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Demographics of Adults With Obstructive Sleep Apnea Who Undergo Nasal Surgery

Swapnil Shah, BS[1,2], Jeanne A. Darbinian, MS, MPH[3], Samuel A. Collazo, MD[2], Dang Khoa Nguyen, MD[4], and Megan L. Durr, MD, FACS[2,5]

Abstract

Objective. To assess the demographic characteristics between adult obstructive sleep apnea (OSA) patients who did and did not undergo nasal surgery (NS).

Study Design. Retrospective cohort study.

Setting. Kaiser Permanente Northern California clinical database.

Methods. Retrospective study of adult patients with ≥1 OSA diagnoses linked to clinical encounters from 2009 to 2016. Qualifying NS procedures performed on or after cohort entry through 2017 were ascertained. Demographic and clinical characteristics were compared; multivariable logistic regression examined associations of these characteristics with undergoing NS.

Results. A total of 174,821 patients had an OSA diagnosis. Among these, 3518 (2.0%) underwent NS, including septoplasty (61.9%), sinus-related (12.9%), turbinate (14.2%), and rhinoplasty (11.1%) procedures. Compared to the nonsurgery group, NS patients were more likely to be male (75.5% vs 62.1%), younger (48.2 ± 13.0 vs 54.7 ± 14.1), have lower body mass index (31.8 ± 6.4 vs 34.3 ± 8.1), and no comorbid conditions (63.1% vs 53.5%), $P < .001$. After adjusting for sex, age, body mass index (BMI), neighborhood deprivation, and comorbidities, black and Asian/Pacific Islander adults with OSA had 42% and 46% decreased odds of undergoing NS compared with non-Hispanic white patients (odds ratio, OR [95% confidence interval, CI]: 0.58 [0.50-0.67] and 0.54 [0.49-0.61]), while Hispanic patients had similar odds (OR [95% CI]: 1.02 [0.93-1.12]). Patients living in neighborhoods of highest deprivation had 18% lower odds of undergoing NS, compared with patients from neighborhoods corresponding to areas of lowest deprivation (adjusted odds ratio [95% CI]: 0.82 [0.75-0.91]).

Conclusion. These findings suggest that younger age, male sex, lower BMI, and higher SES may be associated with a higher likelihood of undergoing NS in OSA patients.

Keywords

CPAP tolerance, nasal obstruction, nasal surgery, OSA

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Obstructive sleep apnea (OSA) affects an estimated 24% of men and 9% of women in the United States[1] and is associated with significantly increased risks of cardiovascular disease, hypertension, and diabetes.[2] In addition, untreated OSA may also lead to decreased cognitive function and excessive daytime sleepiness.[3,4]

The gold-standard medical treatment for OSA is continuous positive airway pressure (CPAP), which maintains the integrity of the upper airway and eliminates OSA in the vast majority of afflicted patients who can tolerate it.[5] Despite this demonstrated benefit, the compliance of CPAP, remains below 50%.[6,7] This is due to a number of concerns including discomfort, poor mask fit, dryness, aerophagia, and eye irritation.[8-10] Other variables influencing CPAP noncompliance include psychosocial factors such as claustrophobia or psychiatric disorders.[9]

Nasal obstruction is another commonly reported reason for CPAP nonadherence.[11,12] Increased nasal resistance is a determinant of CPAP failure,[13] and nasal surgery (NS) can improve CPAP tolerance in the adult population.[12,14-16] NS includes septoplasty, nasal valve reconstruction, functional endoscopic sinus surgery, turbinate reduction, and

[1]Department of Surgery, Creighton University School of Medicine, Omaha, Nebraska, USA
[2]Department of Head and Neck Surgery, Kaiser Permanente, Northern California, Oakland, California, USA
[3]Division of Research, Kaiser Permanente, Northern California, Pleasanton, California, USA
[4]Department of Head and Neck Surgery, University of Arkansas for Medical Sciences, Little Rock, Arkansas, USA
[5]Department of Head and Neck Surgery, University of California-San Francisco, San Francisco, California, USA

