Original Paper

Cardiometabolic Syndrome and Its Association With Education, Smoking, Diet, Physical Activity, and Social Support: Findings From the Pennsylvania 2007 BRFSS Survey

Longjian Liu, MD, PhD, MSc;[1] Ana E. Núñez, MD[2]

The authors aimed to examine the prevalence of cardiometabolic syndrome (CMS) and its association with education, smoking, diet, physical activity, and social support among white, black, and Hispanic adults using data from the 2007 Pennsylvania Behavior Risk Factor Surveillance System (BRFSS) survey, the largest population-based survey in the state. The authors examined associations between CMS and associated factors cross-sectionally using univariate and multivariate methods. The study included a representative sample of 12,629 noninstitutionalized Pennsylvanians aged ≥18. Components of CMS included obesity, hypercholesterolemia, angina (as a surrogate for decreased high-density lipoprotein), prehypertension or hypertension, and prediabetes or diabetes. CMS was identified as the presence of ≥3 CMS components. The results show that the prevalence of CMS was 20.48% in blacks, followed by Hispanics (19.14%) and whites (12.26%), (P<.01). Multivariate logistic regression analyses indicated that physical inactivity, lower educational levels, smoking, daily consumption of vegetables and/or fruits <3 servings, and lack of social support were significantly associated with the odds of having CMS. In conclusion, black and Hispanic adults have a significantly higher prevalence of CMS than whites. The significant association between CMS and risk factors provides new insights in the direction of health promotion to prevent and control CMS in those who are at high risk. J Clin Hypertens (Greenwich). *2010;12:556–564.* ©*2010 Wiley Periodicals, Inc.*

From the Department of Epidemiology and Biostatistics, Drexel University School of Public Health, Philadelphia, PA;[1] and the Department of Medicine, Drexel University College of Medicine, Philadelphia, PA[2]
Address for correspondence:
Longjian Liu, MD, PhD, MSc, Associate Professor of Epidemiology and Medicine, Drexel University School of Public Health, 1505 Race Street, Philadelphia, PA 19102
E-mail: longjian.liu@drexel.edu
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Cardiometabolic syndrome (CMS) is characterized by a group of cardiovascular and metabolic risk factors. They include obesity, atherogenic dyslipidemia (elevated triglycerides [TG], decreased high density lipoprotein [HDL] cholesterol, and increased low-density lipoprotein cholesterol concentrations), elevated blood pressure (BP), and insulin resistance or glucose intolerance.[1–3] People with CMS are at increased risk for developing cardiovascular disease and type 2 diabetes mellitus, as well as having an increased risk of mortality due to all causes and cause-specific disease (cardiovascular diseases in particular).[1,4–9]

CMS has become increasingly common in the United States, with an estimated 50 million or more Americans having the syndrome.[10] Although several studies have examined associations between CMS, clinical management, and disease outcomes,[5,11–13] less attention has been paid to examine CMS in relation to lifestyle-related factors and social support. In the present study, we hypothesized that minority peoples had higher prevalence of CMS than whites, and CMS was significantly associated with social and lifestyle-related factors. To test the hypothesis, we used data from the 2007 Pennsylvania Behavior Risk Factor Surveillance System (BRFSS) survey, the largest population-based survey for documenting health problems as a basis for designs of appropriate prevention and intervention programs.

