Title Page

Title: Recognition and diagnosis of obstructive sleep apnea in older Americans

Short running title: Obstructive sleep apnea in older Americans

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Manuscript word count (not including title, abstract, acknowledgment, references, tables, and figure legends): 2,994
Abstract word count: 273
Title character count (with spaces): 71
Number of references: 57
Number of tables in manuscript: 3 (See list of 3 supplemental tables at end of manuscript)
Number of figures: 1 (plus 2 additional figures as supplementary files)

Impact statement:
1. We certify that this work is novel clinical research.
2. N/A
3. Our research provides new information regarding the national scope of gaps in OSA evaluation among older adults in the U.S. It also sheds light on factors beyond traditional correlates for OSA that may signal OSA risk in older patients.

ABSTRACT

Background/Objectives: Although a high proportion of older Americans are at risk for obstructive sleep apnea (OSA), the magnitude of OSA under-diagnosis and under-treatment within this rapidly expanding population is unknown. The objective of this study was to estimate the proportion of older Americans at elevated risk for OSA who receive OSA evaluations, diagnosis, and treatment.

Design, Setting and Participants: Data were obtained from Round 3 of the National Health and Aging Trends Study, a nationally representative annual survey of community-dwelling Medicare beneficiaries linked to Medicare fee-for-service claims. One third of Round 3 participants, selected at random, were administered specific questions about sleep disturbances, including items that resembled key elements of a validated instrument used to assess OSA risk (the STOP-Bang questionnaire).

Intervention: none.

Measurements: The proportion of older Americans at-risk for OSA who received evaluations with home or in-laboratory sleep studies, OSA diagnosis, and OSA treatment. Clinical, social, and demographic correlates of OSA were also examined.

Results: Among 1,052 participants who completed the sleep module, 56% (95% CI: 53%,59%) were estimated to be at elevated risk for OSA. Only 8% (95% CI: 5%,11%) of the elevated risk individuals had been tested for it. Among those tested, 94% (95% CI: 87%,100%) were diagnosed with OSA. Treatment with positive airway pressure was prescribed for 82% (95% CI: 65%, 99%) of participants with an OSA diagnosis.

Conclusions: Evidence from this nationally representative sample of community dwelling Medicare beneficiaries suggests that increased OSA risk is common, but seldom investigated.

When investigated, OSA is almost always confirmed and usually treated. These findings suggest a significant gap in OSA assessment for older Americans that could have public health implications.

Key Words: Obstructive sleep apnea, Medicare, National Health and Aging Trends Study, polysomnography, STOP-BANG

INTRODUCTION

Obstructive sleep apnea (OSA) is a disorder characterized by repeated episodes of upper-airway obstruction during sleep. A major public health threat, OSA is associated with far-reaching adverse effects that include cardiovascular disease,[1-3] cognitive dysfunction,[4-7] depression,[8] metabolic syndrome,[9, 10] motor vehicle accidents,[11] and diminished quality of life.[12] Healthcare costs of OSA and its associated morbidity are likely to be substantial. [13, 14]

Adults age 65 and older constitute 14.9% of the U.S. population.[15] Although older age is a recognized risk factor for OSA, estimates regarding OSA risk, and discrepancies in OSA recognition and treatment are primarily based on regional data from middle-aged adults.[16-20] Little is known about the national scope of OSA risk, under-recognition, and under-treatment in older adults. These limitations represent gaps in knowledge, as older Americans are more likely to experience many of the costly, preventable health consequences associated with OSA,[21-23] and this demographic is expected to constitute 21.7% of the U.S. population by 2040.[24] To better characterize the national health burden of OSA, inform initiatives to reduce this burden, and optimize health outcomes for one of the primary consumers of health services in the U.S., an improved understanding of the scope and treatment patterns of OSA among older persons is necessary.

The purpose of this study was to determine the proportion of older Americans at-risk for OSA within a large, representative sample of Medicare beneficiaries, and to characterize the national scope of gaps in OSA evaluation, diagnosis and treatment among these at-risk individuals. We hypothesized that, in comparison to general population estimates, a higher proportion of older individuals would be at-risk for OSA, but that these individuals would be less

likely to receive OSA evaluations. As an exploratory analysis, social, clinical, and demographic factors associated with OSA diagnosis among older Americans were also evaluated.

METHODS

All study procedures were approved by the University of Michigan Institutional Review Board (IRBMED).

