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Demographic profile of surgical approaches to obstructive sleep apnea in the United States from 2004 to 2020: a descriptive study

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Abstract

Objectives This study aims to evaluate the quantity, types, and trends of surgical procedures used to treat obstructive sleep apnea (OSA) within a diverse national population, utilizing a comprehensive proprietary healthcare database.

Methods This descriptive observational study analyzed longitudinal data from the Optum Clinformatics® Data Mart databases, covering the period from January 2004 to December 2020. The study included patients aged 18 to 89 years, both male and female, with a confirmed diagnosis of OSA. These patients were either treated with continuous positive airway pressure (CPAP) or underwent surgical interventions.

Results Throughout the study period, 1,250,273 individuals were diagnosed with OSA. The average age at diagnosis was 62 years (SD = 16), with a male predominance of 62.3%, and 75% of the patients were identified as Caucasian. The most frequently performed surgical procedure for OSA was Uvulopalatopharyngoplasty (UPPP). However, the implantable hypoglossal nerve stimulator was more commonly utilized among older patients.

Conclusions This study provides essential insights into the prevalence and characteristics of surgical procedures used in OSA treatment across a diverse national population. The findings underscore the significance of understanding surgical intervention patterns and trends to enhance patient care and outcomes.

Keywords Obstructive sleep apnea · Airway obstruction · Airway management

Introduction

Obstructive sleep apnea (OSA) is characterized by the repetitive obstruction of the upper airway during sleep, often due to the relaxation of upper airway muscles or a structural imbalance between the airway and surrounding skeletal components [1].

Estimates indicate that OSA affects roughly 25–30% of adults in the United States, reflecting its prevalence across the population [2, 3]. Among obese individuals, the incidence is even more pronounced, surpassing 50% [4–12]. OSA is associated with an elevated risk of cardiovascular morbidity and mortality. The primary treatment for OSA remains continuous positive airway pressure (CPAP), although its effectiveness and patient adherence vary; many

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individuals cease using CPAP within the first year [13, 14]. Surgical interventions are available as an alternative to CPAP, either as a long-term solution or as a means to enhance CPAP efficacy [15–17]. Surgical options range from ENT procedures, such as uvulopalatopharyngoplasty, expansion sphincter pharyngoplasty, barbed pharyngoplasty, genioglossus advancement, hyoid myotomy, to radiofrequency tongue base reduction. In more severe cases, oral and maxillofacial surgeries, including maxillomandibular advancement, have shown excellent outcomes [15, 16].

Despite the growing variety of surgical approaches for OSA, there remains a limited understanding of the patterns of surgical care and patient demographics in this field [18, 19]. Moreover, social determinants significantly affect a patient's medical journey, with some minority groups experiencing lower-quality care and facing higher rates of morbidity and mortality [20–22]. Racial, ethnic, and socioeconomic disparities can impact access to OSA treatments. It is therefore vital to deepen our understanding of current surgical practices and identify the obstacles contributing to these disparities [23–26].

This study aims to analyze a comprehensive healthcare database to evaluate the quantity, types, and distribution patterns of therapeutic procedures for OSA across different social groups on a national scale, considering parameters such as BMI, OSA severity, and surgical treatment modalities.

Methods

Study design

This study is a descriptive observational analysis that involved adults diagnosed with OSA who underwent surgical treatment. Data for this analysis was sourced from the Optum Clinformatics® Data Mart Database (Optum), covering the period from January 2004 to December 2020. This database includes de-identified information from a vast claims data warehouse.

Inclusion criteria were as follows: 1) Patients aged 18 years and above up to 89 years; 2) Individuals diagnosed with OSA, identified using specific ICD-9 and ICD-10 codes. 3) Patients with records of CPAP prescriptions were included to ensure selection of individuals with confirmed OSA. Surgical therapies were identified based on Current Procedural Terminology (CPT) codes corresponding to different procedures. Patients without gender definition were excluded.

Since this study utilized only de-identified data and commercially available information, it did not require institutional review at Stanford University School of Medicine, where the statistical analysis was conducted. The database is not publicly accessible; thus, IRB exemption was applicable under 45 CFR § 46.104(d)(4)(ii).

