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Differences between Men and Women in Risk Profile of commonly used metrics in Screening for Obstructive Sleep Apnea using NHANES data.

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Differences between Men and Women in Risk Profile of commonly used metrics in Screening for Obstructive Sleep Apnea using NHANES data.

by

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Differences between Men and Women in Risk Profile of commonly used metrics in Screening for Obstructive Sleep Apnea using NHANES data.

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Obstructive Sleep Apnea (OSA) is a common chronic condition that is often underdiagnosed, especially in women due to differences in symptomology. OSA is diagnosed using polysomnography which is time intensive and impracticable as a screening method. Alternate methods for screening based on symptoms exist with varying sensitivities. This study used the National Health and Nutrition Examination Survey (NHANES) based on a nationally representative US sample (n=20,497) to test for associations between self-reported sleep apnea and risk factors, such as snoring, fatigue, hypertension, and obesity. Data was taken from the sleep questionnaire 2005-2008, along with BMI, blood pressure, and demographic data for 12,600 subjects at least 16 years old. After excluding those with missing data on the set of risk factors, the final sample was 8373. A main objective of the study was to see if there was a difference in risk profile between men and women. Multivariable model (using logistic regression) compared [snoring, observed apnea, somnolence, age, gender, hypertension, BMI, history of

smoking, race/ethnicity, education, and annual household income] to self-reported sleep apnea. Results indicated that observed apnea had the highest risk of OSA (OR:7.435, 95% CI:5.698, 9.745) followed by obesity (OR:4.524, 95% CI:3.523, 5.849). Snoring, age, and annual household income had statistically differing risks between men and women.

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List of Abbreviations

UTMB	University of Texas Medical Branch
GSBS	Graduate School of Biomedical Science
OSA	Obstructive Sleep Apnea
NHANES	National Health and Nutrition Examination Survey
RDI	Respiratory Distress Index
AHI	Apnea-Hypopnea Index
BMI	Body Mass Index
SA-SDQ	Sleep Apnea scale of the Sleep Disorders Questionnaire
AS	Apnea Score
PPV	Positive Predictive Value
NPV	Negative Predictive Value
COPD	Chronic Obstructive Pulmonary Disease
CI	Confidence Intervals
GED	General Educational Development Test
OR	Odds Ratio
Hx SMK	History of Smoking
Somn	Somnolence
AIC	Akaike information criterion
Se	Sensitivity
Sp	Specificity

Chapter 1 Aims and Introduction

AIMS

Obstructive Sleep Apnea (OSA) is a chronic condition in the United States that has a prevalence between 38% and 68% of adults 60 years of age or older according to a retrospective chart review of 596 patients (Samson 2012). Up to 82% of men and 93% of women with OSA may not be diagnosed according to a study of 1,090 employed adults using questionnaire data (Young 1997). OSA is diagnosed using polysomnography which requires the patient to spend an overnight at the hospital while being monitored. It is not feasible to perform polysomnography as a widespread diagnostic test to patients who do not have a high suspicion of having OSA. Primary care physicians may rely on screening questionnaires to determine whom to refer for polysomnography. Various screening questionnaires are used and have been studied on how predictive they are at identifying polysomnography confirmed OSA. Symptom prevalence differ between men and women with OSA, with women presenting with less classic symptoms than men (Young 1996). For this reason, there could be more of an underdiagnosis of OSA in women. OSA is a risk factor for other comorbidities and can increase the risk of mortality.

This proposed study will examine common symptoms of OSA and identify differences between men and women. Using the NHANES nationally representative sample, symptoms used in screening scales will be explored, to maximize detection in ambulatory settings and then compare results to existing scales.

Specific Aim 1: Define and describe the NHANES sample for OSA symptoms and self-reported OSA diagnosis.

1.1 Obtain descriptive statistics for snoring, observed apnea, somnolence, hypertension, obesity, age, gender, smoking history, and covariates (race/ethnicity, education, and annual household income) by self-reported OSA diagnosis.

1.2 Determine final sample and obtain descriptive statistics after applying exclusion criteria: missing data, duplicate id, and age younger than 16 years old.

Specific Aim 2: Determine which variables commonly used in OSA screens are most predictive of OSA in a nationally representative sample.

2.1 Examine Crude (bivariate) associations between symptoms and self-reported OSA diagnosis.

2.2 Examine the association of symptoms when considered together and controlling for covariates in a Multivariate logistic regression model.

Specific Aim 3: Determine differences in risk factors by gender.

3.1 Obtain descriptive statistics for snoring, observed apnea, somnolence, hypertension, obesity, age, smoking history, and covariates (race/ethnicity, education, and annual household income) by gender.

3.2 Examine multivariate logistic regression model of risk factors separately for males and females and determine sensitivities of risk factors for males and females.

INTRODUCTION

The general aim of this study is to determine the association of risk factors and symptoms of obstructive sleep apnea (OSA) to the diagnosis of OSA using a nationally representative cross-sectional survey: NHANES. Another aim is to compare the differences in risk profile between males and females. Finally, sensitivities will be calculated. Further research could take these results to develop novel screens and prospectively study a cohort of subjects validating the screen with polysomnography.

Sleep apnea is the temporary arrest in ventilation during sleep and is frequently caused by an obstructed airway; this is called obstructive sleep apnea (OSA) (Muza 2015). OSA is diagnosed using polysomnography. It is impractical to use polysomnography as a screening device; rather, screens based on symptomology and risk factors are used in ambulatory settings to screen and then refer high risk individuals for diagnostic polysomnography. OSA is underdiagnosed in both males and females, but more in females due to differences in how females present with symptoms of OSA which makes it more difficult for screens to catch since most screens are not gender specific. According to a review, females are more likely to present atypically: decreased snoring, but increased somnolence, morning headache, lack of energy, insomnia, mood disturbance, and nightmares; with a lower corresponding AHI (Bongsignore 2019).

Review of Existing Scales

OSA is diagnosed by polysomnography, but there are several screening tests that use symptoms and risk factors in questionnaires to detect OSA. These are quick and cheap methods for screening in a clinic.

The Berlin Scale has 62% sensitivity and 43% specificity in detecting Respiratory Disturbance Index (RDI) > 10 with two-night polysomnography (Ahmadi 2018). Using a retrospective chart review of 130 sleep clinic patients which 26.2% had OSA as defined as an RDI > 10. It uses five symptoms: high blood pressure, snoring, loud snoring, observed apnea, and somnolence (Table 1). The Berlin Scale is scored by assigning one or two points to each multiple-choice question answered within a category of questions, and then determining high or low risk based on how many categories had a sufficiently high number (Appendix, Figure 2). (1) Category one asks: "Do you snore? *Yes/No/Don't know*", "Your snoring is: *Slightly louder than breathing/As loud as talking/Louder than talking/Very loud*", "How often do you snore? *Daily/Most days/Weekly/Monthly/Never*", (2) "Has your snoring bothered other people? *Yes/No/Don't know*", (3) Has anyone noticed that you quit breathing during sleep? *Daily/Most days/Weekly/Monthly/Never*". (4) Category two asks: "How often do you feel fatigued or tired after your sleep?", "During your waking time, do you feel tired, fatigued, or not up to par?", "Have you ever nodded off or fallen asleep while driving a vehicle?" Answer choices for category two are: *Daily/Most days/Weekly/Monthly/Never*." (5) Category three is a single question: "Do you have high blood pressure?" "*Yes/No/Don't know*." Every question gets scored one point for a positive response, except question 5 and 10 which get two points. Categories 1 and 2 are positive if they score at least two points. Category 3 is positive if the answer is yes or BMI>30. Risk of OSA is high if at least two categories are positive. Positive predictive and negative predictive values can be improved using this scale in certain populations that have a higher prevalence of OSA such as patients with a BMI greater than 30 kg/m2 (Ahmadi 2008). A

meta-analysis with four studies (n=545) that used the Berlin Scale had an aggregate estimate of 77% sensitivity and 74% specificity (Abrishami 2010).

STOP used four symptoms in the Berlin scale (1. Loud Snoring, 2. Somnolence, 3. Observed Apnea, 4. Hypertension), but used loud snoring, instead of snoring (Chung 2008). Pre-operative patients with no prior diagnosis of sleep disorder (n=2467) were given the questionnaire with a subsample of 177 getting subsequent one night polysomnography with measured apnea-hypopnea index (AHI) for validation purposes. AHI is a measure of the number of times an episode of apnea or hypopnea (stopped breathing) occurs in one hour of sleep. OSA is diagnosed as mild with AHI>5, moderate with AHI>15, and severe with AHI>30. The STOP scale is scored as one point for every positive symptom. STOP score of at least 2 points is considered high risk, and ranges from 0-4 (Appendix, Figure 3). When using AHI cutoffs of at least 5, 15, and 30 for a STOP score of at least 2; the sensitivities were 65.6%, 74.3%, and 79.5% respectively.

STOP-BANG has the same four symptoms as the STOP scale (1. Loud Snoring, 2. Somnolence, 3. Observed Apnea, 4. Hypertension) but with four additional measures: (5) age (>50), (6) body mass index (BMI) (>35), (7) male sex, and (8) large neck size (>40 cm) (Chung 2008). Both STOP and STOP-BANG are scored by assigning one point for each risk factor and totaling all the points. Thus, the STOP-BANG scale ranges from 0 to 8 with a score of at least 3 indicating moderate risk of OSA, and a score of at least 5 indicating high risk of OSA (Appendix, Figure 4). STOP-BANG had sensitivities for predicting study results of 83.6%, 92.9%, and 100% respectively for the same 5, 15, and 30 apnea-hypopnea index cutoff scores for STOP-BANG scores of high risk in the same sample (n=177) as was measured for the STOP scale (Chung 2008). STOP and even more-

so STOP-BANG are quick and easy with high sensitivity in moderate and severe OSA patients. In a retrospective study of midlife women seen at a women's health clinic given the STOP-BANG questionnaire and then polysomnography or home sleep apnea testing to determine an AHI. In a study of 66 midlife women a score of 3 or more symptoms had a sensitivity of 77% and specificity of 45% to predict moderate to severe OSA (Orbea 2020).

American Society of Anesthesiologist (ASA) checklist has sensitivities of 72.1%, 78.6%, and 87.2% at AHI cutoffs of 5, 15, and 30 respectively from the same study as STOP and STOP-BANG of 2467 pre-operative patients with no prior diagnosis of sleep disorder that were given the questionnaire with 177 getting subsequent one night polysomnography with measured AHI for validation. (Chung 2008) It uses six symptoms: (1) BMI, (2) large neck size (>17 in men, >16 in women), (3) loud snoring, (4) apnea, and (5) somnolence, but additionally adds (6) anatomical airway problems (Chung 2008). The ASA has a similar cut-off for severity and was not statistically different in its sensitivities at various cut-offs than the Berlin or STOP questionnaires (Chung 2008). It is scored by assigning one point to every question positively answered, and then summing points within each category of question. Risk is determined by how many categories are considered positive (Appendix, Figure 8). The ASA sensitivity is moderately high (72.1%-87.2%) and adequately predictive for complications of OSA 22.8% similar to the STOP questionnaire. The specificity (38.2%, 37.4%, and 36.2% for AHI of 5, 15, and 30 respectively) is not able to determine OSA beyond chance at any level of apnea-hypopnea index. The ASA checklist is more difficult to use than STOP-BANG, because it requires examination of airway and a more extensive medical history.

