Diabetes Risk Assessment in Latinas: Effectiveness of a Brief Diabetes Risk Questionnaire for Detecting Prediabetes in a Community-Based Sample

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ABSTRACT

Objective. Numerous validated questionnaires use self-reported data to quantify individuals' risk of having diabetes or developing it in the future. Evaluations of these tools have primarily used nationally representative data, limiting their application in clinical and community settings. This analysis tested the effectiveness of the American Diabetes Association (ADA) risk questionnaire for identifying prediabetes in a community-based sample of Latinas.

Methods. Data were collected using the ADA risk questionnaire and assessing A1C. Among 204 participants without diabetes, we examined the association between individual characteristics and glycemic status. We then calculated the performance characteristics (sensitivity, specificity, positive predictive value [PPV], and negative predictive value [NPV]) of the ADA risk questionnaire for detecting prediabetes, using A1C results as the gold standard to define the outcome.

Results. All participants were women of self-reported Hispanic/Latino ethnicity. Their mean ADA risk score was 5.6 ± 1.6. Latinas who had prediabetes were older, with significantly higher rates of hypertension and a higher ADA risk score than those without prediabetes. At a risk score ≥5—the threshold for high risk set by the ADA—the questionnaire had the following test performance characteristics: sensitivity 77.8%, specificity 41.7%, PPV 76.2%, and NPV 43.9%.

Conclusion. The ADA risk questionnaire demonstrates reasonable performance for identifying prediabetes in a community-based sample of Latinas. Our data may guide other groups' use of this tool in the same target population. Future research should examine the effectiveness of this questionnaire for recruiting diverse populations into diabetes prevention programs. In addition, unique diabetes risk assessment tools for specific target populations are needed and may outperform questionnaires developed using nationally representative data.

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Type 2 diabetes in the United States disproportionately affects racial/ethnic minorities, who have a higher prevalence of the condition, worse glycemic control, and higher rates of diabetes complications than whites (1–3). Of all major racial/ethnic groups, Hispanics have the highest prevalence of diabetes, recently estimated at 22.6% (4). Furthermore, >50% of Hispanic women (hereafter called Latinas) will develop diabetes, which is higher than any other demographic group (5). Among U.S. Latinos without diabetes, 36.8% have prediabetes and are at elevated risk of developing the disease (4), with their risk estimated to be 70% over a lifetime (6).

A large body of research has demonstrated that diabetes is preventable (7–10), most prominently

the Diabetes Prevention Program trial, which randomized 3,234 adults with prediabetes to receive an intensive lifestyle intervention, metformin, or placebo. This landmark clinical trial demonstrated that a structured, intensive lifestyle intervention focused on motivating healthy dietary behaviors and regular physical activity reduced the incidence of diabetes by 58% compared to placebo (10). The corresponding relative risk reduction for metformin was 31% (10). These data highlight the need for pragmatic methods to identify adults with prediabetes who may benefit from intensive lifestyle interventions or metformin to prevent diabetes.

There are numerous questionnaires that use self-reported data to quantify individuals' risk of having diabetes or developing it in the future (11). In 1993, the American Diabetes Association (ADA) first developed such a questionnaire based on established diabetes risk factors, including age, obesity, and family history of diabetes (12). Since then, many similar tools have been developed worldwide to assess individuals' diabetes risk based on self-reported or clinical data (13–19).

The most commonly used questionnaire in the United States includes items about the following self-reported diabetes risk factors: age, sex, hypertension, obesity, physical inactivity, and family history of diabetes (20). This diabetes risk screening tool was developed from a risk prediction model using nationally representative data from the 1999–2004 National Health and Nutrition Examination Survey. Validation of this risk model was conducted using 2005–2006 data from the same source, in addition to using baseline data from two large cohorts, the Atherosclerosis Risk in Communities Study and the Cardiovascular Health Study. The risk questionnaire based on this predictive model yielded the following performance characteristics: sensitivity 79%, specificity 67%, positive predictive value (PPV) 10%, and negative predictive value (NPV) 99%, with an area under the receiver-operating characteristic curve of 0.83 (20). Based on the favorable performance of this risk questionnaire, the ADA has recently adopted it and added one further question about a history of gestational diabetes in women (21).

Evaluations of these diabetes risk questionnaires have primarily used nationally representative data, which limits their application in clinical and community settings (22). Despite the high diabetes risk observed among U.S. Latinas, there has been little investigation of risk screening questionnaires in this population. Studies that have evaluated such questionnaires in racial/ethnic minorities, predominantly African Americans, suggest that risk screening tools perform less favorably among these subgroups than among whites (14,23) This observation is particularly concerning given racial/ethnic minorities' higher diabetes risk (1), exposing a need to study risk questionnaires in diverse populations and settings.

