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ORIGINAL RESEARCH

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Healthcare disparities for the development of airway stenosis from the medical intensive care unit

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Abstract

Objectives/hypothesis: To identify sociodemographic factors associated with the development of airway stenosis (AS) among intubated medical intensive care unit (MICU) patients.

Study design: Retrospective cohort study.

Methods: A retrospective review of adult MICU intubated patients from 2013 to 2019 at a single academic institution was performed. Univariate and multivariate analysis with logistic regression examined associations between the development of AS and subsite abnormalities such as posterior glottic stenosis (PGS), subglottic stenosis (SGS), tracheal stenosis (TS), vocal fold immobility (VFI), and posterior glottic granuloma (PGG) with age, body mass index (BMI), height, weight, race, ethnicity, sex, rurality, Appalachian status, length of admission, distance to hospital, and median household income.

Results: Of an overall sample of 6603 MICU patients, 449 intubated patients were included in the study, and 204 patients were found to have AS. AS was statistically associated with decreased driving distance to the hospital and increases in BMI. PGS was statistically associated with increases in age. TS was statistically associated with increases in admission duration and not having residence status in Appalachia. VFI was statistically associated with decreases in driving distance to the hospital and not having residence status in Appalachia. Additionally, black patients had a higher odds of developing VFI compared to Caucasian patients.

Conclusion: AS is associated with sociodemographic factors such as age, BMI, shorter distance to hospital, admission duration, and no Appalachian status. These data demonstrate the need to further investigate the impact of social determinants of health on airway pathology and outcomes.

Level of evidence: 4.

KEYWORDS

airway stenosis, glottic stenosis, healthcare access, healthcare disparities, tracheal stenosis

1 | INTRODUCTION

There is a continuously growing body of evidence that sociodemographic factors such as race, ethnicity, socioeconomic status, and rurality can affect overall health outcomes.[1] Previously, a number of these social determinants of health have been associated with affecting outcomes of various otolaryngological pathologies.[2–5] However, only one study to date has assessed the impact of sociodemographic factors on the development of airway stenosis (AS).[6]

AS, or laryngotracheal stenosis, is a spectrum of disorders defined as a narrowing of the upper airway between the larynx and/or trachea proximal to the bronchial bifurcation. Subtypes of AS include posterior glottic stenosis (PGS), subglottic stenosis (SGS), tracheal stenosis (TS), vocal fold immobility (VFI), and posterior glottic granuloma (PGG). AS presents a significant clinical concern, both due to the multidisciplinary treatment required and possible complications varying from recurrent stridor to respiratory arrest.[7,8] Several etiologies have been implicated with AS, but the most common associations include post-tracheostomy AS and post-intubation AS, with incidences varying from 3% to 31%.[9–14] Additional causes include autoimmune, infectious, neoplastic, and idiopathic.[15] AS not only impedes patient health and wellness, but it can also place a considerable financial burden on the patient.[16] Previous studies have estimated the annual cost of AS maintenance to be between $4000 and $8500, depending on etiology.[17]

Previously, diabetes, race, education status, duration of intubation, tobacco use, and obesity were independently identified as sociodemographic risk factors associated with the development with or diagnosis of AS,[6,7,13,14,18] but no study has comprehensively assessed sociodemographic and modifiable factors that may contribute to AS subtypes in a medical intensive care unit (ICU) setting. Although tracheostomies and intubations present a risk for AS, they are often necessary procedures in an intensive care setting. Therefore, recognizing aspects of patient care associated with AS is imperative to understand the etiology of AS and improve the public health infrastructure to minimize airway complications. Based upon previous literature which analyzes sociodemographic factors associated with AS, we hypothesized that the specific factors analyzed in this study would be associated with frequency of developing AS subtypes based on stenosis etiology.

2 | MATERIALS AND METHODS

The institutional review board (IRB) at the University of Kentucky approved this study (IRB #52662). The University of Kentucky Center for Clinical and Translational Science (CCTS) was used to query clinical data from the electronic medical record. A retrospective chart review was conducted using CPT codes (31,500, 31,603, 31,605, 31,622, 31,600, 43,246) for intubation, bronchoscopy, tracheostomy, percutaneous endoscopic gastrostomy, or emergency intubation between January 1, 2013, and July 31, 2019. ICD10 codes (J38.6, J.38.3, J38.00-J38.02, J38.7, J95) for LS, "other disorders of the larynx, including PGG", VFI (J38.00 is unspecified laterality, J38.01 is unilateral, J38.02 is bilateral), "other diseases of the larynx", and "intraoperative and postprocedural complications and disorders of the respiratory system" were utilized, respectively. Likewise, ICD9 codes (478.74, 478.5, 478.3, 478.79, J59) were utilized for the same variables listed above, respectively. Inclusion criteria were patients older than 18 years old identified at the University of Kentucky who were intubated during admission to the MICU and had a complete record of endotracheal/tracheostomy tube size, airway procedures, sociodemographic data, and medical diagnosis. Exclusion criteria were a prior history of tracheostomy or tracheal stent, intubation at an outside hospital, history of airway dilation, history of head and neck cancer, less than 18 years of age, and use of anticoagulants. A sample of 6603 medical records was available based on CPT codes alone. After medical record review, we identified a sample of 440 patients with a complete record of endotracheal/tracheostomy tube size, airway procedures, sociodemographic data, and medical diagnosis. Sociodemographic data collected included: age, BMI, height, weight, race, ethnicity, sex, zip-code, distance to hospital, and median household income. Clinical data included: length of admission, admission service, airway and complication subtype, and additional comorbidities. Data were compiled in Microsoft Excel (Microsoft Corp., Redmond, WA).