Wisconsin survey has 83% sensitivity and 50% specificity using 151 subjects from a general population and using a one-night polysomnography with an apnea-hypopnea index cutoff of 5; and uses three symptoms: (1) snoring, (2) loud snoring, and (3) apnea (Shrama 2006) (Appendix, Figure 5). A meta-analysis with two studies (n=753) found the Wisconsin Survey has 83% sensitivity and 50% specificity (Abrishami 2010).

Sleep Apnea scale of the Sleep Disorders Questionnaire (SA-SDQ) has 75% sensitivity and 65% specificity in men and 80% sensitivity and 67% specificity in women using an AHI greater than 5 (Weatherwax 2003); and uses twelve questions to determine six symptoms: (1) age, (2) BMI, (3) loud snoring, (4) apnea, (5) sweating during sleep, and (6) history of smoking (Weatherwax 2003). The study was 125 patients with epilepsy and used one night polysomnography; 45% had AHI greater than 5 indicating OSA. SA-SDQ is scored by assigning 1-5 points per question answered and then summing all the points (Appendix, Figure 9). The SA-SDQ does have different cut-offs for men and women: 32 for women and 36 for men. Somnolence is not used in this scale which can be advantageous when a patient's medical history might include comorbidities that cause somnolence unrelated to the patient's upper airway anatomy.

Haraldsson's has positive predictive value of 56% for nighttime polysomnography and 63% for daytime polysomnography; and a negative predictive value of 96% and 100% respectively (Haraldsson 1992) in a study of 42 subjects with rhonchopathy using a self-report questionnaire and both daytime and nighttime polysomnography with apnea index cutoff greater than 10. 43% of subjects had OSA. It uses four symptoms: (1) snoring, (2) observed apnea, (3) somnolence, and (4) anatomical airway problems (Haraldsson 1992). Haraldsson's is scored by assigning a value of 0-4 for each of five questions, with a score

of at least 3 to each question indicative of a higher probability of OSA (Appendix, Figure 6). The negative predictive value is high, which makes it useful for screening purposes.

The Apnea Score has 59% sensitivity and 69% specificity for AHI greater than 5, and predictive accuracy of 88% for apnea index greater than 10, and 70-76% for apnea index and apnea-hypopnea index greater than 5 (Kapuniani 1988). Apnea Score has three symptoms: (1) apnea, (2) loud snoring, and (3) history of adenoidectomy; with a positive response to all questions indicative of a higher probability of OSA (Appendix, Figure 7). It was studied with 96 subjects largely from a sleep disorder center that answered a self-report questionnaire. This was compared to one night polysomnography apnea-hypopnea index and analyzed with a stepwise multivariate discriminate analysis to categorize subjects. The Apnea Score is good at identifying moderate-severe OSA of an apnea-hypopnea score cut-off of 40, identifying 100% using the modified Apnea Score that only included “loud snoring” and “stopped breathing” in the questionnaire (Kapuniani 1988).

The various screening instruments were studied and had their predictive metrics calculated in papers that used different subject populations and characteristics, which raises a concern when trying to compare them to each other. Most used a common criterion for validation (AHI>5) from polysomnography to validate the screens, but with a different set of symptoms (TABLES 1 & 2). Sensitivity is a measure of the true positives divided by all patients with that condition. A high sensitivity ensures a low number of false negatives, and thus, high sensitivity is desirable in a screening test. Specificity is a measure of the true negatives divided by all patients without that condition. A high specificity ensures a low number of false positives, and a high specificity is desirable in a diagnostic/confirmatory test. A test that is better at lowering the number of false positives, will more likely have an

increase in the number of false negatives and vice versa. Positive Predictive Value (PPV) is a measure of the number of true positives divided by the total number of positive tests and is the likelihood that a patient has a condition given a positive test result - when the proportion of disease positive cases is equal to the population prevalence. Negative Predictive Value (NPV) is a measure of the number of true negatives divided by the total number of negative tests and is the likelihood that a patient does not have a condition given a negative test. The prevalence of a condition in a population affects PPV and NPV but does not affect sensitivity or specificity. Since most previous studies did not report PPV, sensitivity is the more important metric because they are all screening criteria. The corresponding confirmatory test is the polysomnography which allows for estimation of sensitivity and specificity but is beyond the scope of this study. Higher sensitivity is desirable and sensitivity of 85% is high (Abrishami 2010). The SA-SDQ (sensitivity=80%), Berlin (77%), Wisconsin (83%), and STOP-BANG (84%) all had the highest sensitivities in various subject populations according to a systematic review (Abrishami 2010). The STOP and STOP-BANG both have an ease of use in administering and calculating scores, as well as are acronyms that make it easy for clinicians to remember the screening symptoms. All were done with small sample sizes ($n<200$) and are not nationally representative.

Obstructive Sleep Apnea Using NHANES.

The National Health and Nutrition Examination Survey (NHANES) is a CDC database that includes interview data (including demographic information), laboratory data, and examination data, in two-year cycles. A strength of NHANES is that it is

nationally representative and incudes weighting in order to generalize to the US population. Limitations are that it is a cross-sectional design which does not allow for assessment of change. Also specific to this project, there are no polysomnography data, other than the subjects self-reporting that they have been told by a doctor that they had sleep apnea. A special sleep questionnaire was included in waves 2005-2006 and 2007-2008. These are the only cycles that the sleep questionnaires also included self-report sleep apnea.

Several studies have examined the association between NHANES self-reported OSA and mortality, exposure to toxins, tooth loss, housing characteristics, and hypertension. All of these studies using the sleep questionnaire lend credibility to using a self-reported OSA diagnosis. The weighting and nationally representative sample give the NHANES database strong generalizability. The various following papers in diverse disciplines all using the sleep questionnaire speak to the validity of the self-reported OSA variable.

Using a linked longitudinal database – linking NHANES (year 2005-2008) with mortality data from the National Death Index up to the end of 2011: Du et al. 2018 compared mortality rates between COPD (n=366), self-reported OSA (n=695), overlap syndrome which is the combination of both COPD with OSA (n=90) compared to a reference group without either COPD, OSA, or the overlap syndrome (n=9237) and found that self-reported OSA did not significantly increase mortality in COPD patients than COPD alone (total sample size N=10,388). This study used the sleep questionnaire 2005-2008 and included subjects aged 20 years and older to examine which variables were associated with overall mortality. Hazard ratios were 1.5 for COPD, 1.1 for OSA, and 2.4 for overlap syndrome ($p< 0.01$, Du 2018).

Scinicariello et al. 2017 investigated antimony exposure and its association with sleep time and self-reported OSA. Antimony is an element that is frequently used in plastics as a flame retardant. This study used the sleep questionnaire 2005-2008 and included 2654 subjects aged 20 years and older. Multivariate logistic regression compared urinary antimony to several sleep disorders. Odds ratio of 1.73 with 95% CI (1.04, 2.91) was found comparing antimony to reduced sleep (<6 hrs/night). Odds ratio of 1.57 with 95% CI (1.05, 2.34) was found comparing antimony to OSA (Scinicariello 2017).

Sanders et al. 2016 compared number of teeth lost to risk of OSA. This study used the sleep questionnaire 2005-2008 and included 7305 subjects aged 25 years and older. High risk of OSA was defined as having two out of four cardinal symptoms: snoring, somnolence, observed apnea, and hypertension. Prevalence ratios with 95% CI was constructed from log binomial regression models. Prevalence of high risk OSA increased by 2% per tooth lost (PR= 1.02; (1.01, 1.03)). When treated as an ordinal variable, stronger associations are made: 25% for 5-9 teeth lost, 36% for 9-31, and 61% for all teeth lost (Sanders 2016).

Ansarin et al. 2013 examined the association of OSA with housing characteristics. This study included 5545 subjects aged 16 years and older. Univariate and multivariable regression was used. Prevalence of symptoms was found and demographically broken down. Environmental exposures that were found to have an association with OSA in the multivariable regression: mildew (Beta=-0.34, p-value=0.003) and pets (Beta=-0.33, p-value<0.0001). BMI had a positive linear association (Beta=0.026, p-value<0.0001). Socioeconomic factors that had an association in multivariable regression: Education

without repeating a year (Beta=1.43, p-value<0.0001), and marital status of married (Beta=-0.3, p-value<0.0001) (Ansarin 2013).

Sands-Lincoln et al. 2013 examined the association between OSA and hypertension by race/ethnicity. This study used the 2007-2008 sleep questionnaire to determine probable OSA from symptoms. Multivariable logistic regression determined if probable OSA predicted hypertension by BMI and by race. Significant and strong associations were made; sometimes by overweight, and sometimes by obesity depending on the race (Sands-Lincoln 2013).

The sleep questionnaire from NHANES has been used to investigate OSA, but no study has estimated the prevalence of OSA in the NHANES database. Additionally, no other study has investigated symptoms and related them to a diagnosis of sleep apnea using data from NHANES. Du et al. compared OSA as a risk factor for mortality and compared that to COPD but did not use OSA as a response variable to sleep variables and other variables or examine association between them. Finding association of symptoms to sleep apnea, comparing risk profile by gender, and constructing scales that are predictive of sleep apnea are all needed and can be done using a nationally representative, larger sample with NHANES.

Du et al 2018, Scinicariello et al 2017, Sanders et al 2016, Ansarin et al 2013, and Sands-Lincoln et al 2013 all used the sleep questionnaire 2005-2008 in NHANES to examine OSA in diverse fields of study giving confidence to the validity of self-reported OSA diagnosis. NHANES is missing polysomnography results, but a diagnosis from a healthcare professional of OSA may reasonably serve as proxy for a diagnosis. The OSA screens: SA-SDQ (sensitivity=80%), Berlin (77%), Wisconsin (83%), and STOP-BANG

(84%); have the highest sensitivities for OSA and many of the risk factors in these screening tools are represented in NHANES (Table 2). NHANES does not differentiate between snoring and loud snoring but can still nearly replicate some of these scales. Berlin can be replicated other than the snoring/loud snoring and STOP-BANG is only missing one measurement (neck size). This study aims to define and describe the NHANES sample for OSA symptoms and self-reported OSA diagnosis. Then determine which variables commonly used in OSA screens are most predictive of OSA in a nationally representative sample and between males and females.

Chapter 2 Methods

DATA

The National Health and Nutrition Examination Survey (NHANES) is a cross-sectional survey of U.S. subjects comprising of demographic, health, nutrition, and behavior information. NHANES includes questionnaire, laboratory, and examination data. Data is collected in two-year waves. NHANES is nationally representative and uses weighting to generalize the broader population.