Study population

The study aimed to assess the quantity, types, and distribution patterns of therapeutic procedures for OSA across various social groups on a national level, considering factors such as BMI, OSA severity, and surgical treatment modalities.

The surgical interventions evaluated in the study included palatal procedures, tonsillectomy, tongue base procedures, genioglossus advancement, lingual tonsillectomy, skeletal surgeries (such as maxillomandibular advancement), and hypoglossal nerve stimulation.

Gender and ethnicity data were extracted from the Optum database, which utilizes self-identifying information based on classifications from the United States Census Bureau.

Results

The analysis included a sample of 58,531,304 individuals, among which 1,250,273 were diagnosed with OSA between 2004 and 2020. The annual number of OSA diagnoses increased from 2.7% of total diagnoses in 2004 to 9.4% in 2017 (Table 1). The average age at diagnosis was 62 years, with a higher prevalence in males (61.3%) compared to females (38.7%) (Fig. 1). The racial and ethnic distribution among OSA patients was as follows: 75.6% Caucasian, 10.8% Black, 9.2% Hispanic, 2.3% Asian, and 2.1% unknown or undisclosed. Regarding education, the majority

Table 1 Left: from 2004 to 2020 yearly OSA diagnoses

Year	# Pat	%
2004	35,474	2.8%
2005	52,032	4.2%
2006	52,881	4.2%
2007	60,758	4.9%
2008	63,126	5.0%
2009	69,028	5.5%
2010	67,103	5.4%
2011	66,916	5.4%
2012	69,027	5.5%
2013	66,799	5.3%
2014	70,075	5.6%
2015	78,318	6.3%
2016	102,127	8.2%
2017	118,03	9.4%
2018	104,041	8.3%
2019	97,754	7.8%
2020	76,784	6.1%

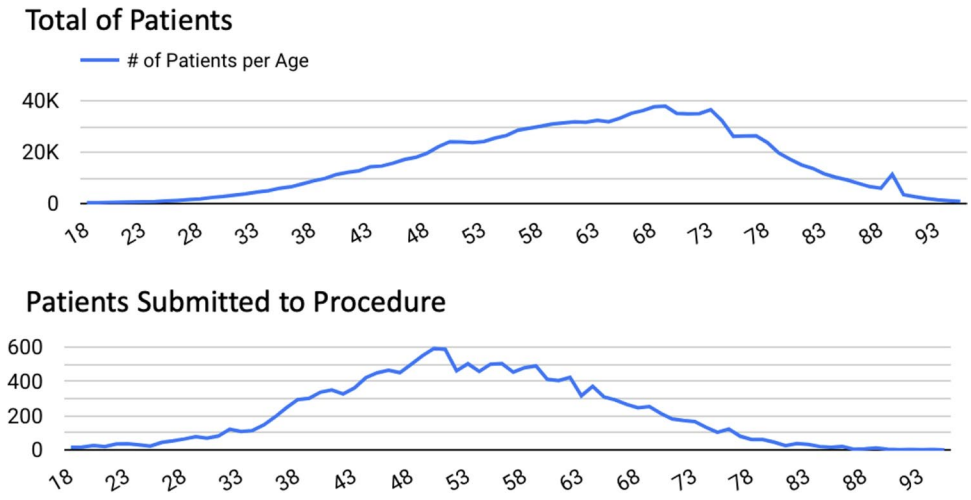

Fig. 1 (**a**) Age distribution of adult OSA diagnosed patients (**b**) Age distribution of patients submitted to therapeutic procedures for the condition

of patients (56.2%) had some post-high school education (Fig. 2).

Throughout the period from 2004 to 2020, the number of individuals diagnosed with obstructive sleep apnea (OSA) increased, whereas the proportion of those opting for surgical interventions declined. In 2006, approximately 2.9% of those diagnosed with OSA underwent surgical procedures. However, this percentage steadily decreased over the years, reaching a low of 0.6% in 2019 (Table 2). The year 2020 was notably impacted by the COVID-19 pandemic, with both OSA diagnoses and surgical interventions dropping to 0.2%.