METHODS

Study Design

The BRFSS is an ongoing nationwide and state-based surveillance system supported by the Centers for Disease Control and Prevention (CDC).[14] As a cross-sectional survey, the BRFSS annually conducts a sample telephone survey of adults who have a landline telephone service in Pennsylvania, regarding various health and behavior risks. This surveillance system is the only available source of timely, accurate data on health-related behaviors covering a statewide sample from across all Pennsylvania counties. The BRFSS survey selects a probability sample of noninstitutionalized adults aged 18 and over. Respondents are selected using a random digit dialing sampling technique and only 1 adult is randomly chosen from each selected household. The survey instruments consist of a set of a core section and state-specific modules. The core section of the survey questionnaire includes questions regarding demographic information. Behavior risk factors and self-reported health conditions that were professionally diagnosed (prehypertension, hypertension, prediabetes, diabetes, angina, and hypercholesterolemia) are asked either in the core section and/or in optional survey modules. In the 2007 Pennsylvania BRFSS, questions concerning vegetable and/or fruit intake were included. The reliability and validity of these measures have been examined and reported as moderate to high, and are generally considered to be valid and reliable in comparison with other surveys and models of administration.[15] Verbal consent was obtained for all participants, and all survey procedures followed the ethic standards of the CDC's Institutional Review Board.[14] A detailed description of the survey design and methods is available elsewhere.[14] The present study used data from the 2007 Pennsylvania BRFSS which were deidentified.[14] We excluded participants who had no information on their self-reported race/ethnicity status (n=488). Therefore, the final study sample included 12,629 participants with an average age of 55.17 years (standard deviation [SD]=16.73) in whites (n= 11,078), 51.08 years (SD=17.17) in blacks (n=1310), and 46.15 years (SD=17.89) in Hispanic participants (n=241).

Definition of CMS

Although there are several criteria for diagnosing CMS,[1,2] the criteria proposed by the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III), with minor modifications by the American Heart Association (AHA), are currently recommended and widely used.[1,2,16] The AHA and the National Heart, Lung, and Blood Institute advise that CMS be identified as the presence of 3 or more of the following components: (1) obesity (waist circumference $\geq$102 cm in men, and $\geq$88 cm in women); (2) elevated TG ($\geq$150 mg/dL); (3) reduced HDL cholesterol ($<$40 mg/dL in men, $<$50 mg/dL in women); (4) elevated BP (systolic and/or diastolic BP $\geq$130/85 mm Hg); and (5) elevated fasting glucose ($\geq$100 mg/dL, including prediabetes and diabetes).[1,2,16] Although the BRFSS was conducted using a phone approach, it included questions that addressed the main components of CMS, including a self-report of a health professional's diagnosis of health conditions. These components included (1) participants' self-reported weight and height, which can be used to estimate obesity (assessed by body mass index $\geq$30 kg/m^2, estimated by the individual's weight in kilograms divided by the squared value of height in meters), and the presence of health conditions including (2) hypercholesterolemia, (3) prehypertension and hypertension (systolic and/or diastolic BP $\geq$130/85 mm Hg), (4) angina (or heart attack), and (5) prediabetes and diabetes mellitus (fasting glucose $\geq$100 mg/dL). In the BRFSS data set, although there were no self-reports of elevated TG and reduced HDL, 2 additional self-reported variables can be used as surrogates for these measures. Because of the inclusion of elevated low-density lipoprotein cholesterol levels (they are reflected in the levels of TG) in the definition of dyslipidemia, self-reports of professionally diagnosed hypercholesterolemia were used in lieu of elevated TG. Hypercholesterolemia has also been used in place of elevated TG in the characterization of CMS by others using BRFSS data

sets.[17,18] Self-reports of professionally diagnosed conditions of angina served as a surrogate for reduced HDL because of the well-established association between reduced HDL and risk of angina.[18–22] Therefore, in the present study, the prevalence of CMS was determined based on the presence of 3 or more CMS components: obesity, hypercholesterolemia, elevated BP (assessed by the conditions of prehypertension and hypertension), angina (as a surrogate for reduced HDL), and elevated fasting glucose (assessed by the condition of prediabetes or diabetes).[1,2,18]

Social and Behavior Variables

In the study, in addition to examining the prevalence of CMS across 3 racial/ethnic groups of white, black, and Hispanic participants, we examined the odds of CMS in relation to 5 potential modifiable factors. These included (1) participant's educational levels (3 levels: those with elementary education or without completion of high school, those with completion of high school, and those with completion of college or higher education); (2) smoking status (ever smoking vs never smoking); (3) eating habits: participants were asked "How many servings of vegetables and/or fruits do you usually eat?" We grouped the eating habits data as those with <3 servings of vegetables and/or fruits, 3 to 4 servings, and 5 or more servings per day. The last category (≥5 servings per day) is the recommendation made by the CDC.[23] (4) Physical activity status: participants were classified into 3 groups: those who met the recommended physical activity level by the CDC (moderate physical activity for 30 minutes or more per day for 5 or more days, or vigorous activity for 20 minutes or more per day for 3 or more days per week), those with insufficient physical activity levels to meet the recommended levels, and those with no moderate or vigorous physical activity at all.[23] (5) Social support: participants were asked "How often do you get the social and emotional support when you need it?" Participants were classified into 3 groups: those who always, sometimes, or rarely/never received social support.