NHANES has a sleep disorders questionnaire that asks participants if they have sleep apnea and if they snore, have apnea, and have somnolence. The data on sleep apnea is only available from 2005-2008, although other sleep symptoms also are available for 2015-2018. The sleep disorders questionnaire 2005-2006 has 200 subjects and the 2007-2008 has 280 subjects that answered they had sleep apnea for a total of 480 subjects in the sleep apnea groups. This is out of about 12,600 total subjects 16 years and older who participated in the sleep questionnaire 2005-2008, with about 95% in the reference group. Inclusion criteria will be all subjects who took the NHANES sleep disorders questionnaire from 2006-2008, who are 16 and older.

DEPENDENT VARIABLE

The outcome variable will be a self-reported diagnosis of sleep apnea: yes, or told by doctor they did not have sleep disorder when answering the initial question: “Have you ever been told you have a sleep disorder?”, and the follow-up question: “What was the sleep disorder?” (Table 3) OSA will serve as a proxy for a polysomnography. Coded as (#) present and (#) absent.

MAIN INDEPENDENT VARIABLES

Independent variables will be considered in the analysis. Eight variables were included from existing scales and have corresponding data in NHANES sleep questionnaire. Snoring (see Table 3) categorized as Never/Rarely vs. Frequently/Often (0,1 vs. 2, 3). Observed apneas (Table 3-) was also collapsed into (0,1) Never/Rare vs. (2,3) Frequently/Often. Somnolence was dichotomized as: (0,1,2) Never/Rare/Frequently vs. (3,4) Often/Almost Always. Smoking history (yes 1/no 2) was taken from the smoking cigarettes questionnaire. Age is taken from demographic questionnaire and categorized: 16-24, 25-34, 35-44, 45-54, 55-64, and 65+. Age was top coded at 65 because of few subjects older than 75. Gender was also taken from the demographic questionnaire and categorized into male (1) and female (2). BMI was defined as obesity (BMI>30) present/absent. Hypertension was defined as being told by doctor or health professional that they had hypertension (yes 1, no 2).

COVARIATES

Covariates will include education level as a categorical variable: Less than 9th Grade, 9-11th Grade, high school diploma/GED or less, some College or Associates degree, and College Graduate and above. Income will be included as quartiles: 0-$19,999, $20,000-$34,999, $35,000-$64,999, and $65,000+. Race/ethnicity will be included: Non-Hispanic White, Hispanic, Non-Hispanic Black, and Other Including multi-racial.

ANALYSIS

Specific Aim 1: Define and describe the NHANES sample for OSA symptoms and self-reported OSA diagnosis.

Subjects were taken from the 2005-2006 and 2007-2008 NHANES cycles. Data was taken from body measurements as well as the questionnaires (Sleep, demographic, blood pressure & cholesterol, and smoking – cigarettes). Of the total number of subjects available in NHANES 2005-2008, all subjects missing data from the sleep questionnaire, had duplicated data, were less than 16 years old, or were missing the outcome variable OSA were excluded. Descriptive statistics of all the risk factors and covariates were performed on the study sample and displayed by the dependent variable (self-reported sleep apnea OSA present or absent). Further exclusion criteria were then applied: to all subjects missing any responses to any risk factor or covariate variable, which left a final sample of subjects. Descriptive statistics on this final sample were performed again on this final sample. (See Figure 1)

Specific Aim 2: Determine which variables commonly used in OSA screens are most predictive of self-reported diagnoses of OSA in a nationally representative sample.

Chi-Square was done on categorical variables (snoring, observed apnea, somnolence, smoking history, gender, hypertension, education level, income, and race/ethnicity) to test for differences between those with and without sleep apnea, and continuous variables (age and BMI) were categorized and use Chi-Square. Multivariate logistic regression will include all risk factors available in the NHANES (snoring, observed apnea, somnolence, smoking history, age, gender, BMI, and Hypertension) to evaluate their simultaneous effect. The model will also be estimated controlling for [education level,

income, and race/ethnicity]. All analysis was done using R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

Specific Aim 3: Differences in risk factors and sensitivities for males and females.

A first step will be to obtain descriptive statistics for snoring, observed apnea, somnolence, hypertension, obesity, age, smoking history, and covariates (race/ethnicity, education, and annual household income) by gender. A second step is to examine multivariate logistic regression model of risk factors separately for males and females. Logistic regression will be used to analyze the effect of gender on sleep apnea while controlling for the covariates and main independent variables by testing for interactions between gender and the other risk factors.

Backwards elimination will include the full model with every two-way interaction between gender and all other independent variables and covariates. Backwards elimination will start with the full model with all interaction terms included and start eliminating interaction terms based on statistical significance of the full model without interaction terms. All interaction terms not initially eliminated will be individually rechecked with final model to confirm that they should be retained. Next, to see the interaction effects, male and female genders will be stratified, and logistic regression done separately for both groups. Finally, sensitivities for the risk factors will be calculated by dividing the true positive from all positive results using 2x2 tables; both as a whole sample, and by male and female. 50 years old was used as the cut-off for age.

Chapter 3 Results

SPECIFIC AIM 1: DEFINE AND DESCRIBE THE NHANES SAMPLE FOR OSA SYMPTOMS AND SELF-REPORTED OSA DIAGNOSIS

Sample Description.

Total Sample. Among the 20,497 participants in the 2005-2006 and 2007-2008 National Health and Nutrition Examination Survey (NHANES), 12,685 participated in the Sleep Questionnaire. 70 of these subjects were excluded for missing data or reporting 'don't know' to the outcome variable obstructive sleep apnea (OSA) (See Figure 1). This leaves 12,615 subjects that were analyzed; 481 (3.81%) reported they had been diagnosed with OSA and 12,134 (96.19%) had not.

Almost half of the sample was non-Hispanic white (45.36%). About half of the sample had a high school diploma or less (5860), and about half had at least some college (4972). About half the sample has an annual household income of at least $35,000 (50.57%), with the largest group having at least $65,000 (26.54%) and not differentiating income above that figure. Race/Ethnicity, and Education level were both found to have statistically significant differences between the OSA and non-OSA groups ($p<0.001$). Non-Hispanic Whites were more likely to have OSA (59.88 OSA, 44.78% non-OSA) and Hispanics were less likely to have OSA (13.31% OSA, 28.07% non-OSA). Subjects that graduated high school were more likely to have OSA, and subjects with no high school were less likely to have OSA. Annual Household Income was nearly statistically significant between OSA and non-OSA ($p<0.07$) with OSA more likely for $65,000 or above (31.80% OSA, 26.33% non-OSA). (See Table 4)

Further variables had missing values (See Table 4 and Table 5). Age ranged from 16 to at least 85 years, where all older ages were top coded to 85, with a mean of 45.123 (sd 20.5). Age was categorized into 10-year increments with a skewed distribution; there were more younger subjects and fewer older subjects, although most OSA cases were older [35-65+] (Table 5).

Subjects with OSA were 2 times more likely to report hypertension than those without OSA (60.08% with OSA and 28.37% without OSA; OR=2.12). While most subjects were obese, 67% of subjects with OSA were obese and 30% without OSA were obese (OR=2.23). Most subjects reported never snoring (31.24%), but 64.24% with OSA reported snoring frequently or often, compared to only 40.82% without OSA. Most respondents reported never being told of an observed apnea (75.07%). Observed apnea can only be known if the subject had been told by another person that they snort/stop breathing, usually by a partner, which many subjects may sleep alone. 48.65% with OSA reported apnea frequently or often, compared to only 8.25% without OSA. The most common response for daytime somnolence was never (33.36%) but 44.70% with OSA reported somnolence often or almost always, compared to only 23.42% without OSA. History of smoking was evenly divided between yes (40.54%) and no (45.36%) but the majority with OSA reported a positive history of smoking (54.26%). Hypertension, BMI, Obesity, Snoring, Snoring dichotomized, Observed Apnea, Observed Apnea dichotomized, Somnolence, Somnolence dichotomized, and History of Smoking were all statistically significant between the OSA and non-OSA groups ($p<0.001$). (See Table 5)

Final sample After exclusions

Among the 12,615 subjects with available information for OSA, many were missing responses to demographic or risk factors and were excluded from further analysis. No one had missing data on Race/Ethnicity, Age, or Gender. For the Sleep Questionnaire: 1,801 subjects were excluded for missing data on Snoring or Observed Apnea, and an additional 14 for Somnolence. 2,427 subjects had missing data from either the Hypertension, Obesity, Demographic, or History of Smoking questionnaires and were also excluded. This left a final analysis of 8,373 subjects; 384 (4.59%) reported they had been diagnosed with OSA, and 7,989 (95.41%) reported they had not. (See Figure 1) After this further exclusion, Race/Ethnicity and Education Level remained statistically significant between the OSA and non-OSA groups ($p<0.001$; Table 6).

All eight risk factors remained statistically significantly associated with OSA on bivariate analysis ($p<0.001$). (See Table 7) Hypertension remained twice as likely in the OSA group (60.08%) compared to non-OSA (30.87%) (OR=1.95). Young age is less likely to have OSA (25-34 OR=0.26) but precipitously increases in likelihood starting at age category 35-44 (OR=1.02) and peaks at the 55-64 age category (OR=1.66). Obesity is also a much more likely present in OSA (72.92%) than in non-OSA (33.77%) (OR=2.16). Subjects with OSA are more likely to be male (67.19%) than subjects without OSA (48.97%) (OR=1.37). While half of the subjects snored frequently/often, 66.93% of subjects with OSA snored frequently/often and 49.46% without OSA snored frequently/often (OR=1.35). Observed apnea was not common, however 51.04% had observed apnea frequently/often in OSA subjects compared to 10.69% in non-OSA (OR=4.77). 44.01% of subjects with OSA reported somnolence often/almost always

compared to 23.47% with OSA (OR=1.88). History of smoking was more evenly divided (54.95% with OSA vs. 46.62% non-OSA, OR=1.18) (See Table 7).

SPECIFIC AIM 2: DETERMINE WHICH VARIABLES COMMONLY USED IN OSA SCREENS ARE MOST PREDICTIVE OF OSA

In aim#1, bivariate associations with OSA were tested with Chi-Square on categorical variables (snoring, observed apnea, somnolence, smoking history, gender, hypertension, obesity, age, and covariates) for differences between those with and without an OSA diagnosis. In aim#2, a multivariate logistic regression model estimated the combined effect of symptoms on OSA. Multivariate logistic regression included all risk factors available in the NHANES (snoring, observed apnea, somnolence, smoking history, age, gender, obesity, and Hypertension) to evaluate their simultaneous effect. The model also controlled for covariates (education level, income, and race/ethnicity).