Rural status was determined by the Beale codes from the 2013 U.S. Department of Agriculture Rural–Urban Continuum Coding (RUCC) system.[19] The Beale code system provides a single-digit numeric continuum ranging from 1 to 9 with one denoting a metro population of 1 million or more, and nine denoting a rural county or a county that does not neighbor a metropolitan area with less than 2500 residents. Patients were further stratified based on whether or not their county belongs to the Appalachian region as denoted by the Appalachian Regional Commission.[20] Driving distance to the medical center was approximated using Google Maps (3.47.3, Mountain View, CA, USA). Median household income for a given zip-code region was obtained from the American Community Survey database from 2019 published by the United States Census Bureau.[21]

Counts and percentages were recorded for each variable. Dichotomous variables were compared using Chi-squared testing for univariate analysis and logistic regression for multivariate comparison. Continuous or categorical variables were compared between groups using the Mann–Whitney *U* test. A *p* value of .05 or greater was considered statistically significant. Odds ratios and confidence intervals were recorded for univariate and multivariate analysis. Both univariate logistic regression analysis and multivariate logistic regression analysis were used to predict associated risk factors. Results were considered statistically significant if the resulting *p* value was less than .05. Statistical analysis was performed using STATA 12.1 (College Station, TX, USA).

3 | RESULTS

The 266 (4.0%) of the 6603 patients who were intubated developed some form of AS. Of these 266 patients, 204 (3.1%) were over the

TABLE 1 Demographics for patients developing airway stenosis and stenosis subtypes

	Controls	Airway stenosis	Posterior glottic stenosis	Subglottic stenosis	Tracheal stenosis	Vocal fold immobility	Posterior glottic granuloma
	n = 245	*n* = 204	*n* = 70	*n* = 48	*n* = 122	*n* = 16	*n* = 14
Variable	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Sex							
Male	102 (41.6)	106 (52.0)	35 (50.0)	27 (56.3)	64 (52.5)	6 (37.5)	4 (28.6)
Female	143 (58.4)	98 (48.0)	35 (50.0)	21 (43.8)	58 (47.5)	10 (62.5)	10 (71.4)
Total	245 (100)	204 (100)	70 (100)	48 (100.0)	122 (100)	16 (100)	14 (100)
Age (year)							
25%	41 (–)	43 (–)	48 (–)	39 (–)	43 (–)	42.5 (–)	39 (–)
50%	54 (–)	56 (–)	58 (–)	53 (–)	55.5 (–)	52.5 (–)	50.5 (–)
75%	63 (–)	65 (–)	70 (–)	60 (–)	64 (–)	60 (–)	63 (–)
Race							
White	221 (90.9)	190 (93.1)	66 (94.3)	42 (87.5)	112 (91.8)	11 (68.8)	13 (92.9)
Black	22 (9.05)	13 (6.37)	3 (4.29)	6 (12.5)	10 (8.20)	5 (31.3)	1 (7.14)
American Indian/Alaskan	0 (0)	1 (0.49)	1 (1.43)	0 (0)	0 (0)	0 (0)	0 (0)
Ethnicity							
Hispanic	5 (2.04)	1 (0.49)	0 (0)	1 (2.08)	1 (0.82)	1 (6.25)	0 (0)
Non-Hispanic	221 (90.2)	198 (97.1)	69 (98.6)	47 (97.9)	120 (98.4)	15 (93.8)	14 (100)
Not reported	19 (7.76)	5 (2.45)	1 (1.43)	0 (0)	1 (0.82)	0 (0)	0 (0)

age of 18 and, therefore, met inclusion criteria. Of the 204 patients that developed AS, 70 (15.6%) developed PGS, 48 (10.7%) developed SGS, 122 (27.2%) developed TS, 16 (3.6%) developed VFI, and 14 (3.1%) developed PGG. 49 (10.9%) patients developed multiple forms of AS. Table 1 details the demographic data of the patients who developed AS. 52% of the patients who developed AS were male, and the average age of patients who developed AS was 54.5 (SD 15.9 year) years old.

Multivariate analysis factors for patients who developed AS are described in Table 2. The average BMI of patients who developed AS was 31.5 (SD 12.0), and the average height was 169 cm (SD 12.1 cm). The average duration of admission for patients who developed AS was 25.1 days (SD 25.4 days). Based on the RUCC codes, 161 (79%) of all patients who developed AS were from rural communities as denoted by a RUCC code greater than 3. Similarly, 48.5% of patients who developed AS were from Appalachian communities. The mean driving distance to the University of Kentucky Medical Center was 54.8 miles (SD 47.2 miles). The average regional income for patients who developed AS was $41,783 (SD $15,546).

