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Diabetes Type 2 Risk Score for African Americans based on Jackson Heart Study data: A cross-sectional study

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Abstract

Introduction: The Finnish Diabetes Risk Score (FINDRISC) has been used as a low-cost screening tool in many European countries for the early identification of people at risk of Type 2 Diabetes (T2D). However, for African American individuals, an optimal Diabetes Risk Score has not been developed. There is a need for an African American Diabetes Risk Score (AADRSC to include exclusive characteristics for African Americans that can be an extension of FINDRISC. Hence, the objective of this study was to develop a diabetes risk score for African Americans and to assess the accuracy of the AADRSC for undiagnosed T2D, using data from the Jackson Heart Study.

Methods: A cross-sectional study was conducted in a sample population of men and women ages 20 to 95 with and without diabetes (n = 3,098) for Exam 1 of the Jackson Heart Study (JHS). Participants with chronic kidney disease were excluded. A univariate analysis was carried out for the selection of relevant risk factors associated with diabetes based on the socioecological model. The variables were identified as significant and were included in a multivariate logistic regression model. Based on the beta coefficients obtained, a risk score was made. The validity of the score was assessed in Exam 1 by comparing the AADRSC with the FINDRISC using receiver operating characteristic curves.

Results: The Area Under the Curve (AUC) was 0.78 for the AADRSC and 0.72 for the FINDRISC (p=0.00012). Using the risk score cutoff value of 11 in the AADRISC to detect T2D resulted in a sensitivity of 66% and a specificity of 71%.

Discussion and Conclusion: The characteristics of the AADRSC showed that it can be used as a simple, safe, and inexpensive test to identify people at high risk of T2D in the African American population. An implication for the field of Public Health is that the AADRSC can be used in primary care for detecting people with a high risk of T2D.

Take-home message: The Finnish Diabetes Risk Score is a simple, inexpensive, and non-invasive tool for helping in predicting T2D in African American adults.

Keywords: African Americans, diabetes mellitus, risk score.

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INTRODUCTION

Type 2 diabetes (T2D) has become a rampant epidemic disease in the U.S. About 34.2 million Americans are living with diabetes (10.5% of the U.S. population) and nearly 1 in 3 (84 million U.S. adults) is living with pre-diabetes, a serious condition that increases the risk of chronic diseases and T2D [1]. The risk of T2D is significantly higher among African Americans than among people of European descent. Black African Americans have a 2.3 higher mortality related to diabetes when compared to whites; studies explained this increase because of segregation, stress, economic inequality, lack of health insurance, and socioeconomic status [2,3]. T2D is related to obesity, diet, lack of physical activity, and certain chronic conditions such as hypertension, among other factors in African Americans [4]. T2D also develops significantly earlier in African Americans than in European Americans and tends to be more severe [4]. If the onset of T2D could be predicted in advance, it may be possible to prevent or delay the development of the disease [5].

The Finnish Diabetes Risk Score (FINDRISC) has been used as a low-cost tool for detecting T2D in European countries [5]. The validity of this score has limitations and must be adapted when applied in populations other than European populations. Omech [6] conducted a study in Botswana using the FINDRISC which suggested the inclusion of other variables related to cardiovascular disease and insulin resistance to improve the effectiveness of the score in populations in Africa. Pollock [7], when analyzing different diabetes test calculation tools, suggested the inclusion of socio-economic variables. Pollock [7] also highlighted the need to include different variables for African Americans and European Americans in the United States, since African Americans have a 60% higher risk of diabetes compared to European Americans. We modified the FINDRISC, incorporating factors particularly important for T2D risk among African Americans such as cardiovascular disease and socioeconomic status, to develop a specific risk score for African Americans called the African American Diabetes Risk Score (AADRSC). We then compared the accuracy of the AADRSC and FINDRISC within the African American population of the study. We also compared the accuracy using a summary of the diabetes risk scores as discussed in the literature (Table 1). The objectives of this work are to develop a diabetes mellitus risk score for African Americans, to determine the main risk factors for the development of type 2 diabetes in African Americans using Jackson Heart Study (the biggest study for cardiovascular diseases and chronic conditions in African Americans) data Exam 1, evaluate the accuracy of the African American Diabetes Risk Score to determine people at risk of type 2 diabetes mellitus and to verify if the model captures most of the people with type 2 diabetes [8].

