

The Association Between Obstructive Sleep Apnea and Hypertension by Race/Ethnicity in a Nationally Representative Sample

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The association between obstructive sleep apnea (OSA) and hypertension by race/ethnicity has not been well characterized in a national sample. Adult participants in the 2007–2008 National Health and Nutrition Examination Survey were reviewed by self-report of sleep apnea diagnosis, snoring, gasping or stopping breathing during sleep, and snoring to derive whether OSA was probable (pOSA). Multivariable logistic regression determined whether pOSA predicted hypertension in the overall cohort, and by body mass index (BMI) group and ethno-racial strata. pOSA predicted hypertension in several groups: (1) Within BMI strata, there was a significant association among overweight individuals [odds

ratio [OR], 1.82; 95% confidence interval [CI], 1.26–2.62]; (2) In race/ethnicity subgroups, the association was significant among Hispanic/Latinos (OR, 1.69; 95% CI, 1.13–2.53) and whites (OR, 1.40; 95% CI, 1.07–1.84); (3) In models stratified by both race/ethnicity and BMI, pOSA predicted hypertension among overweight black/African Americans (OR, 4.74; 95% CI, 1.86–12.03), overweight whites (OR, 1.65; 95% CI, 1.06–2.57), and obese Hispanic/Latino participants (OR, 2.01; 95% CI, 1.16–3.49). A simple, self-report tool for OSA was strongly associated with hypertension, and may serve as a potential future opportunity for OSA diagnosis. *J Clin Hypertens (Greenwich)*. 2013;15:593–599. ©2013 Wiley Periodicals, Inc.

Obstructive sleep apnea (OSA) is a common sleep disorder^{1,2} and is characterized by intermittent collapse of the upper airway during sleep.³ Diagnosis of OSA relies on polysomnography (PSG), which counts the number of apneas (flow cessations) or hypopneas (flow reductions) per hour of sleep to compute the apnea-hypopnea index.⁴ OSA has been linked to hypertension in cross-sectional⁵ and longitudinal^{6,7} studies. A recent meta-analysis of randomized controlled trials as well as recent findings from a randomized controlled trial in nonsleepy individuals concluded that treating OSA with positive airway pressure (PAP) lowers blood pressure (BP).^{8,9} While the pooled estimate of the effect of PAP was modest, the reduction was more prominent in groups with more severe apnea and higher compliance with PAP therapy. Accordingly, the American Heart Association listed OSA among treatable causes of hypertension.¹⁰ These data provide a compelling case for widespread identification and treatment of OSA among patients with hypertension.

The diagnostic gold standard for OSA remains PSG; however, PSG relies on a sleep laboratory, requires technical expertise, is expensive, and is often inaccessible.¹¹ These characteristics make PSG unsuitable

for population-wide case finding. While portable, limited-channel testing is gaining attention, the need persists for a quick, easy, and inexpensive strategy to assess risk on a population-wide level, so that diagnostic testing can be targeted to select groups at highest risk.

Body mass index (BMI) has been used for measuring obesity, which is a risk factor for OSA,¹² and identifies apnea with reasonable accuracy.^{13–15} Among nonobese referrals to sleep centers, however, certain self-reported symptoms may add value in risk assessment.¹³ While choking, gasping, and apneas witnessed during sleep by others are common symptoms of apnea, self-reported snoring is not only a sensitive symptom of OSA^{16–19} but has also been associated with hypertension in OSA.^{20,21} This relationship between OSA symptoms and hypertension may be mediated by race and ethnicity,^{22,23} but availability of robust data in subgroups such as Hispanic/Latinos is limited. Additionally, typical symptom experience, such as witnessed apneas or morning headaches, have been purported to be less useful among women.^{24,25}

To date, limited evidence exists regarding the association between OSA and hypertension by race/ethnicity group in a national, ethnically diverse sample. Accordingly, using data from the National Health and Nutrition Examination Survey (NHANES) (2007–2008) cohort, we aimed to determine whether: (1) self-reported probable sleep apnea, based on snoring, snorting, or previous diagnosis, is significantly associated with hypertension; and (2) differences persist in this association when stratifying by race/ethnicity and obesity categories.