Among the surgical procedures performed, uvulopalatopharyngoplasty (UPPP) was the most common, with a total of 7,636 patients undergoing the procedure (Fig. 3). The average age for UPPP was 50.5 years. The frequency of UPPP peaked in 2006 with 883 cases, but subsequently declined to 100 cases by 2020. This procedure was performed more frequently on males than females (77.5% versus 22.5%, respectively), and the majority of patients identified as white (73.6%), followed by Hispanic (10.8%) and Black individuals (9.8%).

Facial skeletal procedures for OSA, including isolated maxillary or mandibular advancements, as well as the more common combined maxillomandibular advancement (MMA), accounted for a smaller proportion of cases, with a total of 830 procedures or 5.1% of the reported cases (Fig. 4). The gender distribution for these procedures was relatively balanced (48.5% male and 42.6% female), and the number of annual procedures remained steady at around 50 until it dropped to 32 in 2020. Genioglossus advancement saw the most significant decline, with 50 cases reported in 2004 and single-digit cases from 2012 to 2020. The average age for facial skeletal surgeries was 55.2 years.

Another treatment option for OSA, the implantable hypoglossal nerve stimulator, was performed in 1.9% of patients, with its numbers increasing since 2016 (Fig. 5). Compared to other surgical interventions, this procedure was more prevalent among older patients, with a mean age of 62.0 years (Table 3). The male-to-female ratio for this procedure was approximately 2 to 1 (67.1% male and 32.9% female). Unlike other surgical procedures, the rate of patients opting for hypoglossal nerve stimulation has increased over time. However, there were pronounced racial disparities in this treatment modality, with 81.2% of patients identifying as white, 8% as Hispanic, and 6.1% as Black.

Discussion

This investigation analyzed a large healthcare database in the United States to assess the volume, types, and distribution patterns of therapeutic procedures provided for Obstructive Sleep Apnea (OSA) across different social groups. The study considered variables such as Body Mass Index (BMI), OSA severity, and various surgical treatment modalities.

The real-world data presented in this study indicate that single-level palatal surgeries, such as uvulopalatopharyngoplasty (UPPP) and tonsillectomy, have been the most common surgical approaches for treating obstructive sleep apnea (OSA) in the United States [27–29]. These procedures accounted for the majority of sleep surgeries, with UPPP representing 47.2% and tonsillectomy representing 43.1% of the total from 2004 to 2020. However, the frequency of these surgeries has progressively decreased over time. In 2006, there were 1,453 procedures recorded, whereas in 2019, only 456 procedures were reported in the evaluated database. It is