METHODS

Study design and procedure

The cross-sectional study collected a sample that comprises 3,098 individuals. T2D risk factors chosen for this investigation were categorized based on the socioecological model (SEM), which is frequently used in obesity and diabetes studies [9]. The method used in this research began with the selection of variables from secondary data from the Jackson Heart Study (JHS). JHS is the largest study investigating chronic and cardiovascular diseases in African American Population. The criterion for this selection follows the Socio-Ecological Model (SEM) proposed by Bronfenbrenner [9]. The effect of the selected variable on diabetes was described by a simple logistic regression model and the acceptance (or rejection for further analysis) of the variable was based on the p-value. If the p-value is less than 0.05, the variable is selected. Then, a multiple logistic regression was performed with the selected variables. The multiple logistic regression model shows how the outcome (T2D) is determined by the selected variables and their beta coefficients. In the next step, a score was assigned for different beta ranges. The AADRC model is obtained from the multiple logistic regression model and the assigned scores. The receiver operating characteristics (ROC) were used to validate the proposed model. A set of cutoffs was defined for selecting different sensitivities and specificities. Figure 1 shows the method explained before graphically. The next sections of the methodology explained in detail the different steps of the method.

Study participants and sampling

A sample of 20 to 95-year-old men and women who live in Jackson, Mississippi was selected from the baseline of the Jackson Heart Study (JHS) Exam 1(9/26/2000-3/13/2004). Individuals were selected from a pool of 5,301 participants. The JHS is the largest, community-based epidemiologic investigation of environmental and genetic factors associated with cardiovascular disease among African Americans funded by the National Heart, Lung, and Blood Institute (NHLBI) and the National Institute on Minority Health and Health Disparities (NIMHD).

Data analysis

Variables were analyzed as follows: Age was stratified in years: 20-44, 45-54, 55-64, and 65 to 95; BMI was calculated as weight (kg) divided by the square height (m^2), and the stratification used was from 0-29.9 normal weight, and 30 and above obese; waist circumference was measured in centimeters, men > *120* cm (*40* inches) and women > *88* cm (*35* inches) are considered high risk and values below low risk. Diabetes status was provided by yes/no; blood pressure medication status was defined by yes/no; American Health Association (AHA) physical activity categorizations were poor health, intermediate health, and ideal health; a daily portion of green vegetables was reported as 0-5.35; family history of diabetes was defined as yes/no; depression was measured as no (0-9)- yes (10 or more); family income was reported as less than 0-$34,999, $35,000-$99,999, and $100,000 or more; and cardiovascular disease history was defined as yes/no [4–6,8–14].

The exclusion criteria within Exam 1 were participants with chronic kidney disease and participants who developed T2D or those not in Exam 1 based on diabetes status [6]. Simple logistic regression models were used for assessing the association between each of the variables which are age, body mass index, waist circumference, blood pressure medication, physical activity, a daily portion of dark green vegetables, depression, stress, family income, occupational status, family history of diabetes, cardiovascular history, and diabetes that is the outcome variable. The level of statistical significance was *0.05*. The AADRSC was developed and validated according to Barengo's methodology [8].

Factors that had a significant p-value in the simple logistic regression model were included in a multivariate analysis. The multivariate logistic regression model β-coefficients were used to assign each variable a category score. The AADRSC comprised the sum of these individual scores. The AADRSC value was defined using β coefficients as follows: for β=0.01-0.49, the score was 1; for β=0.5-0.90, the score was 2; and for β=0.9-1.20, the score was 3. The lowest category of each variable was 0. The AADRSC value is the sum of these individual scores and varies from 0 to 18 units. The sensitivity and specificity of AADRSC and FINDRISC were assessed using data from the Jackson Heart Study Exam 1. A receiver operating characteristics curve was used to visualize, organize, and evaluate the performance of risk scores of AADRSC [15]. Sensitivity and specificity values were calculated for each score for several cut-off points. The data were analyzed using SAS 9.4 software and Excel for Windows.