Covariates

To control for the confounding effects of covariates on the association between 5 potential modifiable factors and CMS, we adjusted several covariates in multivariate analyses. They included age (per every 10 years), sex (male or female), martial status (single, widowed/separated, married), and self-rated general health status (poor, good, excellent).

Analyses

A serial analysis was conducted on the data. In the first group analysis, we calculated the prevalence rates of CMS and risk factors for CMS by racial/ethnic groups. Chi-square tests were used to test differences in the prevalence rates across racial/ethnic groups.

In the second group analysis, we estimated odds of having CMS in relation to age, race, marital status, educational level, smoking status, eating habits, physical activity, and social support. In this analysis, we used the combined sample of 3 racial/ethnic groups in order to estimate an overall association between CMS and the study factors. This combined data set increased the study sample size and statistical power. Univariate logistic regression analysis was conducted with CMS as the dependent variable, and each of demographic, behavioral, and social support factors as independent variables. This analysis estimated unadjusted odds ratios of CMS and 95% confident intervals (95% CI).

Finally, we estimated multivariate adjusted odds ratios of CMS in relation to race/ethnicity and 5 modifiable risk factors using multivariate logistic regression techniques.[24–26] In model 1, the associations between CMS and each of the study variables were adjusted for age and sex. In model 2, these associations were adjusted for all covariates listed in Table I. The purpose of this analysis was to examine whether there was an independent association between CMS and the study variables with all covariates held constant in the models.[24–26]

All statistical analyses were performed using SAS software version 9.1 (SAS Institute, Cary, NC, 2001). Because the BRFSS surveys applied multistage and complex study designs in the data collection stages, SAS analysis procedures for complex sample surveys were used to produce weighted estimates and sampling errors.[27] A two-sided P value $\leq .05$ was considered statistically significant.

RESULTS

Characteristics of Participants by Race/Ethnicity

Table I illustrates that 7% (95% CI, 6.28%–8.03%) of whites, 11.63% (95% CI, 7.89%–15.36%) of blacks, and 15.54% (95% CI, 4.78%–26.29%) of Hispanics did not complete high school (test of differences across race/ethnicity groups, $P<.01$). About 50% of participants did not meet the recommended daily physical activity level (including those who did not or only insufficiently met the recommendation) in all racial/ethnic groups. Forty-eight percent (48.32%; 95% CI, 41.8%–54.83%) of blacks had <3 servings of vegetables and/or fruits

Table I. Characteristics of Participants Aged ≥18 by Racial/Ethnic Groups, Pennsylvania, 2007