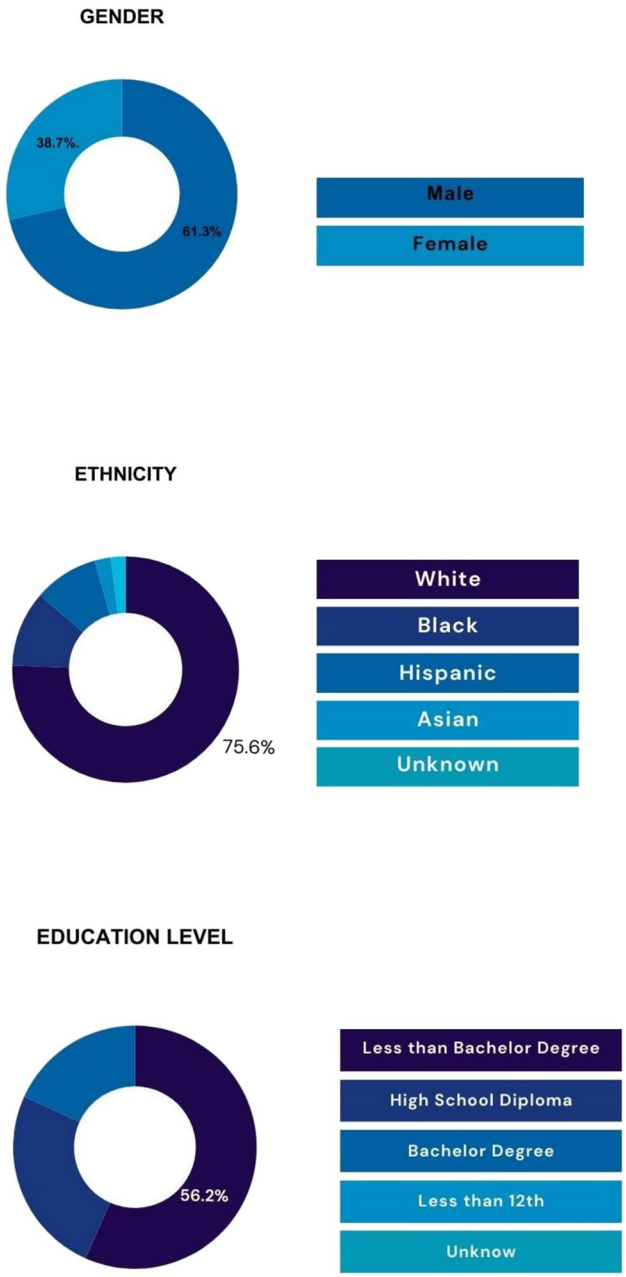

Fig. 2 Demonstrate the distribution of gender, ethnicity and education level among the diagnosed patients with OSA between 2004-2020 in the EUA

important to note that this study relies on the Optum database, which includes over 70 million patients, though other studies have also shown a reduction in surgical procedures for OSA over the years [28, 29].

This comprehensive review of surgical trends for treating Obstructive Sleep Apnea (OSA) across various demographics underscores the need for adaptive healthcare policies that respond to the evolving landscape of patient needs and treatment efficacies. Such insights could drive targeted improvements in clinical training and resource allocation.

The reasons behind the decline in palatal soft tissue surgeries for OSA during the study period remain unclear. The database used in this study does not assess referrals to sleep surgeons, and surgical approaches have evolved to address different phenotypes of OSA. It is possible that with improved patient selection, surgical procedures are now reserved for individuals with favorable anatomy, rather than being considered a necessary step before alternative procedures [30].

The decline in traditional palatal surgeries for OSA, as evidenced by our findings, may reflect an increased adoption of less invasive, more effective alternatives, such as hypoglossal nerve stimulation. This shift could represent a paradigm change in patient management, emphasizing precision medicine tailored to individual anatomical and physiological profiles.

The study findings revealed a male predominance across every subgroup within the cohort, including statistically significant sex disparities among patients who underwent surgical procedures. Although OSA prevalence and severity are generally lower in pre-menopausal women compared to men [31], recent data suggest that women may experience more severe outcomes from the disease, and these outcomes may be even worse than those observed in men with comparable degrees of OSA severity [32–34]. The hypoglossal nerve stimulation (HNS) procedure had the highest proportion of female patients (32.9%), while UPPP had the lowest (22.5%). The specific effects and outcomes of non-continuous positive airway pressure (CPAP) therapies across genders have not been extensively studied. However, recent findings suggest that females may have a higher likelihood of successful HNS therapy [35].

The study results demonstrate that hypoglossal nerve stimulation has been increasingly used as a treatment for OSA, despite an overall decrease in other surgical approaches. However, there remains a significant disparity in its application, with a higher proportion of Caucasian patients (81.2%) receiving this procedure, further highlighting the racial segregation in surgical approaches to OSA.

This national-level database study highlights the existence of sex and ethnic disparities in the treatment of OSA, indicating that sex and ethnic minorities may receive lower-quality healthcare and are less likely to receive routine medical care for OSA. These results raise concerns about healthcare equality and the possibility of selection bias.

The persistent disparities in surgical treatment for OSA highlight a significant area for policy intervention and research. Future studies should explore the barriers to equitable care and investigate the impact of socioeconomic and demographic factors on treatment efficacy. By understanding these dynamics, healthcare systems can develop more inclusive strategies that ensure all patients receive optimal care, regardless of their background.