Considering the limitations of the existing literature, the objective of our study was to test the effectiveness of the ADA risk questionnaire for identifying prediabetes in a community-based sample of Latinas. We hypothesized that this risk questionnaire would perform favorably in Latinas given their high risk of diabetes and associated risk factors (24).

Study Methods

Data Source and Participants

This study is a secondary analysis of data from the PREVENT-DM (Promotora Effectiveness Versus Metformin Trial) clinical trial (NCT02088034), a comparative effectiveness study of intensive lifestyle intervention, metformin, and standard care among Latinas with prediabetes. The design and methods of PREVENT-DM, including the eligibility criteria, have been described in-depth (25), as have the trial's main effects (26). The study protocol was approved by the institutional review boards of Temple University and Northwestern University.

Data for this secondary analysis were collected during recruitment efforts, which included administering the ADA risk questionnaire to identify potential participants' diabetes risk before assessing A1C in those with a score ≥4. A1C was used in the screening process because it does not require an overnight fast or the drawing of multiple blood samples, as is the case for fasting glucose and oral glucose tolerance tests.

The ADA risk questionnaire was administered by the study's research coordinator during community health fairs and at Latino-serving community health centers. For the current study, we excluded Latinas who were found to have diabetes based on subsequent A1C testing (n = 10). This exclusion criterion allowed us to evaluate the ADA risk questionnaire's performance in identifying prediabetes. The final analytic sample included 204 participants.

Measures and Definitions

The ADA risk questionnaire collects self-reported data about the following seven diabetes risk factors, which are categorized as follows: age (<40 years, 40–49 years, 50–59 years, or ≥60 years), sex (male or female), history of gestational diabetes (yes or no), history of hypertension (yes or no), family history of diabetes (yes or no), physical inactivity (yes or no), and weight status based on height and weight (normal, overweight, obese, or morbidly obese). A unique score is assigned for each level of the risk factors, which are then summed for a maximum score of 11.

For the current study, we administered the ADA risk questionnaire without any modifications to all participants. Those who had a score ≥4 underwent venipuncture to assess A1C and determine their glycemic status. According to the ADA diagnostic criteria, prediabetes was

TABLE 1. Participant Characteristics by Glycemic Status (*n* = 204)

Characteristic*	Overall (*n* [%])	Normal (*n* [%])†	Prediabetes (*n* [%])†	*P*‡
Number of participants	204 (100)	60 (100)	144 (100)	NA
Female sex	204 (100)	60 (100)	144 (100)	NA
Hispanic/Latino ethnicity	204 (100)	60 (100)	144 (100)	NA
Age (years)				<0.01
<40	85 (41.7)	36 (60.0)	49 (34.0)	
40–59	96 (47.0)	21 (35.0)	75 (52.1)	
≥60	23 (11.3)	3 (5.0)	20 (13.9)	
History of gestational diabetes	33 (16.2)	7 (11.7)	26 (18.1)	0.26
Family history of diabetes	134 (65.7)	38 (63.3)	96 (66.7)	0.65
Hypertension	104 (51.0)	22 (36.7)	82 (56.9)	<0.01
Physically inactive	70 (34.3)	18 (30.0)	52 (36.1)	0.40
Weight status				0.39
Normal	8 (3.9)	4 (6.7)	4 (2.8)	
Overweight	65 (31.9)	22 (36.7)	43 (29.9)	
Obese	131 (64.2)	34 (56.7)	97 (67.4)	
ADA risk score				<0.01
4	57 (27.9)	25 (41.7)	32 (22.2)	
5–7	124 (60.8)	32 (53.3)	92 (63.9)	
≥8	23 (11.3)	3 (5.0)	20 (13.9)	
	(mean ± SD)	**(mean ± SD)**	**(mean ± SD)**	***P***
ADA risk score	5.6 ± 1.6	5.0 ± 1.4	5.9 ± 1.6	<0.01
A1C (%)	5.8 ± 0.4	5.4 ± 0.3	6.0 ± 0.2	<0.01

**All data on participant characteristics are expressed as n (%) except for ADA risk score and A1C, which are expressed as mean ± SD.*

†The denominator for the reported column percentages is the number of participants with normoglycemia and prediabetes, respectively.

‡P values were based on χ^2 tests for participant characteristics × glycemic status (normal/prediabetes) and t tests for the continuous measures of ADA risk score and A1C.

defined by an A1C value of 5.7–6.4%, and diabetes was defined by an A1C ≥6.5%.