Observed Apnea was the strongest predictor of an OSA diagnosis (OR=7.291, 95% CI:5.597, 9.536). The adjusted estimate was slightly lower than the unadjusted crude estimate (OR=8.710) (Table 8). Obesity was also a very strong predictor of an OSA diagnosis (OR=4.537, 95% CI:3.540, 5.853). The adjusted estimate was slightly lower than the unadjusted crude estimate (OR=5.280). Older age was a strong predictor of an OSA diagnosis. The adjusted odds ratios (OR) was highest for the oldest age group 65+ (OR 3.325, 95% CI:1.762, 6.687) compared to a reference group of ages 16-24 (Table 8, col1 & 2). The effect of age was diminished, when the model was adjusted for all other symptoms and covariates. The adjusted OR was slightly lower than the crude odds ratios of 4.786 for the 65+ age group and compared to a reference group of ages 16-24. Somnolence was predictive of an OSA diagnosis (OR=2.608, 95% CI:2.049, 3.317). The

adjusted estimate remained almost unchanged from the crude estimate (OR=2.563). Male gender was also predictive of a diagnosis of OSA (OR=2.370, 95% CI:1.856, 3.040). The adjusted estimate was slightly lower than the unadjusted crude estimate (OR=2.134). Hypertension was moderately predictive of a diagnosis of OSA (OR=1.834, 95% CI:1.433, 2.353). The adjusted estimate was lower than the unadjusted crude estimate (OR=3.546). History of smoking was not predictive of a diagnosis of OSA (OR=0.9996 ,95% CI:0.7909, 1.264). The unadjusted crude estimate had been (OR=1.396) that was weakly predictive and statistically significant. Snoring was protective from a diagnosis of OSA (OR=0.5726, 95% CI:0.4328, 7559). The adjusted estimate was reversed what the unadjusted crude estimate (OR=2.068) which was predictive of OSA and statistically significant. In summary, the strongest risk factors for self-reported OSA were observed apnea, obesity, older age (55+), somnolence, and male gender, while snoring became strongly protective on adjustment.

Of the covariates, only educational level and Hispanic ethnicity were significant predictors of OSA. Compared to White race as a reference, Hispanic was protective (OR=0.6531, 95% CI:0.4596, 0.9141). Black (OR=0.8265, 95% CI:0.6177, 1.097) and Other (OR=0.6497, 95% CI:0.3214, 1.205) were not statistically significant in an association to OSA. Increased level of education was positively associated with statistical significance with OSA. A bachelor's degree or above had an adjusted estimate (OR=4.481, 95% CI:2.571, 8.146). Annual household income quartile was not statistically significant (p=0.07). The estimate was positively associated with income with the highest quartile $65,000+ (OR=1.080, 95% CI:0.7706, 1.520). (See Table 8)

SPECIFIC AIM 3: DETERMINE DIFFERENCES IN DESCRIPTIVE STATISTICS, CRUDE ASSOCIATIONS, AND MULTIVARIATE LOGISTIC REGRESSION OF RISK FACTORS FOR BOTH MALE AND FEMALE GENDERS.

First, symptoms and OSA were broken down by gender. Second, logistic regression will be used to analyze the effect of gender on sleep apnea while controlling for the covariates and main independent variables by testing for interactions between sex and the other risk factors. Finally, the sample was stratified on gender to show interactive effects where men and women differed.

Tests for two-way interactions between gender and other risk factors were conducted to see if the association between the risk factors and OSA varied between the two genders. Results revealed that Snoring, age, and income had heterogeneous ORs across gender subgroups. Backwards elimination considered the full adjusted model and added the interaction terms: gender*age, gender*HTN, gender*obesity, Gender*Snore, Gender*Observed Apnea, Gender*Somnolence, Gender*HxSmoking. Backwards elimination was forced to keep all main effects for the independent variables and covariates, but kept the interaction terms: Gender*Snore, Gender*Age, and Gender*Income (See Table 9). The final model further increased the estimate of Observed Apnea (OR=7.435, 95% CI:5.698, 9.745), from the non-interaction adjusted model (OR=7.291) (Table 10). Obesity remained a strong predictor (OR=4.524, 95% CI:3.523, 5.849), almost unchanged from the adjusted estimate (OR=4.537). Somnolence maintained its estimate (OR=2.625, 95% CI:2.057, 3.346) from the adjusted estimate (OR=2.608). Hypertension remained almost the same with an estimate (OR=1.818, 95% CI:1.419, 2.334) nearly identical to the adjusted estimate (OR=1.834). History of smoking remained almost the same with an estimate (OR=0.9991, 95% CI:0.7885, 1.266) from the adjusted

estimate (OR=0.996) but remains statistically insignificant. The interaction term Gender*Snore had an estimate (OR=0.2474, 95% CI:0.1438, 0.4179). The interaction term Gender*Age had the 65+ as its highest estimate (OR=5.081, 95% CI:1.346, 21.68). The interaction term Gender*Income had 35-65K as its highest estimate (OR=2.245, 95% CI:1.104, 4.649).

Tests for two-way interactions between gender and other risk factors revealed that Snoring, age, and income had significantly different (heterogeneous) ORs across gender subgroups and stratification of the sample into the gender subgroups revealed those differences (TABLE 15). Older age was associated with OSA in males and not in females. The oldest age group 65+ had the highest OR for men (OR= 7.353, 95% CI:2.853, 25.11). Snoring was protective in males (OR=0.3879, 95% CI:0.2740, 0.5456) and not in females (OR=1.253, 95% CI:0.7615, 2.087). $35,000-$65,000 in females was the only level of income that was statistically significant with an estimate (OR=0.5169, 95% CI:0.2805, 0.9308) but was not statistically significant in males with the same level of income (OR=0.8640, 95% CI:0.7405, 1.823). (See Table 15).

Male gender compared to female gender was sensitive to the diagnosis of OSA (Se:0.6700, Sp:0.5105). Obesity had the highest sensitivity (Se:0.7254, Sp:0.6627), that increased in females (Se:0.7857, Sp:0.6286). Snoring had the second highest sensitivity (Se:0.6725, Sp:0.5072) but a much smaller specificity. Snoring had a very large difference in sensitivity between male (Se:0.6202, Sp:0.4246) and female (Se:0.7698, Sp:0.5830). Increasing age (Se:0.6171, Sp:0.5705) had a higher sensitivity and lower specificity in males (Se:0.6279, Sp:0.5511) than in females (Se:0.5873, Sp:0.5995). Hypertension had a stronger specificity than sensitivity (Se:0.6146, Sp:0.6906). Smoking had a weak

sensitivity and specificity (Se:0.5491, Sp:0.5339). Observed apnea had a weak sensitivity but very strong specificity (Se:0.5139, Sp:0.8935). Somnolence also showed a weaker sensitivity with a much stronger specificity (Se:0.44484, Sp:0.7661) that was enhanced in males (Se:0.4070, Sp:0.8137) compared to females (Se:0.5079, Sp:0.7189) (See Table 17).

In summary, observed apnea followed by obesity and then somnolence are the biggest risks for everyone. Observed apnea in subjects with a diagnosis with OSA was more prevalent in the females (60.32%) than males (46.51%). Observed apnea was strongly predictive of OSA for men and women (OR=7.435, 95% CI:5.698, 9.745). Obesity was strongly predictive for both males and females (OR=4.524, 95% CI:3.523, 5.849). Somnolence (OR=2.625, 95% CI:2.057, 3.346) and hypertension (OR=1.818, 95% CI:1.419, 2.334) were both more modestly predictive for both males and females. The association between age, income, and snoring with OSA differed between men and women. Older age was a risk factor for men, but not for women. Snoring was protective for men but not for women. Women differed from men and were protected by a 35-65K income. Hypertension, education and somnolence were smaller risk factors for everyone. The ORs for men & women only differed on age, income, and snoring.

Chapter 4 Discussion

Obstructive Sleep Apnea (OSA) is positively associated with age until it peaked at the 65-74 decade, then was negatively associated. The adjusted odds ratio for age at 65-74 (OR 3.553) was blunted by nearly half compared to the crude odds ratio (OR 5.943). This is probably because as people age, they accumulate additional risk factors for OSA that was captured in the unadjusted model. At the retirement age, unhealthy lifestyles tend to catch-up to people and present with adverse health outcomes. As people age towards elderly, there may be a survival bias of generally healthier people which could explain why age after retirement age began to be protective against OSA. Hypertension was positively associated with OSA, but this takes us to a 'Chicken and the egg' situation. Is hypertension a risk factor of OSA, or is OSA a risk factor of hypertension? Ultimately that doesn't need to be explained here, since that is outside the scope of this study. What is more practical is that hypertension is easily screened for and diagnosed, which means that the presence of hypertension is useful for the screening of OSA regardless of which causes the other. Obesity had a strong positive association (adjusted OR 4.496) with OSA because the excess soft tissue of someone with a high BMI is narrowing the airways creating resistance and turbulent airflow which is the obstruction to proper pulmonary ventilation. While most excess body fat is abdominal, and that does cause resistance to the diaphragm, the more important fat distribution is probably around the neck. Some screens specifically measure neck circumference such as the STOP-BANG screen (Chung 2008). This body metric was unavailable in the NHANES, and it is possible that if such a metric was included, there would have been a greater reduction in the adjustment of the odds ratio for obesity.

Snoring, often thought as a hallmark of OSA, surprisingly became strongly protective against OSA after adjustment in the multivariable model. It may be that because NHANES does not differentiate loud snoring from non-loud snoring; and loud snoring is the actual risk factor used in many screens, that snoring may not be as predictive of OSA as originally thought. However, this study does show that snoring is strongly associated; it is protective. This is a puzzling development that is difficult to explain, although this association is lost when interaction terms are included. Perhaps snoring is strongly associated with observed apneas which had the strongest positive association (adjusted OR 7.291), and any positive association with OSA was really accounted for by observed apnea. Observed Apnea, however, very predictably has a high association considering that 'apnea' is in the name 'obstructive sleep apnea'. Observed apneas are what is measured in a polysomnography study which is the method to diagnose OSA (Haraldsson 1992). Somnolence is the feeling of not being well-rested even after a full night's sleep or drowsy during the daytime. Somnolence is the result of OSA constantly waking the subject up and preventing deeper sleep as well as causing hypoxia. Somnolence would be a great way for subjects to initiate the inquiry into sleep hygiene with their healthcare provider and not be dependent on another person's complaints and observations, or from a healthcare provider's screening of other variables. Even when other risk factors are identified, health care providers will typically not initiate inquiries into screening for OSA. Somnolence is a vague symptom and can be caused by many other etiologies including drug, alcohol, and neurological pathways. Despite that, the adjusted odds ratio was similar to the crude, and the odds ratio is strongly associated with OSA which establishes itself as a useful variable in screening for OSA.

Male gender had a strong positive association (adjusted with interactions OR 6.703) which shows that even after adjusting for obesity, smoking, and hypertension—all risk factors men typically have with higher frequency and severity than women—male gender is still an independent risk factor. Men typically have more classic symptomology for OSA then women which may be a reason why women are underdiagnosed to a greater extent than men. There is concern that new screens should be tailored to women; this will be explored later (Young 1996). A history of smoking was not significant in the multivariable model. The association between smoking and OSA in the crude model might be better explained by confounding from hypertension which is often worsened by smoking. The 'History of Smoking' variable in NHANES was defined as having smoked more than 100 cigarettes in one's life. This is a reasonable cut-off, as most people either smoke much more than 100 cigarettes in their life or a lot less, and not many people smoke about 100 cigarettes in their life. Even so, there is a great variance in the amount and duration of smoking which is not captured in this variable. Also, whether one is currently smoking or formerly a smoker might be important but is not used in screens because of the great variance in smoking habits and the impracticality that would contribute to an easy-to-use screen.