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METHODS

Study Sample

NHANES (2007–2008) is a nationally representative sample of noninstitutionalized individuals, and recruitment of participants, survey design, and sampling methodology have been explained elsewhere.^{26,27} The overall response rates for the 2007–2008 survey was 10,149 patients (78.4%) for the health interview and 9762 (75.4%) for the physical examination. Because a primary aim was to evaluate associations by race, we first excluded participants in the “other race” category (n=465); we next excluded participants younger than 18 years (n=3715); and, subsequently, anyone with missing covariate data of interest (n=1551). Our final analysis sample (N=4418) included participants with complete data for the primary exposure (sleep apnea symptoms) and outcome (hypertension). All study participants gave informed consent before participation in the examination and study protocol.

Probable OSA

The primary outcome was the probable OSA (pOSA) score, which utilized 3 different questions from the survey items to identify likely sleep apnea. These included self-reported (1) previous sleep apnea diagnosis; (2) snoring, gasping, or stopping breathing during sleep; and (3) snoring during sleep. Participants were asked “In the past 12 months, how often did you [a. snore] or [b. snort, gasp, stop breathing] while you were sleeping?” and possible questionnaire responses were: (1) “never”; (2) “1 or 2 nights per week”; (3) “3 or 4 nights per week”; (4) “5 or more nights per week.” Participants responding to either snoring ≥ 3 to 4 times per week or snoring ≥ 3 to 4 times per week or who reported previous sleep apnea diagnosis were identified as having pOSA.²⁸

Hypertension

Participants were identified as having hypertension or not if they had a systolic BP ≥ 140 mm Hg or diastolic BP ≥ 90 mm Hg, or if they were taking BP-lowering medications.

Sleep Characteristics

Additional survey items on sleep that were assessed evaluated nonrestorative sleep and daytime sleepiness. For nonrestorative sleep, participants were asked “Over the past month, how often do you feel unrested during the day, no matter how many hours of sleep you have had?” Daytime sleepiness was measured using the following question: “In the past month, how often do you feel excessively or overly sleepy during the day?” Response options for both questions included: (1) never; (2) rarely (1 time per month); (3) sometimes (2–4 times per month); (4) often (5–15 times per month); (5) almost always (16–30 times per month).

Covariates

A number of covariates were considered in regression models, including socioeconomic status (SES) and health characteristics (Table II). SES characteristics were measured via self-report from the in-person interview and were considered for the analysis given that they are associated with sleep complaints and hypertension. Objectively measured anthropometrics were obtained according to NHANES protocols, including height (m) and weight (kg) in order to calculate BMI (kg/m^2) and waist circumference (cm).²⁸ Health behaviors were evaluated based on interview questions. Participants were asked “Over the past month, how often did you ...?” Depression status was measured using the 9-item symptom depression scale based on the Patient Health Questionnaire (PHQ-9).²⁹

Statistical Analysis

We summarized demographics, clinical characteristics, and sleep measures among race/ethnicity groups using proportions for categorical variables and means (\pm standard deviations [SDs]) for continuous variables. Comparisons among race/ethnicity groups (Table I and Table S1) were assessed using analysis of variance for continuous characteristics and chi-square tests for categorical covariates (a $P < .05$ means that at least one of the 3 groups is different). We then compared the sleep characteristics, race/ethnicity and anthropometrics across hypertension status using t tests or chi-square tests for continuous or categorical covariates, respectively (Table II). To evaluate the adjusted association between sleep apnea risk and hypertension, we subsequently performed multivariable logistic regression analysis. In the multivariable models we added covariates (described above) that were theoretically important based on previous literature. Multivariate logistic regression models were also stratified by race/ethnicity group and obesity category (Table III and Table IV). Interactions between pOSA and BMI categories (<25 , 25 – 30 , ≥ 30 kg/m^2) and race/ethnicity were also evaluated. The sample weights provided with the NHANES data, which reflect the unequal selection probabilities and other adjustments, were used in all analyses to ensure proper and unbiased estimates and standard errors. All analyses were conducted using SAS Software, version 9.3 (SAS Institute Inc, Cary, NC) or Stata, version 12 (StataCorp, College Station, TX).