Corresponding Author:
Megan L. Durr, MD, FACS, Otolaryngology–Head and Neck Surgery, Zuckerberg San Francisco General Hospital, 1001 Potrero Avenue, Room 3A30, UCSF Box 0870, San Francisco, CA 94110, USA.
Email: Megan.durr@ucsf.edu

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functional rhinoplasty. Depending on OSA severity, NS may contribute to a reduction in therapeutic CPAP device pressures.[17] Studies have also shown that NS in patients with OSA can improve quality of life and daytime sleepiness with conflicting data regarding impact of NS on OSA severity.[18-20] A meta-analysis performed by Ishii et al determined that isolated NS for patients with nasal obstruction and OSA led to improvements in patient Epworth Sleepiness Scale and respiratory disturbance index scores; however, no significant changes in their apnea-hypopnea index score was observed. Therefore, NS plays a valuable role in the treatment of OSA by both improving quality of life and daytime sleepiness and by improving tolerance of CPAP.

There are very few studies assessing the demographics of adult OSA patients who undergo NS. The goal of this study is to analyze clinical and demographic data of OSA patients who did and did not undergo surgery to elucidate potential barriers to NS for adult patients with OSA.

Methods

This retrospective cohort study was conducted within the membership of Kaiser Permanente Northern California (KPNC), which is an integrated health care system that currently provides care to 4.6 million members. The membership is racially and ethnically diverse and is similar demographically to the underlying population, except at extremes of income.[21]

The source population for the study was adults with diagnoses of OSA (International Classification of Diseases diagnosis codes 327.23, version 9, and G47.33, version 10) linked to ≥2 separate clinical encounters or linked to ≥1 encounter and ≥1 record in the subject's medical problem list. Cohort entry was date of the first OSA diagnosis linked to a qualifying clinical encounter, which included inpatient, emergency department, telephone, or ambulatory, occurring between 2009 and 2016 and when the subject was aged 18 to 89 years.

Qualifying NS procedures (septoplasty, sinus-related surgery, turbinate reduction, and rhinoplasty) were performed on or after the index OSA diagnosis through 2017 and ascertained from operating room events within the management system that maintains perioperative records of procedures documented in the operating room log records. The study's principal investigator categorized the NS-related procedures linked to the cohort as OSA-related or non-OSA-related based on principal diagnosis codes in the operating room log records as well as chart review of the preoperative history and physical exam notes indicating that the NS was offered, at least in part, to improve sleep metrics (sleep quality, snoring, and/or CPAP tolerance).

Qualifying surgical procedures were then summarized at the subject level for each of the 4 major subtypes, and final categories were assigned hierarchically as rhinoplasty > septoplasty > turbinate > sinus surgery. Demographic data, including date of birth to compute age at OSA diagnosis, sex, race and ethnicity, and geocoded residential address (to link to US census tract level data), as well as height and weight (for body mass index [BMI] that was calculated within 1 year of OSA diagnosis) and comorbid conditions, were obtained from automated clinical and administrative databases. To approximate medical comorbid status at cohort entry (baseline), we calculated the Deyo version of the Charlson comorbidity index (CCI),[22] using a 2-year pre-OSA diagnosis period to capture relevant inpatient and outpatient diagnosis and procedure codes. Possible scores ranged from 0 to 19 and represented the number of comorbidities identified during this prebaseline period. As a proxy for socioeconomic status (SES), we used the neighborhood deprivation index (NDI), a validated measure of area-level SES,[23] which was calculated using area of residence and US census tract level data derived from the 2016 American Community Survey.