Hispanic race/ethnicity was the only one to be different from White with statistical significance. This shows an underlying biological or cultural/behavioral difference. Race often carries real biological difference that manifests in medical outcomes, but obesity and hypertension were already adjusted for, which may have accounted for some difference since the adjusted odds ratio was closer to 1 than the crude odds ratio, so the remaining difference may be unmeasured confounding variable, or may be actual biological

difference. Socioeconomic explanations may also exist, but education and income were also adjusted for. Highest level of education was surprisingly strongly associated with OSA (adjusted OR 4.436). Typically, a higher level of education means that subjects are less likely to get a particular disease, because they have greater access to healthcare; but similar to the explanation as to why snoring was protective, this greater access might contribute to the likelihood of a diagnosis of OSA. Future screens may take this into account that patient's with less formal education may be at greater risk to being underdiagnosed, and patients with more access to healthcare are not as underdiagnosed as the broader population. This could show that the underdiagnosis is not the fault of the screen—which does not take socioeconomic factors into consideration—but broader challenges of getting patients to access healthcare. Annual household income by quartile did not contribute to an apparent association with OSA, which is unusual that education had a strong positive association while income which would be expected to behave similarly did not.

Two-way interaction terms with gender were found to be significant on the adjusted model. Separate male and female multivariate logistic regression models showed variability in risk for the risk factors involved in interactions. Older Age was associated with OSA in males but not females. Snoring was found to be protective in males and not in females. Higher Income was protective in females but not in males. It would be unusual for annual household income to differ between male and female since that variable would account for the cumulative income of all males and females, and thus should not really vary between gender. It could be possible that physiological attributes of males and females diverge at different income levels which would satisfy this anomaly. For example, lifestyle

differences could affect blood pressure or BMI differently between male and female leading to the protective effect seen in females but missing in males.

Obesity would be expected to have a strong sensitivity because of its strong association with OSA and indeed had the highest sensitivity but had a stronger sensitivity in females than males. It might have been more expected to find obesity with a higher sensitivity in males because the male fat distribution of truncal fat would put more restrictive resistance on inhalation than a female fat distribution, but this was not found. Thinner necks in females could be more sensitive to increased fat surrounding the airways causing the obstructive effect. Snoring had much stronger diagnostic tests in females than in males which helps explain why earlier snoring was found to be protective in males which diverged from females. Snoring which is popularly associated with OSA may suffer from a non-differential bias or may only be associated with OSA if it is loud snoring, which was not captured in this study. Observed apnea and somnolence had much higher specificities than sensitivities which makes sense because of how diagnostic both are, particularly observed apnea. Hypertension and age were more weakly diagnostic, and history of smoking was hardly diagnostic at all which were all represented in the odd ratios previously discussed.

STRENGTHS

A significant strength of this study is the large, well-established dataset used. Several studies have examined the association between self-reported OSA and other variables. All these studies that used the sleep questionnaire in various disciplines lends credibility to using this questionnaire and the sleep apnea data. The nationally representative sample give the NHANES database strong generalizability. Various papers

in diverse disciplines all using the sleep questionnaire speak to the internal validity of the data.

LIMITATIONS

However, several limitations need to be acknowledged. The cross-sectional design does not allow subjects to be followed over time; it can identify correlation, but it cannot make a causal inference. Also specific to this project, there was no polysomnography data, other than the subjects self-reporting that they had been told by a doctor that they had sleep apnea. The outcome variable is the biggest limitation. Self-reported diagnosis may reflect who got diagnosed, so that women, minorities and lower SES may be less likely to get screened by health care professional. Third, polysomnography data would allow for ordinal response variable of none, mild, moderate, or high; as opposed to the binary yes/no used. The Sleep Questionnaire did not differentiate between Obstructive and Central Sleep Apnea. This project assumed that all responses were Obstructive, but 5-10% of cases are Central which has a completely different pathophysiology (Muza 2015). About a third of the subjects in the sleep questionnaire were missing data in at least one variable from a different questionnaire which could bias the results. Finally, socioeconomic covariates were included but did not include health access data such as insurance, legal status, or distance to provider.

CONCLUSION

Age, obesity, observed apnea, somnolence, male gender, and education all had strong positive associations with OSA. Hypertension had a more modest positive association with OSA. Hispanic ethnicity had a more modest negative association with

OSA diagnosis, and smoking was not found to have statistically significant associations with a diagnosis of OSA. Older age was a higher risk factor for males, while snoring was protective of males. Income differed between males and females with middle income being protective of females. Future area of study will include examining interaction with gender, and scales.

Appendix A

Tables and Figure

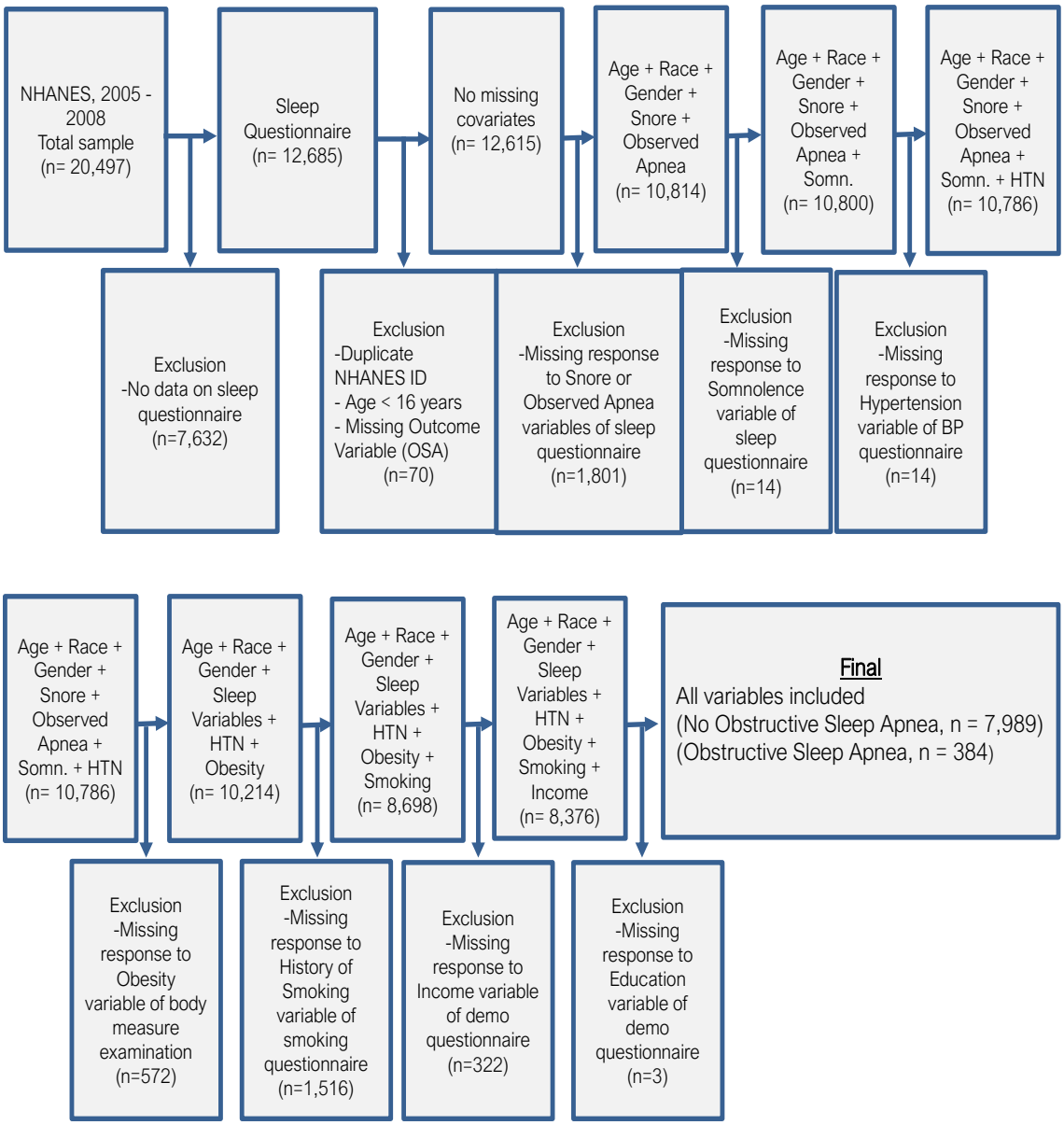

Figure 1: Sample Flowchart.

Table 1: Obstructive Sleep Apnea Scales in Literature

Scale Author (Date)	**Validation Process**	**Sample Description & Size**	**Independent** # of symptoms	**OSA**	**Sensitivity**
Berlin Ahmadi 2008	Retrospective	130 Sleep Clinic Patients	5	RDI > 5, 10	62% 77% (Abrishami 2010)
STOP Chung 2008	Prospective	177 Surgical Patients	4	AHI > 5	65.6%
STOP-BANG Chung 2008	Prospective	177 Surgical Patients	8	AHI > 5	83.6%
ASA Chung 2008	Prospective	211 Surgical Patients	6	AHI > 5	65.6% 72% (Abrishami 2010)
Wisconsin Sharma 2006	Prospective	151 General Population	3	AHI > 5	83% (Abrishami 2010)
Haraldsson's Haraldsson 1992	Prospective	42 Habitual snorers	4	AI > 5	PPV=56% 72% (Abrishami 2010)
Apnea Score Kapuniani 1988	Prospective	53 Sleep Clinic Patients	3	AHI > 5	Accuracy =70% 59% (Abrishami 2010)
SA-SDQ Weatherwax 2003	Prospective	125 Epileptic Patients	6	AHI >5	75% 80% Abrishami (2010)

Table 2: Scale Names with Exact Components Used.

Obsvd. Apnea = Observed Apnea. Somn. = Somnolence. Anatom. Airway Prblms = Anatomical Airway Problems. Hx SMK = History of Smoking. Hx adenoid. = History of Adenoidectomy.