Characteristics	White (n=11,078) % (SEP)	Black (n=1310) % (SEP)	Hispanic (n=241) % (SEP)	*P* Value
Age ≥65 y, %	21.52 (0.55)	13.95 (1.71)	10.98 (2.43)	<.001
Males, %	47.11 (0.84)	44.40 (3.37)	53.19 (5.97)	.410
Marital status: divorced or widowed, %	15.41 (0.46)	20.83 (2.40)	21.09 (5.68)	<.001
General health status: fair or poor, %	13.92 (0.52)	20.77 (2.42)	22.83 (5.92)	<.001
Received education <high school, %	7.15 (0.45)	11.63 (1.91)	15.54 (5.49)	<.01
Smoking status				
Former smoking, %	25.81 (0.66)	14.80 (1.87)	19.59 (4.01)	<.01
Current smoking, %	20.44 (0.70)	27.61 (3.05)	13.85 (3.69)	<.001
Physical activity status				
Met recommendation, %	50.64 (.86)	42.17 (3.38)	52.30 (6.00)	.089
Met insufficiently, %	37.21 (0.82)	41.32 (3.51)	34.20 (5.67)	
Did not meet recommendation, %	12.06 (0.54)	16.52 (2.12)	13.50 (3.07)	
Vegetable and/or fruit intake				
<3 Servings/d	38.82 (0.83)	48.33 (3.32)	36.02 (5.06)	.058
3–4 Servings/d	35.82 (0.79)	31.20 (3.20)	33.62 (5.09)	
≥5 Servings/d	25.37 (0.72)	20.47 (2.37)	30.36 (5.78)	
Received social support when needed				
Rarely, %	19.07 (0.67)	28.81 (2.96)	29.87 (5.38)	<.001
Sometimes, %	34.06 (0.81)	26.23 (3.18)	33.21 (5.44)	
Always, %	46.87 (0.85)	44.96 (3.45)	36.92 (5.38)	
Lacked any health insurance, %	9.17 (0.59)	15.54 (2.90)	17.90 (5.55)	.008
Components of CMS				
BMI ≥30 kg/m^2, %	27.02 (0.73)	38.03 (3.14)	28.92 (5.88)	.008
Elevated blood pressure, %	29.82 (0.69)	45.46 (3.26)	19.52 (3.59)	<.001
Hypercholesterolemia, %	40.31 (0.79)	37.17 (3.46)	44.07 (6.73)	.597
Angina, %	7.13 (0.34)	8.85 (1.93)	9.81 (5.19)	.628
Elevated fasting glucose, %	9.66 (0.39)	18.51 (2.48)	11.33 (3.17)	<.001
CMS, %	12.26 (0.44)	20.48 (2.50)	19.14 (5.62)	.004

Abbreviations: SEP, standard error of proportion; BMI, body mass index; CMS, cardiometabolic syndrome, defined for those with ≥3 CMS components; elevated blood pressure, self-reports of health professional diagnosis of prehypertension or hypertension; elevated fasting glucose, self-reports of health professional diagnosis of prediabetes or diabetes.

per day, followed by whites (38.82%; 95% CI, 37.19%–40.45%) and Hispanics (36%; 95% CI, 26.11%–45.93%). Almost thirty percent of black (28.81%; 95% CI, 23.02%–34.59%) and Hispanic adults (29.87%; 95% CI, 19.53%–40.42%) rarely received social support when they needed it. The corresponding value was 19.07% (95% CI, 17.78%–20.36%) in white adults (test of differences across race/ethnicity groups, $P<.001$).

Of individual CMS components, obesity, hypertension, and hypercholesterolemia were the most prevalent in all racial/ethnic groups, followed by prediabetes or diabetes and angina. Among the 3 racial/ethnic groups, blacks had the highest prevalence of CMS (20.48%; 95% CI, 15.56%–25.39%), followed by Hispanics (19.14%; 95% CI, 8.12%–30.16%) and whites (12.26%; 95% CI, 11.39%–13.14%), ($P<.01$). Figure 1 shows a trend of significant increase in CMS prevalence with an increase in age among all 3 racial/ethnic groups. It also shows that black adults were successively much younger than white adults at similar prevalence rate levels of CMS. For example, the prevalence of CMS was 25.48% (95% CI, 20.10%–30.86%) in black adults aged 45 to 54, while approximately the same level of prevalence was seen in white adults at ages 65 and older (26.17%; 95% CI, 24.69%–27.64%).

CMS and Associated Risk Factors

Table II shows that older age, males, race/ethnicity (black adults in particular), divorced or widowed, lower educational level, and subjects receiving rare social support had significantly higher odds ratios (which closely estimate the relative risks) of CMS as compared to their counterparts.

