Machine Learning for Risk Stratification of OSA Patients Likely to be Hospitalized

2025 Orthodontic Faculty Development Fellowships (OFDFA)

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FollowUp Form

Award Information

In an attempt to make things a little easier for the reviewer who will read this report, please consider these two questions before this is sent for review:

- *Is this an example of your very best work, in that it provides sufficient explanation and justification, and is something otherwise worthy of publication? (We do publish the Final Report on our website, so this does need to be complete and polished.)*
- *Does this Final Report provide the level of detail, etc. that you would expect, if you were the reviewer?*

Title of Project*

Machine Learning for Risk Stratification of OSA Patients Likely to be Hospitalized

Comment: *I wonder if you would consider on the title adding a word such Machine Learning "Investigation"... or another more appropriate word. It appears that it is missing a word on this title. Also see if you study is only about OSA or should you use your new term SDB (Sleep Disorders Breathing) - which includes OSA.*

Award Type

Orthodontic Faculty Development Fellowship Award (OFDFA)

Period of AAOF Support

July 1, 2025 through June 30, 2026

Institution

The Board of Trustees of the University of Illinois

Names of principal advisor(s) / mentor(s), co-investigator(s) and consultant(s)

Min Kyeong Lee (PI), Veerasathpurush Allareddy (mentor, co-investigator), Maysaa Oubaidin (co-investigator)

Amount of Funding

$30,000.00

Abstract

(add specific directions for each type here)

Obstructive sleep apnea (OSA) is disturbance in sleep characterized by collapse of upper airway, decrease in oxygen saturation, and arousal. OSA leads to fragmented sleep and results in significant adverse consequences, such as excessive daytime sleepiness, cardiovascular morbidity, mental illness, poor quality of life, decreased memory and executive function, compromised driving safety, and shorted life expectancy. When defined as five or more events of partial or complete collapse of airway per hour, OSA affects over 1 billion people in the world. Severe OSA may necessitate visits to hospitals on an emergency basis and even lead to hospitalization. Over 2 million hospital-based ED visits in the United States from 2008 to 2010 are attributed to OSA, with a steady increase over the three-year period. Close to 87% of these ED visits were admitted as inpatients into the same hospital, and 820 patients died in the ED. Mean charge of ED visits was $2,833 in 2010 USD, totaling $4.3 billion across the United States in the three-year period. While the burden of OSA is great, it is considered a major and under-recognized public health concern. There is paucity of updated nationally representative estimates of OSA visits to hospital-based emergency departments and subsequent hospitalization outcomes. This proposal aims to identify recent trends in OSA ED visits and to examine outcomes following these hospital-based ED visits using the Healthcare Cost and Utilization Project's Nationwide Emergency Department Sample (NEDS) supported by the Agency for Healthcare Research and Quality. The 2019-2022 NEDS datasets, the largest all-payer hospital-based emergency department sample in the United States, will be used to identify all ED visits with a diagnosis of OSA. This study aims to (1) characterize patients who visit hospital-based ED for OSA and to (2) identify high-risk cohorts of patients who are hospitalized after the ED visits. Machine learning models that effectively process the big datasets will be developed to better adjust for patient level factors to identify risk factors for the outcomes.

Comment: *Abstract was well written.*

Respond to the following questions:

Detailed results and inferences:*

If the work has been published, please attach a pdf of manuscript below by clicking "Upload a file".
OR
Use the text box below to describe in detail the results of your study. The intent is to share the knowledge you have generated with the AAOF and orthodontic community specifically and other who may benefit from your study. Table, Figures, Statistical Analysis, and interpretation of results should also be attached by clicking "Upload a file".

OSA ED J Clinical Sleep Medicine.pdf
Gandhi V, Fisher L, Han MD, Ahn G, Vogel S, Oubaidin M, Yadav S, Allareddy V, Lee MK. Obstructive Sleep Apnea as an Emerging Driver of Emergency Department Utilization and Hospital Admissions: A National Analysis. Submitted to J Clin Sleep Med. In review (manuscript attached).

