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Association between Snoring and Common Co-morbid Medical Conditions

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MF and CL designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SK and CS managed the analyses of the study. Author MN managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Objectives: Habitual snoring is common in both men and women. Obstructive sleep apnea (OSA) is associated with a higher prevalence of conditions such as coronary artery disease (CAD) and stroke. We hypothesized that snoring may share some of these risks.
Methods: The 2012 Behavioral Risk Factor Surveillance System survey addressed demographic factors, comorbidities, and the snoring status of respondents in 4 states, namely Alaska, Nevada, Oregon and Puerto Rico. Data from 17,492 adults (≥ age 18 years) respondents was analyzed. A chi square test for categorical variables and t-test for continuous variables was used. Logistic regression analysis was used to study the association between comorbidities and snoring. Statistical analysis was performed using SAS 9.4 for Windows (SAS Institute, Inc., Cary, NC, USA).
Results: Snoring was reported by 47% male and 53% female respondents. Snorers were older (54.3 +15.4 years' vs 50.7 +19.5 years, p <0.001), of male gender (46.8% vs 35.1%, p <0.0001), had a BMI in the overweight to obese range (p<0.0001) and were more likely to be current or

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former smokers (46.0% vs. 35.9%, p < 0.0001) as compared to non-snorers on bivariate analysis. After controlling for age, BMI and smoking, snoring was associated with a higher odds ratio of CAD/angina, asthma, Asthma-COPD overlap syndrome, arthritis and depression on multivariate analysis, as compared to non-snorers.

Conclusion: Snoring is associated with a higher prevalence of common comorbid medical conditions. Whether co-morbidities are caused by undiagnosed OSA or factors unique to snoring will require prospective, long term interventional studies.

Keywords: Snoring; co-morbidities; behavioral risk factor surveillance system; prevalence.

ABBREVIATIONS

BRFSS : Behavioral Risk Factor Surveillance System
CDC : Center for Disease Control and Prevention
BMI : Body Mass Index
OSA : Obstructive Sleep Apnea
COPD : Chronic Obstructive Pulmonary Disease
ACOS : Asthma- COPD Overlap Syndrome

1. INTRODUCTION

Snoring is the sound generated during sleep by vibration of loose tissue in the upper airway. It is the result of increased airway resistance of the upper respiratory tract; and is also a common finding with obstructive sleep apnea (OSA). Snoring, however, is much more common than OSA with 28% women and 44% men reported to be habitual snorers[1]. OSA is associated with significant adverse effects on health including coronary artery disease (CAD) [2], stroke [3] and cognitive impairment [4]. Snoring is a milder form of sleep disordered breathing and like OSA has been associated with daytime sleepiness and disruption of bed partner sleep. Thus, snoring represents a common problem in the daily lives of patients and their families. However, the health consequences of simple snoring are not clearly understood. Some studies have reported an association between snoring and cardiovascular disease [5,6] while other studies have reported no association [7]. A prospective study has demonstrated that snoring was an independent risk factor for type 2 diabetes mellitus [8]. Few studies, however, have addressed the relationship between snoring and other common co-morbidities such as depression, arthritis, chronic obstructive pulmonary disease (COPD), asthma and cancer.

A diagnosis of snoring does not require a sleep study and therefore most epidemiological studies have used a self-report of snoring to study correlations between snoring and disease burden. Lack of need for formal testing confers the inherent ability to study large databases. Thus, our study used the 2012 Behavioral Risk Factor Surveillance System (BRFSS), a Center for Disease Control (CDC) conducted telephone national health survey, to evaluate the association between snoring and common comorbid conditions. Our hypothesis was that snoring is associated with a higher prevalence of common co-morbid medical conditions as compared to non-snorers. Our specific aim was to evaluate the association between snoring and common co-morbid medical conditions.

2. MATERIALS AND METHODS

This study did not qualify as human subjects research as determined by the Medical University of South Carolina's Institutional Review Board (IRB), and hence IRB approval was not needed. This was a retrospective study which utilized data from the publicly available landline and cellphone 2012 BRFSS dataset.

