

Social Determinants of Health Score: Does It Help Identify Those at Higher Cardiovascular Risk?

Ana Palacio, MD, MPH; Ruaa Mansi, MD, MPH; David Seo, MD; Maritza Suarez, MD; Sylvia Garay, MD; Heidy Medina, MPH; Fei Tang, PhD; and Leonardo Tamariz, MD, MPH

Cardiovascular disease (CVD) continues to be the leading cause of death in the United States and disproportionately affects disadvantaged groups.¹⁻⁶ Cited reasons for CVD disparities have included a higher prevalence of CVD risk factors and underutilization of evidence-based treatments and preventive strategies.^{5,7}

Over the past few years, a large body of evidence has reported that social determinants of health (SDOH)⁸ are associated with health behaviors, CVD outcomes, and life expectancy.⁹⁻¹⁵ Populations in disadvantaged socioeconomic positions are more likely to have adverse CVD outcomes compared with wealthier populations who may be benefiting from current preventive and curative strategies.¹⁵⁻¹⁹

For these reasons, several professional medical organizations have endorsed the need for health systems to screen for²⁰ and address SDOH^{3,21-24} to improve outcomes. The SDOH commonly cited include key social domains such as socioeconomic position (income and education), race and ethnicity, food insecurity, language, culture, social support, access to care, stress, and residential environment.³ The National Academy of Medicine (NAM) recommended a list of validated SDOH questions addressing these domains to be included in electronic health records (EHRs), and HHS made addressing SDOH a pivotal aspect in the transition toward value-based care.^{25,26} However, despite the significant momentum for addressing SDOH,²⁷ there is little evidence on effective strategies using SDOH data at the health system level.^{19,28} Key knowledge gaps have limited the use of SDOH for predicting risk. Among these gaps are the limited number of studies with the necessary upstream diverse SDOH data to conduct multivariate analysis,⁷ the limited understanding of the net contribution of specific SDOH as risk or protective factors for particular conditions,²⁷ and the lack of evidence on SDOH measuring tools that can effectively risk-stratify and identify individuals at higher risk.

Therefore, the aim of our study was 2-fold: (1) to integrate SDOH and EHR data from a large academic center to evaluate the net contribution of each SDOH factor on the 10-year Framingham risk score (FRS) for CVD, taking into account potential collinearity of SDOH; and (2) to use the weighted contribution of each SDOH to develop a social risk score and to test its correlation to traditional

ABSTRACT

OBJECTIVES: Cardiovascular disease (CVD) continues to disproportionately affect disadvantaged populations, leading to calls to address social determinants of health (SDOH) as a preventive strategy. Our aim is to create a weighed SDOH score and to test the impact of each SDOH factor on the Framingham risk score (FRS) and on individual traditional CVD risk factors.

STUDY DESIGN: We conducted a retrospective cohort study.

METHODS: We included patients seen at a primary care clinic at UHealth/University of Miami Health System who answered a SDOH survey between September 16, 2016, and September 10, 2017. The survey included SDOH domains recommended by the American Heart Association position statement and by the National Academy of Medicine. We selected the FRS as well as all traditional CVD risk factors as our outcome metrics.

RESULTS: We included 2876 patients. The mean (SD) age of our cohort was 53.8 (15.8) years, 61% were female, 9% were Black, 38% were Hispanic, and 87% reported speaking English. The statistically significant β coefficients in the FRS model corresponded to being born outside of the United States, being a racial minority, living alone, having a high social isolation score, and having a low geocoded median household income ($P < .01$). Increasing quartile of SDOH score was significantly associated with higher systolic blood pressure, FRS, glycosylated hemoglobin, and smoking pack-years ($P < .05$). It was also associated with fewer minutes spent exercising weekly ($P < .01$).

CONCLUSIONS: The addition of self-reported SDOH data has a dose effect on CVD risk factors. Future studies should address how to intervene to address social factors.

Am J Manag Care. 2020;26(10):e312-e318. doi:10.37765/ajmc.2020.88504

modifiable CVD risk factors such as blood pressure, dyslipidemia, obesity, diabetes control, smoking, and physical activity.

METHODS

Study Design and Study Setting

We conducted a retrospective cohort study of all patients 18 years and older who were seen at a primary care clinic at UHealth/University of Miami Health System and answered a SDOH survey between September 16, 2016, and September 10, 2017. We collected information on this population from the time of the survey to November 30, 2017. We collected outcome metrics from the EHR during this time period, with a mean (SD) follow-up of 10 (5) months.

Patients with upcoming appointments received a message via their preferred form of contact (text or email) asking them to use the provided link to their patient portal, MyUHealthChart, to access and complete a 15-item SDOH survey.

Study Procedures

We used EHR data to collect baseline demographics including race/ethnicity, comorbidities (at the time of the survey), and our selected outcome metrics during the follow-up period. UHealth collects self-reported race/ethnicity using the 2 Census-based questions for race and Hispanic/Latino origin. We collected comorbidities such as hypertension, diabetes, dyslipidemia, coronary artery disease, and stroke present at the time of the survey in either the EHR problem list or the corresponding *International Classification of Diseases* codes in the encounter forms. We collected Census-based block-level information on the median household income using the patient's address and linking the EHR with the 2010 Census.²⁹ We collected data on our outcome metrics from the date an individual responded to the survey up to the end of the study period.

SDOH Survey

Our survey included previously validated questions and was based on the survey proposed by the NAM's Committee on the Recommended Social and Behavioral Domains and Measures for Electronic Health Records.^{3,23,24,30} We chose this survey due to the documented validity of the questions and their relationship with health outcomes (eAppendix [eAppendices available at ajmc.com]).^{31,32} Based on insights from our local South Florida population, we decided to add to the NAM survey 2 questions that have also been previously validated. These questions screen for known correlates of CVD risk factors and disparities, such as a patient's overall health literacy status³³ and delay seeking health care.³⁴ The survey also included a social isolation score.³⁵ As recommended by the American Heart Association (AHA) and NAM, we also included geocoded residential addresses²⁴ in order to ascertain community and neighborhood characteristics. The questionnaire and analysis method are available in eAppendix A.

TAKEAWAY POINTS

Social risks predict outcomes in many conditions; because of this, institutions are moving to collect social determinants. A social score, created by clinicians, can help them in clinical practice. In this paper, we demonstrate the following:

- ▶ Large health care systems can collect and utilize self-reported social determinants of health information to create a social score.
- ▶ Worse social score is associated with increasing cardiovascular risk.
- ▶ Worse social score is associated with not achieving cardiovascular risk factor targets.