RESULTS

The mean (\pm SD) age of the cohort was 46.5 (± 16.4) years. More than half of the participants were women (51.9%) and married (56.6%), and 25.4% were college graduates. Thirty-five percent of participants in the cohort met the criteria for high BP and were identified as having hypertension, and 33.3% were identified as having pOSA (Table I). When stratifying by race/ethnicity, Hispanic/Latino participants had the lowest prevalence of hypertension (20.2%) and black/African Americans had the highest prevalence (40.5%)

TABLE I. Demographic Information Stratified by Race/Ethnicity

Variable	Overall (N=4418)	Non-Hispanic White (n=2230)	Hispanic/ Latinos (n=1255)	Black/African American (n=933)	P Value ^a
Hypertension, %	35.26	37.13	20.22	40.54	<.0001
Probable obstructive sleep apnea, %	33.30	33.76	33.25	30.30	.2160
Daytime sleepiness (indicating "almost always," or "often"), %	18.66	20.04	12.29	17.06	<.0001
Body mass index, kg/m ²	28.7±6.6	28.4±5.3	29.3±9.2	30.2±10.5	<.0001
Age, y	46.5±16.4	48.0±13.6	40.3±21.0	44.0±21.1	<.0001
Men, %	48.15	48.16	51.15	44.64	.0530
Alcohol use (drinks per day)	2.03±2.70	1.90±1.85	3.06±6.73	1.75±2.68	<.0001
Current smoker, %	23.16	23.23	19.66	26.83	.0074
Past smoker, %	48.23	50.97	38.36	41.81	<.0001

^aP value from analysis of variance (for continuous variables) or chi-square test (for categorical variables) testing the global null hypothesis of equivalence across the 3 race/ethnicity groups.

TABLE II. Demographics, Sleep Characteristics, and Anthropometrics by Hypertension Status

Predictor	Subgroup	Overall (N=4418)	Hypertension		P Value ^a
			No (n=2220)	Yes (n=2198)	
Probable OSA, %	No	66.70	71.64	57.64	<.0001
	Yes	33.30	28.36	42.36	
Apnea, %	No	95.23	97.40	91.24	<.0001
	Yes	4.77	2.60	8.76	
Snore, %	Never	29.56	32.81	23.26	<.0001
	Rarely	18.37	20.05	15.11	
	Occasionally	19.19	18.85	19.87	
	Frequently	32.88	28.29	41.76	
Snort, %	Never	78.86	80.78	75.24	.0001
	Rarely	8.41	8.54	8.16	
	Occasionally	6.57	5.85	7.94	
	Frequently	6.16	4.84	8.66	
Daytime sleepiness, %	Never	31.36	30.63	32.70	.1974
	Rarely	21.97	21.83	22.23	
	Sometimes	28.00	28.66	26.79	
	Often	12.91	13.62	11.61	
	Almost always	5.75	5.25	6.67	
Unrestful sleep, %	Never	26.47	24.24	30.58	.0002
	Rarely	16.40	15.73	17.64	
	Sometimes	28.34	29.81	25.65	
	Often	18.03	19.57	15.19	
	Almost always	10.76	10.66	10.95	
Race, %	Non-Hispanic white	75.16	73.00	79.14	<.0001
	Hispanic/Latinos	13.35	16.45	7.65	
	Black/African American	11.49	10.55	13.21	
BMI, kg/m ²		28.7±6.6	27.7±5.8	30.5±7.8	<.0001
Waist circumference, cm		98.6±16.3	95.2±14.5	104.7±17.6	<.0001
BMI group, %	BMI <25	30.79	36.23	20.79	<.0001
	BMI 25–30	34.94	35.41	34.08	
	BMI ≥30	34.27	28.36	45.12	
Sex, %	Female	51.85	52.34	50.95	.4735
	Male	48.15	47.66	49.05	

Abbreviations: BMI, body mass index; OSA, obstructive sleep apnea. ^aP value from *t* test (for continuous variables) or chi-square test (for categorical variables) comparing patients with hypertension with patients without hypertension.