Bivariate analyses compared demographic (age, sex, race/ethnicity, and NDI quartile) and clinical (BMI, CCI scores) variables by NS status (any vs none) among OSA cohort members. Descriptive statistics included counts and percentages and means (±SD). Differences between groups were evaluated using χ^2 tests for categorical data and for continuous variables, t tests, and analysis of variance (ANOVA) for normally distributed data. A P value of <.05 was considered statistically significant; all tests were 2-sided. Pairwise comparisons of mean ages at index OSA diagnosis and at first NS, and mean BMI between NS types were performed using the Student's t test. When multiple pairwise comparisons were evaluated simultaneously, the corresponding P values were adjusted to control the familywise error rate at 5%, using a bootstrap sampling with replacement method. For categorical data, multiple pairwise comparisons of the proportion or column percentages of each category or level for a specific characteristic (eg., non-Hispanic white for race/ethnicity; age <45 for age at OSA diagnosis; BMI ≥30.0 kg/m^2, NDI Q4) between study groups (no NS vs 1+ relevant procedures) and between all 6 pairwise combinations of NS types (eg, rhinoplasty vs septoplasty, septoplasty vs turbinate, etc) were also considered simultaneously, with P values adjusted at 5% using bootstrap resampling for the Fisher test. Multivariable logistic regression was used to examine the association of selected characteristics with the probability of undergoing NS, producing adjusted odds ratios (aORs) and 95% confidence intervals. The final model included covariates that were associated with the outcome (NS) or were clinically relevant. All analyses were performed using SAS version 9.4. The KPNC Institutional Review Board approved this study with waiver of informed consent.

Results

The OSA cohort consisted of 174,821 adults; 37.7% were female and 62.3% male. Mean age at index OSA diagnosis was 54.5 ± 14.1 years. A total of 3794 patients in the cohort underwent 1 or more nasal procedures of which 3518 (2.0%) were deemed qualifying nasal surgeries. The 140 subjects who only underwent nonqualifying nasal surgeries were added back to the non-NS cohort totaling 171,303. As shown in **Table 1**, subjects who underwent NS were younger (mean ± SD age at index OSA diagnosis 48.6 ± 13.1 vs 54.7 ± 14.1 years, $P < .001$), had a lower mean BMI (31.8 ± 6.4 vs 34.3 ± 8.1, $P < .001$), and lower comorbidity burden at baseline (36.9% vs 46.5% had ≥1 comorbid condition, $P < .001$ for all pairwise comparisons) than those who did not undergo NS. Those who had NS were also more likely to be male, less likely to be black or Asian/Pacific Islander (Asian/PI), and to be from less deprived neighborhoods (28.5% vs 24.9% were from least deprived areas).

Among subjects who underwent a qualifying nasal surgical procedure, 61.9% underwent septoplasty, 12.9% sinus-related surgeries, 14.2% turbinate surgery, and 11.1% rhinoplasty (**Table 2**). The septoplasty subgroup had the highest proportion of males (79.6%), followed by

Table 1. The OSA Cohort: Demographic and Clinical Characteristics by Nasal Surgery Status