Scale Name **Author (date)**	**BP**	**Snore**	**Loud Snore**	**Obsvd. Apnea**	**Somn.**	**Age**	**BMI**
Berlin (Ahmadi 2008)	x	x	x	x	x		
STOP (Chung 2008)	x		x	x	x		
STOP-BANG (Chung 2008)	x		x	x	x	x	x
ASA checklist (Chung 2008)			x	x	x		x
Wisconsin (Sharma 2006)		x	x	x			
SA-SDQ (Weatherwax 2003)			x	x		x	x
Haraldsson's (Haraldsson 1992)		x		x	x		
Apnea Score (Kapuniani 1988)			x	x			
NHANES	x	x		x	x	x	x

Scale Name Author (date)	Male	Neck Size	Anatom. Airway Prblms.	Sweat during sleep	Hx SMK	Hx adenoid.
Berlin (Ahmadi 2008)						
STOP (Chung 2008)						
STOP-BANG (Chung 2008)	x	x				
ASA checklist (Chung 2008)		x	x			
Wisconsin (Sharma 2006)						
SA-SDQ (Weatherwax 2003)				x	x	
Haraldsson's (Haraldsson 1992)			x			
Apnea Score (Kapuniani 1988)						x
NHANES	x				x	

Table 3: Variable name, date, and exact question from NHANES

Variable	**Question Asked**	**Possible Responses**	**NHANES numeric code**
Blood Pressure	{Have you/Has SP} ever been told by a doctor or other health professional that {you/s/he} had hypertension, also called high blood pressure?	Yes No Refused, Don't Know, Missing	1 2 7, 9, .
Snoring	How often do you snore?	Never, Rarely (1-2 nights/week), Occasionally (3-4 nights/week), Frequently (5 or more nights/week), Refused, Don't know, Missing	0 1 2 3 7, 9, .
Apnea	How often do you snort/stop breathing?	Never, Rarely (1-2 nights/week), Occasionally (3-4 nights/week), Frequently (5 or more nights/week), Refused, Don't know, Missing	0 1 2 3 7, 9, .
Somnolence	How often feel unrested during the day?	Never, Rarely (1 time a month), Sometimes (2-4 times a month), Often (5-15 times a month), Almost Always (16-30 times a month), Refused, Don't know, Missing	0 1 2 3 4 7, 9, .
Age	Best age in years of the sample person at time of HH screening.	Range of values 0-85. Ages over 85 top coded as 85. Missing	0-84 85 .
BMI	Body Mass Index (kg/m**2)	Range of Values Missing	11.74-130.21 .

Hypertension	{Have you/Has SP} ever been told by a doctor or other health professional that {you/s/he} had hypertension, also called high blood pressure?	Yes No Refused, Don't know, Missing	1 2 7, 9, .
Gender	Gender of the sample person.	Male, Female, Missing	1 2 .
History of Smoking	{Have you/Has SP} smoked at least 100 cigarettes in {your/his/her}entire life?	Yes, No, Refused, Don't know, Missing	1 2 7, 9, .
Sleep apnea	{Have you/Has SP} ever been told by a doctor or other health professional that {you have/s/he has} a sleep disorder? What was the sleep disorder?	Yes, No, Refused, Don't know, Missing Sleep Apnea, Refused, Don't know, Missing	1 2 7, 9, . 1 7, 9, .
Race/Ethnicity	Recode of reported race and ethnicity information	Mexican American, Other Hispanic Non-Hispanic White Non-Hispanic Black Other Missing	1, 2 3 4 5 .
Education	(SP Interview Version) What is the highest grade or level of school {you have/SP has} completed or the highest degree {you have/s/he has} received?	Less than 9th grade 9-11th grade High school grad/GED/equivalent Some college/AA College graduate or above Refused, Don't Know, Missing	1 2 3 4 5 7, 9, .
Annual Household Income	Total household income (reported as a range value in dollars)	$0-$19,999 $20,000-$34,999 $35,000-$64,999 $65,000 and greater > 20K, Refused, Don't know, Missing	1, 2, 3, 4, 12 5, 6 7, 8, 9 10, 11 12, 77, 99, .

Table 4: Descriptive Data of Covariates

*<.05, ** <.01, ***<.001

Variable	OSA (n=481)	No OSA (n=12,134)	TOTAL (n=12,615)
Race/Ethnicity* **			
Hispanic	13.31% (64)	28.07% (3406)	27.51% (3470)
Non-Hispanic White	59.88% (288)	44.78% (5434)	45.36% (5722)
Non-Hispanic Black	23.91% (115)	22.94% (2784)	22.98% (2899)
Other Including multi-racial	02.91% (14)	04.20% (510)	04.15% (524)
Missing	00.00% (0)	00.00% (0)	00.00% (0)
Education Level* **			
Less than 9th Grade	06.03% (29)	11.49% (1394)	11.28% (1423)
9-11th Grade	12.06% (58)	14.38% (1745)	14.29% (1803)
High School Grad/GED	27.44% (132)	20.62% (2502)	20.88% (2634)
Some College or AA degree	29.31% (141)	22.76% (2762)	23.01% (2903)
College Graduate or above	23.28% (112)	16.13% (1957)	16.40% (2069)
Missing	01.87% (9)	14.62% (1774)	14.13% (1783)
Annual Household Income			
0-19,999	23.28% (112)	24.30% (2949)	24.26% (3061)
20,000-34,999	19.13% (92)	20.60% (2499)	20.54% (2591)
35,000-64,999	21.83% (105)	24.11% (2926)	24.03% (3031)
65,000 and above	31.80% (153)	26.33% (3195)	26.54% (3348)
Missing	03.95% (19)	04.65% (565)	04.63% (584)

Table 5: Descriptive Data of Outcome and Independent Variables

*<.05, ** <.01, ***<.001

Variable	OSA (n=481)	No OSA (n=12,134)	TOTAL (n=12,615)
Hypertension* **			
Present	60.08% (289)	28.37% (3442)	29.58% (3732)
Absent	39.50% (190)	71.47% (8672)	70.25% (8862)
Missing	00.42% (2)	00.16% (19)	00.17% (21)
Age* **			
16-24	04.99% (24)	22.55% (2736)	21.88% (2760)
25-34	04.57% (22)	15.43% (1872)	15.01% (1894)
35-44	16.63% (80)	14.42% (1750)	14.51% (1830)
45-54	19.96% (96)	13.80% (1674)	14.03% (1770)
55-64	23.91% (115)	12.54% (1522)	12.98% (1637)
>=65	29.94% (144)	21.26% (2580)	21.59% (2724)
Missing	00.00% (0)	00.00% (0)	00.00% (0)
BMI* **			
Underweight	00.21% (1)	02.33% (283)	02.26% (284)
Normal	06.65% (32)	30.69% (3724)	29.77% (3756)
Overweight	19.13% (92)	31.24% (3791)	30.78% (3883)
Obese	66.94% (322)	30.29% (3675)	31.68% (3997)

Missing	07.07% (34)	05.45% (661)	05.51% (695)
Obesity* **			
Present	66.94% (322)	30.29% (3675)	31.68% (3997)
Absent	25.99% (125)	64.27% (7798)	62.81% (7923)
Missing	07.07% (34)	05.45% (661)	05.51% (695)
Gender* **			
Male	63.83% (307)	48.25% (5855)	48.85% (6162)
Female	36.17% (174)	51.75% (6279)	51.15% (6453)
Missing	00.00% (0)	00.00% (0)	00.00% (0)
Snoring* **			
Never	21.41% (103)	31.63% (3838)	31.24% (3941)
Rarely	09.77% (47)	16.30% (1978)	16.05% (2025)
Frequently	12.27% (59)	15.30% (1857)	15.19% (1916)
Often	51.98% (250)	25.52% (3096)	26.52% (3346)
Missing	04.57% (22)	11.25% (1365)	10.99% (1387)
Snoring Dichotomized* **			
Never/Rarely	31.19% (150)	47.93% (5816)	47.29% (5966)
Frequently/Often	64.24% (309)	40.82% (4953)	41.71% (5262)
Missing	04.57% (22)	11.25% (1365)	10.99% (1387)
Apnea* **			
Never	33.06% (159)	76.73% (9311)	75.07% (9470)
Rare	11.64% (56)	06.96% (845)	07.14% (901)
Frequently	16.22% (78)	04.76% (577)	05.19% (655)
Often	32.43% (156)	03.53% (428)	04.63% (584)
Missing	06.65% (32)	08.02% (973)	07.97% (1005)
Apnea Dichotomized* **			
Never/Rare	44.70% (215)	83.70% (10156)	82.21% (10371)
Frequently/Often	48.65% (234)	08.28% (1005)	09.82% (1239)
Missing	06.65% (32)	08.02% (973)	07.97% (1005)
Somnolence* **			
Never	19.33% (93)	33.91% (4115)	33.36% (4208)
Rare	10.60% (51)	15.79% (1916)	15.59% (1967)
Frequently	25.36% (122)	26.69% (3238)	26.63% (3360)
Often	21.83% (105)	14.24% (1728)	14.53% (1833)
Almost Always	22.87% (110)	09.18% (1114)	09.70% (1224)
Missing	00.00% (0)	00.19% (23)	00.18% (23)
Somnolence * **Dichotomized**			
Never/Rare/Frequently	55.30% (266)	76.39% (9269)	75.58% (9535)
Often/Almost Always	44.70% (215)	23.42% (2842)	24.23% (3057)
Missing	00.00% (0)	00.19% (23)	00.18% (23)
History of Smoking* **			
Yes	54.26% (261)	40.00% (4853)	40.54% (5114)
No	43.87% (211)	45.42% (5511)	45.36% (5722)
Missing	01.87% (9)	14.59% (1770)	14.10% (1779)

Table 6: Descriptive Data of Covariates after Exclusion Criteria.

*<.05, ** <.01, ***<.001

Variable	OSA (n=384)	No OSA (n=7,989)	TOTAL (n=8,373)
Race/Ethnicity* **			
Hispanic	13.80% (53)	25.85% (2065)	25.30% (2118)
Non-Hispanic White	61.20% (235)	48.43% (3869)	49.01% (4104)
Non-Hispanic Black	21.88% (84)	21.50% (1718)	21.52% (1802)
Other/multi-racial	03.13% (12)	04.22% (337)	04.17% (349)
Education Level* **			
Less than 9th Grade	04.95% (19)	11.93% (953)	11.61% (972)
9-11th Grade	11.72% (45)	16.54% (1321)	16.31% (1366)
High School Grad/GED	26.56% (102)	24.32% (1943)	24.42% (2045)
Some College or AA degree	31.51% (121)	27.38% (2187)	27.56% (2308)
College Graduate or above	25.26% (97)	19.84% (1585)	20.09% (1682)
Annual Household Income			
0-19,999	22.40% (86)	23.22% (1855)	23.18% (1941)
20,000-34,999	20.05% (77)	21.75% (1738)	21.68% (1815)
35,000-64,999	21.88% (84)	25.47% (2035)	25.31% (2119)
65,000 and above	35.68% (137)	29.55% (2361)	29.83% (2498)

Table 7: Descriptive Data of Outcome and Independent Variables after Exclusion Criteria
*<.05, ** <.01, ***<.001

Variable	**OSA (n=384)**	**No OSA (n=7,989)**	**TOTAL (n=8,373)**
Hypertension* **			
Present	60.68% (233)	30.87% (2466)	32.23% (2699)
Age* **			
16-24	02.86% (11)	10.26% (820)	09.92% (831)
25-34	04.95% (19)	19.10% (1516)	18.33% (1535)
35-44	18.23% (70)	17.86% (1427)	17.88% (1497)
45-54	21.61% (83)	17.12% (1368)	17.33% (1451)
55-64	23.44% (90)	14.13% (1129)	14.56% (1219)
>=65	28.91% (111)	21.64% (1729)	21.98% (1840)
Obesity* **			
Present	72.92% (280)	33.77% (2698)	35.57% (2978)
Gender* **			
Male	67.19% (258)	48.97% (3912)	49.80% (4170)
Snoring Dichotomized* **			
Frequently/Often	66.93% (257)	49.46% (3951)	50.26% (4208)
Apnea Dichotomized* **			
Frequently/Often	51.04% (196)	10.69% (854)	12.54% (1050)
Somnolence * Dichotomized**			
Often/Almost Always	44.01% (169)	23.47% (1875)	24.41% (2044)
History of Smoking**			
Yes	54.95% (211)	46.62% (3725)	47.01% (3936)