Comment: *As the recipient of this award, what is the main reason the award recipient is NOT the first author of this manuscript. Indeed, the award winner is listed as the senior author, which is also an indication that the study was managed by the award recipient. Upon, reviewing the manuscript, the author is listed as responsible for Acquiring Funding, contributing to conception, supervising, and critically revising the manuscript. Was the author working under the guidance of the award recipient???*

Were the original, specific aims of the proposal realized?*

Yes, we found that an estimated 4,573,554 ED visits had a diagnosis of OSA during the years 2021-2022. Males (56.7%) and older adults predominated, and most encounters occurred in metropolitan teaching hospitals (71.5%) and the southern U.S. region (34.9%). Common comorbidities included obesity (45.5%), hypertension (73.7%), chronic pulmonary disease (37.0%), and diabetes with complications (32.4%). Nearly 65.4% of visits resulted in inpatient admission into the same hospital where the ED visit occurred, 0.1% died in the EDs. Multivariable analysis identified metastatic cancer (OR=4.60, p<0.001), alcohol abuse (OR=3.21, p<0.001), obesity (OR=2.41, p<0.001), and diabetes with complications (OR=1.73, p<0.001) as independent predictors of hospitalization. Female sex and higher income quartiles were associated with lower odds of hospitalization.

Were the results published?*

No

Comment: *However, the manuscript was submitted for publication and it awaiting a response form the journal. If not accepted, does the authors intent to submit to another journal?*

Have the results of this proposal been presented?*

Yes

To what extent have you used, or how do you intend to use, AAOF funding to further your career?*

The OFDFA funding supported my activities in research, teaching, clinic, and service. This second OFDFA support was instrumental in my securing a tenure this spring. We have a manuscript under review in the Journal of Clinical Sleep Medicine and presented an e-poster at the 2026 Annual AAO Meeting. The AAOF funding helped my research team become more productive by supporting research personnel.

Comment: *As the second OFDFA funding from AAOF, is the award recipient prepared to further its research and apply for NIH grants, and is there a desire to continue asking AAOF to support its scientific endeavors? Congratulations on being awarded your second OFDFA*

Accounting: Were there any leftover funds?*

If "yes", enter your best estimate and work with your grants manager to finalize financial reports and send refund payable to: AAOF
Attn: George
401 N. Lindbergh Blvd.
St. Louis, MO. 63141-7839

If "no", enter zero.

$26.35

Comment: *Glad that all funds were used by the award recipient.*

Not Published

Are there plans to publish? If not, why not?*

The manuscript is under review with the Journal of Clinical Sleep Medicine (Gandhi V, Fisher L, Han MD, Ahn G, Vogel S, Oubaidin M, Yadav S, Allareddy V, Lee MK. Obstructive Sleep Apnea as an Emerging Driver of Emergency Department Utilization and Hospital Admissions: A National Analysis. Submitted to J Clin Sleep Med. In review.)

Presented

Please list titles, author or co-authors of these presentation/s, year and locations:*

Lee MK, Fisher L, Han M, Ahn G, Vogel S, Oubaidin M, Allareddy V. Profile of Hospital Emergency Visits Due to Obstructive Sleep Apnea. E-poster presentation at AAO Annual Session in May 2026 (Orlando, FL).

Comment: *Are there other venues that this investigation could be presented?*

Was AAOF support acknowledged?

If so, please describe:

Yes, the support from AAOF was listed under the funding.

Comment: *Thanks for the AAOF acknowledgment.*

Internal Review

Reviewer comments

I have revised this final report and am satisfied with the outcome. One observation, however, relates to authorship. If the funding was awarded to this applicant to support this project, it would generally be expected that the recipient would serve as the first author on the resulting publication. An exception would be if the work primarily supported a graduate student's master's thesis, in which case it would be appropriate for the student to be the first author. In this case, however, the first author is another faculty member from the same institution rather than a trainee. If that faculty member was the primary intellectual contributor to the project, it may be appropriate for future OFDFA support to be directed to that individual, particularly since Dr. Lee has already received two OFDFA awards.

Reviewer Status*

Approved

Comment: *Can we request a statement for what the money was spent on, or this is not an appropriate request? Does the AAOF ever wants to know in what OFDFA's resources were spent on?*

File Attachment Summary

Applicant File Uploads

- OSA ED J Clinical Sleep Medicine.pdf

Obstructive Sleep Apnea as an Emerging Driver of Emergency Department Utilization and Hospital Admissions: A National Analysis

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Declarations

Ethics approval and consent to participate

The study was granted Institutional Review Board Exempt status by the Office of Human Subjects Protection Office of the University of Illinois Chicago, as it involved de-identified, publicly available data.

Consent for publication

Authors of this research paper provide consent to the Journal of Clinical Sleep Medicine for publication.

Availability of data and material

Additional data and supplemental material will be provided on request to the corresponding author of this manuscript.

Competing interests

Authors of this manuscript have no financial and non-financial competing interests to declare.

Funding

The study was supported by Dr. Allan G. Brodie Chair Endowment, Dr. Robert and Donna Litowitz Term Gift, and the American Association of Orthodontists Foundation Orthodontic Faculty Development Award to Dr. Min Kyeong Lee.