Characteristic, n (%)	Full cohort (n = 174,821)	Nasal surgery status: None (n = 171,303)	Nasal surgery status: ≥1 procedures (n = 3518)	*P* value[a]
Sex				<.001
Female	65,818 (37.7)	64,955 (37.9)	863 (24.5)	
Male	109,003 (62.3)	106,348 (62.1)	2655 (75.5)	
Age at OSA diagnosis, y[b]	54.5 ± 14.1	54.7 ± 14.1	48.6 ± 13.1	<.001[c]
Age (at diagnosis) group, y				<.001
<45	42,698 (24.4)	41,350 (24.1)[d]	1348 (38.3)	
45 to 54	42,082 (24.1)	41,122 (24.0)[d]	960 (27.3)	
55 to 64	46,025 (26.3)	45,234 (26.4)[d]	791 (22.5)	
≥65	44,016 (25.2)	43,597 (25.5)[d]	419 (11.9)	
Race/ethnicity				<.001
Non-Hispanic white	100,414 (57.4)	98,262 (57.4)[d]	2152 (61.2)	
Black	16,239 (9.3)	16,050 (9.4)[d]	189 (5.4)	
Hispanic	27,494 (15.7)	26,826 (15.7)[d]	668 (19.0)	
Asian/Pacific Islander	23,715 (13.6)	23,333 (13.6)[d]	382 (10.9)	
Other/unknown[e]	6959 (4.0)	6,832 (4.0)	127 (3.6)	
Neighborhood deprivation index[f], quartile				<.001
Q1 (least deprived)	43,564 (24.9)	42,561 (24.9)[d]	1003 (28.5)	
Q2	43,502 (24.9)	42,611 (24.9)	891 (25.3)	
Q3	43,642 (25.0)	42,802 (25.0)	840 (23.9)	
Q4 (most deprived)	43,584 (24.9)	42,809 (25.0)[d]	775 (22.0)	
Unknown	529 (0.3)	520 (0.3)	9 (0.3)	
BMI, kg/m^{2}[b]	34.3 ± 8.1	34.3 ± 8.1	31.8 ± 6.4	<.001[c]
<25.0	14,740 (8.4)	14,357 (8.4)[d]	383 (10.9)	<.001
25.0-29.9	42,798 (24.5)	41,662 (24.3)[d]	1136 (32.3)	
≥30.0	114,057 (65.2)	112,088 (65.4)[d]	1969 (56.0)	
Unknown	3226 (1.9)	3196 (1.9)	30 (1.0)	
Charlson comorbidity score[g]				<.001
0	93,911 (53.7)	91,691 (53.5)[d]	2220 (63.1)	
1	37,190 (21.3)	36,347 (21.2)[d]	843 (24.0)	
2	17,123 (9.8)	16,886 (9.9)[d]	237 (6.7)	
≥3	26,597 (15.2)	26,379 (15.4)[d]	218 (6.2)	

Abbreviations: BMI, body mass index; OSA, obstructive sleep apnea.
[a]From χ^2 test, unless otherwise specified.
[b]Mean ± standard deviation values are shown.
[c]From Student's *t* test.
[d]$P < .001$ between 2 groups (none vs any nasal surgery) for column percentages shown for each characteristic (eg, non-Hispanic white, comparing 57.4% vs 61.2%); *P* value from Fisher test, adjusted using bootstrap method.
[e]Other includes native American and multiracial.
[f]From 2016 American Community Survey, US Census.
[g]Derived from modified version of Deyo Charlson index score, using inpatient and outpatient diagnosis and procedure codes. For the cohort, possible scores ranged from 0 to 19 and represent the number of comorbid conditions identified during the 24 months prior to index OSA diagnosis date. Among nasal surgery recipients, 36.9% had ≥1 comorbid condition versus 46.5% among those who did not ($P < .001$).

Table 2. Characteristics of the 3518 OSA Cohort Members Who Underwent ≥1 Nasal Surgical Procedures, by Surgery Type

