarried (reference)						
Married	1.42	0.35	1.45	.147	0.88	2.30
Uninsured (reference)						
Insured	2.83	0.94	3.13	.002 ^c	1.47	5.42
Age at diagnosis of diabetes	1.01	0.01	0.75	.454	0.99	1.03

^aLower bound 95% confidence interval.

^bUpper bound 95% confidence interval.

^cSignificant.

opportunity for the public health programs to target those sociodemographic groups who do not have a PCP and those who have lower level of educational attainment. In addition, the clinicians may also educate their patients about the importance of A1C test for self-management when their patients are diagnosed with diabetes.

The findings presented in this study are subject to at least three potential limitations. First, the responses are self-reported during a telephone survey and, thus, were not validated using any medical reports or charts, leaving room for underestimation or overestimation.

Second, it appears that there were some inconsistencies in the question related to A1C test as evident by the number of A1C tests that respondents reported. There is no additional benefit of taking A1C test more than four times in a year, as CDC recommends A1C test to be taken up by diabetic individuals only every three months. Thus, the maximum number of A1C test in any given 12 months should not have exceeded four. Since some respondents reported the number of tests taken to be as high as 76 in the past 12 months, it is possible that this question was misunderstood by the respondents. The investigators found this (number of tests >4 in the past

Table 4. Predictive Margins for Educational Level and Insurance Status.^a

Educational Level	Margin	Standard Error	t	P> t	95% Confidence Interval	
<High school	.831	.031	26.82	.000	.770	.892
High school graduate	.873	.022	39.08	.000	.829	.917
Some college	.878	.024	36.20	.000	.830	.926
College graduate	.926	.018	49.42	.000	.890	.963
Insurance status						
No insurance	.784	.037	20.92	.000	.710	.857
Yes insurance	.908	.015	58.70	.000	.877	.938

^aPredictive margins for only educational level and insurance status were calculated because these two variables were significantly associated with outcome in the multivariate analysis.

Table 5. Average Marginal Effects of Educational Level and Insurance Status.^a

Educational Level	Dy/dx	Standard Error	t	P> t	95% Confidence Interval	
<High school (reference)						
High school graduate	.042	.039	1.08	.281	-.034	.118
Some college	.046	.038	1.23	.218	-.027	.121
College graduate	.095	.037	2.51	.012	.020	.169
Insurance status						
No insurance (reference)						
Yes insurance	.124	.045	2.75	.006	.035	.212

^aAverage marginal effects for only educational level and insurance status were calculated because these 2 variables were significantly associated with outcome in the multivariate analysis.

12 months) data unreliable, thus treated these responses as *don't know*. If, for some reasons, those numbers are real, the findings of this study would be less reliable. It is speculated that those participants who reported higher number of A1C tests may have mistaken the A1C test with blood sugar test. We suggest that the BRFSS team may try to distinguish A1C test from blood sugar test during the interviews.

Third, the reliability and validity of the diabetes prevalence-related question has been examined,¹⁹ however, the authors are not aware of any reliability and validity studies conducted related to BRFSS question on A1C.

Declaration of Conflicting Interests

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