Exposure to Social Risk: SDOH Score

We defined SDOH exposure as a weighted score. We calculated the score using the SDOH variables collected for each individual (eAppendix). To derive the weighted SDOH score, we used linear regression and confirmatory factor analysis (CFA) and estimated the coefficients of change of contributory variables on the FRS (dependent variable). For each of the 2 methods, we multiplied the resulting coefficients by each SDOH variable shown in **Table 1** (0, SDOH absent, and 1, SDOH present) and then added the results to create the weighted score.

Outcome Measures

Our outcomes measures were (1) the 10-year FRS for CVD (FRS-CVD) and (2) modifiable CVD risk factors available in the EHR.³⁶ Traditional modifiable CVD risk factors included blood pressure, low-density lipoprotein (LDL) cholesterol, body mass index (BMI), physical activity, tobacco use, and stress, as well as glycated hemoglobin (A1C) for those with diabetes. We collected all measures of blood pressure, A1C, LDL cholesterol, and BMI available in the EHR during the study period and reported the last value available for each CVD risk factor. We collected the information on tobacco use from the EHR and physical activity from the SDOH survey at baseline. We collected all the variables needed to calculate the FRS-CVD during the study period. These include age, gender, total cholesterol, high-density lipoprotein cholesterol, smoking status, history of diabetes, systolic blood pressure, and use of medications for hypertension. We used the latest set of values for the FRS-CVD calculation and reported the mean FRS-CVD of the cohort. We also categorized patients as having a low FRS-CVD if they had a score of less than 10; a moderate score, 10 to 20; and a high score, greater than 20.³⁶ The rationale for using the FRS-CVD score is that it is a reliable and validated way of evaluating future cardiovascular risk and is used broadly by clinicians. We captured all systolic and diastolic blood pressure measures during the study period and reported mean blood pressure for all patients participating in the study. We classified blood pressure as not being controlled if it was higher than 140/90 mm Hg.^{37,38} We captured all A1C values during the study period and reported the mean A1C only for patients with a diagnosis of diabetes at baseline. We used the American Diabetes Association (ADA) A1C cutoff point of greater than 7% to categorize patients as not having met their A1C target.³⁹ We captured all LDL cholesterol values during the study period and

TABLE 1. Prevalence of SDOH in 2229 Primary Care Patients

Domain	SDOH	Prevalence
Place of birth	Not born in the United States	39%
Education	Education high school or less	21%
Health literacy	Not/little or somewhat confident in filling out forms	9%
Financial strain	Somewhat hard or very hard to pay for basics	33%
Stress	Stress quite a lot or very much	22%
Living arrangements	Lives alone	17%
Social isolation	Talks on phone with family less than once a week	9%
Social isolation	Never or less than once a week gets together with friends	24%
Social isolation	Never attends church	31%
Social isolation	Never attends meetings	56%
Social isolation scale	Social isolation score	36%
Delay care	Delayed care in past 12 months when needed it	31%
Census-based income	Federal poverty level	2%
Minority	Being Hispanic or Black	51%

SDOH, social determinants of health.

used the mean LDL cholesterol for all participants. We categorized patients with diabetes as having met their target LDL cholesterol level if they achieved a goal of 100 mg/dL or less, according to ADA standards.^{40,41} We used the last weight value available during the study period to calculate BMI for each patient. We categorized subjects as overweight if their BMI was 25 to 29.9 and obese if their BMI was 30 or higher.⁴² From the EHR, we collected information regarding current smoker status, self-reported pack-year history, and achievement of smoking cessation.⁴³ We captured self-reported physical activity via the SDOH survey at baseline. We captured if subjects exercised, how many times a week they exercised, and for how many minutes each time.⁴⁴ As recommended by AHA, we multiplied the number of times people exercised by the number of minutes each time to obtain the total exercise minutes per week.⁴⁵

Statistical Analysis

We conducted 2 complementary analyses to accomplish the aims of our study. First, we used CFA to evaluate the effect of each variable on the FRS and to evaluate collinearity among the SDOH variables. Variables that were correlated to one another and contributed together to the FRS were considered a latent variable or a domain.⁴⁶ To compare the goodness of fit, we used the root mean square error of approximation and comparative fit index. We compared 2 models to represent the best fit for the overall data. Model 1 was a 1-factor model that used each of the nondichotomized SDOH variables. Model 2 was a 2-factor model with financial strain, education, and social isolation as latent factors.

Second, we constructed a weighted SDOH score using the coefficients derived from the CFA (eAppendix B). Combining the CFA

results to create a score has been previously described.⁴⁷ We then multiplied the β coefficient by each SDOH variable (0, SDOH absent, and 1, SDOH present), then added the results to create the weighted score. To calibrate the model, we used the Hosmer-Lemeshow statistic and calculated the observed and expected observations and model fit. We excluded observations when data were missing and did not impute the SDOH results.

As a sensitivity analysis, to test the effect of a SDOH score on CVD risk using a robust methodological approach, we also used linear regression to determine the net contribution of each SDOH. We used the linear regression coefficients to create a SDOH score using the same approach described previously for the CFA-based score (eAppendix C).

Analyses were performed using Stata 14.0 (StataCorp), and all significance tests were 2-tailed.

RESULTS

Baseline Characteristics

A total of 7883 patients were enrolled in our primary care clinics at the time the survey was deployed. The comparison of basic demographics of the responders and nonresponders are shown in the eAppendix. A total of 2876 patients attending primary care visits responded to the SDOH survey during the study period (response rate, 36%). We had complete data for only 2229 patients. The mean (SD) age of our cohort was 53.8 (15.8) years, 61% were female, 9% were Black, 38% were Hispanic, and 87% reported speaking English. The median (interquartile range) household income of the cohort was \$53,677 (\$42,813-\$67,760). The prevalence of each SDOH characteristic in the entire cohort is depicted in Table 1. Thirty-three percent of survey respondents said that they had a hard time paying for basics, 31% delayed care, and 36% were socially isolated.

When evaluating the distribution of all baseline characteristics by quartile of SDOH score, we found that an increasing SDOH score correlated with being a member of a racial/ethnic minority group, not being employed, having an education of high school or less, residing in a community with lower household income according to Census data, and having a higher prevalence of baseline CVD risk factors ($P < .01$) (Table 2).

Net Contribution of SDOH to the 10-Year FRS-CVD

Our CFA showed that several variables correlated with one another and were highly associated with the FRS-CVD. The latent variables were financial strain (income, difficulty paying for basics, and delaying care), which had the highest association with the FRS-CVD (0.87), followed by education (literacy and schooling) (0.72) and social isolation (0.68) (eAppendix C Figure 1).