TABLE III. Association Between pOSA and Hypertension: Overall and by BMI Group

Outcome	OSA	Model	BMI Groups							
			Overall (N=4418)		BMI <25 (n=1233) Normal		BMI 25–30 (n=1551) Overweight		BMI ≥30 (n=1634) Obese	
			OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value
Hypertension	pOSA	m1	1.86 (1.58–2.18)	<.0001	1.18 (0.78–1.76)	.4333	1.77 (1.34–2.34)	.0001	1.46 (1.14–1.88)	.0029
		m2	1.40 (1.13–1.75)	.0025	0.91 (0.54–1.53)	.7131	1.82 (1.26–2.62)	.0014	1.32 (0.96–1.81)	.0927

Abbreviations: CI, confidence interval; m1, unadjusted; m2, adjusted for age, sex, race, marital status, education, income to poverty ratio, health status, access to insurance, alcohol intake, current smoking, past smoking, depression, and body mass index (BMI) group (in “Overall” only); OR, odds ratio; pOSA, probable obstructive sleep apnea.

TABLE IV. Association Between pOSA and Hypertension: Overall, and by Race/Ethnicity Group

Outcome	OSA	Model	Race/Ethnicity Groups							
			Overall (N=4418)		Non-Hispanic White (n=2230)		Hispanic/Latino (n=1255)		Black/African American (n=933)	
			OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value
Hypertension	pOSA	m1	1.86 (1.58–2.18)	<.0001	1.78 (1.46–2.18)	<.0001	2.88 (2.18–3.80)	<.0001	1.88 (1.39–2.55)	<.0001
		m2	1.40 (1.13–1.75)	.0025	1.40 (1.07–1.84)	.0149	1.69 (1.13–2.53)	.0105	1.34 (0.88–2.03)	.1734

Abbreviations: CI, confidence interval; m1, unadjusted; m2, adjusted for age, sex, body mass index; group, marital status, education, income to poverty ratio, health status, access to insurance, alcohol intake, current smoking, past smoking, depression, and race (in “Overall” only); OR, odds ratio; pOSA, probable obstructive sleep apnea.

($P<.001$). While only 13.2% of non-Hispanic whites were uninsured, 24.2% of black/African Americans and 45.2% of Hispanic/Latinos reported not having health insurance ($P<.001$). Individuals with hypertension had a greater BMI ($30.5 \text{ kg/m}^2 \pm 7.8$ vs $27.7 \text{ kg/m}^2 \pm 5.8$, $P<.001$) and waist circumference ($104.7 \text{ cm} \pm 17.6$ vs $95.2 \text{ cm} \pm 14.5$, $P<.001$) than nonhypertensive patients (Table II). When comparing sleep characteristics by hypertension status, hypertensive individuals were more likely to have apnea symptoms ($P<.001$), including previous physician diagnosis of sleep apnea ($P<.001$), frequent snoring ($P<.001$), and nonrestorative sleep ($P<.001$); however, there were no differences between hypertensive and nonhypertensive participants for daytime sleepiness ($P=.197$), which was consistent with previous reports (Table II).¹³

We evaluated whether pOSA predicted hypertension first in the entire cohort, then within BMI and race/ethnicity strata. Among the entire cohort, pOSA was a significant predictor of hypertension in unadjusted models (odds ratio [OR], 1.86; 95% confidence interval [CI], 1.58–2.18) and in models adjusted for age, sex, race, marital status, education, income to poverty ratio, health status, access to insurance, alcohol intake, current and past smoking, and depression (OR, 1.40; 95% CI, 1.13–1.75) (Table III and Table IV). In obesity subgroups, the strongest significant association was observed among overweight individuals (OR, 1.82; 95% CI, 1.26–2.62), and this was not significant among normal (BMI <25 kg/m²) or obese (BMI ≥30 kg/m²) groups in fully adjusted models (Table III). When