Data sources and study population

National Health and Aging Trends study: Data were obtained from Round 3 of the National Health and Aging Trends Study (NHATS), a nationally representative, longitudinal survey of Medicare beneficiaries designed to assess the impact of aging (http://www.nhats.org/). Funded by the National Institute on Aging (U01AG032947), NHATS has performed annual face-to-face interviews in beneficiaries' residencies since 2011. NHATS' protocol includes assessment of physical and cognitive capacity measures, specific health conditions, disability, pain, mood, symptom severity and frequency, well-being, mobility, accommodations, self-care, social support activities, demographics, and socioeconomic characteristics. Proxy respondents are used if a participant is unable to answer NHATS questions. Completed with an 88% response rate,[25] Round 3 included interviews from 5,097 participants, who, through survey weights, represented 32,639,407 older Americans. Survey weights accounted for differential selection probabilities and potential non-response bias.

NHATS Sleep module: In 2013, NHATS also asked questions about sleep disturbances and symptoms of sleep-disordered breathing. Six of these "sleep module" items, which closely resemble items of the STOP-Bang questionnaire, [26] were adapted for use in this study. The

STOP-Bang is a validated, 8-item screening instrument that assesses characteristics known to confer risk for OSA, and form the acronym "STOP-BANG" (**S**noring, **T**iredness, **O**bserved apneas, high blood **P**ressure, **B**MI, **A**ge, **N**eck circumference, **G**ender). Item scores (1/0) are based on yes/no answers.[27, 28] The sensitivity of a STOP-Bang score of ≥3 as the cut-off to predict any OSA [apnea hypopnea index (AHI) >5], moderate-to-severe OSA (AHI >15), or severe OSA (AHI >30) was demonstrated to be 83.9%, 92.9% and 100% respectively.[28] In general, scores of 0-2 are considered low-risk; scores of 3-4 are considered "elevated" risk; and scores of >=5 (or, scores of 3 that include specific combinations of STOP-Bang items) are considered high-risk.[29] The utility of the STOP-Bang has been widely demonstrated in a variety of large patient samples, many of which included high proportions of elderly patients.[27, 30-34] *The NHATS sleep module was administered to a random subset of n=1,052 Round 3 participants, which through sampling weights, corresponds to 7,082,963 beneficiaries (Figure 1)*. Responses to sleep-specific items from this module were used to estimate the proportion of Medicare enrollees who were at-risk for OSA. For primary analyses, participants were considered to be at-risk for OSA if they scored ≥ 3 points on the surrogate NHATS STOP-Bang items (supplementary Table S1). As all respondents scored at least "1" on the STOP-Bang based on the age item (> 50 years old, which could differentially affect estimation of OSA risk within our pool of respondents), an additional dataset in which the age item was dropped from the score was also created for exploratory analyses. Additional NHATS sleep module items included questions about initial and sleep maintenance insomnia, sleep duration, hypnotic use, napping frequency, and napping duration (supplementary Table S2).

Linkage to claims data: NHATS data were linked to Medicare fee-for-service claims files to identify sleep module participants (n=1,052) who received formal OSA evaluations, diagnosis

and treatment. The linked dataset allowed us to estimate the proportion of beneficiaries whose claims included CPT codes for in-laboratory polysomnography (PSG, the gold standard method for OSA diagnosis) or home sleep apnea testing (HSAT), an ICD-9 coded OSA diagnosis, and HCPCS codes for positive airway pressure (PAP) equipment (supplementary Table S3). To minimize the likelihood of including prevalent OSA cases diagnosed before 2011, beneficiaries with existing PAP claims or OSA diagnosis codes who did not have PSG/ HSAT claims during the 2011-2013 observation period were excluded from analyses.

Statistical methods

Descriptive statistics procedures for complex survey data (chi-square) were used to examine demographic and health characteristics for all Round 3 participants with linked fee-for-service claims. Among sleep module participants with available claims, for primary analyses, we estimated: 1) the proportion of participants at elevated risk for OSA (i.e. 'at-risk'); 2) the proportion of 'at-risk' participants who were evaluated for OSA with HSAT or in-laboratory PSG; 3) the proportion of 'at-risk' participants diagnosed with OSA following HSAT or PSG; and 4) the proportion of 'at-risk' participants with OSA who were prescribed PAP treatment. These steps were repeated for low-risk participants (surrogate STOP-Bang score ≤ 2).

Bivariate logistic regression models were constructed to examine associations of clinically relevant characteristics postulated to be associated with ICD-9-coded OSA diagnoses across the full Round 3 fee-for service Medicare linked sample (n=3,195).