Relationship Between the Weighted SDOH Score and Modifiable CVD Risk Factors

The linear regression model of the CFA coefficients generated a weighted SDOH score that ranged from 8 to 22. Univariate linear

TABLE 2. Baseline Characteristics of the Population by Quartile of SDOH Score

Characteristic	Quartile 1 (n = 550)	Quartile 2 (n = 560)	Quartile 3 (n = 560)	Quartile 4 (n = 560)	P
Weighted SDOH score, median (IQR)	9.1 (7.0-11.6)	13.6 (12.2-15.3)	19.9 (15.9-21.1)	23.4 (22.2-27.7)	<.01
Age in years, mean (SD)	55.8 (16.4)	52.4 (15.0)	52.8 (16.2)	52.1 (16.0)	.42
Black, %	5	6	7	18	<.01
Hispanic, %	35	40	42	49	<.01
Female gender, %	41	41	42	35	.03
Not employed, %	3	26	31	55	<.01
High school education or less, %	12	17	19	24	<.01
Hypertension, %	61	67	68	75	.03
Coronary artery disease, %	11	13	13	17	.04
Stroke, %	1	3	6	10	<.01
Dyslipidemia, %	39	42	43	56	.03
Diabetes, %	21	29	29	35	.04
Household income, median (IQR)	\$75,767 (\$70,391-\$97,713)	\$61,244 (\$54,208-\$62,714)	\$49,063 (\$44,615-\$50,554)	\$32,486 (\$26,713-\$38,327)	<.01

IQR, interquartile range; SDOH, social determinants of health.

TABLE 3. Modifiable Cardiovascular Risk Factors by Quartile of SDOH Score

Characteristic	Quartile 1 (n = 550)	Quartile 2 (n = 560)	Quartile 3 (n = 560)	Quartile 4 (n = 560)	P
Systolic blood pressure, mean (SD)	121 (15)	125 (13)	135 (17)	137 (18)	<.01
Framingham risk score, mean (SD)	9.4 (9.6)	10.6 (10.3)	11.7 (11.1)	11.9 (11.2)	.22
LDL cholesterol, mean (SD)	85.8 (28.1)	87.3 (36.5)	92.0 (34.1)	95.7 (36.1)	.34
A1C, mean (SD)	6.5 (1.2)	7.2 (1.6)	8.7 (1.6)	8.9 (1.1)	<.01
BMI, mean (SD)	29.4 (5.9)	30.1 (7.1)	30.7 (7.4)	30.9 (6.9)	.05
Weekly minutes of exercise, mean (SD)	100.8 (113.3)	92.9 (108.9)	89.3 (109.2)	81.0 (107.1)	<.01
Active smoking, %	36	42	42	59	<.01
Reported quitting smoking, %	37	35	27	20	<.01
Smoking pack-years, mean (SD)	16.0 (15.9)	27.9 (24.3)	31.3 (25.7)	38.4 (25.1)	.01

A1C, glycated hemoglobin; BMI, body mass index; BP, blood pressure; LDL, low-density lipoprotein; SDOH, social determinants of health.

regression models showed that as the quartiles of SDOH increased, the mean values of blood pressure, A1C, and smoking pack-years increased ($P < .01$); BMI tended to increase ($P = .05$); and minutes of physical activity decreased ($P < .01$) (Table 3).

Nevertheless, in a multivariate linear regression model adjusted for age, gender, race, and ethnicity, increasing SDOH score was independently associated with increases in FRS, systolic blood pressure, A1C, BMI, and smoking pack-years and with a decrease in physical activity (Table 4).

Impact of Increasing SDOH Score on Clinical Benchmarks of CVD Risk Factor Control

Our logistic regression models on the impact of increasing SDOH score on different clinical benchmarks of CVD risk factor control (Table 5) showed that as SDOH score increased there were statistically significant odds of not meeting the established benchmarks of blood pressure less than 140/90 mm Hg, A1C less than 7%, physical

activity of more than 150 minutes per week, and not smoking. There was a clear dose effect between the quartile of SDOH score and the odds of not achieving these metrics. In the case of high FRS-CVD and obesity, the odds were significant only for quartiles 3 and 4 of the SDOH score.

The correlations between the linear regression-based SDOH score and outcomes were similar in significance and magnitude (eAppendix) to the correlations found with the CFA-based SDOH score. The linear regression found that the most significant were financial strain, social score, and income, but this methodology does not identify correlations among variables.

DISCUSSION

Our study found that among patients receiving primary care within a large health system in South Florida, patient-reported SDOH variables were significantly associated with the FRS-CVD. Moreover, we report

CLINICAL

TABLE 4. Adjusted Association Between Cardiovascular Risk Factors and SDOH Score

Outcome	SDOH burden, β coefficient*	95% CI	P
Systolic blood pressure	0.25	0.20-0.33	<.01
Framingham risk score	0.16	0.01-0.19	<.01
LDL cholesterol	0.35	-0.90 to 0.18	.20
A1C	0.02	0.001-0.10	.03
BMI	0.34	0.30-0.38	<.01
Exercise	-9.8	-11.9 to -7.8	<.01
Smoking pack-years	3.5	3.0-3.9	<.01

A1C, glycated hemoglobin; BMI, body mass index; LDL, low-density lipoprotein; SDOH, social determinants of health.

*Adjusted for age and gender.

TABLE 5. Quartiles of SDOH Score and Clinical Cardiovascular Benchmarks

Quartile of weighted score	Blood pressure > 140/90 mm Hg	P	A1C > 7%	P
1	Reference		Reference	
2	1.31 (1.01-2.46)	.04	1.25 (1.12-2.47)	.03
3	1.59 (1.15-3.05)	.02	1.47 (1.21-3.14)	.01
4	1.62 (1.32-3.56)	.01	1.56 (1.37-3.69)	.01
Quartile of weighted score	High Framingham risk score	P	Obese	P
1	Reference		Reference	
2	1.10 (0.71-1.72)	.65	1.09 (0.78-1.53)	.14
3	1.37 (1.15-2.11)	.02	1.24 (1.01-1.65)	.05
4	1.85 (1.21-2.45)	.01	1.36 (1.19-1.88)	.04
Quartile of weighted score	Exercise < 150 minutes/week	P	Active smoking	P
1	Reference		Reference	
2	1.21 (1.08-1.36)	<.01	1.55 (1.73-2.11)	<.01
3	1.47 (1.30-1.67)	<.01	1.92 (1.73-2.11)	<.01
4	1.94 (1.76-2.90)	<.01	2.12 (1.80-2.45)	<.01

A1C, glycated hemoglobin; SDOH, social determinants of health.

that an increasing SDOH score was significantly associated with a higher FRS-CVD, worsening of most modifiable CVD risk factors, and higher odds of not achieving CVD preventive benchmarks.