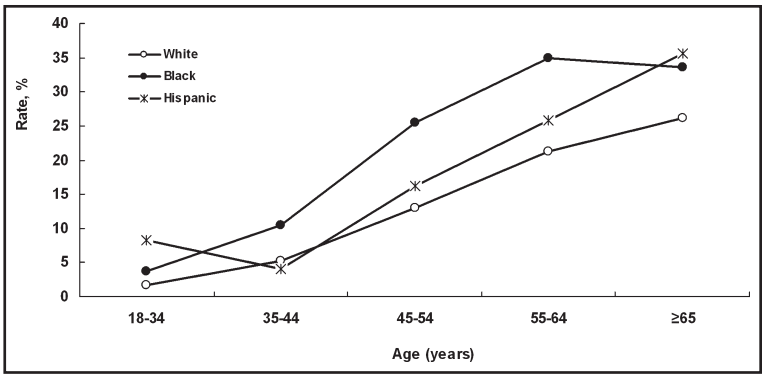

Figure 1. Prevalence (%) of cardiometabolic syndrome by age groups among white, black, and Hispanic adults, Pennsylvania 2007 Behavior Risk Factor Surveillance System.

Table II. Unadjusted Odds Ratios (ORs) of Cardiometabolic Syndrome in Relation to Demographic, Behavioral Factors, and Social Support

	OR (95% CI)	*P* Value
Age, y (≥65 vs <65)	2.75 (2.25–3.30)	<.001
Sex: males vs females	1.19 (1.00–1.43)	.071
Race/ethnicity		
Blacks vs whites	1.70 (1.16–2.50)	.006
Hispanics vs whites	1.55 (0.75–3.21)	.245
Martial status		
Divorced or widowed vs married	1.90 (1.55–2.33)	<.001
Education levels		
Elementary vs ≥college	2.55 (1.77–3.68)	<.001
High school vs ≥college	1.88 (1.54–2.29)	<.001
Smoking (ever vs never)	1.43 (1.18–1.72)	<.001
Vegetables and/or fruits intake/d		
<3 Servings vs ≥5 servings	1.34 (1.05–1.71)	.019
3∼4 Servings vs ≥5 servings	1.27 (1.00–1.62)	.053
Physical activity		
Not met vs met recommendation	3.05 (2.33–3.98)	<.001
Insufficient vs met recommendation	1.52 (1.23–1.88)	<.001
Received social support when needed		
Rarely vs always	1.29 (1.02–1.64)	.036
Sometimes vs always	0.96 (0.77–1.20)	.724

Abbreviation: CI, confidence interval.

Table III shows that after adjustment for age and sex (model 1), and for the inclusion of other covariates (model 2), the adjusted odds ratios (95% CI) of CMS in relation to race/ethnicity (blacks vs whites), lower education level, smoking, eating <3 servings of vegetables and/or fruits per day, physical inactivity, and lack of social support (rarely vs always) remained significant. Of the 5 modifiable factors, physical activity and educational levels had the highest odds ratios. Figure 2 shows the combined effects of these 2 factors on the prevalence of CMS. Thus, subjects who had the lowest educational level and did not meet the recommended level of physical activity had a significantly higher prevalence rate of CMS (30.28%; 95% CI, 25.23%–35.34%), and those who had the highest educational level and met the recommended level of physical activity had the lowest prevalence rate of CMS (10.23%; 95% CI, 9.14%–11.31%).

DISCUSSION

The present study used the most recently released Pennsylvania BRFSS data and has demonstrated that CMS affects about 1 in 5 adults among black and Hispanic adults aged 18 years and older, and more than 1 in 10 adults in whites. Educational level, smoking, diet and physical activity behaviors, and social support were significantly associated with the odds of having CMS.

Of the 5 CMS contributing components, obesity, hypertension, and hypercholesterolemia were the three most prevalent adverse conditions in the study populations. Overall, blacks had the highest rates of individual CMS components, followed by Hispanic adults. This finding may partly explain why black and Hispanic adults have a higher risk of having diabetes and diabetic complications of cardiovascular disease than whites. The results suggest that CMS is preventable through lifestyle changes and vigorous clinical management plans. The significant gap in CMS between white and minority groups calls for urgent action of health promotion among the minority populations.