BRFSS consists of cross-sectional health-related telephone surveys that state health departments conduct monthly with a standardized questionnaire. It is used to collect data about U.S. residents regarding their health-related risk behaviors, chronic health conditions, and use of preventive services. Respondent data are aggregated by the CDC for each state, and published at year's end by each state. Currently, BRFSS collects data in all 50 states as well as the District of Columbia and three U.S. territories. More than 400,000 adult interviews are completed each year. In addition to the core module, individual states can choose to add more questions designated as optional modules or state-added questions. The BRFSS has been used in the US for more than 30 years to determine the prevalence of many chronic diseases, and is a valuable resource in determining disease burden in the US.

Since questions on sleep and snoring were only included in the BRFSS survey modules for Alaska, Nevada, Oregon and Puerto Rico, only respondents from these states were analyzed. Data points extracted included demographic factors, self-reported physician diagnosis of chronic health conditions, and the snoring status of respondents. The demographic factors included were age, gender, body mass index (BMI), race, education, marital status, employment, income, smoking status, and alcohol consumption. Respondents were asked about a history of snoring, but the survey did not contain questions regarding a history of OSA. The co-morbidities analyzed were CAD/angina, arthritis, depression, diabetes, kidney disease, stroke, cancer, asthma, COPD and asthma-COPD overlap syndrome (ACOS).

The diagnosis of COPD, asthma and ACOS was determined from 3 questions: (1)" Has a doctor, nurse, or other health professional ever told you that you have chronic obstructive pulmonary disease, emphysema or chronic bronchitis", (2)" Has a doctor, nurse, or other health professional ever told you that you have asthma" (3) "Do you still have asthma". Respondents were included in the COPD group if they answered "Yes" to question (1) and "No" to (2) and (3). Respondents were included in the asthma group if they answered "Yes" to questions (2) and (3) but "No" to (1). If respondents answered "Yes" to all three questions, they were included in the ACOS group and were not included in the COPD or asthma group.

2.1 Statistical Analysis

We performed the statistical analysis using SAS 9.4 (SAS Institute, Inc. Cary, North Carolina). We first described the study sample demographics, lifestyle factors and co-morbidities based on the presence or absence of snoring using Pearson's chi square test for categorical variables and t-test for continuous variables. Two-sided significance between variables was established at $p < 0.1$ to include these into a multivariate model. Multivariate logistic regression was used to study correlations between significant co-morbid conditions, and snoring, controlling for demographic factors. We further stratified the study population by gender and performed a similar analysis for studying correlations between comorbid conditions and snoring in men and women. We estimated the prevalence odds ratios (OR) and their 95% confidence intervals (CI) to determine the magnitude of the association between co-morbidities and snoring controlling for significant demographic factors.

3. RESULTS

Fig. 1. Shows the consort diagram for inclusion of respondents in the study. There were 20,816 respondents from Alaska, Oregon, Nevada and Puerto Rico. 3174 respondents were excluded as they were ≤ 18 years of age and another 150 were excluded for incomplete data. Of the final 17,492 respondents, 9330 were self-reported snorers and 8162 were not.

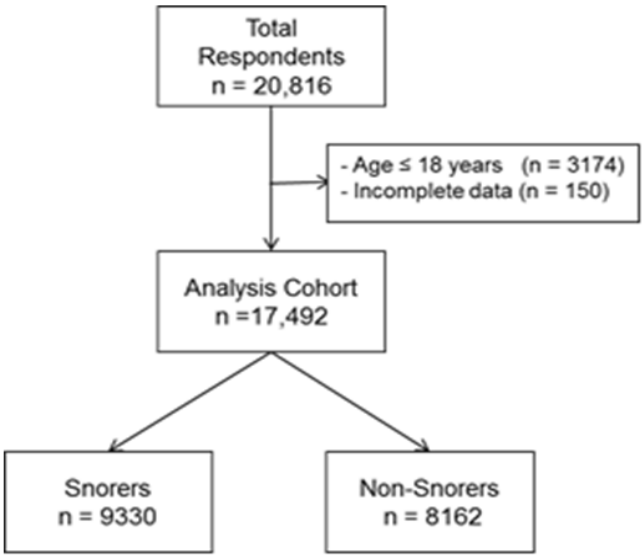

Fig. 1. Flow chart for inclusion of respondents in the study

Table 1. Demographic characteristics of respondents ≥ 18 years of age based on the presence or absence of snoring in the 2012 behavioral risk factor surveillance system database on bivariate analysis

