Using Dried Blood Spots to Estimate the Prevalence of Elevated Glycosylated Hemoglobin and Undiagnosed Diabetes among Spanish Speakers in the Southwest*

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Abstract

Diabetes is a major cause of morbidity and mortality in the US. Prevalence of diabetes among Hispanics is nearly twice that of non-Hispanic whites. Similarly, age-adjusted mortality rates from diabetes are 50% higher for Hispanics. One explanation for this may be high rates of uninsured among Hispanics leading to undiagnosed and poorly managed diabetes leading to greater complications and comorbidity. Given their marginal legal and economic status, recent immigrant arrivals and those with limited or no English proficiency may be at particularly high risk for undiagnosed diabetes. This paper uses dried blood spot techniques to estimate the prevalence of elevated glycosylated hemoglobin (HbA1c) and undiagnosed diabetes in a population-based sample of spanish speakers in the Phoenix metro area. We find that more than 30% have elevated HbA1c and nearly a quarter have undiagnosed diabetes. We also find significant educational disparities in these outcomes.

Diabetes is a major cause of morbidity and mortality in the US. An estimated 20.8 million Americans have diabetes (Cowie et al. 2006) including one in five Americans age 60 and above (CDC 2008). An additional 54 million Americans are pre-diabetic (Cowie et al. 2006). Diabetes represents the sixth leading underlying cause of mortality and contributes to more than 224,000 deaths annually (Anderson and Smith 2005; Gu, Cowie, and Harris 1998; Hu, Stempfer, and Solomon et al 2001). In addition diabetes is associated with peripheral vascular disease resulting in a number of serious complications including heart disease and stroke (Geiss, Herman, and Smith 1995; Kuller 1995), hypertension (Geiss, Rolka, and Engelgau 2002), retinopathy (Klein and Klein 1995), kidney disease (CDC 2008), neuropathy (Eastman 1995) and amputations (CDC 2008). Health care costs associated with diabetes and its complications total more than $92 billion annually (Hogan, Dall, and Nikolov 2003).

Previous research has documented large ethnic disparities in diabetes prevalence and mortality. In particular, elevated rates of diabetes have been observed among Hispanics/Latinos. For example, Mexican-Americans and Puerto Ricans are 1.7 and 1.8 times more likely to be diabetic compared to non-Hispanic whites, respectively (Cowie et al 2006; CDC 2008). The age-adjusted mortality rate from diabetes is more than 50% higher for Hispanics relative to non-Hispanics whites (Arias et al. 2003).

Key to preventing mortality and complications associated with diabetes is timely diagnosis and proper glucose control (Stratton, Adler, and Neil et al. 2000; The Diabetes Control and Complications Trial Research Group 1993). Unfortunately, 6.2 million Americans, representing around one-third of all diabetes cases, are undiagnosed. Hispanics are three times more likely to be uninsured compared to non-Hispanic whites

(DeNavas-Walt, Proctor, and Smith 2008), putting this population at greater risk of undiagnosed diabetes and its complications. Given their marginal legal and economic status, recent immigrant arrivals and those with limited or no English proficiency may be at particularly high risk for undiagnosed diabetes. We know of no previous studies that have examined undiagnosed diabetes among Spanish-speakers in the US. This study investigates rates of undiagnosed diabetes within a population-based sample of Spanish-speakers in the Phoenix metropolitan area.

Data

The data for this analysis come from the Southwest Migration Study (SWMS). The aims of the SWMS are to examine the interrelationships between migration, health, and the environment. The SWMS is a joint effort between investigators at Arizona State University and Universidad Autónoma de Sinaloa (UAS), in Culiacán, Mexico. This first set of SWMS data is a small-scale pilot project designed to binationally test data collection procedures in a two-country setting.

In the Phoenix component, Census blocks were sampled from the eight most populous cities in Maricopa County (Phoenix, Tempe, Mesa, Chandler, Glendale, Scottsdale, Peoria, and Gilbert). These eight cities comprised approximately 88% of the entire population of Maricopa County. Blocks were eligible to be sampled if they were at least 25% Hispanic, based on the 2000 Census. Blocks were then sampled, proportionate to size, from all eligible blocks. Interviewers from UAS conducted face to face interviews at housing units in sampled blocks over a 10 day period in March, 2009. Interviewers went door to door, and an individual was eligible for interview if he or she was at least 18 years old and Spanish speaking. If multiple Spanish-speaking adults were in a household,

interviewers asked to survey the eligible adult with the most recent birthday. Restricting eligibility to Spanish speakers was necessary because the interviewers from UAS, while bilingual, had fluent proficiency only in Spanish. The interview protocol consisted of three parts. First was a standard questionnaire that asked a variety of closed-ended questions covering demographic, employment, health, and basic migration history (nativity, parental nativity, year of entry to the US). Second was a yearly life history calendar that measured geographic location, employment status, and family events. Third was a set of biomarker measurements including height, weight, peak lung flow, and dried blood spots that were later assayed for diabetes risk (glycosylated hemoglobin-HbA_{1c}). The response rate of households that were found to an eligible occupant present was 58%. This compares favorably with other studies of immigrant populations, such as the New Immigrant Survey (69% response rate). The sample size for the Phoenix survey was N=415.