Clinically relevant independent variables associated with OSA diagnosis (p-value <0.15 in bivariate analyses) were included in a multivariable logistic regression model with OSA diagnosis as the dependent variable. Independent variables included: age (categorical), sex, marital status, presence of bothersome pain, body mass index (BMI), use of a mobility device,

diabetes, and cardiovascular disease, a composite variable defined as a positive response if participants endorsed one or more of the following conditions: hypertension, congestive heart failure, myocardial infarction, or stroke.

Bivariate logistic regression models were also used to explore other characteristics not captured in the STOP-Bang items (comorbidities, independent mobility) that could influence the likelihood of OSA evaluation with sleep studies among at-risk respondents.

All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Inclusion and exclusion criteria, and sample sizes of Round 3 and sleep module participants are presented in a flowchart (supplementary Figure S4). Demographic and clinical characteristics of the 3,195 live NHATS participants are described in Table 1.

Among the 1,052 sleep module participants, 56% (95% CI: 53-59%) were 'at-risk' for OSA based on a surrogate STOP-Bang score of 3 or more. Among these at-risk individuals, only 8% (95% CI: 5-11%) received OSA evaluation with PSG or HSAT. The majority - 94% (95% CI: 87-100%) of those evaluated - received an ICD-9-coded OSA diagnosis, and of those, 82% (95% CI: 65-99%) were prescribed PAP equipment (Figure 1). Among the remainder of respondents (44%) with surrogate STOP-Bang scores of 2 or less, 2% received OSA evaluations (95% CI: 0.8-4%). Of those, 90% received an ICD-9 coded OSA diagnosis (95% CI: 88-92%) and 50% were prescribed PAP equipment (95% CI: 38-62%). Table 2 summarizes the proportion of sleep module participants who received OSA testing based on each surrogate STOP-Bang score. Proportions of respondents who endorsed additional sleep-related symptoms or

characteristics (outside of the STOP-Bang), and likelihood of evaluation, are summarized in supplementary Table S2.

Upon recalculation of OSA risk with the age item dropped from the surrogate STOP-Bang score, (supplementary Figure S5), the proportion of at-risk respondents remained high (20%), and, among this 20%, 13% received a sleep study (87% of those at risk for OSA did not receive a sleep study). Nearly all of the 13% of patients in this group who underwent sleep studies were diagnosed with OSA (94%).

In analyses of Round 3 sample (n=3,195), older age, male sex, marital/cohabitant status, higher BMI, use of a mobility device, pain, cardiovascular disease, and diabetes were independently associated with OSA diagnosis, but education, race, and depressive symptoms were not (Table 3). Multivariate models suggested significant associations between OSA diagnosis, male sex, and BMI.

Bivariate analyses compared characteristics - those with potential to influence the likelihood of OSA evaluation with PSG or HSAT -- between the 92% of unevaluated respondents and the 8% who were evaluated. Independent drivers and those who needed help "getting around and outside the house" were more likely to be evaluated. Beneficiaries with BMI>30 were also more likely to be evaluated. OSA evaluation was not associated with presence of dementia, depression, diabetes, pain, cancer or stroke.

DISCUSSION

This study of a nationally representative sample of Medicare beneficiaries suggests that a large proportion of older Americans who are at increased risk for OSA do not receive evaluations for this condition. Using NHATS items that resemble the STOP-Bang questionnaire,

56% were found to be at increased risk for OSA. Excluding age as a risk factor, 20% of older beneficiaries still met criteria for elevated OSA risk. Among at-risk individuals who received evaluations with PSG or HSAT, nearly all (94%) received a diagnosis of OSA, and 82% of these individuals received treatment with positive airway pressure. Our study provides new evidence that, among older Americans, increased risk for OSA is common, seldom investigated, and when investigated, usually confirmed and treated. These data also invite speculation that older individuals may be vulnerable to disparities in clinical evaluation for OSA. Follow-on work that validates the full STOP-Bang questionnaire and demonstrates health consequences that may be offset by efficient OSA detection among older individuals will be necessary to shape future OSA screening guidelines for geriatric patients; however, these data provide an important first step in highlighting the national scope of OSA risk, recognition, and treatment among older Americans.

. The national magnitude and impact of OSA under-evaluation in the U.S., particularly among older patients, remains unknown.[35, 36 37] Perhaps the most comprehensive study of sleep-disordered breathing and predictive clinical correlates that focused solely on older Americans was completed in the 1980s. In this study, Ancoli-Israel and colleagues conducted interviews and HSAT in older San Diego residents.[38] Depending on HSAT measures used, at least 24% had evidence of sleep-disordered breathing. In keeping with the STOP-Bang, features most reliably associated with sleep-disordered breathing included BMI, male gender, and sleepiness frequency. In the Sleep Heart Health Study – a cohort study designed to investigate OSA as a risk factor for cardiovascular diseases [39]– older adults accounted for approximately 60% percent of the sample. In the same study, male gender, snoring and breathing pauses were also identified as predictors of OSA.[20] However, the scope of national gaps of OSA *evaluation* among older

patients was not a focus of these studies, and factors that may prompt or dissuade providers from referring older patients for OSA evaluations have not been sufficiently explored.