Statistical Analysis

Summary statistics were used to characterize all participants with respect to demographic characteristics, diabetes risk factors, and ADA risk score. χ^2 tests were then used to examine the association between these categorical participant characteristics and glycemic status (normal/prediabetes).

We calculated the following test performance characteristics of the ADA risk questionnaire for identifying prediabetes: sensitivity, specificity, PPV, and NPV. In calculating these test performance characteristics, A1C results were used as the gold standard to define prediabetes. Sensitivity, specificity, PPV, and NPV were calculated separately at different thresholds of diabetes risk defined by participants' ADA risk score (4, 5, 6, 7, and ≥8).

In a sensitivity analysis, we examined the same test performance characteristics among all 214 participants who were screened for eligibility in this manner, including the 10 participants found to have diabetes. Otherwise, all statistical analyses included the full sample of 204 participants and were conducted using Stata 13 (StataCorp, College Station, Tex.).

Results

Table 1 displays participants' demographic characteristics, diabetes risk factors, A1C values, and ADA risk scores. All participants were women of self-reported Hispanic/Latino ethnicity, almost 90% of whom were <60 years of age. There was a high prevalence of diabetes risk factors, including gestational diabetes (16.2%), hypertension (51%), obesity (64.2%), and family history of diabetes (65.7%). The mean ADA risk score was 5.6 ± 1.6, and the mean A1C value was 5.8 ± 0.4%. Latinas

TABLE 2. Test Performance Characteristics of ADA Risk Questionnaire for Detecting Prediabetes by Thresholds of Risk Score (*n* = 204)*

ADA Risk Score†	Sensitivity (%)‡	Specificity (%)§	PPV (%)‖	NPV (%)¶
4	96.5	8.3	71.6	50.0
5	77.8	41.7	76.2	43.9
6	56.3	68.3	81.0	39.4
7	34.7	83.3	83.3	34.7
≥8	13.9	95.0	87.0	31.5

**Prediabetes was defined by an A1C value of 5.7–6.4%.*
†Test performance characteristics in each row were based on the threshold for a positive risk score being greater than or equal to the number displayed.
‡Sensitivity represents the proportion of participants with prediabetes who have a risk score at or above the threshold.
§Specificity represents the proportion of participants without prediabetes who have a risk score below the threshold.
‖PPV represents the proportion of participants with a risk score at or above the threshold who have prediabetes.
¶NPV represents the proportion of participants with a risk score below the threshold who do not have prediabetes.

who had prediabetes were older, with significantly higher rates of hypertension and a higher ADA risk score than those without prediabetes. There were no other significant differences in participant characteristics by glycemic status.

Table 2 shows the test performance characteristics of the ADA risk questionnaire, stratified by the risk score. In general, as the threshold of ADA risk score increased from 4 to 8, there were incremental decreases in the sensitivity and NPV and incremental increases in the specificity and PPV. With a score of ≥5, the threshold for high risk recommended by the ADA, the questionnaire had the following test performance characteristics: sensitivity 77.8%, specificity 41.7%, PPV 76.2%, and NPV 43.9%. In a sensitivity analysis including those found to have diabetes on subsequent glycemic testing with a risk score of ≥5, we observed the following test performance characteristics: sensitivity 78.6%, specificity 41.7%, PPV 77.6%, and NPV 43.1%.

Discussion

To our knowledge, this is the first study to examine the performance of the ADA risk questionnaire in a community-based sample of Latinas, the demographic group with the highest diabetes risk. Latina participants with prediabetes had significantly higher ADA risk scores than those with normal glycemic status. Using the scoring threshold suggested by ADA, the questionnaire demonstrated reasonable performance in identifying Latinas with prediabetes, especially sensitivity and PPV. However, the specificity at this threshold was low. Increasing the threshold of risk score decreased sensitivity and increased specificity. The performance characteristics for detecting prediabetes and diabetes together were very similar to those reported for prediabetes alone.

The only other study to test the effectiveness of the ADA risk questionnaire for identifying prediabetes included a nationally representative sample from the National Health and Nutrition Examination Survey. This study only reported the questionnaire's performance characteristics for a risk score of ≥4, which exhibited sensitivity of 76%, specificity of 54%, PPV of 53%, and NPV of 77% (27). At this same threshold, our study found higher sensitivity and much lower specificity, which is likely related to Latinas' high diabetes risk relative to a nationally representative population of U.S. adults. The discrepancy between our findings and those from a national sample echoes previous studies demonstrating divergent performance of the same diabetes risk assessment tools in different populations (11,28,29). This observation highlights a need to study the performance of risk assessment questionnaires in the population in which they will be used.