Characteristic, n (%)	Nasal surgery type: Rhinoplasty (n = 390, 11.1%)	Septoplasty (n = 2177, 61.9%)	Turbinate (n = 499, 14.2%)	Sinus (n = 452, 12.9%)	*P* value[a]
Sex					<.001
Female	102 (26.2)	445 (20.4)[b,c]	167 (33.5)[b]	149 (33.0)[c]	
Male	288 (73.9)	1,732 (79.6)[b,c]	332 (66.5)[b]	303 (67.0)[c]	
Age at OSA diagnosis, y[d]	50.1 ± 13.5	47.2 ± 12.7	46.6 ± 13.1	55.7 ± 12.3	<.001[e]
Age at first nasal surgery, y[d,f]	51.7 ± 13.8	48.7 ± 13.0	48.2 ± 13.5	57.8 ± 12.3	<.001[e]
Race/ethnicity					<.001
Non-Hispanic white	280 (71.8)[b,g,h,i]	1,335 (63.3)[g]	257 (51.5)[b,h]	280 (62.0)[i]	
Black	7 (1.8)[h,j]	82 (43.4)[b,c]	62 (12.4)[b,h]	38 (8.4)[c,j]	
Hispanic	63 (16.2)	445 (20.4)[c]	99 (19.8)	61 (13.5)[c]	
Asian/Pacific Islander	24 (6.1)[h,j]	226 (10.4)	72 (14.4)[h]	60 (13.3)[j]	
Other/unknown[k]	16 (4.1)	89 (4.1)	9 (1.8)	13 (2.9)	
NDI quartile[l]					.01
Q1	114 (29.2)	651 (29.9)	119 (23.9)	119 (26.3)	
Q2	96 (24.6)	568 (26.1)	112 (22.4)	115 (25.4)	
Q3	83 (21.3)	517 (23.8)	123 (24.7)	117 (25.9)	
Q4	95 (24.4)	436 (20.0)[b]	144 (28.9)[b]	100 (23.1)	
BMI, kg/m^2[d,m]	31.2 ± 5.7[j]	31.6 ± 6.1[c]	32.2 ± 6.7	33.3 ± 7.4[c,j]	<.001[e]
CC score					<.001
0	249 (63.8)[j]	1442 (66.2)[c]	336 (67.3)[i]	193 (42.7)[c,i,j]	
1	83 (21.3)[j]	495 (22.7)[c]	123 (24.7)	142 (31.4)[c,j]	
2	27 (6.9)	141 (6.5)	23 (4.6)[i]	46 (10.2)[i]	
≥3	31 (8.0)[j]	99 (4.6)[c]	17 (3.4)[i]	71 (15.7)[c,i,j]	

Abbreviations: ANOVA, analysis of variance; BMI, body mass index; CC, Charlson comorbidity; NDI, neighborhood deprivation index; OSA, obstructive sleep apnea.
[a]From χ^2 test, unless otherwise specified.
[b]For adjusted $P < .05$ (from Fisher test using bootstrap method) pairwise comparisons: septoplasty versus turbinate.
[c]For adjusted $P < .05$ (from Fisher test using bootstrap method) pairwise comparisons: septoplasty versus sinus.
[d]Mean ± standard deviation values are shown.
[e]*F* statistic from ANOVA. All pairwise differences among nasals surgery types for mean age at first OSA diagnosis and mean age at first nasal surgery are statistically significant except for septoplasty versus turbinate.
[f]Mean age at first nasal surgery for the 3518 who underwent a qualifying procedure was 50.1 ± 13.5 years.
[g]For adjusted $P < 0.05$ (from Fisher test using bootstrap method) pairwise comparisons: rhinoplasty versus septoplasty.
[h]For adjusted $P < 0.05$ (from Fisher test using bootstrap method) pairwise comparisons: rhinoplasty versus turbinate.
[i]For adjusted $P < .05$ (from Fisher test using bootstrap method) pairwise comparisons: turbinate versus sinus.
[j]For adjusted $P < .05$ (from Fisher test using bootstrap method) pairwise comparisons: rhinoplasty versus sinus.
[k]Other includes native American and multiracial.
[l]0.2% to 0.5% with missing data not shown.
[m]0.4% to 1.0% with missing data not shown.

rhinoplasty, sinus surgery, and turbinate surgery at 73.9%, 67.0%, and 66.5%, respectively. Patients who underwent sinus surgery were on average older at first NS than the subgroups that underwent the other 3 types of NS (57.8 years vs 48.2-51.7 years, *P* value from ANOVA <.001 [**Table 2**]).