Table 8: Logistic Regression

	ALL # VARIABLES	
Variable	Crude OR (95% CI) (n=8,373)	Adjusted OR (95% CI), including covariates (n=8,373)
Age 16-24	Ref	Ref
Age 25-34	0.9343 (0.4496, 2.039)	0.7482 (0.3514, 1.668)
Age 35-44	3.657 (2.009, 7.338)	2.215 (1.175, 4.562)
Age 45-54	4.523 (2.505, 9.028)	2.517 (1.339, 5.175)
Age 55-64	5.943 (3.301, 11.84)	3.128 (1.655, 6.464)
Age 65+	4.786 (2.682, 9.477)	3.325 (1.762, 6.867)
Hypertension Present	3.456 (2.804, 4.271)	1.834 (1.433, 2.353)
Obesity Present	5.280 (4.210, 6.670)	4.537 (3.540, 5.853)
Snoring Frequently/Often	2.068 (1.668, 2.576)	0.5726 (0.4328, 0.7559)
Obs. Apnea Frequently/Often	8.710 (7.045, 10.77)	7.291 (5.597, 9.536)
Somnolence Often/Almost Always	2.563 (2.080, 3.154)	2.608 (2.049, 3.317)
Gender Male	2.134 (1.721, 2.660)	2.370 (1.856, 3.040)
Hx Smoking Yes	1.396 (1.137, 1.716)	0.9996 (0.7909, 1.264)

Race White	Ref	Ref
Race Black	0.8050 (0.6203, 1.035)	0.8265 (0.6177, 1.097)
Race Hispanic	0.4226 (0.3092, 0.5672)	0.6531 (0.4596, 0.9141)
Race Other	0.5862 (0.3076, 1.013)	0.6497 (0.3214, 1.205)
Edu. <9	Ref	Ref
Edu. 9-11	1.709 (1.009, 3.007)	2.012 (1.130, 3.705)
Edu. HS Grad	2.633 (1.642, 4.453)	2.951 (1.737, 5.244)
E Some College	2.775 (1.744, 4.669)	3.436 (2.024, 6.104)
Edu Bachelors+	3.0695 (1.910, 5.203)	4.481 (2.571, 8.146)
Income 0-20K	Ref	Ref
Income 20-35K	0.9556 (0.6969, 1.308)	0.8475 (0.5962, 1.202)
Income 35-65K	0.8904 (0.6544, 1.211)	0.8293 (0.5860, 1.173)
Income 65K+	1.252 (0.9515, 1.655)	1.080 (0.7706, 1.520)

Table 9: Backwards Selection of two-way interaction terms with Gender.

Race, Education, Obesity, Hypertension, Income, and Age interaction terms with Gender were dropped. Snoring, Somnolence, Smoking, and Observed Apnea interaction terms with Gender were kept.

Term	**AIC**
Full Model without interaction terms	2361.5
Full Model with interaction terms	2346.1
Drop Race*Gender	2341.8
Drop Education*Gender	2336.1
Drop Obesity*Gender	2334.1
Drop Hypertension*Gender	2333
Drop Smoking*Gender	2334.6
Drop Apnea*Gender	2335.9
Drop Somnolence*Gender	2337.4

Table 10: Logistic Regression with Interaction Terms.

Variable	Adjusted OR (95% CI), including covariates (n=8,373)	Adjusted OR with Interactions (95% CI) (n=8,373)
Age 16-24	Ref	Ref
Age 25-34	0.7482 (0.3514, 1.668)	0.3151 (0.09033, 1.023)
Age 35-44	2.215 (1.175, 4.562)	1.124 (0.4751, 2.975)
Age 45-54	2.517 (1.339, 5.175)	1.007 (0.430, 2.652)
Age 55-64	3.128 (1.655, 6.464)	1.698 (0.7395, 4.419)
Age 65+	3.325 (1.762, 6.867)	1.283 (0.5477, 3.385)
Hypertension Present	1.834 (1.433, 2.353)	1.818 (1.419, 2.334)
Obesity Present	4.537 (3.540, 5.853)	4.524 (3.523, 5.849)
Snoring Frequently/Often	0.5726 (0.4328, 0.7559)	1.444 (0.9165, 2.327)
Obs. Apnea Frequently/Often	7.291 (5.597, 9.536)	7.435 (5.698, 9.745)
Somnolence Often/Almost Always	2.608 (2.049, 3.317)	2.625 (2.057, 3.346)
Gender Male	2.370 (1.856, 3.040)	0.9456 (0.2225, 3.575)
Hx Smoking Yes	0.9996 (0.7909, 1.264)	0.9991 (0.7885, 1.266)
Race White	Ref	Ref

Race Black	0.8265 (0.6177, 1.097)	0.8103 (0.6039, 1.079)
Race Hispanic	0.6531 (0.4596, 0.9141)	0.6484 (0.4557, 0.9090)
Race Other	0.6497 (0.3214, 1.205)	0.6420 (0.3166, 1.196)
Edu. <9	Ref	Ref
Edu. 9-11	2.012 (1.130, 3.705)	1.950 (1.096, 3.808)
Edu. HS Grad	2.951 (1.737, 5.244)	2.801 (1.651, 4.967)
E Some College	3.436 (2.024, 6.104)	3.212 (1.895, 5.698)
Edu Bachelors+	4.481 (2.571, 8.146)	4.180 (2.403, 7.583)
Income 0-20K	Ref	Ref
Income 20-35K	0.8475 (0.5962, 1.202)	0.7333 (0.4234, 1.252)
Income 35-65K	0.8293 (0.5860, 1.173)	0.5035 (0.2796, 0.8851)
Income 65K+	1.080 (0.7706, 1.520)	0.7212 (0.4212, 1.226)
Gender*Snore	-	0.2474 (0.1438, 0.4179)
Gender* **Age 16-24**	Ref	Ref
Gender*Age 25-34	-	4.837 (0.9785, 27.57)
Gender*Age 35-44	-	3.541 (0.9094, 15.51)

Gender*Age 45-54	-	4.965 (1.291, 21.51)
Gender*Age 55-64	-	3.077 (0.8096, 13.18)
Gender*Age 65+	-	5.081 (1.346, 21.68)
Gender*Income 0-20K	Ref	Ref
Gender*Income 20-35K	-	1.319 (0.6512, 2.699)
Gender*Income 35-65K	-	2.245 (1.104, 4.649)
Gender*Income 65K+	-	2.014 (1.043, 3.926)

Table 11: Male gender dataset covariates

*<.05, ** <.01, ***<.001

Variable	**OSA (n=258)**	**No OSA (n=3,912)**	**TOTAL (n=4,170)**
Race/Ethnicity* **			
Hispanic	12.79% (33)	25.46% (996)	24.68% (1029)
Non-Hispanic White	65.12% (168)	49.39% (1930)	50.31% (2098)
Non-Hispanic Black	19.77% (51)	21.22% (830)	21.13% (881)
Other/multi-racial	02.33% (6)	03.99% (156)	03.88% (162)
Education Level* **			
Less than 9th Grade	05.81% (15)	13.88% (543)	13.38% (558)
9-11th Grade	10.47% (27)	16.44% (643)	16.07% (670)
High School Grad/GED	26.74% (69)	24.97% (977)	25.08% (1046)
Some College or AA degree	31.01% (80)	25.03% (979)	25.40% (1059)
College Graduate or above	25.97% (67)	19.68% (770)	20.07% (837)
Annual Household Income **			
0-19,999	16.67% (43)	21.34% (835)	21.06% (878)
20,000-34,999	18.99% (49)	22.29% (872)	22.09% (921)
35,000-64,999	24.03% (62)	25.79% (1009)	25.68% (1071)
65,000 and above	40.31% (104)	30.57% (1196)	31.18% (1300)

Table 12: Female gender dataset covariates

*<.05, ** <.01, ***<.001

Variable	**OSA (n=126)**	**No OSA (n=4,077)**	**TOTAL (n=4,203)**
Race/Ethnicity			
Hispanic	15.87% (20)	26.22% (1069)	25.91% (1089)
Non-Hispanic White	53.17% (67)	47.56% (1939)	47.73% (2006)
Non-Hispanic Black	26.19% (33)	21.78% (888)	21.91% (921)
Other Including multi-racial	04.76% (6)	04.44% (181)	04.45% (187)
Education Level			
Less than 9th Grade	03.17% (4)	10.06% (410)	09.85% (414)
9-11th Grade	14.29% (18)	16.63% (678)	16.56% (696)
High School Grad/GED	26.19% (33)	23.69% (966)	23.77% (999)
Some College or AA degree	32.54% (41)	29.63% (1208)	29.72% (1249)
College Graduate or above	23.81% (30)	19.99% (815)	20.10% (845)
Annual Household Income			
0-19,999	34.13% (43)	25.02% (1020)	25.29% (1063)
20,000-34,999	22.22% (28)	21.24% (866)	21.27% (894)
35,000-64,999	17.46% (22)	25.17% (1026)	24.93% (1048)
65,000 and above	26.19% (33)	28.57% (1165)	28.50% (1198)

Table 13: Male gender dataset Independent variables

*<.05, ** <.01, ***<.001

Variable	**OSA (n=258)**	**No OSA (n=3,912)**	**TOTAL (n=4,170)**
Hypertension* **			
Present	58.14% (150)	31.01% (1213)	32.69% (1363)
Age* **			
16-24	01.55% (4)	09.33% (365)	08.85% (369)
25-34	05.43% (14)	17.33% (678)	16.59% (692)
35-44	17.83% (46)	18.02% (705)	18.01% (751)
45-54	21.71% (56)	17.43% (682)	17.70% (738)
55-64	21.32% (55)	14.39% (563)	14.82% (618)
>=65	32.17% (83)	23.49% (919)	24.03% (1002)
Obesity* **			
Present	70.16% (181)	30.27% (1184)	32.73% (1365)
Snoring Dichotomized			
Frequently/Often	62.02% (160)	57.54% (2251)	57.82% (2411)
Apnea Dichotomized* **			
Frequently/Often	46.51% (120)	13.60% (530)	15.59% (650)
Somnolence * Dichotomized**			
Often/Almost Always	40.70% (105)	18.63% (729)	20.00% (834)
History of Smoking			
Yes	57.36% (148)	56.13% (2196)	56.21% (2344)