Ethical aspects

Jackson Heart Study (JHS) is a national dataset collected with all ethical approvals. This study used secondary data analysis which further received the institutional review board's (IRB) approval from Jackson State University. The data did not have any personal identifiers and were anonymous.

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RESULTS

The sample population of the Jackson Heart Study exam 1 comprised of 3,098 men and women after excluding people with chronic kidney disease (n = 2,203). The baseline characteristics of the study population are presented in Table 2.

The simple logistic regression analyses for each variable were run with the dependent variable being diabetes status. After the univariate analyses, the next variables were significantly associated with the diabetes status: age, body mass index, waist circumference, blood pressure medication, physical activity categorization, depression group, family income, cardiovascular disease history, and family history of T2D (Table 3). The daily portion of vegetables defined as a portion of vegetables from 0-5 was not significantly related to diabetes status, thus, was not included in the multivariate logistic regression model (Table 4).

The significant predictors of diabetes status in the final multivariate logistic regression model were as follows: age, waist circumference, body mass index, blood pressure medication status, physical activity, family income, depression, family history of diabetes, and cardiovascular disease history (Table 3). All the variables of the multiple regression model were included, and the scores were assigned based on Barengo's method [8] and criteria in the same way as described in the univariate logistic regression analysis (Tables 3 and 4). The multiple logistic regression model was included for better understanding, and the beta coefficients were used for score development [8].

The score validation was made using the risk score cutoff value of 10 in the AADRSC to identify diabetes resulting in a sensitivity of 75%, a specificity of 63%, a positive predictive value of 39.7, and a negative predictive value of 88 (Table 3). Increasing the cutoff value of the score to 12 or 13 changed the sensitivity to 51.5% and 39.6%, and the false-positive rates to 81% and 88%. The corresponding sensitivity and specificity of the modified FINDRISC for the cut-off score of 14 were 77%, and 52% respectively, with a positive predictive value of 31.8 and a negative predictive value of 89 whereas a cut-off score corresponding to 15 decreased the sensitivity to 66% decreasing the specificity to 63% (Table 5).

Figures 2 and 3 show the receiver operating characteristics (ROC) curves for the AADRSC and FINDRISC according to unknown T2D status. The area under the ROC curve for unknown T2D was *78%* for the AADRSC compared with *72%* original FINDRISC with a p = 0.00012.