Authors' contributions

VG: Contributed to conception, design, data acquisition, and interpretation, drafted and critically revised the manuscript.

LF: Data acquisition, and interpretation, drafted and critically revised the manuscript.

GA: Data acquisition, and interpretation, drafted and critically revised the manuscript.

SV: Data acquisition, and interpretation, drafted and critically revised the manuscript.

MH: Contributed to conception, supervised, and critically revised the manuscript.

MO: Contributed to conception, supervised, and critically revised the manuscript.

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VA: Acquired Funding, contributed to conception, design, data acquisition and interpretation, supervised, and critically revised the manuscript.

MKL: Acquired Funding, contributed to conception, supervised, and critically revised the manuscript.

Obstructive Sleep Apnea as an Emerging Driver of Emergency Department Utilization and Hospital Admissions: A National Analysis

ABSTRACT

Study Objectives: Obstructive sleep apnea (OSA) is increasingly recognized as a major public health concern with implications for both chronic disease management and acute care utilization. This study aimed to evaluate the demographic, hospital-level, and clinical characteristics of patients presenting to hospital-based emergency departments (EDs) with OSA-related diagnoses and to identify predictors of inpatient admission and healthcare burden.

Methods: A retrospective cross-sectional analysis was performed using data from the 2021–2022 Nationwide Emergency Department Sample (NEDS), the largest all-payer database in the United States (US). OSA-related ED encounters were identified using ICD-10-CM codes. Weighted analyses were conducted to estimate national prevalence and distribution by patient demographics, hospital characteristics, comorbidities, and disposition outcomes. Multivariable logistic regression models were used to determine independent predictors of inpatient admission and mortality.

Results: An estimated 4,573,554 ED visits had a diagnosis of OSA during years 2021-2022. Males (56.7%) and older adults predominated, and most encounters occurred in metropolitan teaching hospitals (71.5%) and the southern U.S. region (34.9%). Common comorbidities included obesity (45.5%), hypertension (73.7%), chronic pulmonary disease (37.0%), and diabetes with complications (32.4%). Nearly 65.4% of visits resulted in inpatient admission into the same hospital where the ED visit occurred, 0.1% died in the EDs. Multivariable analysis identified metastatic cancer (OR=4.60, $p<0.001$), alcohol abuse (OR=3.21, $p<0.001$), obesity (OR=2.41, $p<0.001$), and diabetes with complications (OR=1.73, $p<0.001$) as independent predictors of hospitalization. Female sex and higher income quartiles were associated with lower odds of hospitalization.

Conclusions: OSA represents a substantial and underrecognized contributor to emergency care utilization in the US. The high burden of cardiometabolic and respiratory comorbidities and elevated admission rates underscore the need for preventive screening, optimized outpatient management, and integrated multidisciplinary strategies to reduce OSA-related acute care demand.

Keywords: obstructive sleep apnea; emergency department; healthcare utilization; comorbidities; hospitalization; health disparities

Brief Significance Statement: This study identifies obstructive sleep apnea as a significant contributor to emergency department utilization and hospital admissions in the US. Findings highlight high comorbidity burden, regional and socioeconomic disparities, and modifiable risk factors, underscoring the need for integrated screening and preventive management strategies.

Introduction

Over the last decade, hospital-based emergency departments (EDs) in the United States (US) have consistently managed exceptionally high patient loads, averaging approximately 137 million visits annually, equivalent to more than 42,000 visits per 100,000 individuals. The vast majority of these encounters, roughly 118 million each year, conclude with patients being treated and discharged, whereas about 19.5 million result in inpatient admissions.[1] In 2021 alone, the economic impact of ED utilization was substantial, with national expenditures surpassing $80 billion and an average cost estimated at nearly $750 per encounter.[2] These statistics underscore the considerable strain ED utilization imposes on the healthcare system. Gaining a deeper understanding of the determinants and trends driving ED use is therefore essential to develop preventive strategies and optimize healthcare resource distribution, particularly for conditions that are both time- and resource-intensive.

Obstructive sleep apnea (OSA) is a prevalent sleep-related breathing disorder defined by recurrent episodes of upper airway obstruction during sleep, resulting in intermittent hypoxemia, sleep fragmentation, and increased sympathetic activation.[3] These disturbances contribute to excessive daytime sleepiness, impaired neurocognitive performance, and elevated cardiovascular and metabolic morbidity.[4] Despite increased awareness, OSA remains substantially underdiagnosed in the United States.[5] Epidemiologic data indicate that approximately 34% of men and 17% of women meet diagnostic criteria for OSA based on an apnea-hypopnea index (AHI) greater than 5 events per hour.[6,7] Among adults aged 30 to 70 years, roughly one in four exhibit at least mild OSA, and nearly 10% have moderate to severe disease (AHI ≥ 15 events/hour).[8]

These trends reflect the expanding public health burden of OSA and its growing contribution to healthcare utilization and chronic disease risk.