Table 14: Female gender dataset Independent variables

*<.05, ** <.01, ***<.001

Variable	**OSA (n=126)**	**No OSA (n=4,077)**	**TOTAL (n=4,203)**
Hypertension* **			
Present	65.87% (83)	30.73% (1253)	31.79% (1336)
Age* **			
16-24	05.56% (7)	11.16% (455)	10.99% (462)
25-34	03.97% (5)	20.55% (838)	20.06% (843)
35-44	19.05% (24)	17.71% (722)	17.75% (746)
45-54	21.43% (27)	16.83% (686)	16.96% (713)
55-64	27.79% (35)	13.88% (566)	14.30% (601)
>=65	22.22% (28)	19.87% (810)	19.94% (838)
Obesity* **			
Present	78.57% (99)	37.14% (1514)	38.38% (1613)
Snoring Dichotomized* **			
Frequently/Often	76.98% (97)	41.75% (1700)	42.76% (1797)
Apnea Dichotomized* **			
Frequently/Often	60.32% (76)	07.95% (324)	09.52% (400)
Somnolence * Dichotomized**			
Often/Almost Always	50.79% (64)	28.11% (1146)	28.79% (1210)
History of Smoking **			
Yes	50.00% (63)	37.50% (1529)	37.88% (1592)

Table 15: Logistic Regression. Male and Female

	ALL # VARIABLES	
Variable	Male Adjusted OR (95% CI) (n=4,170)	Female Adjusted OR (95% CI) (n=4,203)
Age 16-24	Ref	Ref
Age 25-34	1.562 (0.5385, 5.663)	0.2959 (0.08401, 0.9698)
Age 35-44	4.251 (1.646, 14.51)	0.9841 (0.4079, 2.642)
Age 45-54	5.368 (2.090, 18.28)	0.8627 (0.3568, 2.325)
Age 55-64	5.856 (2.250, 20.10)	1.439 (0.6040, 3.850)
Age 65+	7.353 (2.853, 25.11)	1.111 (0.4475, 3.060)
Hypertension Present	1.687 (1.252, 2.277)	2.150 (1.370, 3.410)
Obesity Present	4.567 (3.390, 6.204)	4.630 (2.932, 7.526)
Snoring Frequently/Often	0.3879 (0.2740, 0.5456)	1.253 (0.7615, 2.087)
Obs. Apnea Frequently/Often	6.202 (4.431, 8.739)	10.32 (6.680, 16.16)
Somnolence Often/Almost Always	3.150 (2.327, 4.257)	1.888 (1.254, 2.837)
Hx Smoking Yes	0.8352 (0.6244, 1.119)	1.423 (0.9482, 2.136)
Race White	Ref	Ref

Race Black	0.7591 (0.5243, 1.084)	0.8774 (0.5320, 1.424)
Race Hispanic	0.5809 (0.3716, 0.8857)	0.827 (0.4559, 1.448)
Race Other	0.5102 (0.1877, 1.158)	1.031 (0.3458, 2.629)
Edu. <9	Ref	Ref
Edu. 9-11	1.609 (0.8093, 3.302)	3.472 (1.171, 12.87)
Edu. HS Grad	2.258 (1.224, 4.394)	4.869 (1.743, 17.46)
E Some College	2.657 (1.440, 5.178)	5.411 (1.947, 19.36)
Edu Bachelors+	3.075 (1.613, 6.157)	8.808 (3.025, 32.49)
Income 0-20K	Ref	Ref
Income 20-35K	0.9897 (0.6217, 1.580)	0.7729 (0.4410, 1.337)
Income 35-65K	0.8640 (0.7405, 1.823)	0.5169 (0.2805, 0.9308)
Income 65K+	1.499 (0.9687, 2.351)	0.7412 (0.4150, 1.318)

Table 16: Sensitivity and Specificity for each Variable

Variable	Sensitivity	Specificity	Male Sen	Male Spe	Female Sen	Female Spe
Age (older)	0.6171	0.5705	0.6279	0.5511	0.5873	0.5995
Hypertension	0.6146	0.6906	0.5814	0.6899	0.6587	0.6927
Obesity	0.7254	0.6627	0.7016	0.6973	0.7857	0.6286
Snoring	0.6725	0.5072	0.6202	0.4246	0.7698	0.5830
Obs. Apnea	0.5139	0.8935	0.4651	0.8645	0.6032	0.9205
Somnolence	0.4484	0.7661	0.4070	0.8137	0.5079	0.7189
Smoking	0.5491	0.5339	0.5736	0.4387	0.5000	0.6250
Male Gender (male)	0.6700	0.5105	-	-	-	-

OSA Scales from Literature

Height _____ m Weight _____ kg Age_____ Male/Female
Please choose the correct response to each question.

Category 1

1. Do you snore?
a. Yes
b. No
c. Don't know
If you snore:
2. Your snoring is:
a. Slightly louder than breathing
b. As loud as talking
c. Louder than talking
d. Very loud—can be heard in adjacent rooms
3. How often do you snore?
a. Nearly every day
b. 3–4 times a week
c. 1–2 times a week
d. 1–2 times a month
e. Never or nearly never
4. Has your snoring ever bothered other people?
a. Yes
b. No
c. Don't know
5. Has anyone noticed that you quit breathing during your sleep?
a. Nearly every day
b. 3–4 times a week
c. 1–2 times a week
d. 1–2 times a month
e. Never or nearly never

Category 2

6. How often do you feel tired or fatigued after your sleep?
a. Nearly every day
b. 3–4 times a week
c. 1–2 times a week
d. 1–2 times a month
e. Never or nearly never
7. During your waking time, do you feel tired, fatigued, or not up to par?
a. Nearly every day
b. 3–4 times a week
c. 1–2 times a week
d. 1–2 times a month
e. Never or nearly never
8. Have you ever nodded off or fallen asleep while driving a vehicle?
a. Yes
b. No
If yes:
9. How often does this occur?
a. Nearly every day
b. 3–4 times a week
c. 1–2 times a week
d. 1–2 times a month
e. Never or nearly never

Category 3

10. Do you have high blood pressure?
a. Yes
b. No
c. Don't know

Scoring Berlin Questionnaire

The questionnaire consists of three categories related to the risk of having OSA.
Categories and scoring:
Category 1: items 1, 2, 3, 4, and 5
Item 1: If *yes* is the response, assign 1 point.
Item 2: If *c* or *d* is the response, assign 1 point.
Item 3: If *a* or *b* is the response, assign 1 point.
Item 4: If *a* is the response, assign 1 point.
Item 5: If *a* or *b* is the response, assign 2 points.

Figure 2: Berlin Questionnaire

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1- Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?
2- Do you often feel tired, fatigued, or sleepy during daytime?
3- Has anyone observed you stop breathing during your sleep?
4- Do you have or are you being treated for high blood pressure?
- all items: yes /no

High risk of OSA: answering yes to two or more questions

Low risk of OSA: answering yes to less than two questions

Figure 3: STOP Checklist

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1- Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?
2- Do you often feel tired, fatigued, or sleepy during daytime?
3- Has anyone observed you stop breathing during your sleep?
4- Do you have or are you being treated for high blood pressure?
5- BMI at least 35 kg/m2?
6- Age at least 50 yr old?
7- Neck circumference at least 40 cm?
8- Gender male?
- all items: yes /no

High risk of OSA: answering yes to three or more items

Low risk of OSA: answering yes to less than three

Figure 4: STOP-BANG Checklist

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1- habitual snoring
2- extremely loud snoring
3- breathing pauses during the sleep

Figure 5: Wisconsin Checklist

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1- Do you suffer from snoring?
2- Have you been told of repeated breath cessations during sleep?
3- Do you suffer from mid-sleep awakening?
4- Do have difficulty initially falling sleep, or falling sleep after mid-sleep awakening?
5- Are you so tired that you suffer from involuntary day-time sleep spells?
- all items: Don't know (0), hardly ever or never (1), occasionally (2), often (3), incessantly (4)

OSA if score at least 3 in each question

Figure 6: Haraldsson's Checklist

1- Frequency of stop breathing during sleep

2- Frequency of loud snoring

3- History of adenoidectomy

Items 1-2 : never (0), rarely (0), sometimes (0), often (1), always (1) Item

3: yes (1)/no (0)

OSA is probable if total score 3

Figure 7: Apnea Score Checklist

Category 1: Predisposing Physical Characteristics

a. BMI ≥35 kg/m^2
b. Neck circumference >43 cm/17 inches (men) or 40 cm/16 inches (women)
c. Craniofacial abnormalities affecting the airway.
d. Anatomical nasal obstruction
e. Tonsils nearly touching or touching the midline.

Category 2: History of Apparent Airway Obstruction during Sleep

Two or more of the following are present (if patient lives alone or sleep is not observed by another person, then only one of the following needs to be present):
a. Snoring (loud enough to be heard through closed door)
b. Frequent snoring
c. Observed pauses in breathing during sleep.
d. Awakens from sleep with choking sensation.
e. Frequent arousals from sleep

Category 3: Somnolence

One or more of the following are present:
a. Frequent somnolence or fatigue despite adequate "sleep"
b. Falls asleep easily in a non-stimulating environment (*e.g.* , watching TV, reading, riding in or driving a car) despite adequate "sleep"
c. [Parent or teacher comments that child appears sleepy during the day, is easily distracted, is overly aggressive, or has difficulty concentrating]*
d. [Child often difficult to arouse at usual awakening time]*

Scoring:

If two or more items in category 1 are positive, category 1 is positive.
If two or more items in category 2 are positive, category 2 is positive.
If one or more items in category 3 are positive, category 3 is positive.
High risk of OSA: two or more categories scored as positive.
Low risk of OSA: only one or no category scored as positive.

Figure 8: ASA Checklist

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1=never

2=rarely

3=sometimes

4=usually

5=always

Q1. ‘I am told I snore loudly or bother others.’ (Raw score from above responses)

Q2. ‘I am told I stop breathing at night.’ (Raw score from above responses)

Q3. ‘I awake suddenly gasping for breath, unable to breathe.’ (Raw score from above responses)

Q4. ‘I sweat a great deal at night.’ (Raw score from above responses)

Q5. ‘I have high blood pressure (or once had it)’ (Raw score from above responses)

Q6. ‘I have a problem with my nose blocking up when I want to sleep’ (Raw score from above responses)

Q7. ‘My snoring/breathing problem is much worse if I sleep on my back’ (Raw score from above responses)

Q8. ‘My snoring/breathing problem is much worse if I'm asleep right after drinking alcohol’ (Raw score from above responses)

Q9. Current weight in *pounds* (five categories to get raw score of 1–5, as follows: ≤134 pounds=1, ≤159 pounds=2, ≤183 pounds=3, ≤209 pounds=4, ≥210 pounds=5)

Q10.How many years as a smoker (five categories to get raw score of 1–5, as follows: 0 years=1, 1 year=2, ≤12 years=3, ≤25 years=4, ≥26 years=5)

Q11.Current age (five categories to get raw score of 1–5, as follows: ≤25 years=1, ≤35 years=2, ≤44 years=3, ≤50 years=4, ≥51 years=5)

Q12.Body mass index (BMI: calculated from weight in kilograms/height in meters squared) (five categories to get raw score of 1–5, as follows: ≤22.1=1, ≤25.6=2, ≤27.4=3, ≤30.9=4, ≥31=5)

Figure 9. Sleep Apnea scale of Sleep Disorders Questionnaire (SA-SDQ)

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