Although traditional correlates of OSA (snoring, sleepiness, hypertension) are recognized triggers for PSG and HSAT in the general population,[40] many of these characteristics are also attributed to normal aging. Consequently, older patients who exhibit these characteristics may be more likely than their middle-aged counterparts to escape sleep evaluations. Older patients may also be less likely to seek medical attention for symptoms that signal OSA in younger individuals,[20] or more likely to experience sequelae not classically associated with OSA in younger patients.[4, 41-44] Accordingly, our analyses also examined factors associated with OSA diagnosis (and likelihood of evaluation) outside of the STOP-Bang construct across the entire sample of n=3,195 participants. In keeping with previous studies,[38, 45] male gender and BMI remained strong predictors of OSA diagnosis. Additional noteworthy correlates of OSA diagnosis included the presence of bothersome pain, use of a mobility device, diabetes, and married/cohabitation status (table 3), as well as poor overall health and independent use of a vehicle (Results). Potential factors associated with the likelihood of OSA evaluation included independent use of a vehicle and need for mobility assistance in and around the house. The above associations allow speculation that characteristics not captured by the STOP-Bang, including symptoms associated with sleep disturbances (pain), input from a bed partner/caregiver, or transportation barriers could confer OSA risk or influence likelihood of evaluation among older adults. In this regard, other sleep-specific characteristics queried by the NHATS sleep module such as insomnia, short sleep duration, or frequency of hypnotic use (supplementary Table S2) could explain the high prevalence of OSA diagnosis among the 2% of *low-risk* respondents who received OSA evaluations with PSG or home sleep apnea tests.

Definitive conclusions cannot be drawn regarding snoring or hypersomnolence as predictors of OSA from our logistic regression models, as NHATS items pertaining to these symptoms were only given to participants in the sleep module which precluded their inclusion in logistic regression models. Furthermore, although only 8% of sleep module respondents were classified as snorers, complex item phrasing (see supplemental Table S1) may have dissuaded a positive response. Additional studies are necessary to assess the prevalence of snoring and its association with OSA among older Americans.

These findings raise questions about the implications of OSA screening with the STOP-Bang among older patients. Although the STOP-Bang has not been formally validated in adults over age 65, previous validation studies that have included high numbers of older individuals,[27, 30-32] and the large proportion of respondents with surrogate STOP-Bang scores of 3 or more who received an OSA diagnosis (94%) following PSG or HSAT in this sample combine to suggest that this instrument could still offer adequate positive predictive value for OSA screening among older patients.

Our findings also invite questions about the predictive value of other factors and symptoms outside of the STOP-Bang. For example, age-related weakness of pharyngeal dilator muscles, thought to arise from vibratory trauma to the oropharynx, is hypothesized to contribute to OSA risk in older adults. Although snoring could contribute to this phenomenon, and is captured by the STOP-Bang, the STOP-Bang does not directly assess signs of pharyngeal muscle weakness.[46-48] Furthermore, the STOP-Bang is designed to capture those who are male and obese, even though OSA is not strongly associated with a gender predilection in older individuals, and obesity is not as frequently encountered in the elderly. Future research that focuses on assessment of additional predictors of OSA not included in the STOP-Bang as

screening tools could reduce the underestimation of this condition among older women and non-obese adults.

Although additional studies are necessary to determine whether complications of OSA among older adults parallel those of middle aged adults, recent studies that have included older subjects would suggest that a substantial proportion of older patients, and males in particular, may be subject to the same cardiovascular risks and all-cause mortality.[49-51] Furthermore, older patients may be more vulnerable to other OSA-related consequences, including falls, cognitive impairment or dementia. [52-54] Prior work demonstrates a link between OSA and cognitive dysfunction in dementia patients,[55] and some studies suggest that CPAP may improve performance in specific cognitive domains, or delay cognitive decline.[55, 56] Confirmation of benefits of CPAP on cognitive function and cardiovascular risk would provide support for population-based OSA screening for older adults.