The pathophysiology of OSA is multifactorial, arising from the interaction of anatomical susceptibility, ventilatory control instability, and systemic comorbidities.[9] Key risk factors include advancing age, male sex, and elevated body mass index (BMI).[10,11] Additional structural and lifestyle contributors include craniofacial morphology (retrognathia, maxillary constriction), increased neck circumference, macroglossia, alcohol consumption, smoking, and nasal obstruction.[12,13] Hormonal changes associated with menopause heighten risk among women, and cardiometabolic disorders such as hypertension, insulin resistance, and type 2 diabetes are strongly linked with both OSA severity and adverse outcomes.[14] Understanding these risk determinants is essential to inform early detection, precision prevention, and targeted intervention strategies in high-risk populations.

Beyond its chronic health implications, OSA poses substantial challenges to acute care delivery and healthcare resource utilization. Individuals with undiagnosed or poorly controlled OSA are more likely to present to EDs with cardiopulmonary, metabolic, and neurocognitive complaints, often reflecting the systemic sequelae of nocturnal hypoxemia and sympathetic overactivation.[15,16] Population-level studies have demonstrated increased rates of ED visits, hospital admissions, and healthcare expenditures among patients with OSA compared with matched controls.[17,18] Moreover, the overlap between OSA and other chronic conditions such as obesity, hypertension, arrhythmias, and type 2 diabetes further compounds acute care demand and diagnostic complexity.[19] As a chronic disease, OSA is typically managed in an ambulatory outpatient setting, but its

management and resource utilization patterns in an acute setting are unclear. A detailed evaluation of OSA-related ED utilization patterns is therefore critical to identify modifiable risk pathways, inform preventive care strategies, and optimize healthcare resource allocation across emergency settings, to complement insights gained from ambulatory settings.

To address these knowledge gaps, the present study employs a large, nationally representative hospital based ED database to evaluate the demographic characteristics and healthcare utilization patterns of individuals presenting to U.S. hospital-based EDs with OSA related diagnoses. The primary objectives of this analysis are to: (1) characterize patient-level demographics including age, sex, race/ethnicity, and median household income among OSA-related ED encounters; (2) examine hospital-level characteristics such as geographic region and teaching status; (3) identify the prevalence of secondary comorbidities frequently associated with OSA within this patient population; (4) estimate the economic burden of OSA-related ED visits, including payer type and total visit charges; and (5) assess the associations between patient- and system-level factors and in-patient admission due to OSA using multivariable logistic regression modeling.

Methods

Database Description

This study utilized data from the Nationwide Emergency Department Sample (NEDS), the largest publicly available, all-payer inpatient healthcare database in the United States. The NEDS is maintained by the Agency for Healthcare Research and Quality (AHRQ), a division of the U.S. Department of Health and Human Services. Data

were extracted for the period from 2021 to 2022.[20] The NEDS sampling design is structured to provide a representative snapshot of ED visits across the United States annually. The study was granted Institutional Review Board Exempt status by the Office of Human Subjects Protection XXXX-XXXXX, as it involved de-identified, publicly available data. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.[21]

Data Use Agreement

This retrospective analysis was conducted using NEDS data obtained from the Healthcare Cost and Utilization Project (HCUP) of AHRQ. Prior to data acquisition, the author (XX and XXX) signed a data use agreement. In compliance with this agreement, individual cell counts of 10 or fewer are not disclosed to ensure patient confidentiality; therefore, such values are omitted from the reported results.

Study Population and Observations

For this study, the NEDS database was examined for ED visits related to OSA, using the ICD-10-CM code G47.33.[22] This code was used in any of the 40 diagnoses fields in the dataset to identify ED visits with a diagnosis of OSA. The dataset incorporated a broad range of variables, including patient demographics (age at admission, sex, and race/ethnicity), total charge per visit, comorbid medical conditions, insurance status (Medicare, Medicaid, private insurance, uninsured, or other), and socioeconomic status derived from ZIP code-level income data. Hospital characteristics such as geographic region (Northeast, Midwest, South, or West) and teaching status (teaching vs. non-teaching) were also included. Primary outcomes included discharge disposition (e.g.,

routine discharge, transfer to short- or long-term care facilities, or referral to home health services) and hospital ED charges. The ED charges were adjusted to year 2022 levels using the Bureau of Labor Statistics Inflation adjustment for hospital care.[23]