This study provides guidance for clinicians seeking to assess diabetes risk in Latinas. Our findings suggest that the ADA risk questionnaire may help providers decide which patients require screening tests for prediabetes and diabetes. In 2015, the U.S. Preventive Services Task Force recommended dysglycemia screening among adults who are 40–70 years of age and overweight or obese (30). Because these screening criteria could miss up to 55% of adults with prediabetes and diabetes (31), clinicians may want to screen Latinas before these age- and weight-related cutoffs. The ADA questionnaire assesses and sums other risk factors that may also prompt screening for dysglycemia (32). Therefore, our findings may guide how clinicians use those risk factors to make screening decisions for Latinas. In health fairs and other community settings where the ADA risk questionnaire is used but laboratory testing is not available, our findings can help inform the need for subsequent glycemic screening tests.

In research and outreach targeting similar populations, our results may help guide recruitment efforts. The ADA recommends a risk score

of 5 to define elevated diabetes risk (21), which seems to yield the most favorable balance of sensitivity and specificity in our Latina sample. However, by presenting a range of test performance characteristics stratified by ADA risk score, our study can help clinicians and researchers decide the most appropriate risk threshold for their unique needs. For example, medical students at a community health fair may want to use the ADA risk questionnaire to identify adults with elevated diabetes risk and refer them to a clinic for medical evaluation. In this case, they may choose a threshold ADA risk score of ≥4 (i.e., maximal sensitivity). On the other hand, a research study targeting Latinas with prediabetes may choose a threshold of 8 (i.e., maximal specificity) if funds for laboratory testing are limited.

This analysis has the following limitations. Examining the psychometric properties of the ADA risk questionnaire among Latinas was not part of our analysis, and to our knowledge, such an analysis has not been published elsewhere. Although there are cultural and linguistic differences between Latinas and other population subgroups, the major risk factors for diabetes included in the ADA questionnaire are common to all racial/ethnic groups (33). Nonetheless, future studies should test the psychometric properties of the ADA risk questionnaire in Latinas and examine its validity for measuring diabetes risk in this population.

In the PREVENT-DM recruitment protocol, potential participants with a risk score <4 were not invited for A1C testing (25). Therefore, these women were not included in the current analysis because their prediabetes status could not be ascertained. By excluding lower-risk Latinas, our estimates of the ADA risk questionnaire's performance characteristics may be biased. However, sensitivity and specificity are test characteristics that are thought to be independent of disease prevalence in the tested population (34). Therefore, our findings would likely not have differed greatly if Latinas with a risk score <4 were included in the analysis.

We used A1C values to define the presence of prediabetes and diabetes. Fasting plasma glucose and oral glucose tolerance tests are also used to define dysglycemia, with distinct diagnostic values that were not assessed in this study. Although previous research has demonstrated that these alternate definitions of dysglycemia are overlapping, each test identifies a small proportion of individuals that the other tests do not (35). A1C is recommended as a screening test for dysglycemia, does not require an overnight fast, and has the lowest intra-individual variation compared to the other two tests (32,36). However, it is possible that the performance characteristics of the ADA risk questionnaire reported here would have differed if the other tests were also used to define prediabetes and diabetes. Using a more inclusive definition would identify a larger number of participants with these conditions, potentially affecting estimates of sensitivity, specificity, PPV, and NPV.

Because our sample included only Latinas, the results have limited generalizability in other demographic groups. Finally, the similar test performance characteristics observed for prediabetes and diabetes compared to prediabetes alone may be related to the small number of participants with diabetes.

Conclusion

This is the first study evaluating the performance of the ADA risk questionnaire in Latinas, the demographic group at highest risk of developing diabetes. The performance characteristics reported here, stratified by risk score, may guide other groups' use of this tool in the same target population. Our findings may be particularly useful for future research because diabetes risk questionnaires have demonstrated limited uptake in clinical settings (37). Future research should examine the effectiveness of the ADA risk questionnaire for recruiting diverse populations into diabetes prevention programs. In addition, unique diabetes risk assessment tools for specific target populations are needed and may outperform questionnaires developed using nationally representative data.

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Duality of Interest

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

Author Contributions

A.B.S. and M.J.O. researched data, contributed to the discussion, and wrote, reviewed, and edited the manuscript. C.M.M. researched data, contributed to the discussion, and reviewed and edited the manuscript. A.P. and C.J.H. contributed to the discussion and reviewed and edited the manuscript. M.J.O. is the guarantor of this work and, as such, had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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