Increasingly, professional organizations and CMS encourage the collection of SDOH to improve quality of care and reduce disparities. However, how to use the SDOH information to reduce health disparities has been less clear, and to date most efforts have concentrated on referring individuals with identified social needs to appropriate nonclinical or community services (eg, social work). Our results provide insights on how health systems can use SDOH for risk stratification of specific disparate conditions that affect their quality-of-care metrics. A SDOH score that is predictive of control of CVD risk factors, such as the one we report in this communication, can be a helpful tool to select individual patients who are at risk

of poor control and who could benefit from tailored system-based services such as more frequent follow-up; health coaching; and telehealth, psychological, nutritional, or pharmacy support. In addition, our study contributes information on the SDOH that are more likely to affect CVD risk and suggests that SDOH are clustered into 3 domains: financial strain and access to care; education and health literacy; and social isolation. These data may inform the type or content of interventions that could be most helpful to individual patients based on their own social risk. It should also inform future studies that are evaluating the role of upstream SDOH and the mediating effects of SDOH on behaviors and outcomes.¹⁸ In models adjusted for age, gender, race/ethnicity, and geocoded income, our study found a strong correlation between the SDOH score and all CVD risk factors except LDL cholesterol and diastolic blood pressure. This contributes to the literature describing that racial disparities in behaviors (eg, smoking) and CVD risk factor control (eg, blood pressure) are mediated by SDOH.^{7,8,15}

Our results support and complement the findings by Caleyachetty et al⁴⁸ that reported a similar relationship between social risk factors and the achievement of ideal Life's Simple 7 scores in a sample of US adults. This study defined social risk as low-income, low-education, non-White race, and living alone. In our study, we did not include race/ethnicity and income in our social risk score calculation for 2 reasons: (1) Most of our patient population had an income above the usual economic cutoff points,⁴⁹ and (2) given that health disparities are most likely to be the result of social and environmental factors and not of biological mediators associated with race,⁵⁰ we wanted to explore the role of modifiable social risk factors independently. Moreover, there is evidence that the exclusive use of Census-based deprivation indicators may fail to correlate with certain outcomes if local SDOH, which may function as effect modifiers, are not considered.⁵¹

Our findings also contribute to the understanding of racial/ethnic disparities. Members of minority groups in our health system were more likely to have a high burden of social risks; however, in our adjusted models, social risks rather than race/ethnicity predicted the difference in CVD risk or control. This supports the theory that the CVD disparities that persist in the United States are more likely mediated by social and environmental factors rather than biological ones.⁵²

We also show the heterogeneity of the Hispanic population. Our Hispanic population had less exposure to barriers that have been described in other studies—such as lack of insurance, language barriers, and low income—but had a high prevalence of social isolation and stress, and one-third still reported difficulty paying for basics.⁵³

Limitations

Our study has several limitations that deserve mention. First, our SDOH collection strategy required patients to have either a smartphone or computer to access a link to the survey in their patient portal. Although this strategy made the collection feasible, it may have

produced a selection biased toward patients who are financially better off and therefore limited the generalizability of findings to groups of patients with access to this type of technology. Although important, this limitation most likely underestimates the impact of SDOH on CVD control. Moreover, it has allowed us to understand that even among patients with more resources, there is a cumulative effect of SDOH on control of CVD risks.⁵⁴ Thus, all health systems should be interested in addressing the unmet social needs of the populations they serve. Second, we created a weighted SDOH score based on the FRS but have not yet validated it on a separate population or on major adverse cardiovascular events. This limits our ability to comment on the generalizability of the score; however, we believe the findings demonstrate a valid process for using SDOH at a larger scale and for the development of predictive models. Third, certain measures such as blood pressure had significantly more data points than A1C and LDL cholesterol, which could have affected the predictive ability of those models. Fourth, our follow-up period was short and limited our ability to measure the impact of SDOH on metrics of CVD risk factors. Fifth, we excluded NAM-recommended questions that needed timely health system response, such as those on domestic violence. Although a limitation, this adaptation facilitates the dissemination of an automated large-scale risk stratification tool and it reflects all the domains recommended by the AHA position statement.

CONCLUSIONS

Our study findings reveal that in an insured population in South Florida, there is a dose-effect relationship between a weighted SDOH score and cardiovascular risk, but some SDOH were more contributory than others. Health systems could use this approach to create a clinical decision tool to identify patients most likely to have adverse CVD outcomes. Future studies should integrate multilevel social and clinical data across different geographic locations and populations to develop models that describe predictors and mediators of health disparities for major adverse cardiovascular events. These data are necessary to understand whether risk engines that include SDOH can be generalizable across populations. ■

Author Affiliations: Division of Population Health and Computational Medicine (AP, RM, DS, MS, SG, HM, LT) and Division of Cardiology (DS), Miller School of Medicine at the University of Miami, Miami, FL; Geriatric Research Education and Clinical Center, Veterans Affairs Medical Center (AM, LT, FT), Miami, FL.

Source of Funding: Research reported in this publication was conducted under the auspices of the Precision Medicine and Health Disparities Collaborative (Vanderbilt-Meharry-Miami Center of Excellence in Precision Medicine and Population Health), supported by the National Institute on Minority Health and Health Disparities and the National Human Genome Research Institute of the National Institutes of Health under award number U54MD010722.

Author Disclosures: The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (AP, RM, DS, MS, LT); acquisition of data (AP, DS, MS, SG, LT); analysis and interpretation of data (AP, RM, FT, LT); drafting of the manuscript (AP, RM, DS, SG, HM, LT); critical revision of the manuscript for important intellectual content (AP, RM, DS, HM, FT); statistical analysis (FT, LT); obtaining funding (DS); administrative, technical, or logistic support (AP, DS, MS, SG, HM); and supervision (AP, DS).

Address Correspondence to: Ana Palacio, MD, MPH, University of Miami, 1120 NW 14th St, Ste 967, Miami, FL 33136. Email: apalacio2@med.miami.edu.