To our knowledge, this is the first study to characterize the national scope of OSA risk and likelihood of evaluation among older Americans. Strengths include a large representative sample of Medicare beneficiaries and high response rate (88%). Linkage of to Medicare fee-for-service claims files allowed coupling of beneficiary characteristics (collected through in-person interviews) with objective claims data regarding PSG or HSAT, OSA diagnosis, and Medicare prescriptions of PAP equipment. The use of sampling weights allowed the generalization of results to the population.

Potential limitations should be acknowledged. Although three of the six NHATS surrogate STOP-Bang items were objectively measured (age, gender, and BMI), the remaining items required reformatting to allow uniform scoring. Although these items closely resemble STOP-Bang items, these adapted items have not been validated formally. A possibility also

exists that absence of an neck circumference item could have excluded some at-risk participants. To examine the influence on overall OSA risk of allowance of two points for the NHATS snoring item (which queried the presence of snoring OR gasping/choking within the same item), we performed sensitivity analyses among subjects with positive responses to this item. Our analyses suggest that the majority of participants who were given two points for a positive snoring item (92%) would have still received a surrogate STOP-Bang score of ≥3, even if they were assigned only one point. Additionally, when more specific but less sensitive STOP-Bang scoring methods were applied to our sleep module sample, [57] a similarly low proportion of at-risk participants (2%) were evaluated for OSA. Potential barriers to OSA evaluations among at-risk older patients require further exploration; that said, we acknowledge that clinical decisions to refer for PSG or HSAT could in part be influenced by data not available in NHATS. Finally, it is possible that excluding Medicare Advantage patients (36% of the sample) could reduce generalizability.

Our data highlight a national gap in evaluation among one of the most rapidly growing demographics in the U.S. If older individuals with OSA are subject to the same benefits of treatment as middle-aged adults, research that addresses potential causes and solutions for these gaps, and demonstrates the value of OSA screening among older patients, could offer a vital opportunity to improve one of the nation's top health epidemics.

ACKNOWLEDGEMENTS:

The corresponding author (TB) attests that everyone who has contributed significantly to the manuscript has been listed on the author bylines. The authors would also like to thank Brady T. West and Maureen E. Skehan for their statistical expertise and data management assistance,

respectively. The authors also thank Chunyang Feng for her assistance with data acquisition and management.

Conflict of interest: Dr. Braley conducts investigator-initiated studies funded by the National Multiple Sclerosis Society, the American Sleep Medicine Foundation, and the Patient-Centered Outcomes Research Institute. Dr. Braley recently completed a sleep apnea clinical trial that received material support, but no financial support, from Biogen-Idec. She is also named in a provisional patent, held by the University of Michigan, concerning treatment for sleep apnea. Dr. Chervin is named in or has developed patented and copyrighted materials owned by the University of Michigan designed to assist with assessment or treatment of sleep disorders. Dr. Chervin serves on the boards of the American Academy of Sleep Medicine (currently as President); the International Pediatric Sleep Society; and the non-profit Sweet Dreamzzz. He is an editor for UpToDate, has edited a book for Cambridge University Press, and has consulted for Zansors. Drs. Dunietz, Lisabeth, Skolarus, and Burke have no potential conflicts of interest to report.

Author contributions:

Tiffany J. Braley: study conception and design, analysis and interpretation of data, drafting the article or revising it critically for important intellectual content, and final approval of the version to be published.

Galit L. Dunietz: acquisition of data, analysis and interpretation of data, drafting the article or revising it critically for important intellectual content, and final approval of the version to be published.

Ronald D. Chervin: analysis and interpretation of data, revising manuscript critically for important intellectual content, and final approval of the version to be published.

Lynda D. Lisabeth: analysis and interpretation of data, revising manuscript critically for important intellectual content and final approval of the version to be published.

Lesli E. Skolarus: analysis and interpretation of data, revising manuscript critically for important intellectual content and final approval of the version to be published.

James F. Burke: study conception and design, analysis and interpretation of data, revising manuscript critically for important intellectual content and final approval of the version to be published.

Sponsor's role: This work was supported by an American Sleep Medicine Foundation Strategic Research Award 115-SR-15 (Braley). This work was also supported in part by the National Institute of Minority Health and Health Disparities (R01 MD008879) and National Institute of Aging at the National Institute of Health (U01AG032947), NIH/NINDS K23 NS073685 (Skolarus), and NIH/NINDS K08NS082597 (Burke). Dr. Dunietz' work for this project was supported by a T32 Grant from NINDS (NIH/NINDS T32 NS007222).