Table 2 Total surgeries by surgery type and in surgical OSA patients between 2004-2020 in EUA of OSA patients diagnosis between 200-2017 and patients number opting for surgical procedures

Year	Total Pat. #	Cum. Pat. #	OSA Pat.#	Cum. OSA Pat. #	Surgery #	Cum. Surg. #	% OSA Pat	% Surgery Pat	Total % OSA Diag	Total % Surg
2004	3,498,710	3,498,710	35,474,	35,474	623.0	623.0	1.0%	1.8%	1.0%	1.76%
2005	4,916,692	8,415,402	52,032	87,506	1,326.0	1,949.0	1.1%	2.5%	1.0%	2.15%
2006	3,989,423	12,404,825	52,881	140,387	1,559.0	3,508.0	1.3%	2.9%	1.1%	2.42%
2007	3,972,471	16,377,296	60,758	201,145	1,521.0	5,028.0	1.5%	2.5%	1.2%	2.44%
2008	3,706,459	20,083,755	63,126	264,271	1,424.0	6,453.0	1.7%	2.3%	1.3%	2.4%
2009	3,203,623	23,287,378	69,028	333,299	1,416.0	7,869.0	2.2%	2.1%	1.5%	2.34%
2010	2,804,376	26,091,754	67,103	400,402	1,288.0	9,157.0	2.4%	1.9%	1,60%	2.28%
2011	2,707,420	28,799,174	66,916	467,318	1,037.0	10,194.0	2.5%	1.5%	1.7%	2.19%
2012	2,718,182	31,517,356	69,027	536,345	955.0	11,149.0	2.5%	1.4%	1.8%	2.1%
2013	2,707,942	34,225,298	66,799	603,144	831.0	11,980.0	2.5%	1.2%	1.9%	2.02%
2014	2,887,533	37,112,831	70,075	673,219	636.0	12,616.0	2.4%	0.9%	1.9%	1.92%
2015	3,267,258	40,380,089	78,318	751,537	619.0	13,235.0	2.4%	0.8%	2.0%	1.82%
2016	3,944,512	44,324,601	102,127	853,664	591.0	13,826.0	2.6%	0.6%	2.0%	1.73%
2017	4,244,576	48,569,177	118,03	971,694	637.0	14,463.0	2.8%	0.5%	2.1%	1.64%
2018	3,574,927	52,144,104	104,041	1,075,735	629.0	15,092.0	2.9%	0.6%	2.1%	1.57%
2019	3,244,917	55,389,021	97,754	1,173,489	631.0	15,723.0	3.0%	0.6%	2.2%	1.51%
2020	3,142,283	58,531,304	76,784	1,250,273	445.0	16,168.0	2.4%	0.6%	2.2%	1.46%
Grand…	**58,531,304**	**58,531,304**	**1,250,273**	**1,250,273**	**16,168.0**	**16,168.0**	**2.1%**	**1.3%**	**2.1%**	**1.29%**