Measures

Assays of glycosylated hemoglobin (HbA_{1c}), using the Roche Diagnostics Unimate method on an Integra 700 Analyzer, were obtained from dried blood spots which provide a high quality, minimally-invasive method for collecting blood samples in non-clinical settings (McDade, Williams and Snodgrass 2007). Previous research has confirmed the validity and reliability of HbA_{1c} values derived from dried blood spots (Eross et al. 1984; Little et al. 1986; Jeppsson et al. 1996). In addition to analyzing differences in HbA_{1c} levels, we created three dichotomous measures of elevated blood glucose using cutoffs at 5.6% (1 SD above the normal mean), 6.1% (2 SD above the normal mean) and 6.5% (3 SD above the normal mean). These coincide with criteria used by Rohlfing and

colleagues (2000) to estimate undiagnosed diabetes using National Health and Nutrition Examination Survey (NHANES). Based on the NHANES sensitivity and specificity associated with these three cutoffs are 83.4/84.4, 63.2/97.4, and 42.8/99.6 respectively (Rohlfing et al. 2000). Among Mexican Americans, using HbA_{1c} values above 6% resulted in a sensitivity of 83.6 and a specificity of 97.8 (Rohlfing et al. 2000). In addition, SWMS respondents were asked if they had ever been diagnosed with diabetes. We then created three dichotomous measures of undiagnosed diabetes for those answering in the negative and whose HbA_{1c} levels exceeded 5.6%, 6.1%, and 6.5 %. While we focus on the 6.1% values which previous research suggests maximizes sensitivity and specificity among Mexican Americans, we also present results for the other cutoffs. BMI is calculated as weight (kg)/height (m^2) based on anthropometric measurement. We further stratify our analysis by a series of sociodemographic characteristics including gender, age, nativity, and educational attainment.

Preliminary Results

Descriptive statistics for the sample are provided in table 1. The average age of SWMS respondents was 35.7 and 21% were aged 45 and over. Sixty-four percent of the sample is female. This is most likely due to the fact that surveys were conducted in person during the daytime. Thirty-two percent of the sample is overweight (BMI 25-29.9), and 42% are obese (BMI $\geq$ 30) while the average BMI is 29.2. The sample is largely foreign-born (87%). Forty-three percent of the sample have a high school education or beyond. Approximately 15% of the sample report having been told by a physician that they have diabetes. However, proportions of elevated HbA_{1c} suggest potential large numbers of

undiagnosed diabetes cases in this population. Seventy eight percent, 30%, and 10% had HbA_{1c} above 5.6, 6.1%, and 6.5%, respectively.

[Table 1 here]

Table 2 presents estimates of average HbA_{1c}, prevalence of elevated glycosylated hemoglobin (above 5.6, 6.1, and 6.5), physician diagnosed diabetes, and undiagnosed diabetes stratified by sociodemographic background. The mean HbA_{1c} of 6.1% in the sample suggests high rates of glucose disregulation. Levels of HbA_{1c} did not vary significantly by gender, nativity, or education, though values did rise significantly with age ($p<.001$) and BMI ($P<.01$).

The results also show that there is a substantial proportion of the sample with elevated HbA_{1c} levels. More than three-quarters of respondents aged 55 and older had HbA_{1c} levels greater than 6.1 while more than 75% of the 25 and older had HbA_{1c} greater than 5.6. The prevalence of HbA_{1c} greater than 6.1 for the obese was nearly three times higher compared to normal weight respondents. There were also significant educational differentials in the prevalence of HbA_{1c} greater than 6.1 ($p<.001$). However, there were no significant gender or nativity differences in the prevalence of elevated HbA_{1c} (≥ 6.1).

[Table 2 here]

There were significant sociodemographic disparities in the rates of physician diagnosed diabetes. Eighteen percent of females reported having been diagnosed with diabetes compared to just 10% for men. Physician diagnosed diabetes also increased with age. Those with more completed schooling had significantly lower rates of diagnosed diabetes. Rates of diagnosed diabetes did not differ between US and foreign born respondents nor did they differ by BMI.

Using $HbA_{1c} \geq 6.1$ as a threshold (2 SD above the normal mean), nearly 1 in 4 SWMS respondents (22.9%) had undiagnosed diabetes. Using the less conservative (though less sensitive) standard (1 SD above the normal mean), two-thirds of the sample were undiagnosed diabetics, while prevalence of undiagnosed diabetes was only 5.4% using the most conservative standard (3 SD above the normal mean). As expected, prevalence of undiagnosed diabetes was significantly higher for obese respondents compared to their normal weight peers.