	Snorers	Non-snores	p value
Age	54.3±15.43	50.7±19.50	<0.0001
Gender (Male)	4366(46.8)	2868(35.1)	<0.0001
Race			
White, non-Hispanic	4808(51.5)	4803(50.0)	<0.0001
Black, non-Hispanic	137(1.5)	109(1.3)	
Other races, non-Hispanic	572(6.1)	582(7.1)	
Multiracial, non-Hispanic	335(3.6)	259(3.2)	
Hispanic	3407(36.5)	3071(37.6)	
Education			
Did not graduate high school	1094(11.7)	986(12.1)	<0.0001
Graduated from high school	2425(26.0)	2010(24.6)	
Attended technical college or school	32764(29.6)	2300(28.1)	
Graduated from college	3038(32.6)	2850(34.9)	
Marital status			
Married	5295(57.0)	3799(46.7)	<0.0001
Never married/ member of unmarried couple	1561(16.8)	2061(25.3)	
Divorced /widowed /separated	5395(57.0)	2270(27.9)	
Income			
< 15000	1612(17.3)	1501(18.4)	<0.0001
15000-25000	1634(17.5)	1355(16.6)	
25000-35000	813(8.7)	752(9.2)	
35000-50000	1053(11.3)	873(10.7)	
>50000	3068(32.9)	2468(30.2)	
Employment			
Employed	4473(48.1)	3738(46.0)	<0.0001
Homemaker/ student	1050(11.3)	1478(18.2)	
Unemployed	3785(40.7)	2919(35.9)	
Body mass index			
Normal	2145(23.0)	3533(43.3)	<0.0001
Underweight	419(4.5)	560(6.9)	
Overweight	3574(38.3)	2664(32.6)	
Obese	2709(29.0)	1253(15.4)	
Morbidly obese	483(5.2)	152(1.9)	
Smoking status			
Current smoker	1465(15.7)	1033(12.7)	<0.0001
Former smoker	2813(30.3)	1890(23.2)	
Non-smoker	5011(53.9)	5207(64.0)	
Alcohol consumption*	790 (8.5)	586 (7.2)	0.002

** Women ≥ 1 alcoholic drink/day, Men ≥ 2 alcoholic drinks/day*

On bivariate analysis, as compared to non-snorers, snorers were older (54.3 ± 15.4 vs 50.7 ± 19.5 years, p <0.001), of male gender (46.8% vs 35.1%, p <0.0001), had a body mass index (BMI) in the overweight to obese range (p<0.0001) and were more likely to be current or former smokers (46.0% vs 35.9%, p < 0.0001) (Table 1). Snorers also had a higher prevalence of alcohol consumption as compared to non-snorers (8.5% vs. 7.2%, p = 0.002). Snorers had a higher prevalence of CAD/angina (8.0% vs 5.0%, p < 0.0001), asthma (10% vs 8%, p < 0.0001), COPD (8% vs 5%, p < 0.0001), ACOS (3% vs 2%, p < 0.0001), arthritis (36% vs 27%, p < 0.0001), depression (23% vs 16%, p < 0.0001), cancer (8% vs 7%, p = 0.001) and diabetes mellitus (15% vs 11%, p < 0.0001), as compared to non-snorers on bivariate analysis (Table 2). No significant difference in the prevalence of stroke was seen between snorers and non-snorers.

Demographic factors and co-morbid conditions with a p < 0.1 were transitioned to multivariate

analysis to assess their relationship with snoring (Fig. 2).

Self-reported snoring was associated with a higher OR of CAD/angina, asthma, ACOS, arthritis and depression on multivariate analysis. Snoring was not associated with a higher prevalence of diabetes, cancer or chronic kidney disease.

On further stratification by gender, we found no association between co-morbidities and snoring in males except for arthritis (OR: 1.15, 95% CI: 1.02-1.30, p=0.03), and depression (OR: 1.38, 95% CI: 1.19-1.60, p<0.0001). There was a positive association between co-morbidities and snoring in females, for asthma (OR: 1.18, 95% CI: 1.01-1.38, p=0.03), ACOS (OR: 1.80, 95% CI: 1.38-2.36, p<0.0001), coronary heart disease or angina (OR: 1.32, 95% CI: 1.10-1.59, p=0.03), arthritis (OR: 1.30, 95% CI: 1.19-1.44, p<0.0001), depression (OR: 1.65, 95% CI: 1.48-1.83, p<0.0001), and diabetes (OR: 1.16, 95% CI: 1.02-1.32, p=0.03) (Fig. 3).