stratifying by race/ethnicity, pOSA was the strongest predictor of hypertension among Hispanic/Latinos in unadjusted models (OR, 2.88; 95% CI, 2.18–3.80), and this association remained significant in fully adjusted models (OR, 1.69; 95% CI, 1.13–2.53) (Table IV). Among black/African American patients, pOSA was not a significant predictor of hypertension in fully adjusted models (Table IV), but effect modification by BMI group was evident (P value for interaction=.009). In multivariate models stratified by race/ethnicity and BMI, pOSA was associated with greater than a 4-fold odds of hypertension among overweight black/African Americans (OR, 4.74; 95% CI, 1.86–12.03) (Figure 1, Table S2). This association was also significant among overweight non-Hispanic whites (OR, 1.65; 95% CI, 1.06–2.57) in fully adjusted models. A significant association between pOSA and hypertension demonstrated a 2-fold increased odds in fully adjusted models among obese Hispanic/Latino participants (OR, 2.01; 95% CI, 1.16–3.49), but not among overweight Hispanic/Latinos (OR, 1.59; 95% CI, 0.71–3.55) (Figure 1, Table S2).

DISCUSSION

These findings suggest that a pOSA score, which was based on symptoms and/or previous diagnosis, is an independent predictor of hypertension in an ethnically diverse sample. pOSA was most useful in overweight individuals (BMI of 25–30 kg/m²) and among Hispanic/Latinos. A strong and significant association was also demonstrated between pOSA and hypertension among

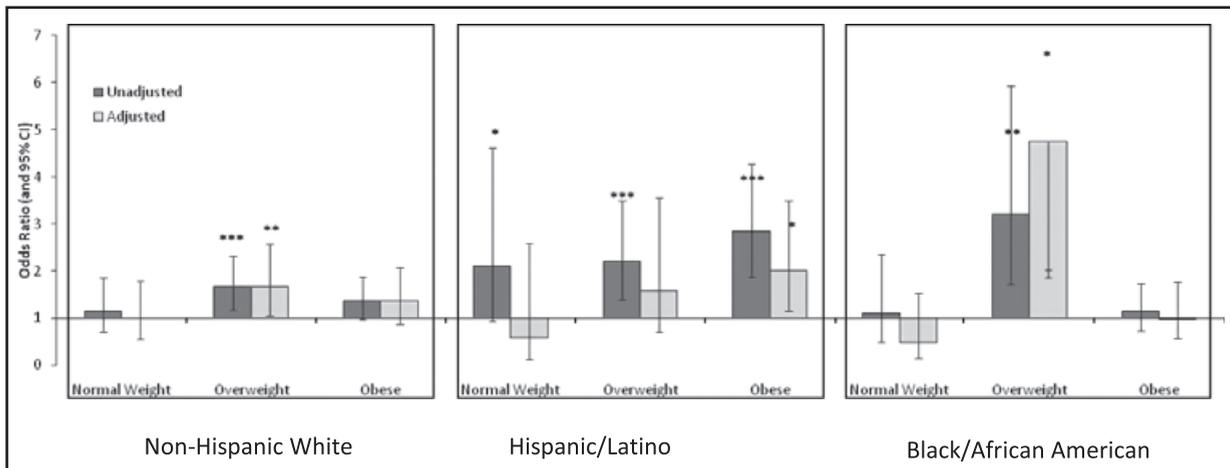


FIGURE 1. Association between probable obstructive sleep apnea and hypertension stratified by race and body mass index group. CI indicates confidence interval.

obese Hispanic/Latinos, unlike the other race/ethnicity groups, where obesity may have “overshadowed” any additive risk conferred by background sleep apnea.

Convincing evidence suggested that sleep apnea symptoms are associated with hypertension among overweight individuals. OSA among obese populations has been widely studied³⁰; however, our findings suggest that these self-reported symptoms are more relevant in patients who are overweight but not obese. A possible reason for this is that obesity or morbid obesity already confers significant risk for cardiovascular disease, independent of the presence of OSA. However, in overweight groups such symptom assessment is helpful in marking those with hypertension, and future studies utilizing OSA screening should target this weight group.