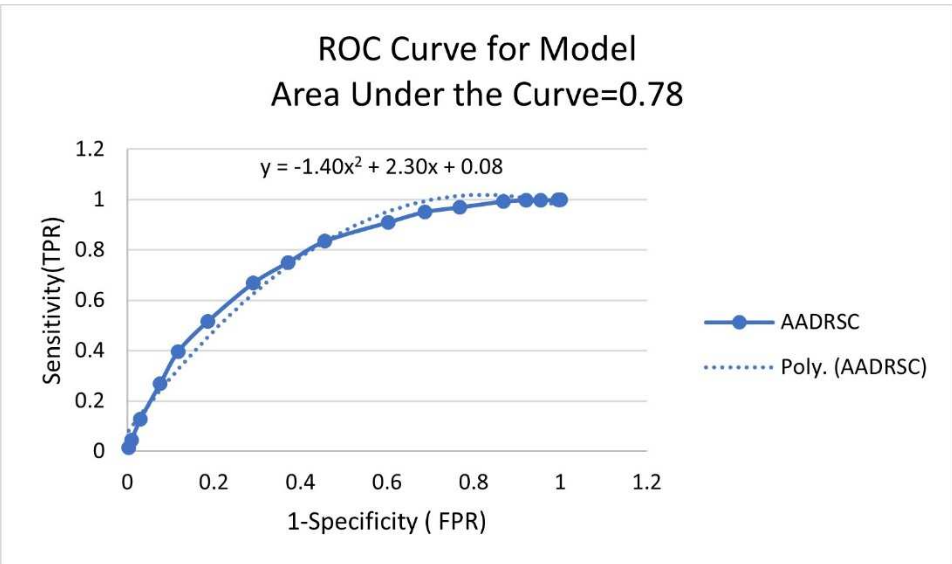

Figure 1. African American Diabetes Risk Score curve model

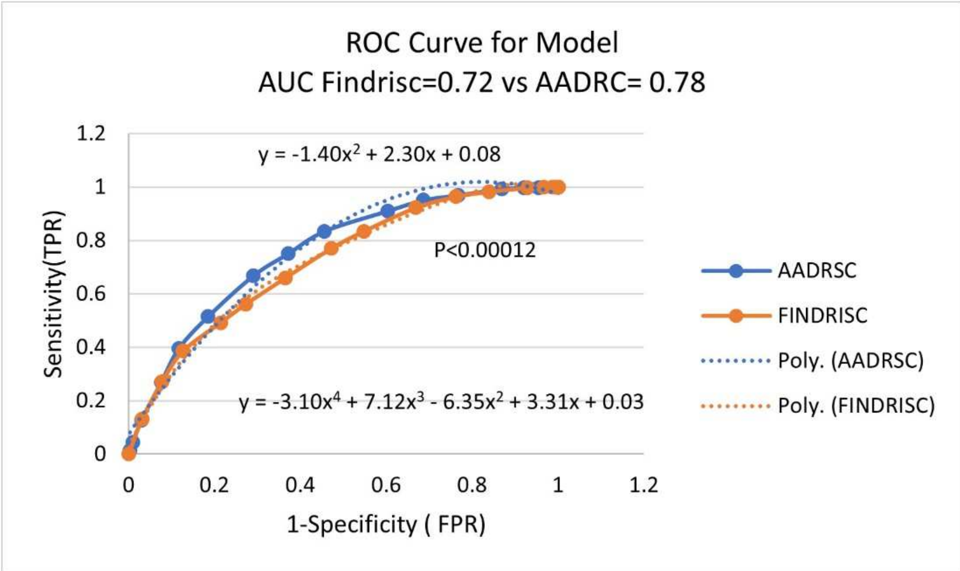

Figure 2. Receiver Operating Characteristics Curves (Roc) for the African American Diabetes Risk Score (AADRSC) and Finnish Diabetes Risk Score (FINDRISC).

Table 1. Diabetes Risk Scores-related works.

	Findrisc	Barengo	Omech	Bernabe	Pollock	AADRSC
Year	2,003	2,016	2,016	2,016	2,017	**2,020**
Risk Score	Yes	Modified Findrisc Yes	They tested Validity of Findrisc	Yes	No (prediabetes)	**Yes**
Design	Cross-sectional	Cross-sectional	Cross-sectional	Cross-sectional	Comparative/ Longitudinal	**Cross-Sectional**
Data	Nal pop registry Finnish data	Ser Epss	Survey	CRONICAS	BHS	**JHS Exam 1**
Sample Population	4,435	2,613	291	CRONICAS/ 2,945 ENINBSC 4,206	2,122	**3,098**
Population age	25-64 years	18-74 years	Aged greater 20 years	18-70 years	Young people	**Adults from 20-95 years**
Validation	Roc	Roc	Roc	Roc	Cox models	**Roc**
Analyzed population	Europeans	Colombian	Africans	Peruvians	Americans	**African Americans**
Variable selection	Non-invasive methods	Invasive and non-invasive	Invasive and non-invasive	Invasive and non-invasive	Invasive and non-invasive	**Socioecologic al Model/ Non-invasive methods**
Adjusted to population	Default	Yes	Yes	Yes	Yes	**Yes**
Socio-Economical Variables	No	No	No	No	N/A	**Yes**