Table 2. The distribution of co-morbidities amongst respondents based on the presence or absence of snoring in the 2012 behavioral risk factor surveillance system database on bivariate analysis

	Snorers	Non-snores	p value
Asthma	948(10.2)	621(7.7)	<0.0001
COPD	701(7.5)	384(4.7)	<0.0001
ACOS	286(3.1)	123(1.5)	<0.0001
Myocardial infarction	520(5.6)	353(4.3)	0.0002
Coronary heart disease/Angina	715(7.7)	401(4.9)	<0.0001
Stroke	310(3.3)	230(2.8)	0.0544
Cancer	773(8.3)	568(7.0)	0.001
Arthritis	3286(35.5)	2182(26.9)	<0.0001
Depression	2119(22.8)	1263(15.5)	<0.0001
Kidney disease	294(3.2)	211(2.6)	0.0256
Diabetes	1400(15.4)	851(10.7)	<0.0001
Presence of at least 1 comorbidity	5589(59.9)	3983(48.8)	<0.0001

Abbreviations: COPD = Chronic obstructive pulmonary disease, ACOS = Asthma-COPD overlap syndrome

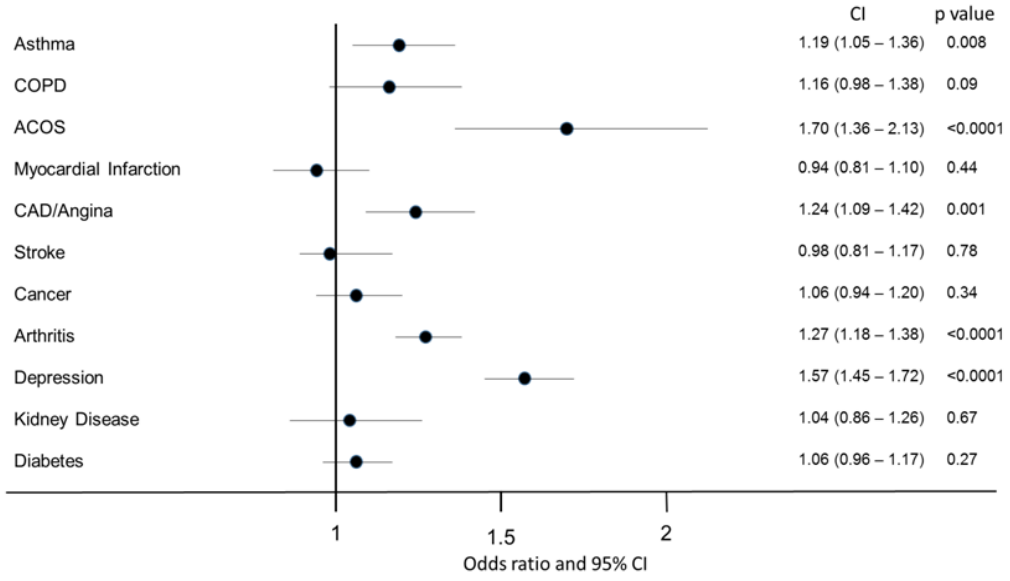

Fig. 2. Logistic regression model adjusted for baseline differences in demographic variables showed that snorers had a higher prevalence of comorbidities for 5 of the 11 sampled chronic conditions as compared to non-snorers