As shown in **Table 3**, after adjusting for sex, age, BMI, neighborhood deprivation, and comorbidities, black and Asian/PI adults with OSA had 42% and 46% decreased odds of undergoing NS compared with non-Hispanic white patients (aOR [95% CI]: 0.58 [0.50-0.67] and 0.54 [0.49-0.61]), while Hispanic patients had similar odds (aOR [95% CI]: 1.02 [0.93-1.12]). Age at OSA diagnosis, baseline BMI and comorbid disease status, and higher NDI (corresponding to most deprived neighborhoods) were independently inversely associated with having NS. For every 10-year increase in age, the odds of undergoing NS were 26% lower (aOR [95% CI]: 0.74 [0.72-0.76], $P < .001$). Patients with obesity had 45% lower odds of undergoing NS compared with under- and healthy weight cohort members (aOR [95% CI]: 0.55 [0.49-0.62], $P < .001$); and patients with ≥3 comorbid conditions had 39% decreased odds of having NS (aOR [95% CI]: 0.61 [0.53-0.71], $P < .001$). Cohort members whose address aligned with neighborhoods of highest deprivation had 18% lower odds of undergoing NS, compared with patients from census tracts corresponding to areas of lowest deprivation (aOR [95% CI]: 0.82 [0.75-0.91], $P < .001$).

Table 3. The Multivariable Association of Selected Characteristics With Undergoing Nasal Surgery

Variable	OR (95% CI)	*P* value[a]
Sex		
Male	1.00	
Female	0.59 (0.55-0.64)	<.001[b]
Age at OSA diagnosis (per 10-y increase)	0.74 (0.72-0.76)	<.001[b]
Race/ethnicity		
Non-Hispanic white	1.00	
Black	0.58 (0.50-0.67)	<.001[b]
Asian/PI	0.54 (0.49-0.61)	<.001[b]
Hispanic	1.02 (0.93-1.12)	.68
Other/unknown	0.69 (0.58-0.83)	<.001[b]
Body mass index, kg/m^2		
<25.0	1.00	
25.0-29.9	0.91 (0.80-1.02)	.10
≥30.0	0.55 (0.49-0.62)	<.001[b]
Unknown	0.28 (0.19-0.40)	<.001[b]
Charlson comorbidity score		
0	1.00	
1	1.21 (1.11-1.31)	<.001[b]
2	0.89 (0.78-1.03)	.11
3+	0.61 (0.53-0.71)	<.001[b]
NDI quartile (2016 ACS)		
Q1 (area of lowest deprivation)	1.00	
Q2	0.90 (0.82-0.99)	.03[b]
Q3	0.86 (0.78-0.95)	.001[b]
Q4 (area of highest deprivation)	0.82 (0.75-0.91)	<.001[b]
Missing	0.74 (0.38-1.44)	.37

Abbreviations: ACS, American Community Survey; CI, confidence interval; NDI, neighborhood deprivation index; OR, odds ratio; OSA, obstructive sleep apnea; PI, Pacific Islander.
[a]From Wald χ^2 test.
[b]Statistically significant: $P < .05$ and 95% CI does not include 1.00.

Discussion

This study compared demographic characteristics of adult OSA patients who underwent NS compared with those who did not undergo NS. We identified several important findings including that patients who were younger and male were more likely to undergo NS. We also found that 2.0% of adults with OSA underwent NS during the 9-year period of this study, and that the most common NS was septoplasty.

In an effort to improve the health and quality of life consequences of OSA, several lifestyle, medical, and surgical therapies are available.[24] Treatment options include CPAP, mandibular advancement devices, and positional therapy. Surgical options include soft tissue surgery of the palate, tongue base, lateral pharynx, and supraglottis as well as maxillomandibular advancement, genioglossus advancement hyoid suspension, hypoglossal nerve stimulation, bariatric surgery, and tracheotomy. CPAP remains the first-line treatment for OSA, but its success rates are undermined by nonadherence.