The prevalence of CMS dramatically increases by age in all racial/ethnic groups. However, black adults had a significantly increasing trend of CMS

Table III. Multivariate Adjusted Odds Ratios (95% CI) of Cardiometabolic Syndrome in Relation to Demographic, Behavior Factors, and Social Support Status

	Model 1		Model 2	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Race/ethnicity				
Blacks vs whites	1.90 (1.30–2.78)	.001	1.81 (1.21–2.72)	.004
Hispanics vs whites	1.80 (0.87–3.74)	.114	1.75 (0.84–3.66)	.138
Education levels				
Elementary vs ≥college	1.94 (1.31–2.88)	.001	1.80 (1.20–2.69)	.004
High school vs ≥college	1.66 (1.36–2.03)	.001	1.61 (1.31–1.98)	.001
Smoking status				
Ever smoking vs never smoking	1.33 (1.10–1.61)	.004	1.25 (1.03–1.53)	.023
Vegetables and/or fruits intake, per day				
<3 Servings vs ≥5 servings	1.35 (1.04–1.73)	.022	1.33 (1.03–1.71)	.030
3∼4 Servings vs ≥5 servings	1.31 (1.02–1.68)	.036	1.26 (0.99–1.60)	.061
Physical activity				
Did not meet vs met recommendation	2.52 (1.89–3.35)	<.001	2.26 (1.69–3.02)	<.001
Insufficiently met vs met recommendation	1.48 (1.19–1.83)	<.001	1.45 (1.17–1.81)	.001
Received social support when needed				
Rarely vs always	1.44 (1.25–1.65)	.005	1.28 (1.01–1.63)	.041
Sometimes vs always	1.08 (0.86–1.35)	.516	1.11 (0.89–1.39)	.365

Model 1: adjusted for age and sex. Model 2: adjusted for age, sex, race, martial status, educational level, smoking, vegetable and/or fruit consumption, physical activity, social support and general health status. Abbreviations: CI, confidence interval; OR, odds ratio.

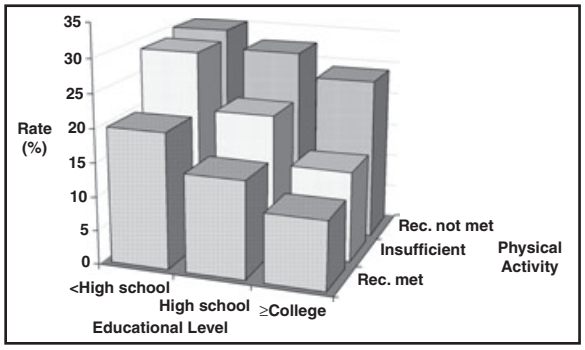

Figure 2. Prevalence (%) of cardiometabolic syndrome by educational levels and physical activity status, Pennsylvania 2007 Behavior Risk Factor Surveillance System. Rec. not met indicates did not meet the recommended level of physical activity; Insufficient, insufficient physical activity levels to meet the recommended level of physical activity; Rec. met, met the recommended level of physical activity.

rates as compared to whites ages 35 and older. The mechanisms behind this observation are not yet completely known. It has been suggested that the significantly higher prevalence of obesity, prehypertension, hypertension, prediabetes, and diabetes in blacks may be the major drivers of CMS, which partly explains the racial/ethnic disparity. However, the detailed pathophysiology is complex and has been only partially elucidated; further experimental and population-based studies are needed.[4,5]

Of the 5 modifiable factors, educational attainment and physical activity had the strongest impact on the prevalence of CMS. The study suggested that subjects with only an elementary school educational level, or not having completed high school, had a significantly higher risk of having CMS as compared to those with college or higher educational levels. Subjects who had low educational levels have been suggested to be linked with health literacy, health behaviors, and barriers to health care access.[28–31] The present study observed a high proportion of those who did not complete high school in all 3 racial/ethnic populations. Given the significant relationship between educational levels and risk of CMS, the results indicate the challenge of disease control and health promotion among minority populations with low educational attainments levels. Several epidemiologic studies have also demonstrated a protective effect of physical activity against the risks for cardiometabolic diseases, cancer, and anxiety and depression.[32–35] Our study further adds evidence of a dose-response relationship between physical activity and the odds of having CMS to the literature.

Of the 5 modifiable factors, smoking is a well-established risk factor for a number of diseases.[31,36,37] The present study not only confirmed the previous findings of smoking and risk of CMS,

but also highlighted that the current smoking rates are still unacceptably higher in black adults (27.61%), followed by white (20.44%) and Hispanic adults (13.85%).