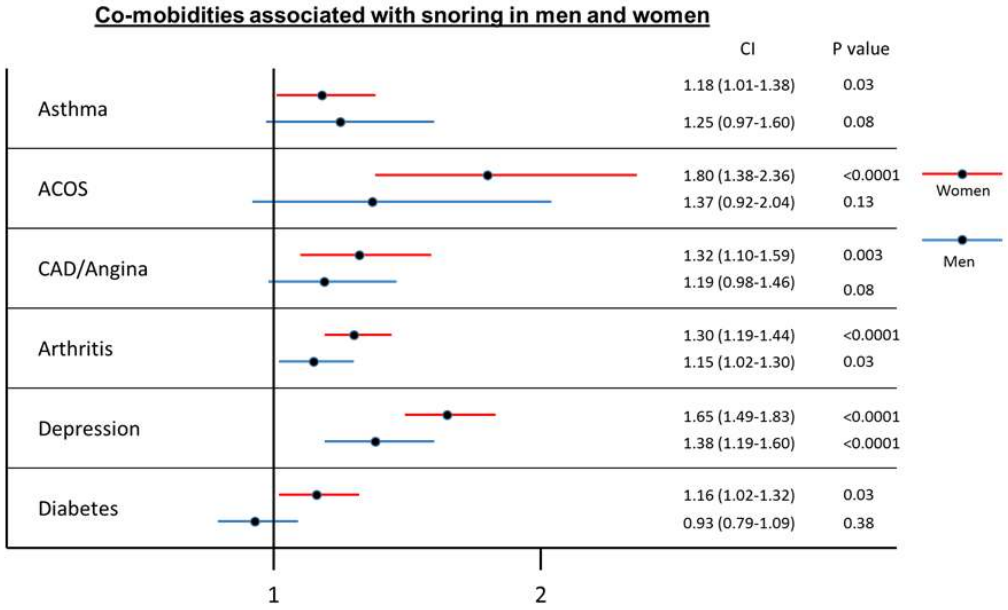

Fig. 3. Stratification of comorbidities by gender showed a trend towards more co-morbid conditions in association with snoring in women as compared to men

Abbreviations: CAD = Coronary artery disease, ACOS = Asthma-COPD overlap syndrome

4. DISCUSSION

Our study demonstrates that self-reported snoring is strongly associated with a higher prevalence of multiple medical co-morbidities such as CAD/angina, asthma, ACOS, arthritis and depression. As shown in prior studies, snoring was more common in men, more common with aging, and was associated with a higher BMI [6].

Cardiovascular disease and snoring both have a high prevalence in the general population. Consequently, understanding the interaction between the two is important. However, studies in this regard have shown mixed results. Consistent with our study, an epidemiologic study by Norton, et al. [1] found an association between snoring, hypertension and heart disease after correcting for obesity and smoking. Another study by Bhattacharyya, N. [6] which also used the 2012 BRFSS survey data, found a strong association of snoring with CAD and depression in a multivariate model, although the association of snoring with other co-morbidities was not evaluated. Conversely, Yaboah, et al. [7] did not find an association between snoring and cardiovascular disease in a study of 5338 participants on 7.5 average years of follow up. Despite some negative studies, the bulk of evidence points toward a positive association between snoring and cardiac disease.

The mechanisms by which snoring may predispose to cardiovascular disease are poorly understood. In a recent study, self-reported snoring was associated with higher pulse wave velocity and augmentation indexes, which are markers of arterial stiffness, as compared to non-snorers [9]. In addition, there is emerging evidence that systemic inflammation and oxidative stress may be associated with primary snoring. A recent pediatric study revealed higher levels of serum resistin, an adipokine which increases insulin resistance, in children with primary snoring as compared to non-snorers [10]. Snoring has also been found to be associated with high C-reactive protein levels, as compared to non-snorers [11]. Thus, snoring maybe associated with a pro-inflammatory state, similar to that seen with OSA [12,13], and this maybe one of the underlying mechanisms by which snoring predisposes to cardiovascular disease.

Similarly, stroke is a disease of the cerebral vasculature which is susceptible to inflammation and oxidative stress associated with snoring.

While our study failed to show statistical significance for stroke, it was missed only by a narrow margin. A recent meta-analysis by Li et al. [14] however, showed an association between habitual snoring and stroke. Future longitudinal studies are required to further delineate the association between stroke and snoring.

Our results also demonstrated an association between arthritis and snoring. The BRFSS questionnaire did not distinguish between rheumatoid arthritis which is an inflammatory arthritis and osteoarthritis (OA). Obesity is common in patients with OA and may explain some of the association. However, OA has also recently been shown to have increased levels of circulating inflammatory cytokines in obese patients [15]. Thus, the association between snoring and a pro-inflammatory state may partly explain the pathogenesis of arthritis.