Statistical Analysis

Descriptive statistics were used to summarize the data. The NEDS is a 20% stratified probability sample of all discharges from U.S. ED. Each ED visit is associated with a discharge weight, enabling projection of the sample to generate national-level estimates that approximate the total number of ED visits in the country. The NEDS sampling design incorporates stratification based on hospital region, teaching status, urban/rural classification, ownership, and bed size. These factors were accounted for during data analysis. A multivariable logistic regression model was used to examine patient-related factors associated with ED visits due to OSA leading to in-patient admissions into the same hospital where the ED visit occurred. The mix of patient-related factors, including age, sex, race, insurance status, median household income categories, region of hospital, and co-morbid burden, was used as an independent variable (predictor variable) in the regression model. Variances were computed using the Taylor Linearization Method with a “With Replacement” Design. Change in parameter estimates was computed for each level of the predictor variable. Effects of clustering of outcomes within hospitals were adjusted in the regression model. Standard errors were computed using the Robust Binder method. All statistical tests were two-sided, and a p-value of <0.05 was deemed to be statistically significant. Statistical analyses were conducted using SAS Callable SUDAAN Software (Version 11.0.3, Research Triangle Institute, NC).

Results

Demographic Characteristics of Patients

A total of 4,573,554 emergency department (ED) visits in 2021-2022 had a diagnosis of obstructive sleep apnea (OSA). Of these, 48.9% occurred in 2021 and 51.1% in 2022. Males constituted the majority of visits (56.7%), while females accounted for 43.3%. The racial/ethnic distribution revealed that most encounters involved White patients (72.7%), followed by Black (15.9%), Hispanic (7.6%), Asian/Pacific Islander (1.6%), and Native American (0.6%) populations. Regarding insurance coverage, Medicare (59.0%) represented the most common payer type, followed by private insurance (23.6%), Medicaid (12.2%), and self-pay (2.0%). In terms of socioeconomic status, nearly 55.5% of patients resided in the lower half of national median household income quartiles, indicating a disproportionate burden among lower-income groups (Table 1).

Demographic Characteristics of Hospitals

Hospital-level data indicated that the largest proportion of ED visits with a diagnosis of OSA occurred in the Southern United States (34.9%), followed by the Midwest (30.7%), Northeast (17.6%), and West (16.8%). Most encounters were reported in metropolitan teaching hospitals (71.5%), compared with metropolitan non-teaching (16.9%) and nonmetropolitan (11.6%) facilities, highlighting the predominance of care delivery in urban academic settings. The mean age of patients was reported to be 63.8 years (SE=0.15), and the average ED charge per visit was $8,336 (SE=185), with a combined nationwide ED charge of over $30.4 billions over the two-year period (Table 1).

Prevalence of Co-morbid Conditions in Individuals with OSA

The prevalence of comorbid conditions among ED visits with a diagnosis of OSA is reported in Table 2. The most prevalent conditions included obesity (45.5%), hypertension (uncomplicated: 36.1%; complicated: 37.6%), chronic pulmonary disease (37.0%), and diabetes with chronic complications (32.4%). Other frequent comorbidities were depression (18.4%), hypothyroidism (17.7%), and peripheral vascular disease (7.6%). Less common conditions included autoimmune disorders (4.7%), dementia (4.8%), and alcohol (3.2%) or drug abuse (2.9%). Malignant neoplasms without metastasis were identified in 2.7%, and metastatic cancer in 1.9% of visits.

Patients' Disposition Status

Among all OSA-related ED encounters, 65.4% resulted in inpatient admission into the same hospital where the ED visit occurred, 30.3% were treated and discharged, and 1.1% were transferred to another short-term hospital. A smaller proportion were discharged to home healthcare (1.2%), other care facilities (1.5%), or against medical advice (0.5%). 0.1% of patients died in the ED. Of those subsequently admitted to inpatient care in the same hospital (n=2,988,647), 54.0% were routinely discharged, 21.3% received home health care, 17.9% were transferred to another facility, 2.2% were transferred to another short-term hospital, 1.4% left against medical advice, and 3.1% died during hospitalization.

Predictors of Inpatient Admission following ED Visits

Multivariable logistic regression identified several demographic and clinical predictors of inpatient admission (into the same hospital where the original ED visit occurred) among ED visits with a diagnosis of OSA. Increasing age was significantly

associated with higher odds of admission (OR=1.01 per year; p<0.001). Female sex demonstrated lower odds compared with males (OR=0.73; p<0.001). Insurance type was a strong predictor, with higher odds for Medicare (OR=1.28), Medicaid (OR=1.14), and self-pay (OR=1.27) patients compared to those with private insurance (p<0.001). Geographically, ED visits in the Northeast (OR=1.54; p<0.001) and South (OR=1.22; p=0.05) regions had greater odds of admission, whereas those in the Midwest (OR=0.80; p<0.05) had lower odds relative to the West.