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Table 1: Demographic and health characteristics of NHATS Round 3 participants		
Demographic and Health characteristics of NHATS Round 3 Participants	Unweighted Frequencies (N)[a]	Weighted Proportion (%) (SE)[a]
Sample Size N	3,195[b]	100
Female	1,910	57 (1.0)
Male	1,285	43 (1.0)
Age 65-69	267	13 (0.8)
Age 70-74	664	30 (0.9)
Age 75-79	621	21 (0.8)
Age 80-84	676	17 (0.7)
Age 85-89	528	12 (0.6)
Age 90+	439	7 (0.5)
White Non-Hispanic	2,348	84 (1.1)
Black Non-Hispanic	626	7 (0.6)
Hispanic, Asian, American-Indian, Pacific Islander	196	8 (0.8)
Race missing	25	<1 (0.3)
Less than high school	722	19 (1.0)
High school	769	25 (0.8)
Some college or vocational	737	25 (0.9)
Bachelor's degree or higher	780	28 (1.5)
Educational status missing	187	<3 (0.3)
Married	1,419	53 (1.0)
Not married	1,608	45 (1.0)
Marital status Missing	168	2 (0.2)
Body Mass Index >35	238	8 (0.6)
Body Mass Index ≤35	2,773	89 (0.7)
Body Mass Index data missing	184	<3 (0.2)
Cardiovascular disease [c]	1,206	36 (1.1)
No Cardiovascular disease	1,822	62 (1.2)
Missing cardiovascular data	167	2 (0.2)
Diabetes	802	25 (0.9)
No diabetes	2,226	73 (0.9)
Missing data on diabetes	167	2 (0.2)

[a] Unweighted frequencies represent sample counts, weighted proportion represent corresponding population proportion (through sampling weights 3,195 respondents corresponds to 20,346,443 beneficiaries) [b] Live participants who completed Round 3 NHATS interviews; [c] Cardiovascular disease represents a composite variable that includes one or more of the following: hypertension, myocardial infarction, congestive heart failure or stroke.

Table 2: Composition of OSA risk factors among NHATS sleep module participants evaluated for OSA, within each surrogate STOP-Bang score category

STOP-Bang Score (%)	Male	BMI>35	HTN	Fatigue	Snore	Age	Evaluated	OSA Diagnosis
1 (10.8)	0	0	0	0	0	100%	1.4%	100%
2 (33.4)	21%	1%	65%	12%	0	100%	3%	88%
3 (35.5)	53%	8%	84%	51%	2%	92%	5%	93%
4 (14.8)	78%	23%	96%	100%	11%	100%	12%	96%
5 (3.2)	39%	22%	92%	81%	83%	100%	16%	83%
6 (2.0)	76%	29%	100%	94%	100%	100%	11%	100%
7 (0.3)	100%	100%	100%	100%	100%	100%	72%	100%

BMI=Body Mass Index; HTN=Hypertension; Risk score=by STOP-Bang items

No surrogate STOP-Bang score of 8 available, as NHATS did not include a neck circumference item

Table 3: Predictors of ICD-9 OSA diagnosis among all Round 3 NHATS fee-for-service participants

Predictors of OSA	Bivariate Model Odds Ratio (95% CI)	Multivariate Model Odds Ratio (95% CI)
Age		
65-69	Reference	Reference
70-74	0.8 (0.5, 1.3)	0.9 (0.5, 1.4)
75-79	0.8 (0.5, 1.2)	0.9 (0.5, 1.5)
80-84	0.6 (0.3, 0.9)	0.8 (0.4, 1.3)
85-89	0.5 (0.3, 0.8)	0.8 (0.4, 1.5)
90+	0.2 (0.1, 0.5)	0.4 (0.2, 1.0)
Sex		
Male	1.4 (1.0, 1.9)	1.4 (1.1, 2.0)
Female	Reference	Reference
Married/cohabitation		
Yes	1.5 (1.1, 2.1)	1.4 (1.0, 2.0)
No	Reference	Reference
Body Mass Index[a]	1.1 (1.1, 1.2)	1.1 (1.0, 1.1)
Use Mobility Device		
Yes	1.4 (1.1, 1.9)	1.3 (0.9, 1.8)
No	Reference	Reference
Pain in the Last Month		
Yes	1.8 (1.3, 2.4)	1.4 (1.0, 2.0)
No	Reference	Reference
Cardiovascular Disease		
Yes	1.6 (1.1, 2.4)	1.1 (0.7, 1.7)
No	Reference	Reference
Diabetes		
Yes	2.2 (1.5, 3.1)	1.3 (1.0, 1.9)
No	Reference	Reference

OSA=Obstructive Sleep Apnea; NHATS=National Health and Aging Trends Survey; CI=Confidence Interval; N/A=not included in multivariate model; [a] The odds ratio of BMI represents the association for a one-unit increase in BMI on the odds of OSA diagnosis. For example, the odds of carrying an OSA diagnosis for an individual with BMI=30, is $(1.1)^4$=1.46 times that of an individual with BMI=26

LEGENDS

Figure 1 legend: Proportion of OSA recognition and treatment among 'At Risk' NHATS participants (PSG=polysomnography, HSAT=home sleep apnea testing); N=1,052 respondents reflects the unweighted sample frequencies that represent 7,082,963 older Americans in the general population.