The majority of large US sleep cohorts evaluating this topic have been relatively homogeneous, consisting mostly of non-Hispanic white participants.^{31–33} The present study offers a more ethno-racially diverse sample and highlights both the increased odds of hypertension among black/African Americans and Hispanic/Latinos with pOSA, as well as the need for further investigation and oversampling of these race groups in future studies.³²

This recommendation is supported by the finding that the prevalence of hypertension and uncontrolled hypertension is disproportionately high among black/African Americans compared with non-Hispanic whites (OR, 2.54; 95% CI, 1.90–3.40),³⁴ and prevalence of hypertension among this race group has significantly increased from 1988 to 1994 through 2007 to 2008 ($P=.04$).^{35,36} In addition, very little evidence exists regarding sleep health among Hispanic/Latinos, the fastest-growing minority population in the United States.³⁷ The Hispanic/Latino population has disproportionately high levels of obesity, hypertension, and cardiovascular disease,^{38–40} all of which are linked to sleep apnea. Our findings indicate that pOSA was

associated with a 69% increased odds of hypertension among Hispanic/Latinos independent of sociodemographics and traditional cardiovascular risk factors. Although the prevalence of OSA in Hispanic/Latinos is unknown, studies suggest a greater prevalence of snoring among Hispanic/Latinos compared with their non-Hispanic white counterparts (OR, 2.30; 95% CI, 1.43–3.69 for men and OR, 2.25; 95% CI, 1.48–3.42 for women).⁴¹ Thus, given the observed differences in race-stratified adults, a better understanding of risk factors and treatment opportunities for sleep apnea and hypertension among black/African Americans and Hispanic/Latinos is needed when developing novel, population-wide preventative and therapeutic strategies.

The nation-wide obesity epidemic may be contributing to rising sleep apnea rates in the United States. As previously noted, PSG assessment is costly, time-consuming, and not accessible to a large proportion of the US population. Access to healthcare, a sleep specialist, or even a general health provider is unavailable for many. Symptom-based screening offers an attractive alternative, given the risk of adverse cardiovascular outcomes associated with untreated OSA. According to these data, although approximately 19% of the overall population reported being uninsured, this number was disproportionately higher (45%) among Hispanic/Latino individuals. Therefore, PSG testing, case identification, initiation of treatment, and potential benefits of that treatment, including potential BP-lowering effects, would be inaccessible to just less than half of the Hispanic/Latinos in this study. Implementing a simple tool such as pOSA, as well as exploring treatment options, is all the more critical in this ethno-racial group given the current limitations in clinical application.

LIMITATIONS

We note several limitations and strengths of the current study. The cross-sectional study design limits causal

inference. Additionally, self-reports may have introduced misclassification. We surmise that such misclassification would be nondifferential with respect to the presence of OSA, and so we expect that the utility of the pOSA score would be biased toward the null. We recognize that the prevalence of overweight and obese individuals in our sample was relatively high and that we did not have an even distribution of lower-weight individuals. In an effort to address this issue, we presented all models stratified by BMI group in addition to the overall results. Residual confounding is also inherent in the observational study design; however, this robust dataset allows us to evaluate differences by race/ethnicity, an area of sleep research that remains under-explored. We used a nationally representative sample, which has clear benefits in generalizability compared with prior studies that draw from specialized, clinic-based cohorts. Finally, the tool we developed relies on simple symptoms of OSA, which are easily obtainable and feasible on a mass scale and were strongly associated with increased BP.

CONCLUSIONS

Symptom-based identification of OSA is an important area for future prevention efforts, especially given the rising rates of obesity and sleep apnea. Symptoms had the strongest association with hypertension among overweight individuals, a group that deserves attention in prospective evaluations in the future. Future studies should also attempt to validate our sleep apnea assessment tool by conducting confirmatory sleep studies in a community-based sample. Additionally, differences persisted by race/ethnicity groups, and further exploration of this association in studies that oversample for Hispanic/Latino and black/African American patients is warranted. Finally, prior studies have shown that PAP therapy yields greater BP reductions in some subgroups than others.⁸ Whether these differences are a function of race/ethnicity deserves investigation.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Demographic information stratified by race.

Table S2. Association between probable obstructive sleep apnea and hypertension stratified by race and body mass index group [see Figure 2].