Several comorbidities were independently associated with higher odds of inpatient admission, including metastatic cancer (OR=4.60), alcohol abuse (OR=3.21), drug abuse (OR=2.84), lymphoma (OR=2.57), obesity (OR=2.41), solid tumors (malignant) (OR=2.15), dementia (OR=2.10), and diabetes with complications (OR=1.73) (p<0.001). Conversely, uncomplicated hypertension (OR=0.72; p<0.001) and diabetes without complications (OR=0.79; p<0.001) were associated with lower admission odds.

Discussion

The present study provides the first large-scale, nationally representative characterization of ED visits involving a diagnosis of OSA in the United States using recent data from 2021-2022. Our findings highlight a substantial and growing healthcare burden associated with OSA, with more than 4.5 million ED visits (with a diagnosis of OSA) over two years. Males, older adults, and White patients accounted for the majority of encounters, and most visits occurred in metropolitan teaching hospitals, emphasizing the concentration of OSA-related acute care within urban academic settings. These data underscore that OSA, while classically viewed as a chronic and outpatient-managed disorder, increasingly contributes to acute care utilization and hospital admissions,

aligning with previous evidence showing higher healthcare use and expenditures among individuals with untreated or poorly controlled OSA.[24,25]

Consistent with prior studies, we observed a high prevalence of cardiometabolic and respiratory comorbidities among those with OSA presenting to the ED.[11,26,27] Obesity, hypertension, chronic pulmonary disease, and diabetes with complications were among the most frequent concurrent diagnoses conditions that are mechanistically intertwined with OSA through shared pathways of intermittent hypoxia, sympathetic overactivity, and systemic inflammation.[28,29] These findings reinforce the concept of OSA as a multisystem disorder that amplifies the risk of acute decompensation, contributing to ED visits and inpatient admissions. Notably, our regression analyses demonstrated that obesity, chronic pulmonary disease, and metabolic disorders independently predicted hospitalization, suggesting that these comorbidities may serve as clinical indicators for more severe or destabilized presentations requiring higher-intensity care.[30]

Socioeconomic and regional differences in OSA-related ED utilization were also evident. ED visits from lower-income quartiles represented more than half of all visits, mirroring known disparities in OSA diagnosis, access to sleep medicine services, and adherence to continuous positive airway pressure (CPAP) therapy.[31,32] The predominance of encounters in the Southern and Midwestern regions parallels geographic patterns of obesity and cardiometabolic disease in the U.S.[33] Moreover, ED visits covered by public insurance (Medicare and Medicaid) exhibited higher odds of inpatient admission than those with private insurance coverage, highlighting the intersection of socioeconomic vulnerability and disease severity. Addressing these

disparities through community screening programs and improved continuity of care may help mitigate unnecessary ED visits and reduce preventable hospitalizations.

Although in-ED mortality among patients with OSA was low (0.1%), nearly two-thirds of encounters resulted in hospital admission, indicating substantial acute-care intensity. The strongest predictors of admission included metastatic cancer, substance abuse, obesity, and cardiometabolic disease, all of which are recognized amplifiers of OSA severity and adverse outcomes.[34-36] These findings suggest that OSA often coexists with systemic illness burden rather than representing an isolated sleep disorder, thereby complicating ED management and disposition decisions. Early identification of high-risk OSA patients in acute settings could facilitate targeted interventions and more efficient resource allocation.

Prior population-based analyses have focused primarily on outpatient and inpatient cohorts; few have examined OSA-related encounters in emergency departments. Kendzerska and colleagues reported higher rates of hospitalization and ED visits among adults with OSA compared with matched controls, with increased risk proportional to disease severity.[15] Similarly, Tarasiuk et al estimated that undiagnosed OSA contributed billions of dollars annually in avoidable healthcare costs.[17] Our results complement these studies by quantifying contemporary trends and highlighting demographic, regional, and comorbidity-specific patterns of ED utilization across the U.S., particularly during a period marked by evolving post-pandemic healthcare dynamics.