REFERENCES

- Pool LR, Ning H, Lloyd-Jones DM, Allen NB. Trends in racial/ethnic disparities in cardiovascular health among US adults from 1999-2012. *J Am Heart Assoc.* 2017;6(9):e006027. doi:10.1161/JAHA.117.006027
- Singh JA, Lu X, Ibrahim S, Cram P. Trends in and disparities for acute myocardial infarction: an analysis of Medicare claims data from 1992 to 2010. *BMC Med.* 2014;12:190. doi:10.1186/s12916-014-0190-6
- Havranek EP, Mujahid MS, Barr DA, et al; American Heart Association Council on Quality of Care and Outcomes Research, Council on Epidemiology and Prevention, Council on Cardiovascular and Stroke Nursing, Council on Lifestyle and Cardiometabolic Health, and Stroke Council. Social determinants of risk and outcomes for cardiovascular disease: a scientific statement from the American Heart Association. *Circulation.* 2015;132(9):873-898. doi:10.1161/CIR.0000000000000228
- Bonow RO, Grant AO, Jacobs AK. The cardiovascular state of the union: confronting healthcare disparities. *Circulation.* 2005;111(10):1205-1207. doi:10.1161/01.CIR.0000160705.97642.92
- Sabatine MS, Blake GJ, Drazner MH, et al. Influence of race on death and ischemic complications in patients with non-ST-elevation acute coronary syndromes despite modern, protocol-guided treatment. *Circulation.* 2005;111(10):1217-1224. doi:10.1161/01.CIR.0000157733.50479.89
- Iyer DG, Shah NS, Hastings KG, et al. Years of potential life lost because of cardiovascular disease in Asian-American subgroups, 2003-2012. *J Am Heart Assoc.* 2019;8(7):e010744. doi:10.1161/JAHA.118.010744
- Mensah GA, Mokdad AH, Ford ES, Greenlund KJ, Croft JB. State of disparities in cardiovascular health in the United States. *Circulation.* 2005;111(10):1233-1241. doi:10.1161/01.CIR.0000158136.76824.04
- Diez Roux AV, Mujahid MS, Hirsch JA, Moore K, Moore LV. The impact of neighborhoods on CV risk. *Glob Heart.* 2016;11(3):353-363. doi:10.1016/j.ghheart.2016.08.002
- Patel RC, Sánchez BN, Morgenstern LB, Li C, Lisabeth LD. Impact of stroke risk factors on ethnic stroke disparities among midlife Mexican Americans and non-Hispanic Whites. *Stroke.* 2017;48(10):2872-2874. doi:10.1161/STROKEAHA.117.018861
- Ergou S, Echouffo-Tcheugui JB, Kip KE, Ayer A, Reis SE. Association of cumulative social risk with mortality and adverse cardiovascular disease outcomes. *BMC Cardiovasc Disord.* 2017;17(1):110. doi:10.1186/s12872-017-0539-9
- Carnethon MR, Pu J, Howard G, et al; American Heart Association Council on Epidemiology and Prevention; Council on Cardiovascular Disease in the Young; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; Council on Functional Genomics and Translational Biology; and Stroke Council. Cardiovascular health in African Americans: a scientific statement from the American Heart Association. *Circulation.* 2017;136(21):e393-e423. doi:10.1161/CIR.0000000000000534
- Banks MP, Kershaw K, Carson AP, Gordon-Larsen P, Schreiner PJ, Carnethon MR. Association of modifiable risk factors in young adulthood with racial disparity in incident type 2 diabetes during middle adulthood. *JAMA.* 2017;318(24):2457-2465. doi:10.1001/jama.2017.19546
- Graham G. Racial and ethnic differences in acute coronary syndrome and myocardial infarction within the United States: from demographics to outcomes. *Clin Cardiol.* 2016;39(5):299-306. doi:10.1002/clc.22524
- Meara ER, Richards S, Cutler DM. The gap gets bigger: changes in mortality and life expectancy, by education, 1981-2000. *Health Aff (Millwood).* 2008;27(2):350-360. doi:10.1377/hlthaff.27.2.350
- Pampel FC, Krueger PM, Denney JT. Socioeconomic disparities in health behaviors. *Annu Rev Sociol.* 2010;36:349-370. doi:10.1146/annurev.soc.012809.102529
- Heart disease facts. CDC. Accessed July 24, 2017. <https://www.cdc.gov/heartdisease/facts.htm>
- Ferdinand KC, Yadav K, Nasser SA, et al. Disparities in hypertension and cardiovascular disease in blacks: the critical role of medication adherence. *J Clin Hypertens (Greenwich).* 2017;19(10):1015-1024. doi:10.1111/jch.13089
- Palmer RC, Ismond D, Rodriguez EJ, Kaufman JS. Social determinants of health: future directions for health disparities research. *Am J Public Health.* 2019;109(S1):S70-S71. doi:10.2105/AJPH.2019.304964
- Glass TA, McAtee MJ. Behavioral science at a crossroads in public health: extending horizons, envisioning the future. *Soc Sci Med.* 2006;62(7):1650-1671. doi:10.1016/j.socscimed.2005.08.044
- Byhoff E, Freund KM, Garg A. Accelerating the implementation of social determinants of health interventions in internal medicine. *J Gen Intern Med.* 2018;33(2):223-225. doi:10.1007/s11606-017-4230-8
- Alley DE, Asomugha CN, Conway PH, Sanghavi DM. Accountable health communities—addressing social needs through Medicare and Medicaid. *N Engl J Med.* 2016;374(1):8-11. doi:10.1056/NEJMp1512532
- Council on Community Pediatrics. Poverty and child health in the United States. *Pediatrics.* 2016;137(4):e20160339. doi:10.1542/peds.2016-0339
- Institute of Medicine. *Capturing Social and Behavioral Domains in Electronic Health Records: Phase 1.* The National Academies Press; 2014.
- Institute of Medicine. *Capturing Social and Behavioral Domains and Measures in Electronic Health Records: Phase 2.* The National Academies Press; 2014.
- DeSalvo K, Leavitt MO. For an option to address social determinants of health, look to Medicaid. *Health Affairs.* July 8, 2019. Accessed November 10, 2019. <https://www.healthaffairs.org/doi/10.1377/hlthaff.20190701.764626>
- Dzau VJ, McClellan MB, McGinnis JM, et al. Vital directions for health and health care: priorities from a National Academy of Medicine initiative. *JAMA.* 2017;317(14):1461-1470. doi:10.1001/jama.2017.1964
- Billoux A, Verlander K, Anthony S, Alley D. Standardized screening for health-related social needs in clinical settings: the Accountable Health Communities screening tool. National Academy of Medicine. May 30, 2017. Accessed March 15, 2018. <https://nam.edu/wp-content/uploads/2017/05/Standardized-Screening-for-Health-Related-Social-Needs-in-Clinical-Settings.pdf>
- Hallqvist J, Lynch J, Bartley M, Lang T, Blane D. Can we disentangle life course processes of accumulation, critical period and social mobility? an analysis of disadvantaged socio-economic positions and myocardial infarction in the Stockholm Heart Epidemiology Program. *Soc Sci Med.* 2004;58(8):1555-1562. doi:10.1016/S0277-9536(03)00344-7
- Decennial Census datasets: 2010. United States Census Bureau. Accessed July 24, 2017. https://www.census.gov/programs-surveys/decennial-census/data/datasets.2010.html?sec_ak_reference=18.3496d117.1583826946.38ad391
- Adler NE, Glymour MM, Fielding J. Addressing social determinants of health and health inequalities. *JAMA.* 2016;316(16):1641-1642. doi:10.1001/jama.2016.14058
- Palacio A, Suarez M, Tamariz L, Seo D. A road map to integrate social determinants of health into electronic health records. *Popul Health Manag.* 2017;20(6):424-426. doi:10.1089/pop.2017.0019