Airway inflammation is a hallmark of COPD, asthma and ACOS. COPD missed significance, but both ACOS and asthma were found to be associated with snoring in our study. The results are supported by a recent study by Alchakaki et al. [16] which demonstrated that expiratory snoring predicted obstructive airway disorders. Cigarette smoking and environmental smoke exposure have been identified as risk factors for both COPD and snoring [17,18], which may explain some of the association between COPD and snoring. Our analysis controlled for the categorical variables of current and past smoking, however it did not include the intensity of smoking which might underestimate this association and explain why COPD narrowly missed significance. The common pathways of nasal and airway inflammation also likely drive some of this concordance.

There are other factors that correlate with the obstructive lung diseases that might be altered by snoring. Gastroesophageal reflux disease (GERD) has been associated with obesity and snoring [19] and also with asthma [20]. Snoring increases trans-diaphragmatic pressure swings and may worsen GERD and thereby asthma control. Furthermore, shear stress in the airways, potentially induced by snoring, could participate in remodeling of the airway wall or lung parenchyma [21]. Thus, alteration of airflow patterns in the upper airway, may contribute further to inflammatory and/or non-inflammatory associations seen between snoring and obstructive airways disease in our study.

Depression was also found to be associated with snoring. Depression is a highly prevalent condition and is a complex disease related to biochemical and social factors. Maternal snoring has been found to be associated with prenatal depression [22]. Frequent snoring has been found to be associated with probable major depression in a national sample of adults from the National Health and Nutrition Examination Survey, 2005-2008 [23]. Potentially, sleep disruption related to snoring and co-existent OSA in some patients may be partly responsible for this association.

Our study failed to show an association between snoring and diabetes, cancer or chronic kidney disease. Previously, a study by Al-Delaimy et al. [8] had shown that snoring is associated with diabetes. Colorectal cancer has also been associated with sleep duration and snoring by Zhang et al. [24]. These discrepancies may be related to response bias in our study. True diabetes may be under represented by 27% false negative self-report as reported by the CDC. Similarly, it is unknown if our respondents were up to date on their age-appropriate cancer screening workup.

Men have a higher prevalence of snoring than women. We analyzed our data to see if there is any difference in the co-morbidities associated with snoring in men and women. Interestingly only arthritis and depression were found to be significant co-morbidities associated with snoring in men while asthma, ACOS, CAD, arthritis, depression and diabetes were all significantly associated with snoring in women. In our analysis, the confidence intervals overlap greatly. We cannot demonstrate that these associations are real, but there is a trend towards more co-morbid conditions in association with snoring in women as compared to men.

Obesity is a known risk factor for snoring [25]. Our study had a higher proportion of snorers who were obese and morbidly obese as compared to non-snorers. A few studies have shown that BMI strongly influences snoring [26]. Abnormal deposition of fat in the throat causing increased pressure and weakening of pharynx can lead to snoring [27]. Large studies are needed to address weight loss strategies as well as their influence on snoring and co-morbidities in obese and morbidly obese patients.

Our study has some limitations. BRFSS is a cross-sectional questionnaire and implies only

associations and not causality. Moreover, comorbid conditions were recorded by self-report only. Self-reported data can result in oversampling. In addition, sleep module questions were only available for Oregon, Nevada, Alaska and Puerto Rica. Hence, the results may not be generalizable to the entire population of the United States. Sleep studies were not performed and thus, it is possible that some subjects, who reported snoring, may have had OSA, which has been shown to be associated with co-morbidities such as depression and CAD. Nevertheless, primary snoring is much more common than OSA, and this study highlights important epidemiological associations between snoring and several medical co-morbidities. The strength of our study is the large sample size available for analysis.

5. CONCLUSION

Our study demonstrates that snoring is a common condition and is associated with several medical co-morbidities including asthma, ACOS, coronary artery disease/angina, arthritis, and depression. Future large scale, interventional longitudinal studies will be needed to better understand the underlying mechanisms of these associations and evaluate the effect of aggressive treatment of snoring on cardiovascular disease and other common co-morbidities.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This study did not qualify as research on human subjects as determined by the Medical University of South Carolina's Institutional review board (IRB), and hence IRB approval was not needed. Additionally, BRFSS is a publicly available database.

COMPETING INTERESTS

Dr. Lal has received grant support from Jazz pharmaceuticals and Invado pharmaceuticals and is a consultant for Ikaria and Cipla pharmaceuticals.

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