Variables	Age, BMI, WC, History of antihypertensive drug treatment, PA, fruits consumption	Age, BMI, WC, FPG, History of anti-hypertensive drug treatment, PA, fruits consumption, past and family history of T2D, Impaired glucose reg	Age, BMI, WC, History of anti-hypertensive drug treatment, PA, fruits consumption, and A1C	Sex, age, education, self-reporting smoking, PA, alcohol use, BMI, WC WTHR, HT, chol, HDL	Age, gender, Height, weight, BMI, WC, HTN, Family history of diabetes, alcohol use, current smoker, HDL, glucose, TG, BP, pulse	Age, BMI, WC, blood pressure medication, AHA Physical Activity categorization, family income, depression, family history of diabetes, cardiovascular disease history
Score	0-20 Cutoff 9	0-9 Cutoff 4	Cutoff 17	0-4 cutoff 2	N/A	0-18 cutoff 11

Table 2. Baseline characteristics of the study sample.

		Mean	**SD**
Age		55.12	12.76
BMI		31.81	7.31
WC		100.96	16.12
Depression		11.05	8.21
Daily portion of dark green vegetables		0.35	0.337
		(%)	**N**
Diabetes Status			
	No	77.62	689
	Yes	22.38	2,390
Sex			
	Men	37.96	1,176
	Women	62.04	1,922
Age (years)			
	20-44	22.95	711
	45-54	24.18	749
	55-64	27.66	857
	65-95	25.21	781
BMI			
	0-29.9 (Kg/m²)	46.18	1,428
	30 or more (Kg/m²)	53.82	1,664
Waist circumference			
	Men >102 cm		1,060
	Women >88 cm	65.72	2,032
Blood pressure medication			
	No	46.95	1,440

	Yes	53.05	1,627
Physical activity			
	0 poor health	49.39	1,528
	1 Intermediate health	31.25	967
	2 Ideal Health	19.36	599
Family history of diabetes			
	No	39.92	998
	Yes	60.08	1,502
Cardiovascular disease history			
	No	89.32	2,767
	Yes	10.68	331
Family Income			
	$0-34,999	50.04	1,334
	$35,000-$99,999	42.35	1,129
	$100,000 or more	7.61	203
Depression			
	No	50.76	1,033
	Yes	49.24	1,002
Blood pressure medication			
	No	46.95	1,440
	Yes	53.05	1,627

Physical activity			
	0 poor health	49.39	1,528
	1 Intermediate health	31.25	967
	2 Ideal Health	19.36	599
Family history of diabetes			
	No	39.92	998
	Yes	60.08	1,502
Cardiovascular disease history			
	No	89.32	2,767
	Yes	10.68	331
Family Income			
	$0-34,999	50.04	1,334
	$35,000-$99,999	42.35	1,129
	$100,000 or more	7.61	203
Depression			
	No	50.76	1,033
	Yes	49.24	1,002

Table 3. Results of the simple logistic regression models with diabetes status as the dependent variable.

Variables	**Beta coefficient**	**OR[a]**	**(95% CI[b])**	**Wald**	**P-value**

				Chi-Square	
Age	-0.508	0.602	0.553-0.654	140.45	<.0001
BMI	-0.819	0.411	0.368-0.528	79.256	<.0001
WC	-1.171	0.31	0.250-0.385	112.429	<.0001
Blood pressure medication	0.76	4.575	3.737-5.600	217.27	<.0001
Physical Activity					<.0001
0vs1	-0.378	0.463	0.358-0.597	38.536	<.0001
A daily portion of dark green vegetables	-0.106	0.899	0.696-1.161	0.664	0.414
Depression	-0.236	0.789	0.638-0.976	4.76	0.029
Family income	0.442	1.557	1.333-1.818	31.27	<.0001
Family history of diabetes	0.507	2.761	2.230-3.418	86.84	<.0001
Cardiovascular disease history	0.558	3.058	2.412-3.878	85.16	<.0001

[a] Odds ratio

[b] Confidence interval

Table 4. Multiple Logistic Regression Models with diabetes status as dependent variable Full Model n=3,098. P-values and Wald Chi-square.