32. Palacio AM, Seo D, Suarez M, Tamariz L. Integrating social determinants of health into the electronic health records of a large health system: a qualitative perspective. *Perspectives in Health Information Management*. 2018. Accessed November 10, 2019. <https://perspectives.ahima.org/integratingsocialdeterminants/>
33. Chew LD, Griffin JM, Partin MR, et al. Validation of screening questions for limited health literacy in a large VA outpatient population. *J Gen Intern Med*. 2008;23(5):561-566. doi:10.1007/s11606-008-0520-5
34. Statistical brief on the health care access module, 2013 and 2014. CDC. October 2015. Accessed November 10, 2019. https://www.cdc.gov/briefs/data_documentation/pdf/2013-2014_HCS.pdf
35. Pantell M, Rehkopf D, Jutte D, Syme SL, Balmes J, Adler N. Social isolation: a predictor of mortality comparable to traditional clinical risk factors. *Am J Public Health*. 2013;103(11):2056-2062. doi:10.2105/AJPH.2013.301261
36. D'Agostino RB Sr, Vasan RS, Pencina MJ, et al. General cardiovascular risk profile for use in primary care: the Framingham Heart Study. *Circulation*. 2008;117(6):743-753. doi:10.1161/CIRCULATIONAHA.107.699579
37. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: executive summary: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *J Am Coll Cardiol*. 2018;71(6):1269-1324. doi:10.1161/HYP.0000000000000666
38. Cifu AS, Davis AM. Prevention, detection, evaluation, and management of high blood pressure in adults. *JAMA*. 2017;318(21):2132-2134. doi:10.1001/jama.2017.18706
39. American Diabetes Association. 6. glycemic targets: *Standards of Medical Care in Diabetes—2018*. *Diabetes Care*. 2018;41(suppl 1):S55-S64. doi:10.2337/dc18-S006
40. Eldor R, Raz I. American Diabetes Association indications for statins in diabetes: is there evidence? *Diabetes Care*. 2009;32(suppl 2):S384-S391. doi:10.2337/dc09-S345
41. American Diabetes Association. 9. cardiovascular disease and risk management: *Standards of Medical Care in Diabetes—2018*. *Diabetes Care*. 2018;41(suppl 1):S86-S104. doi:10.2337/dc18-S009
42. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults—the evidence report. National Institutes of Health. *Obes Res*. 1998;6(suppl 2):51S-209S.
43. Global Adult Tobacco Survey Collaborative Group. *Tobacco Questions for Surveys: A Subset of Key Questions From the Global Adult Tobacco Survey (GATS)*. 2nd ed. CDC; 2011.
44. Coleman KJ, Ngor E, Reynolds K, et al. Initial validation of an exercise "vital sign" in electronic medical records. *Med Sci Sports Exerc*. 2012;44(11):2071-2076. doi:10.1249/MSS.0b013e3182630ec1
45. American Heart Association recommendations for physical activity in adults and kids. American Heart Association. Accessed March 5, 2018. <https://www.heart.org/en/healthy-living/fitness/fitness-basics/aha-recs-for-physical-activity-in-adults>
46. Carle AC, Riley W, Hays RD, Cella D. Confirmatory factor analysis of the Patient Reported Outcomes Measurement Information System (PROMIS) adult domain framework using item response theory scores. *Med Care*. 2015;53(10):894-900. doi:10.1097/MLR.0000000000000413
47. Loncke J, Eichelsheim VI, Branje SJJ, Buysse A, Meeus WHJ, Loeys T. Factor score regression with social relations model components: a case study exploring antecedents and consequences of perceived support in families. *Front Psychol*. 2018;9:1699. doi:10.3389/fpsyg.2018.01699
48. Caleyachetty R, Echouffo-Tcheugui JB, Muennig P, Zhu W, Muntner P, Shimbo D. Association between cumulative social risk and ideal cardiovascular health in US adults: NHANES 1999-2006. *Int J Cardiol*. 2015;191:296-300. doi:10.1016/j.ijcard.2015.05.007
49. Williams DR, Wyatt R. Racial bias in health care and health: challenges and opportunities. *JAMA*. 2015;314(6):555-556. doi:10.1001/jama.2015.9260
50. Egede LE. Race, ethnicity, culture, and disparities in health care. *J Gen Intern Med*. 2006;21(6):667-669. doi:10.1111/j.1525-1497.2006.0512.x
51. Knighton AJ, Stephenson B, Savitz LA. Measuring the effect of social determinants on patient outcomes: a systematic literature review. *J Health Care Poor Underserved*. 2018;29(1):81-106. doi:10.1353/hpu.2018.0009
52. Colantonio LD, Gamboa CM, Richman JS, et al. Black-White differences in incident fatal, nonfatal, and total coronary heart disease. *Circulation*. 2017;136(2):152-166. doi:10.1161/CIRCULATIONAHA.116.025848
53. Larimer KA, Gulanic M, Penckofer S. Understanding determinants of cardiovascular health in a Mexican American community. *Health Promot Pract*. 2017;18(4):534-544. doi:10.1177/1524839917698095
54. Palacio A, Seo D, Medina H, Singh V, Suarez M, Tamariz L. Provider perspectives on the collection of social determinants of health. *Popul Health Manag*. 2018;21(6):501-508. doi:10.1089/pop.2017.0166

Visit ajmc.com/link/88504 to download PDF and eAppendix

eAppendix A

UHealth Social Determinants of Health Survey

1.	How long have you lived in the USA?			
<input type="checkbox"/>	< 1 Year	<input type="checkbox"/>	1-5 Years	
<input type="checkbox"/>	5-10 Years	<input type="checkbox"/>	11-20 Years	
<input type="checkbox"/>	>20 Years			
<input type="checkbox"/>	Born in the U.S.			
<input type="checkbox"/>	Do not live in the U.S.			