Several studies, including our own studies, have reported that eating vegetables and fruits are associated with the reduction of serum total cholesterol and low-density lipoprotein cholesterol, prevention of inflammation and oxidative stress, and subsequent reduction of the risk of cardiometabolic disorder and cardiovascular disease.[38–43] Our present study observed that those who had the lowest intakes of vegetables and/or fruits (<3 servings per day) had markedly higher odds of having CMS as compared to those who had 5 or more servings per day. This finding is consistent with results in our previous report that used data from the Multi-Ethnic Study of Atherosclerosis.[39] The present study further indicates that more than one-third of adults had less than 3 servings of vegetables and/or fruits per day. Of them, black adults had the highest rate.

Evidence of the associations between CMS and social support is limited. Our present study is among the first to demonstrate a significant association between lack of social support and increased odds of having CMS. Subjects who received only limited or rarely received social support had 1.28 times higher odds of having CMS. Given almost 30% of black and Hispanic adults received only limited social support when they needed it, the study highlights a serious public health issue in which not only a looming health disparity is observed among minority populations, but also stresses the challenge and opportunity in reducing the gaps among the underserved groups.

The present study had 2 major strengths, including (1) its findings are based on a representative population sample randomly selected from across the state, and (2) survey procedures were standardized according to the national BRFSS criteria.[14] However, several limitations should be kept in mind when interpreting the results. First, although the present study identified cardiovascular risks and determinants, it may underestimate the CMS rates in the study populations, because the BRFSS surveys had no direct measures of BP, waist circumference, and serum lipid profiles (TG and HDL) and fasting glucose, which are used in the NCEP definition of CMS.[1,2,10] In our present study, we applied body mass index and self-reported medical conditions as surrogates for measures of obesity, hypertension, decreased HDL, and increased TG and glucose. It may have bias, especially when we study the differences in CMS rates by race/ethnicity groups. Ford and coworkers reported that CMS is more common in black women than in black men. This contrasts with the similar sex prevalence for whites. Black men in particular have a relatively low prevalence of CMS, using NCEP criteria, compared with other racial/ethnic groups.[10] Reasons for lower frequency of CMS in black men suggest that they may have lower waist circumferences on average, lower triglycerides, and higher HDL cholesterol levels.[1,10] However, we are unable to test these differences because these measures are not directly available using the present data set. As compared to the national average rates of 21.5% to 31.9% CMS prevalence in people aged 20 and older in the Third National Health and Nutrition Examination Survey (NHANES-III), which used direct measures of physical examination and blood tests,[10] the prevalence of CMS in Pennsylvania seems lower although the study examined CMS rates in people aged 18 and older. This difference still existed when we applied the same age groups as the NHANES-III did and compared these age-adjusted CMS rates. Similar to our study, Reppert and his colleagues observed that prevalence of CMS in Illinois might be underestimated as well by using Illinois 2005 BRFSS data.[18] Second, like any other study, it cannot conclude any confident cause-effect associations because of the nature of a cross-sectional study design.[25,26] Although we emphasize the potential upstream role of smoking, eating, and physical activity behaviors, it is also conceivable that having CMS may influence people's behaviors when a person has had CMS. Thus, the present study only highlights the associational characteristics between having CMS and certain behavioral factors, and refrains from drawing any causal inferences. Third, the BRFSS interview data were based on self-reported answers and were therefore subject to nonsampling errors including recall bias. Last, the BRFSS surveys recruited participants who had residents' land-line phone connection service. Thus, if a household did not have the service, it would not have been selected in the study, and as a result, potential selection bias favoring homeowners over some tenants (for example) might have occurred.

Despite the aforementioned limitations, evaluating the impact of multiple factors that affect CMS and health, as seen in the study, extends previous observations by updating the prevalence of CMS among a sample of multiethnic populations, and examining its associations with socially and behaviorally modifiable factors. The results further

highlight the health disparities among minority populations. Findings of the study may assist researchers in their designs of interventions to prevent cardiometabolic diseases by optimizing the focus on the risk factors emphasized in this study and targeting the subjects at greatest risk of CMS.

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