Variables	Beta coefficient	OR[a]	Wald Chi sq	p-value	(95% CI[b])	Score
Age						
45-54	0.6418	1.9	7.4391	0.0064	1.198-3.013	2
55-64	0.9613	2.615	17.449	<.0001	1.666-4.106	3
65-95	1.117	3.056	20.704	<.0001	1.889-4.944	3
BMI						
0-29.9 (Kg/m2)						
30 or more (Kg/m2)	0.626	1.87	11.136	<.0008	1.295-2.701	2
WC						
Men >102 cm	0.271	1.312	1.552	0.2127	0.856-2.012	1
Women >88 cm						
Blood pressure medication status	0.967	2.631	35.578	<.0001	1.915-3.615	3
Physical activity						
0 poor health	0.362	1.437	3.258	0.0711	0.969-2.131	1
1 Intermediate health	0.338	1.403	2.537	0.112	0.925-2.128	1
2 Ideal Health						

Family Income						
$0-34,999	0.235	1.265	0.633	0.426	0.709-2.257	1
$35,000-$99,999	0.064	1.066	0.048	0.826	0.601-1.892	1
$100,000 or more						
Depression						
0-10						
10-or more	0.063	1.065	0.195	0.6581	0.805-1.409	1
Family History of Diabetes	1.091	2.977	47.058	<.0001	1.594-3.697	3
Cardiovascular disease history	0.887	2.427	17.084	<.0001	1.594-3.697	2

[a] Odds ratio

[b] Confidence interval

Table 5. The characteristics of the AADRSC and the FINDRISC using different cutoff values for unknown Type 2 diabetes.

	Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**
Unknown Type 2 diabetes mellitus				
AADRSC				
Cutoff value 11	0.668	0.710	0.397	0.882
Cutoff value 12	0.515	0.815	0.443	0.855
Cutoff value 13	0.396	0.883	0.492	0.836
FINDRISC				
Cutoff value 14	0.771	0.528	0.318	0.890
Cutoff value 15	0.660	0.635	0.341	0.867
Cutoff value 16	0.562	0.727	0.371	0.853

DISCUSSION

Sedentarism, obesity, and aging are among the factors highly related to diabetes onset [16,22]. Studies suggest that T2D can be prevented by lifestyle intervention [5]. The research is based on data from the Jackson Heart Study, Exam 1. Variables from the Jackson Heart Study were selected with the help of some constructs of the socioecological model [23]. Each variable or risk factor was analyzed with a simple logistic regression to evaluate the significance. Significant variables were selected for a multiple-logistic regression. The score was obtained based on the beta coefficients of the model. The risk score was validated by comparing it with the FINDRISC.

The AADRSC included *9* variables adapted for African Americans compared to the FINDRISC (eight variables only for Europeans). The exclusion criterion comprised patients with chronic kidney disease. According to Omech [6], African Americans with chronic kidney disease usually have diabetes [24]. The status of diabetes is linked to the hemoglobin A1c result [13]. On the other hand, cardiovascular disease history was included in the study because previous research suggests that this factor increases diabetes onset [17].

AADRSC includes variables such as family income [7], depression, and cardiovascular disease history; these variables are especially important for African Americans and improved the model significantly [17,18]. The main idea of the risk score is that it is easily applicable to the primary care level without the need for calculators or special equipment. The risk of diabetes increases with age, body mass index, waist circumference, taking blood pressure medication, reduced physical activity, depression, being from a low-income group, having a family history of diabetes, and cardiovascular disease history [25]. There was no association between the consumption of a daily portion of dark green vegetables and diabetes, and for this reason, this variable was not included in the model. The family history of diabetes was one of the most significant predictors of diabetes risk as well as age group (65-95 years) and age group (55-64). The prevalence of people who have a known family history of diabetes was extremely high in our study's population (60% of our participants had a family history of diabetes). Blood pressure medication status was found to have a high significance (was scored with *3* in the final risk score). Body mass index has a higher score than waist circumference according to the model and was scored *2* and *1*, respectively. Cardiovascular disease history is another important factor that was scored with 2. Socio-economic factors like income were included and the score was *1*.