The elevated inpatient admission rate and comorbidity burden among OSA patients emphasize the need for integrated screening and management strategies that extend beyond sleep laboratories. Implementing systematic OSA risk assessment tools

within ED and primary-care workflows could facilitate early detection and referral, potentially reducing recurrent acute-care visits.[37] Policy initiatives should focus on expanding access to diagnostic testing, ensuring CPAP adherence support, and addressing modifiable risk factors such as obesity, smoking, and alcohol use—interventions that have demonstrated long-term reductions in cardiovascular morbidity and healthcare costs.[38,39]

This study has several limitations inherent to secondary data analysis. Diagnostic coding (ICD-10) may underreport or misclassify OSA, and the database does not include polysomnographic data or OSA severity indices. Additionally, causal relationships between OSA and ED presentation cannot be inferred. Information regarding CPAP adherence, sleep medicine follow-up, or outpatient management was unavailable. Despite these limitations, the use of a large, nationally weighted dataset enhances the generalizability of our findings and provides valuable insight into real-world healthcare utilization patterns.

Conclusion

In summary, this national analysis demonstrates that OSA-related visits represent a considerable and complex component of emergency care utilization in the United States. The high prevalence of comorbid cardiometabolic and respiratory diseases, coupled with substantial admission rates and regional disparities, underscores the need for improved screening, preventive management, and multidisciplinary coordination to mitigate the acute-care burden of OSA. Future research should explore predictive risk models, intervention pathways, and cost-effectiveness analyses to inform targeted policy and clinical decision-making.

Table 1. Characteristics of Emergency Department Visits with a Diagnosis of Obstructive Sleep Apnea in the United States in the years 2021 and 2022.

Characteristics	Response	ED visit due to OSA
		N= 4,573,554
Year of ED Visit	2021	2,237,024 (48.9%)
	2022	2,336,530 (51.1%)
Sex	Female	1,979,386 (43.3%)
	Male	2,594,061 (56.7%)
	missing information	107
Race/ Ethnicity	White	3,240,571 (70.9%)
	Black	707,212 (15.5%)
	Hispanic	338,785 (7.4%)
	Asia/pacific islander	69,608 (1.5%)
	Native American	26,553 (0.6%)
	Others	74,434 (1.6%)
	missing information	116,391 (2.5%)
Insurance Status	Medicare	2,696,440 (59.0%)
	Medicaid	558,057 (12.2%)
	Private insurance	1,077,563 (23.6%)
	self-pay	89,744 (2.0%)
	No charge	4,115 (0.1%)
	Other	144,872 (3.2%)
Median Household Income (Based on the Address/Zip code)	0-25th percentile	1,329,309 (29.1%)
	26th to 50th percentile	1,208,157 (26.4%)
	51st to 75th percentile	1,108,846 (24.2%)
	76th to 100th percentile	873,592 (19.1%)
	missing information	53,651 (1.2%)
Region of Hospital	Northeast	806,663 (17.6%)
	Midwest	1,404,079 (30.7%)
	South	1,595,168 (34.9%)
	West	767,645 (16.8%)
Teaching Status of Hospital	Metropolitan non-teaching	771,545 (16.9%)
	Metropolitan teaching	3,269,372 (71.5%)
	Non-metropolitan hospital	532,637 (11.6%)

Mean Age	63.8 years	Standard error of mean = 0.15
Average ED Charge/Visit	$8,336	Standard error of mean = 186
Total ED Charges across the entire country for years 2021 and 2022	$30,405,309,240	

Table 2. Comorbid Conditions in Emergency Department Patients with a Diagnosis of Obstructive Sleep Apnea.

Comorbid Medical Conditions	**ED visit due to OSA N = 4,573,554**
Alcohol Abuse	148,478 (3.2%)
Autoimmune Conditions	213,850 (4.7%)
Leukemia	29,552 (0.6%)
Lymphoma	38,064 (0.8%)
Metastatic Cancer	85,049 (1.9%)
Solid Tumor without Metastasis, In Situ	1,300 (<0.1%)
Solid Tumor without Metastasis, Malignant	122,969 (2.7%)
Dementia	221,391 (4.8%)
Depression	839,274 (18.4%)
Diabetes with Chronic Complications	1,483,599 (32.4%)
Diabetes without Chronic Complications	726,331 (15.9%)
Drug Abuse	132,281 (2.9%)
Hypertension, Complicated	1,719,037 (37.6%)
Hypertension, Uncomplicated	1,653,052 (36.1%)
Chronic Pulmonary Disease	1,692,674 (37.0%)
Obesity	2,082,830 (45.5%)
Peripheral Vascular Disease	345,812 (7.6%)
Hypothyroidism	809,920 (17.7%)
Other Thyroid Disorders	77,735 (1.7%)

Table 3. Disposition Status of patients from the Emergency Department.