2.	What is the highest level of school you have completed?			
<input type="checkbox"/>	Elementary/ Primary (1-5)	<input type="checkbox"/>	Middle School (6-8)	
<input type="checkbox"/>	High School (9-12)	<input type="checkbox"/>	College (13-16)	
<input type="checkbox"/>	Graduate (17-22)	<input type="checkbox"/>	Post-Graduate (23+)	

3.	What is the highest degree you earned?			
<input type="checkbox"/>	High School diploma	<input type="checkbox"/>	GED	
<input type="checkbox"/>	Vocational certificate (Post high school or GED)	<input type="checkbox"/>	<i>Association degree (Junior College)</i>	
<input type="checkbox"/>	Bachelor's degree	<input type="checkbox"/>	Master's degree	
<input type="checkbox"/>	Doctorate	<input type="checkbox"/>	None	

		Not at all confident	A little confident	Somewhat confident	Quite confident	Extremely confident
4.	If you need to go to the doctor, clinic or hospital, how confident are you in filling out the medical forms by yourself?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5.	How hard is it for you to pay for the very basics like food, housing, medical care, and heating? Would you say it is ...
----	--

<input type="checkbox"/>	Very hard
<input type="checkbox"/>	Somewhat hard
<input type="checkbox"/>	Not hard at all

6.	Stress means a situation in which a person feels tense, restless, nervous, or anxious, or is unable to sleep at night because his or her mind is troubled all the time. Do you feel this kind of stress these days?		
<input type="checkbox"/>	Not at all	<input type="checkbox"/>	A little bit
<input type="checkbox"/>	Somewhat	<input type="checkbox"/>	Quite a bit
<input type="checkbox"/>	Very much		

7.	Are you physically active?		
<input type="checkbox"/>	Yes		
<input type="checkbox"/>	No		

8.	On average, how many days per week do you engage in moderate to strenuous exercise (like walking fast, running, jogging, dancing, swimming, biking, or other activities that cause a light or heavy sweat)?				
<input type="checkbox"/>	None	<input type="checkbox"/>	1 time/week	<input type="checkbox"/>	2 times/week
<input type="checkbox"/>	3 times/ Week	<input type="checkbox"/>	4 times/week	<input type="checkbox"/>	5 times/week
<input type="checkbox"/>	6 times/week	<input type="checkbox"/>	7 times/week		

9.	On average, how many minutes do you engage in exercise at this level?						
<input type="checkbox"/>	0 minutes	<input type="checkbox"/>	10 minutes	<input type="checkbox"/>	20 minutes	<input type="checkbox"/>	30 minutes
<input type="checkbox"/>	40 minutes	<input type="checkbox"/>	50 minutes	<input type="checkbox"/>	60 minutes	<input type="checkbox"/>	90 minutes
<input type="checkbox"/>	120 minutes	<input type="checkbox"/>	150 minutes or more				

10.	What are your current living arrangements?			
<input type="checkbox"/>	Alone in house/apartment	<input type="checkbox"/>	Spouse or domestic partner	
<input type="checkbox"/>	With other family members	<input type="checkbox"/>	With friends	
<input type="checkbox"/>	Nursing Home	<input type="checkbox"/>	Assisted living	
<input type="checkbox"/>	Homeless			

11.	In a typical week, how many times do you talk on the telephone with family, friends, or neighbors?				
<input type="checkbox"/>	Never/ No Telephone	<input type="checkbox"/>	Less than once a week	<input type="checkbox"/>	Once a week
<input type="checkbox"/>	2 times a week	<input type="checkbox"/>	3 or more times a week		

12.	How often do you get together with friends or relatives?				
<input type="checkbox"/>	Never	<input type="checkbox"/>	Less than once a week	<input type="checkbox"/>	Once a week
<input type="checkbox"/>	2 times a week	<input type="checkbox"/>	3 or more times a week		

13.	How often do you attend church or religious services?				
<input type="checkbox"/>	Never/ Does not belong	<input type="checkbox"/>	Once a year	<input type="checkbox"/>	2 times a year
<input type="checkbox"/>	3 times a year	<input type="checkbox"/>	4 or more times a year	<input type="checkbox"/>	Refuse to answer

14.	How often do you attend meetings of the clubs or organizations you belong to?				
<input type="checkbox"/>	Never/Does not belong	<input type="checkbox"/>	Once a year	<input type="checkbox"/>	2 times a year
<input type="checkbox"/>	3 times a year	<input type="checkbox"/>	4 or more times a year		

15.	Have you delayed getting needed medical care for any of the following reasons in the past 12 months? Select the most frequent reason. (you can select more than one reason)			
-----	---	--	--	--

<input type="checkbox"/>	You couldn't get through the telephone
<input type="checkbox"/>	You couldn't get an appointment soon enough
<input type="checkbox"/>	Once you get there, you had to wait too long to see the doctor
<input type="checkbox"/>	The clinic wasn't open when you could get there
<input type="checkbox"/>	You didn't have transportation
<input type="checkbox"/>	No, I did not delay getting medical care/ did not need medical care

Survey methods

In order to define if a specific social risk was present or absent, we dichotomized the answer to each question based on existing literature on the selected questions. This assignment was necessary for the development of the SDOH score. All variables of the survey were used individually except for variables related to social isolation which form a scale.³⁶ Survey responder received 1 point for risks defined as present as follows: living alone, having a high school education or less, stating that it was somewhat hard of very hard to pay for basic needs, feeling not confident, little or somewhat confident filling out forms, feeling quite a bit or very much stress, delaying care at least once in the past 12 months, and for the social isolation we created a score that included averaging 3 or more interactions per week with other people (assessed with the questions "In a typical week, how many times do you talk on the telephone with family, friends, or neighbors?" and "How often do you get together with friends or relatives?"), reporting that they attended church or religious services 4 or more times per year, and reporting that they belonged to a club or organization such as a church group, union, fraternal or athletic group, or school group. Scores ranged from 0 to 4, with 0 representing the highest level of social isolation and 4 representing the lowest level.³⁶