A ROC curve was used to validate the performance of the risk score. The area under the ROC curve indicated the performance of the AADRSC and FINDRISC on the Jackson Heart Study, Exam 1. The performance of both risk scores (AADRSC and FINDRISC) in screening risks associated with T2D in the Jackson Heart Study Exam 1 was good. AADRSC showed a better performance than the original FINDRISC. Several factors may favor the use of the AADRSC in African Americans over the FINDRISC. AADRSC has a better area under the curve with 78% vs 72% for the FINDRISC when tested in the same population in Exam 1 of Jackson Heart Study data. Another important reason for preferring the use of the AADRSC is the adaptation of the score to the African American population.

Strengths and limitations

The strengths of this cross-sectional study include the low-cost procedure for obtaining the risk score for a patient. A total of *3,098* participants from Jackson Heart Study exam 1 were included. The data collection was ethically sound as it was done using data and with the institutional review board's (IRB) approval. Therefore, the AADRSC can be used as an important tool for physicians at the primary care level. The study was completed in a short time, and this is one of the advantages pointed out by Friis [19]. Some important limitations were identified: participants were only from Jackson, Mississippi, and not from the entire country. Some variables were self-reported and thus amenable to recall bias [14]. According to Tsenkova [20], depression is a robust risk factor for the development of diabetes. Another limitation of the study is its cross-sectional design. This limits the predictive value and can only disclose associations. In conclusion, the effectiveness and accuracy of the AADRSC show that it can be used as a simple, safe, and inexpensive screening test to identify T2D risk in African Americans and the AADRSC identifies people at risk for diabetes. The acceptable sensitivity of 75% can be a limitation but to add to existing literature, it is important to have a unique diabetes risk score for African Americans because there is no risk score for African Americans at this point.

Implications for policymakers and stakeholders

The AADRSC implies that it can be used for the primary care of people within the African American community. It is a non-invasive and inexpensive tool, so healthcare providers can use it easily. The score can determine whether patients are at risk of suffering from diabetes. Also, primary care physicians can further determine their patients' diabetes status with specific tests on those with high risk for the condition.

Furthermore, the implementation of early detection programs for diabetes is particularly important for onset prevention, and the AADRSC tool is a good resource for this purpose. Since physical activity is a modifiable risk factor that is included in the AADRSC model, strategies can be developed for managing interventions in people at high risk of T2D. Generally, behaviors related to depression lead to poor decisions regarding body weight management, which could be controlled with physical activity [20, 25]. This lifestyle change would help minimize the effects of aging and the risk of diabetes [25]. The AADRSC can be used to identify at-risk patients, who could subsequently be enrolled in educational programs targeting the importance of physical activity and the management of caloric intake. Overall, the AADRSC is an effective tool for detecting people with a high risk of diabetes [21].

Implications for future research

The important next step is the implementation of the AADRSC within the African American population as a tool to detect unknown T2D in primary care. The AADRSC can be a useful tool for research focused on lifestyle interventions for reducing the devastating effects of T2D on the population [25]. Another topic for the future can be the development of similar scores for preventing T2D within children. Furthermore, the AADRSC can be developed for Latin and Asian Americans.

CONCLUSION

Scores for early assessment of the risk of developing diabetes are a valuable and straightforward tool for decision-making toward health improvement in primary care. The AADRSC in this study was developed with a focus on proposing a simple measurement tool for determining diabetes risk in patients by using non-invasive methods. The AADRSC has important benefits for identifying people at risk of T2D in African Americans with and area under the curve of 0.78 compared with FINDRISC 0.70 (p=0.0002). The AADRSC can be used a safe simple and inexpensive tool for detecting T2D in African American population.

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Institutional Review Board Statement: "The study was conducted in accordance with the IRB approved by the Institutional Review Board (or Ethics Committee) of Jackson State University Protocol # entitled Development of a Diabetes type 2 risk score for African Americans: Jackson Heart Study and June 29, 2020, of approval.

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