Disposition Status	**ED visit due to OSA N = 4,573,554**
Routine Discharge	1,386,176 (30.3%)
Transferred to another Short-Term Hospital	48,282 (1.1%)
Transfer Other*	67,170 (1.5%)
Home Health Care	53,333 (1.2%)

Discharged Against Medical Advice	23,976 (0.5%)
Admitted as an inpatient to same hospital	2,989,461 (65.4%)
Died in ED	4,490 (0.1%)
Not Admitted, Destination Unknown	649 (<0.1%)
Not Admitted, Discharged Alive, Destination Unknown	18 (<0.01%)

*Transfer Others: Includes Skilled Nursing Facility (SNF), Intermediate Care Facility (ICF), Another Type of Facility

Table 4. Disposition Status of patients subsequently admitted to Inpatient Care.

Disposition Status	**N (%)** **N = 2,988,647****
Routine Discharge	1,614,853 (54.0%)
Transferred to a Short-Term Hospital	65,778 (2.2%)
Transfer Other*	535,860 (17.9%)
Home Health Care	636,786 (21.3%)
Discharged Against Medical Advice	41,723 (1.4%)
Died in hospital	93,523 (3.1%)
Discharged alive, destination unknown	124 (<0.01%)

*Transfer Others: Includes Skilled Nursing Facility (SNF), Intermediate Care Facility (ICF), Another Type of Facility

** denotes data with missing responses.

Table 5. Predictors of In-patient Admissions (versus Routine Discharge) from Emergency Department Visit (Multivariable Logistic Regression Analysis)

Characteristic		Odds Ratio (95% CI)	p-value
Age in years at admission	Each 1-year increase in age	1.01 (1.01 — 1.02)	<0.001
Sex	Female	0.73 (0.72 — 0.75)	<0.001
	Male	Reference	
Race	Black	0.93 (0.85 — 1.03)	0.17
	Hispanic	1.00 (0.90 — 1.10)	0.94
	Asian/Pacific Islander	1.07 (0.93 — 1.22)	0.34
	Native American	0.76 (0.57 — 1.02)	0.07
	Other Races	1.18 (1.03 — 1.36)	<0.05
	Missing Race Information	1.27 (0.94 — 1.70)	0.11
	White	Reference	
Insurance Status	Medicare	1.28 (1.21 — 1.37)	<0.001
	Medicaid	1.14 (1.08 — 1.21)	<0.001
	Self-pay	1.27 (1.16 — 1.39)	<0.001
	No charge	1.59 (1.26 — 2.00)	<0.001
	Other Insurance	1.21 (1.11 — 1.33)	<0.001
	Private insurance	Reference	
Geographic Region	Northeast	1.54 (1.20 — 1.96)	<0.001
	Midwest	0.80 (0.64 — 0.99)	<0.05
	South	1.22 (1.00 — 1.48)	0.05
	West	Reference	
	Quartile 1 (lowest 25% in nation)	0.83 (0.72 — 0.96)	<0.05

Median household income levels	Quartile 2	0.91 (0.81 — 1.03)	0.14
	Quartile 3	0.93 (0.84 — 1.03)	0.15
	Missing	0.92 (0.80 — 1.07)	0.28
	Quartile 4 (highest 25% in nation)	Reference	
Comorbid conditions	Alcohol Abuse	3.21 (3.01 — 3.43)	<0.001
	Autoimmune Conditions	1.41 (1.35 — 1.47)	<0.001
	Leukemia	2.45 (2.25 — 2.68)	<0.001
	Lymphoma	2.57 (2.33 — 2.83)	<0.001
	Metastatic Cancer	4.60 (4.17 — 5.08)	<0.001
	Solid Tumor without Metastasis, in situ	1.18 (0.80 — 1.74)	0.41
	Solid Tumor without Metastasis, Malignant	2.15 (2.01 — 2.31)	<0.001
	Dementia	2.10 (1.92 — 2.28)	<0.001
	Depression	1.44 (1.34 — 1.55)	<0.001
	Diabetes with Chronic Complications	1.73 (1.68 — 1.78)	<0.001
	Diabetes without Chronic Complications	0.79 (0.77 — 0.81)	<0.001
	Drug Abuse	2.84 (2.64— 3.06)	<0.001
	Hypertension, Complicated	1.18 (1.14 — 1.23)	<0.001
	Hypertension, Uncomplicated	0.72 (0.70 — 0.74)	<0.001
	Chronic Pulmonary Disease	1.33 (1.29 — 1.37)	<0.001
	Obesity	2.41 (2.26 — 2.57)	<0.001
	Peripheral Vascular Disease	1.33 (1.15 — 1.55)	<0.001
	Hypothyroidism	1.26 (1.23 — 1.29)	<0.001
	Other Thyroid Disorders	1.25 (1.16 — 1.35)	<0.001

	Solid Tumor without Metastasis, In Situ	Reference

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