NS serves as 1 possible intervention to alleviate nasal obstruction that may be limiting CPAP tolerance. There have been several studies evaluating NS outcomes on both OSA severity and CPAP tolerance with some conflicting results. Most studies demonstrated that NS resulted in decreased nasal resistance as well as improved daytime sleepiness and CPAP tolerance.[12,13,25-28] Several studies have also demonstrated that despite improving sleepiness and quality of life, NS does not generally improve OSA severity. In general, studies indicate that NS may be a cost-effective option for improving CPAP tolerance.[29,30] The associated improved nasal breathing and daytime sleepiness, along with the relatively low-risk profile of most NS, collectively make this treatment modality a commonly recommended option for patients with baseline nasal obstruction and difficulty tolerating CPAP. Additionally, there may be significant utility in the use of topical nasal treatments alongside NS that further improve CPAP tolerance and subjective quality of life in patients with OSA.[31,32]

In our study, we observed a sex disparity for OSA patients that underwent NS within our cohort. In prior studies, men were found to have greater nasal surface areas (SA) and airflow volumes (V) when compared to women, likely due to taller piriform apertures, internal nasal cavities and choanae.[33] However, a comparison of their SA:V ratios, nasal airflow rate, and heat flux were deemed to be insignificant suggesting that nasal physiology was comparable between sexes. Reasons why a smaller proportion of women underwent NS may be multifactorial. Women may present with insomnia, restless legs, depression, nightmares, palpitations, and hallucinations rather than the classic symptoms of snoring and daytime sleepiness seen in men with OSA. Thus, it is possible that more attention is devoted to treating or alleviating these symptoms rather than to interventions aimed at treating their OSA or improving CPAP compliance. There are numerous factors that could be associated with this sex difference, and more qualitative studies on the decision-making behaviors of OSA patients are needed to elucidate why more men with OSA underwent NS compared to women.

We also observed that cohort members who underwent NS were on average younger at index OSA diagnosis than their counterparts who did not undergo NS. This finding may have implications for the lower perioperative risks and higher success rates of surgery in younger populations. It is well known that the risk of developing OSA increases with age, and the low numbers of surgeries in the elderly population is likely attributable to higher medical co-morbidities, decreased functional status, and limited data on surgical outcomes.[34] Nasal surgeries tend to have less complicated postoperative courses than airway surgeries for OSA so otolaryngologists should not discount NS as an option for older patients who may not be optimal surgical candidates for larger upper airway OSA procedures.

The geographical impact of ethnic differences in external nasal anatomy has previously been well documented. These variations in structure may contribute to the need for NS, both in the context of aesthetic and functional purposes, however little data show that these anatomical differences contribute to increased susceptibility to sinonasal or obstructive disease.[35-37] Differences between groups include that of alar base/width, nasolabial angle, degree of nasal flaring, degree of tip protrusion/shape, total nasal length, directional orientation of nostrils, and the presence of a dorsal hump amongst several other identifying features.[38]

Another associated factor in the decision to pursue NS is CPAP tolerance/adherence. In a study analyzing the relationship between CPAP adherence and race, it was determined that longer sleep latency and shorter sleep duration were closely related to poor CPAP adherence as was being of black race.[39] Findings that longer sleep latency and shorter sleep duration were more common in minority populations from disadvantaged backgrounds with less education, lower incomes and residing in communities of lower SES lend support to the hypothesis that these are associated with greater levels of psychological distress, life stressors, and depression.[40,41] These findings support previous reports that non-white populations are disproportionately afflicted by sleep health disparities; however, whether this is due to socioeconomic factors, racial/ethnic representation in medicine, or cultural mores is unknown and warrants additional discussion on the variables impacting these disadvantaged groups.

Our findings that patients residing within neighborhoods of highest deprivation had 18% lower odds of undergoing NS than areas of lowest deprivation support that accessibility to surgical options, including NS, may be significantly limited by a patient's income and their SES. Per a scoping review assessing sociodemographic and health care barriers in the management of OSA, patients with lower income and occupational status, as well as those without private medical and dental insurance were less likely to receive PAP alternatives.[42] Additional studies highlight that while referral delays were identified as a barrier to surgical management for OSA, lower referral rates for CPAP alternatives and lower rates of follow-up were associated with hospital systems located within lower income neighborhoods, those of which serve patient populations less likely to possess adequate health insurance.[43,44] This highlights a need for improved communication between otolaryngologists housed at large academic centers and primary care providers and sleep medicine providers serving patients within lower income communities, provider and patient education regarding options for the stepwise management of OSA, and greater transparency regarding financial support available to patients to minimize costs related to their treatment.