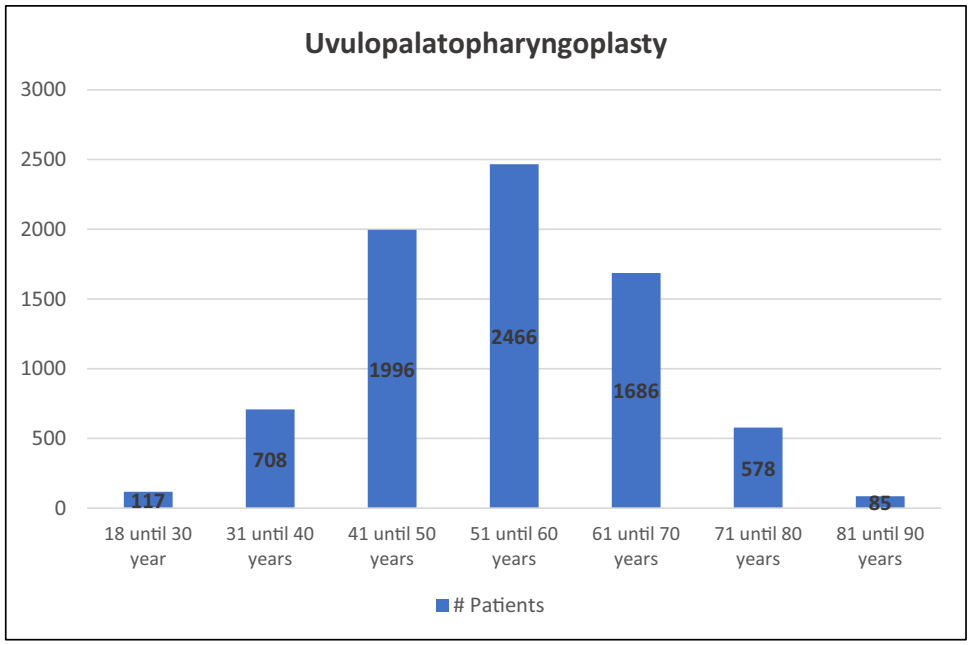

Fig. 3 Age, overall number, gender, and ethnicity of patients submitted specifically to UPPP

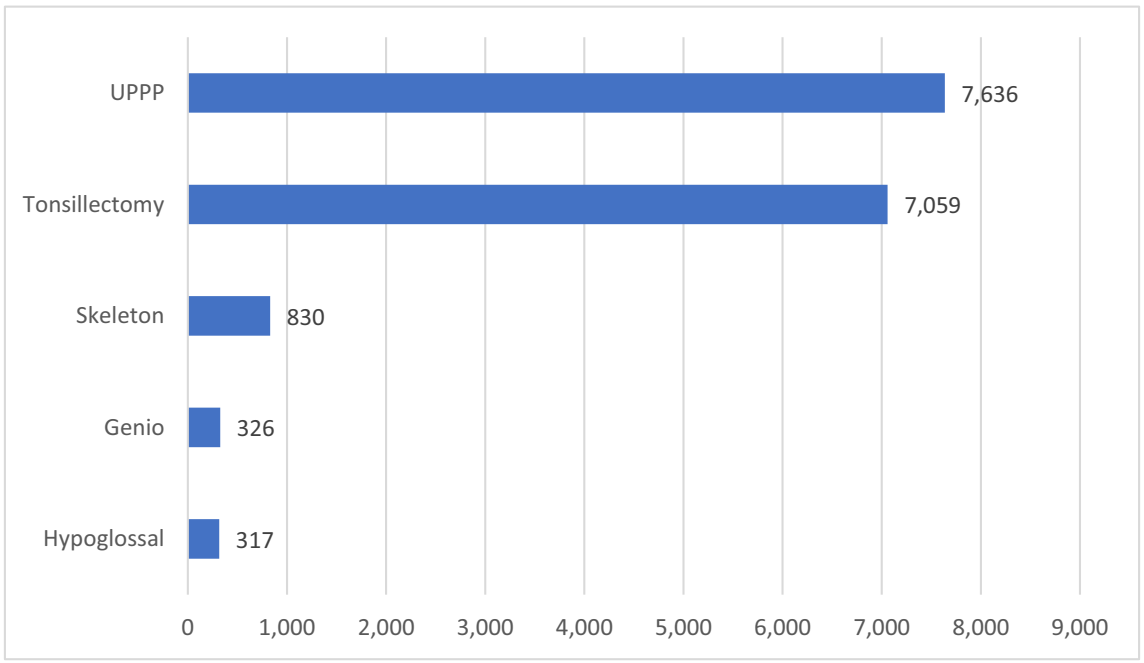

Fig. 4 Percentage of each surgical procedure

The limitations of this study should be acknowledged. The Optum database primarily includes patients with private insurance, which may introduce a selection bias toward younger patients with active medical insurance and better access to healthcare. The analysis is also limited to the quality of data input by clinicians, and there is a possibility that the available codes may not accurately reflect patients' true diagnoses from the prior year. As a database study, certain variables could not be evaluated, such as CPAP adherence and comorbidities. Additionally, other therapies, such as oral appliances and surgical procedures not included in the utilized code list, were not accounted for.