eAppendix Table 1. Dichotomization of the Survey

Domain	Reference answer	Presence of SDOH	Reference
Years in the US	Born in the US	Not born in the US	
Highest level of education	Some college or more	High school or less	Khaing. Eur J Prev Cardiol. 2017
Confident filling forms	Quite and extremely	Not at all, little , somewhat	Chew. JGIM.2008
Financial strain	Not hard paying for basics	Somewhat and very hard	Franks. Ann Fam Med. 2010
Stress	Not at all, a little bit and somewhat	Quite a bit and very much	Fairfield. Am J Preventive Med. 2018
Living arrangements	Living alone	Living with spouse, family or friends	Pantell. Am J Public Health. 2013
Talk on the phone with relatives or friends	Once or more a week	Less than once a week	Pantell. Am J Public Health. 2013
Get together	Once or more a week	Less than once a week	Pantell. Am J Public Health. 2013
Attend church	4 or more times a year	Less than 4 times/year	Pantell. Am J Public Health. 2013
Attend meetings	4 or more times a year	Less than 4 times/year	Pantell. Am J Public Health. 2013
Delaying medical care in past 12 months	No	Yes	Primeau. JGIM.2014
Race and ethnicity	White	Hispanic or Black	

eAppendix Table 2. Comparison between survey responders and non-responders

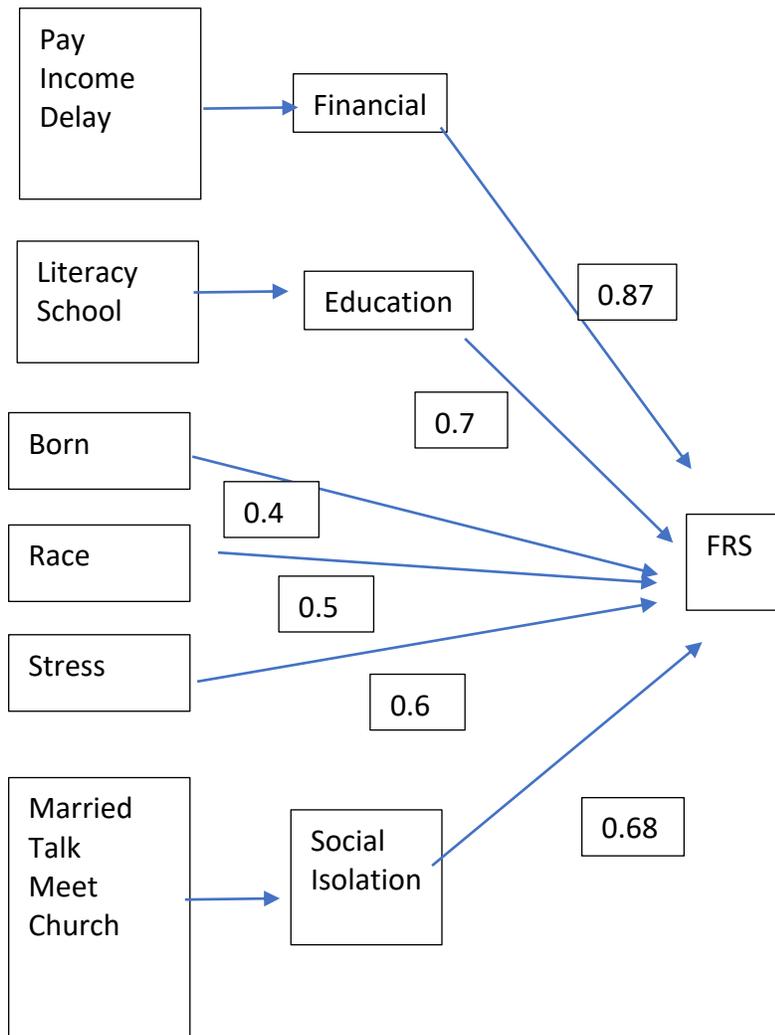
Characteristic	Survey responders	Non-survey responders	p-value
Number	2,876	5,007	
Female, %	61	55	<0.01
Hispanic, %	38	30	<0.01
Black, %	9	11	<0.01
Age 45-64, %	40	38	0.08

eAppendix B. Confirmatory factor analysis
eAppendix Table 3. Correlation between SDOH factors

	Delay	Hardpay	Born	Literacy	Married	Talk	Meet	Church	Stress	School	Race	Income
Delay	1											
Hardpay	0.20*	1										
Born	0.04*	0.122*	1									
Literacy	0.12*	0.24*	0.09*	1								
Married	0.05	0.04	0.01	0.06	1							
Talk	0.21*	0.16*	0.01	0.04	0.06*	1						
Meet	0.04	0.06	0.05	0.08	0.09*	0.05*	1					
Church	0.04	0.01	0.03	0.01	0.12*	0.15*	0.10*	1				
Stress	0.16*	0.24*	0.02	0.10*	0.01	0.06	0.07	0.10	1			
School	0.03	0.17*	0.02	0.24*	0.008	0.001	0.002	0.001	0.08*	1		
Race	0.04*	0.16*	0.52*	0.08*	-0.04*	0.10*	0.12*	0.34*	0.05*	0.07*	1	
Income	-0.03	-0.12*	-0.01	-0.04*	-0.08*	-0.06*	-0.01	-0.01	-0.10*	-0.05*	-0.06	1

*p<0.05

eAppendix Figure 1. CFA coefficients



eAppendix Table 4. Model fit

	RMSEA	CFI
Model 1	0.22	0.65
Model 2	0.09	0.90

eAppendix C (Sensitivity analysis)

Model derivation:

We used linear regression to estimate the beta coefficients for each variable and multiplied the coefficient with the presence or absence of the variable (0 or 1).

SDH	Beta coefficient	p-value
Not born in the US	9.88	0.02
Education high school or less	17.55	<0.01
Not/little or somewhat confident in filling out forms	36.2	<0.01
Somewhat hard or very hard to pay for basics	11.0	0.02
Stress quite or very much	11.8	0.02
Lives alone	0.46	0.93
Talks on phone with family less than once a week	3.10	0.68
Never or less than once a week gets together with friends	20.7	<0.01
Never attends church	5.0	0.28
Never attends meetings	18.6	<0.01
Delayed care	3.3	0.48
Minority	12	<0.01

Model calibration

We transformed the Framingham score into a categorical variable using high risk (>10 of the score) as 1 and low and moderate risk as 0. We the run a logistic regression model using the same variables for the model derivation and calculated the observed and expected observations on each decile of risk. The Hosmer-Lemeshow chi-square statistic was 9.05 and the p-value was 0.33. The table below reports the observed and expected observations.

Decile	Observed	Expected
1	234	229
2	207	214
3	204	197
4	204	205
5	193	193
6	187	186
7	187	181
8	169	177
9	187	181
10	167	156