Increased BMI and obesity are well-documented risk factors for OSA diagnosis and severity. The linear association of BMI and comorbidities such as cardiovascular disease, stroke or diabetes increase risk for surgical complications related to anesthesia, postoperative infection, thromboembolism, and renal failure.[45] This study observed that the mean BMI was higher in the group of patients that did not receive NS and that patients with obesity had 45% lower odds of undergoing NS compared with under- and healthy weight cohort members. While concern for increased intraoperative and postoperative complications related to patient BMI may have influenced surgeon recommendation of NS to patients, recent literature demonstrates that upper airway surgery and other surgical procedures in the management of OSA, such as maxillomandibular advancement, may not only be effective in partially reducing the symptom burden of OSA but is safe for patients with "obese categorized" BMIs.[46-48] This supports the use of NS in the increased BMI population suffering from OSA.

In our multicenter retrospective cohort study of a large, diverse population of adult patients with OSA, we compared selected demographic characteristics between subjects who underwent NS in the treatment of their nasal obstruction and those who did not. Compared with their non-NS counterparts, the subset of surgical patients was overall younger in age (at OSA diagnosis) and had a higher proportion of males and non-Hispanic white and Hispanic race or ethnicity, and lower proportion identified as black and Asian/PI race.

A potential limitation of this study is that it solely compares OSA patients who underwent NS and those who did not. Another potential limitation of our study is the OSA diagnosis was not assigned based on sleep study results but instead through a pre-existing diagnosis of OSA, defined via ≥2 separate clinical encounters or linked to ≥1 encounter and ≥1 record in the subject's medical problem list. This study is also limited by an inability to quantify the severity of patients' OSA or their CPAP tolerance status. Furthermore, we are unable to confirm that the NS was conducted specifically for OSA treatment. Although NS may be a reasonable form of treatment for certain patients, others are likely to benefit sufficiently with medical management of nasal obstruction. NS is generally not recommended as the sole treatment for OSA, thus there is often overlap in the goals of NS, including treatment of nasal obstruction along with the simultaneous goal of addressing sleep quality and/or CPAP compliance. Even with a comprehensive chart review, it can be difficult to pinpoint a single goal for NS in this patient population. Additionally, the study does not account for turbinate reductions performed in the office. Further studies are needed to understand the potential anatomical, physiologic, and socioeconomic differences in OSA patients undergoing NS.

Conclusion

Our study's findings suggest that younger age, male sex, lower BMI, and higher SES may be associated with a higher likelihood of undergoing NS in OSA patients. More research is needed to assess trends and outcomes in NS for OSA patients.

Author Contributions

Swapnil Shah, concept and design, acquisition, analysis or interpretation of data, drafting of the manuscript, critical review of the manuscript for important intellectual content, administrative, technical or material support; **Jeanne A. Darbinian**, design of study, methods, and analysis plan, acquisition, analysis and interpretation of data, drafting of the manuscript and critical review for important intellectual content, administrative, technical or material support, statistical analysis; **Samuel A. Collazo**, concept and design, drafting of the manuscript, critical review of the manuscript for important intellectual content, administrative, technical or material support; **Dang Khoa Nguyen**, drafting of the manuscript, critical review of the manuscript for important intellectual content; **Megan L. Durr**, concept and design, acquisition, analysis or interpretation of data, drafting of the manuscript, critical review of the manuscript for important intellectual content, administrative, technical or material support, supervision.

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ORCID iD

Swapnil Shah http://orcid.org/0000-0002-4085-7143
Megan L. Durr http://orcid.org/0000-0003-1084-8702

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