Levels of undiagnosed diabetes vary by sociodemogrpahic background. As expected, statistically significantly higher prevalence rates of undiagnosed diabetes are found for older respondents compared to their younger peers. Nearly half (47.1%) of those aged 55-64 and nearly two-thirds (65.5%) of those aged 65 and older had undiagnosed diabetes compare to just 7.9% among those age 18-24. Undiagnosed diabetes was also more prevalent among those with primary education compared to their more educated peers. We find no statistically significant differences in prevalence of undiagnosed diabetes between men and women or between those born in and outside of the US.

Discussion

Our preliminary analysis demonstrates high prevalence rates of elevate glycosylated hemoglobin and undiagnosed diabetes among Spanish-speakers in a population based sample. We find that more than 30% have elevated HbA_{1c} and nearly a quarter have undiagnosed diabetes. We also consistently find significant educational disparities in these outcomes. However, we find no evidence that foreign born individuals have higher rates of elevated HbA_{1c} or undiagnosed diabetes.

For PAA we plan to extend this analysis to include multivariate analysis of elevated glycosylated hemoglobin and undiagnosed diabetes. This will include additional investigation of occupation and migration histories drawn from life history calendars. The additional data from the life history calendars will allow us to determine the extent to which undiagnosed diabetes varies with time in the United States or age at arrival among the foreign born.

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Table 1. Descriptive Statistics SWMS 2009

	%	Mean	Std Dev
$HbA_{1c} \geq 5.6$	78.8		
$HbA_{1c} \geq 6.1$	30.7		
$HbA_{1c} \geq 6.5$	10.4		
Diagnosed Diabetes	15.0		
BMI		29.2	6.3
<25	25.5		
25-24.99	32.4		
≥30	42.1		
Age		35.7	12.6
18-24	19.4		
25-34	33.3		
35-44	25.4		
45-54	12.2		
55-64	6.0		
65+	3.6		
Female	64.4		
Male	35.6		
Education			
Primary	29.3		
Secondary	27.6		
High School	30.9		
College+	12.2		
US Born	13.0		
Foreign Born	87.0		

Table 2. Distribution of HbA_{1c} and undiagnosed diabetes by demographic background

	Mean HbA_{1c}		HbA_{1c} ≥ 5.6		HbA_{1c} ≥ 6.1		HbA_{1c} ≥ 6.5		Diagnosed Diabetes		Undiagnosed Diabetes 5.6[a]		Undiagnosed Diabetes 6.1[b]		Undiagnosed Diabetes 6.5[c]	
Total	6.1															
%			78.8		30.7		10.4		15.0		66.7		22.9		5.4	
Male	6.0		82.2		29.7		10.9		10.1		64.4		24.8		7.9	
Female	6.1	*ns*	71.3	*	31.3	*ns*	10.3	*ns*	17.8	*	67.8	*ns*	22.0	*ns*	4.2	*ns*
BMI <25	5.7		64.4		15.1		1.4		9.9		57.5		11.0		1.4	
BMI 25-29.9	6		80.2		20.9		7.7		11.7		70.3		15.4		5.5	
BMI ≥30	6.3	**	84.6	**	44.7	***	17.9	***	20.1	*ns*	68.3	*ns*	33.3	***	8.9	*ns*
Age																
18-24	5.7		57.1		7.9		1.6		4.9		55.6		7.9		1.6	
25-34	5.8		76.8		19.6		3.6		5.8		72.3		17.0		2.7	
35-44	6.2		87.5		41.3		12.5		17.9		71.3		32.5		5.0	
45-54	6.9		91.2		47.1		29.4		35.3		58.8		26.5		14.7	
55-64	6.6		94.1		76.5		29.4		32.0		64.7		47.1		17.7	
65+	7.1	***	100	***	100	***	37.5	***	40.0	***	62.5	*ns*	65.5	***	12.5	**
US Born	6.1		72.1		25.6		4.7		14.8		62.8		18.6		0.0	
Foreign Born	5.8	*ns*	79.6	*ns*	31.5	*ns*	11.5	*ns*	15.3	*ns*	67.0	*ns*	23.3	*ns*	6.3	*ns*
Education																
Primary	6.3		84.4		51.1		13.3		20.5		68.9		37.8		5.6	
Secondary	6.1		76.1		22.7		11.4		7.0		68.2		15.9		5.7	
High School	5.9		74.7		22.1		8.4		16.3		63.2		17.9		5.3	
College	6	*ns*	80.5	*ns*	24.4	***	7.3	*ns*	17.7	*	65.9	*ns*	17.1	**	4.9	*ns*

a using HbA_{1c} ≥ 5.6 as threshold

b using HbA_{1c} ≥ 6.1 as threshold

c using HbA_{1c} ≥ 6.5 as threshold

ns = non significant at p<.05