SUPPLEMENTAL FILES

Supplementary table S1: NHATS and corresponding STOP-Bang items

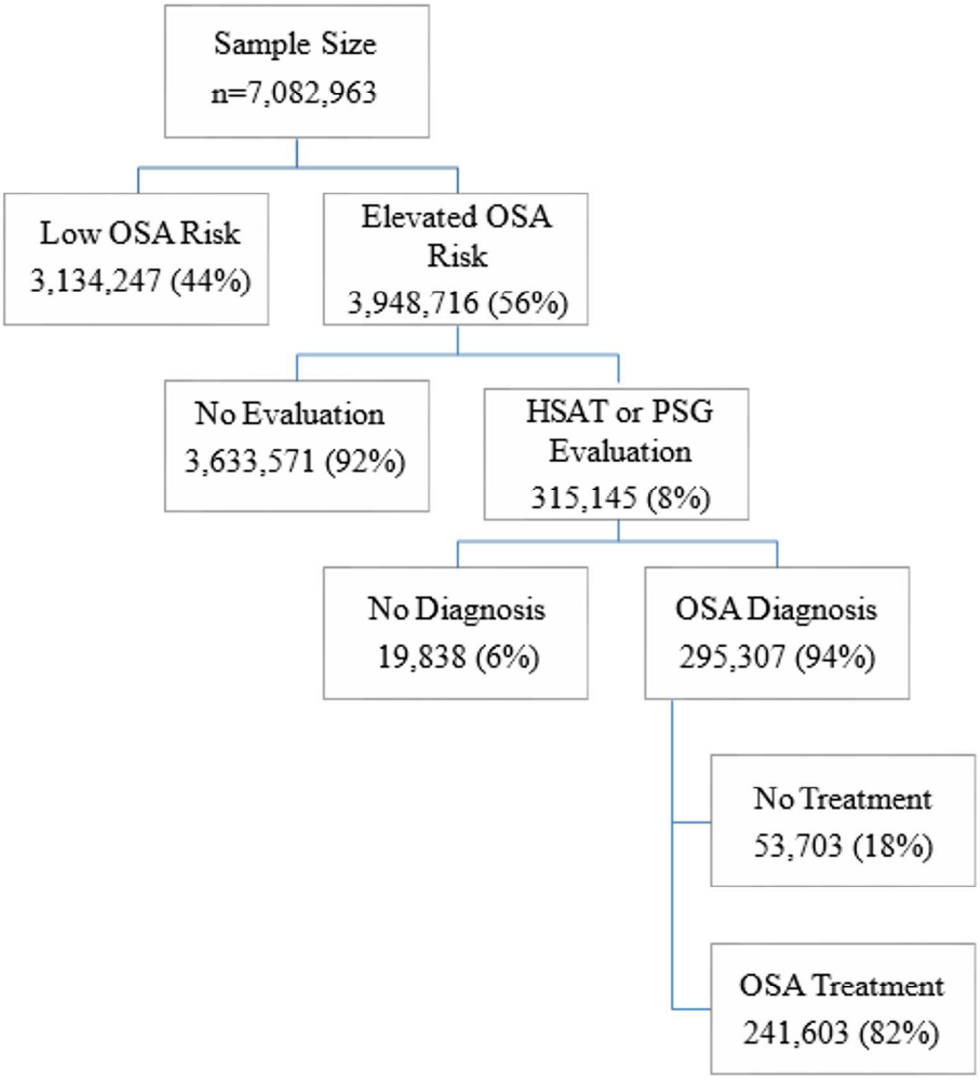
Supplementary table S2: Sleep characteristics of NHATS participants by OSA risk and evaluation with home or in-laboratory sleep apnea testing

Supplementary table S3: Coding scheme for OSA evaluation (CPT codes), OSA diagnosis (ICD-9 codes), and PAP equipment codes (HCPCS codes)

Supplementary Figure S4: Flow Chart of participants in the National Health and Aging Trends Survey (NHATS) 2013; In the final analytic sample, the 1,052 respondents reflect the unweighted sample frequencies and represent 7,082,963 older Americans in the general population.