Improving the healthcare delivery system could directly enhance data outcomes by increasing the accuracy and completeness of the database used in the study. For instance, integrating comprehensive electronic health records with

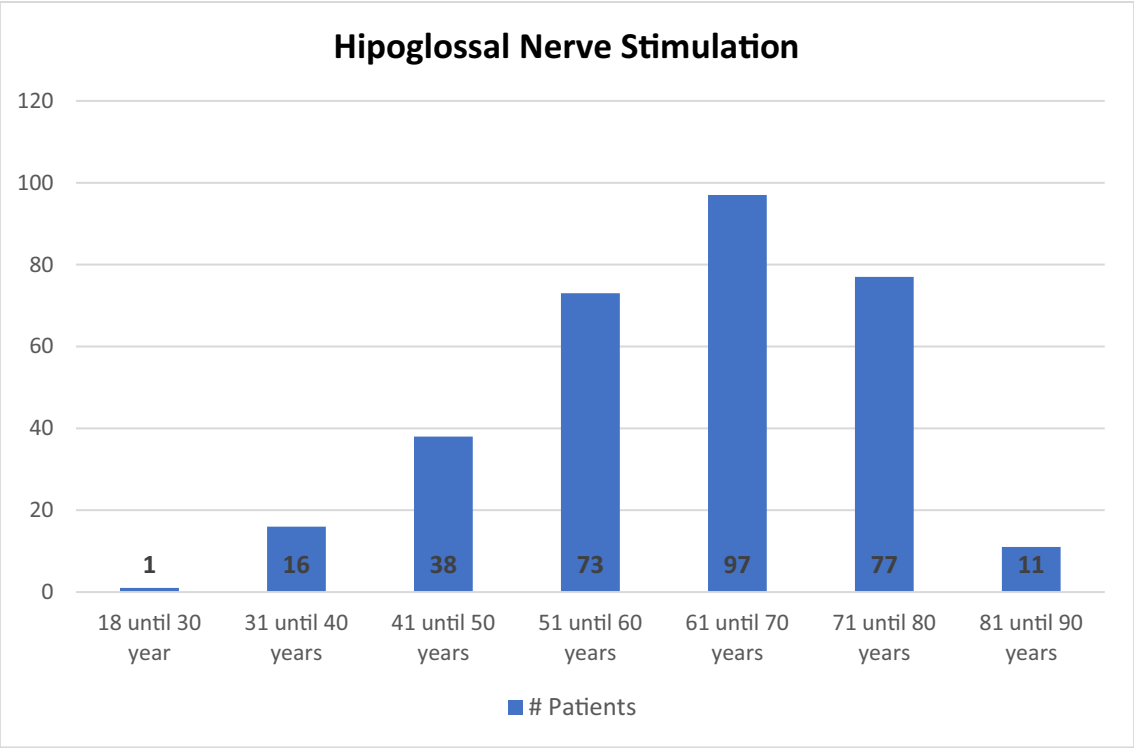

Fig. 5 Age, overall number, gender, and ethnicity of patients submitted specifically to HNS

Table 3 Medium age of patients in each type surgery

Procedure	Average age
Tonsillectomy	50.5
UPPP	54.7
Skeleton	55.2
Genio	55.8
Hypoglossal	62

real-time data capture could ensure that more detailed patient information is recorded, leading to a richer dataset. This, in turn, could facilitate more nuanced analyses of surgical outcomes and patient demographics in relation to Obstructive Sleep Apnea (OSA) treatments. Additionally, standardizing data entry processes across different healthcare providers could reduce discrepancies and improve the reliability of the study findings, enabling a more effective assessment of treatment modalities and their impacts across diverse populations.

Conclusion

This descriptive observational study offers valuable demographic insights that provide a broad overview of OSA treatment in the USA. Nonetheless, further retrospective and prospective studies are necessary to explore healthcare disparities in OSA treatment, taking into account factors such as BMI, OSA severity, and non-surgical treatment options, to effectively address these inequalities.

Abbreviations CPAP: Continuous positive airway pressure; CPT: Current procedural terminology; HNS: Hypoglossal nerve stimulation; ICD: International classification of diseases; MMA: Maxilla-mandibular advancement; OSA: Obstructive sleep apnea; SD: Standard deviation; UPPP: Uvulopalatopharyngoplasty

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Data availability All data supporting the findings of this study are available within the paper and its Identifier: DOI https://doi.org/10.17605/OSF.IO/H235F

Declarations All authors have seen and approved the manuscript.

Ethical approval For this type of study formal consent is not required.

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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