Supplementary Figure S5: Proportion of OSA recognition and treatment among 'At Risk' NHATS participants (PSG=polysomnography, HSAT=home sleep apnea testing) after scoring

the age item as "0" to assess the potential influence of the age item toward OSA risk. N=1,052 respondents reflects the unweighted sample frequencies that represent 7,082,963 older Americans in the general population.



Supplementary table S1: NHATS and corresponding STOP-Bang items			
NHATS Item #	**Round 3 Sleep Module Questions (n=1,052 Participants)**	**Corresponding STOP-Bang item(s)**	**Sleep Module Weighted Proportions [b]**
SL5	In the last month, how often did you have trouble staying asleep because you snored loudly, or you woke up gasping or choking? Would you say every night (1), most nights (2), some nights (3), rarely (4), or never (5)? [a]	- Do you snore loudly? - Has anyone observed you stop breathing during your sleep?	Yes=8% No=89%
SL8	In the last month, how often did you have trouble staying awake at times during the day when you wanted to be awake? Would you say every day (1), most days (2), some days (3), rarely (4), or never (5)? [a]	- Do you often feel tired, fatigued, or sleepy during daytime?	Yes=37% No=60%
Selected questions from NHATS Round 3			
IS4	Are you male or female?	- Gender male?	Male=43% Female=57%
IS5	I also want to confirm your birth date is (BIRTH MONTH BIRTH DAY, BIRTH YEAR). Is that correct?	- Age over 50 years old?	>50 years=100%
HC2	I will read a list of some diseases and conditions that a doctor may have said you have. Please tell me if a doctor ever told you that you had - RESPONSE [3] C. high blood pressure or hypertension?	- Do you have or are you being treated for high blood pressure?	Yes=69% No=31%
HW2	How much do you currently weigh? HeightFeet HeightInch	-BMI > 35 kg/m^2?	Yes=9% No=91%
HW7			
HW8			

Positive NHATS items were summed to yield total surrogate STOP-Bang score. With the exception of item SL5 (in which positive responses correspond to 2 STOP-Bang questions and were therefore allowed 2 points) each positive NHATS response equates to 1 point on the STOP-Bang. No NHATS item that corresponded to STOP-Bang neck circumference item was available. [a] Scores of 1,2 or 3 were classified as positive responses.

[b] Missing ≤3%

Supplementary table S2: Sleep characteristics of NHATS participants by OSA risk and evaluation with home or in-laboratory sleep apnea testing

Sleep characteristics	Low OSA risk		Elevated OSA risk	
	Evaluated (%)	Not evaluated (%)	Evaluated (%)	Not evaluated (%)
Sleep Duration (hours)				
≤5	48	11	4	13
6	17	18	20	19
7-8	35	58	71	55
≥9	0	12	5	13
Initial Insomnia				
Yes	43	20	18	23
No	57	80	82	77
Maintenance Insomnia				
Yes	46	10	11	17
No	54	90	89	83
Habitual napping				
Yes	22	18	42	33
No	88	82	58	67
Poor Sleep Quality				
Yes	53	5	3	10
No	47	95	97	90
Use of Hypnotics				
Yes	54	19	28	27
No	46	81	72	73

OSA=Obstructive sleep apnea

Supplementary table S3: Coding scheme for OSA evaluation (CPT codes), OSA diagnosis (ICD-9 codes), and PAP equipment codes (HCPCS codes)	
OSA Evaluation	G0398 (home sleep study)
	G0399 (home sleep study)
	G0400 (home sleep study)
	95800 (sleep study, unattended)
	95801 (sleep study, unattended)
	95806 (sleep study, unattended)
	95807 (sleep study, attended)
	95808 (PSG)
	95810 (in-lab PSG)
	95811 (PAP titration)
OSA Diagnosis	327.23 (OSA)
	327.20 (organic sleep apnea, unspecified)
	780.57 (unspecified sleep apnea)
	780.53 (hypersomnia with sleep apnea, unspecified)
	780.51 (insomnia with sleep apnea, unspecified)
OSA Treatment	E0601 (CPAP, auto CPAP)
	E0470 (ResMed S9VPAP Adapt)
	E0470 (Bilevel, auto bilevel)
	E0471 (Bilevel with backup rate)
	E0562 (heated humidifier)
	A7035 (headgear)
	A7034 (nasal mask)
	A7030 (full face mask)
	A7027 (oral/nasal mask)
	A7033 (nasal pillows)
	A7037 (tubing)
	A7038 (disposable filters)