Both univariate and multivariate analysis results are shown in Table 3. Univariate analysis was utilized to analyze factors directly associated with social determinants of health, specifically, BMI, race, ethnicity, rurality, Appalachian status, distance to the hospital, and median household income. On univariate analysis, patients had a 2.2% higher odds of developing AS for every 1 kg/m^2 increase in BMI (odds ratio [OR]: 1.02; 95% confidence interval (95% CI): [1.00–1.01]; p = .019). BMI was not, however, statistically correlated with any subtypes of AS on univariate analysis. Black patients demonstrated an increased risk of developing VFI (OR: 6.06; 95% CI: [1.98–18.6]; p = .002) compared to Caucasian patients. Race was not statistically correlated with the development of any other forms of AS on univariate analysis. Similarly, associations between ethnicity and AS subtypes were not statistically significant. Although rurality did not demonstrate any statistically significant associations with AS on univariate analysis, patients from Appalachian regions were less likely to be diagnosed with both TS (OR: 0.549; 95% CI: [0.360–0.836]; p = .005) and VFI (OR: 0.278; 95% CI: [0.088–0.876]; p = .03) compared to patients that did not live in Appalachia. Similarly, patients who lived closer to the University of Kentucky Medical Center were more likely to be diagnosed with AS (OR: 0.996; 95% CI: [0.992–0.999]; p = .02) and VFI (OR: 0.980; 95% CI: [0.964–0.996]; p = .01) on univariate analysis. Median household income was not statistically associated with the development of AS.

A multivariate sociodemographic model was utilized to analyze a variety of factors and the association with AS and AS subtypes. In brief, every one-year increase in age was associated with a 3% increase in odds of developing PGS (OR: 1.03; 95% CI: [1.01–1.04]; p = .006). Additionally, for every one-day increase in length of admission, patients had a 1% increase in odds of developing TS (OR: 1.01; 95% CI: [1.00–1.02]; p = .03). Similar to the results on univariate analysis, black patients had an increased odds of developing VFI (OR: 6.07; 95% CI: [1.56–23.6]; p = .009) compared to Caucasian patients. Patients had a 63% lower odds of being diagnosed with TS if they lived in Appalachian regions (OR: 0.369; 95% CI: [0.191–0.713];

TABLE 2 Multivariate analysis factors affecting airway stenosis and stenosis subtypes

Variable	Airway stenosis *n* = *204*	Posterior glottic stenosis *n* = *70*	Subglottic stenosis *n* = *48*	Tracheal stenosis *n* = *122*	Vocal fold immobility *n* = *16*	Posterior glottic granuloma *n* = *14*
BMI						
25%	22.7	22.3	24.6	23.2	28.3	22.1
50%	29.0	29.0	29.9	29.3	30.6	28.9
75%	36.6	35.1	38.3	37.3	42.1	40.6
Height (cm)						
25%	157	160	157	157	159	164
50%	168	1703	166	168	169	179
75%	178	178	178	180	183	187
Weight (kg)						
25%	66	65	66	68	75	69
50%	83	80	85	86	85	94
75%	107	101	112	111	117	123
Length of admission (days)						
25%	8.8	6.0	10.0	10.0	9.8	8.5
50%	18.0	14.0	18.5	20.5	15.0	22.5
75%	33.3	25.0	32.3	36.5	22.3	33.8
Rural–urban continuum codes						
1–3	87	27	23	56	9	6
4–6	52	24	12	26	4	5
7–9	65	19	13	40	3	3
Appalachian status						
Yes	99	41	21	52	4	4
No	105	29	27	70	12	10
Distance to hospital (mi)						
25%	12.7	17.4	9.4	10.0	9.4	11.9
50%	39.2	45.9	32.7	34.0	20.0	32.7
75%	91.8	87.4	87.9	93.2	35.7	35.8
Median household income ($)						
25%	$ 30,071	$ 28,948	$ 34,229	$ 30,071	$ 34,740	$ 32,300
50%	$ 38,323	$ 38,590	$ 39,975	$ 38,323	$ 47,714	$ 45,652
75%	$ 51,093	$ 50,152	$ 51,494	$ 51,093	$ 59,536	$ 51,068

$p = .003$) compared to patients from non-Appalachian regions. Weight, height, sex, ethnicity, rurality, driving distance to the University of Kentucky Medical Center, and median household income were not statistically associated with the development of AS on multivariate analysis.

4 | DISCUSSION

This study demonstrates potential sociodemographic factors that may contribute to the development of AS and AS subtypes in an ICU setting. Although one study to date has analyzed social determinants of health that may contribute to generalized laryngotracheal stenosis,[6] this is the first study to additionally look at stenosis subtypes and their association with rural status, Appalachian status, and distance to the medical center. Factors associated with the development of AS varied by subtype.

Increased age was positively associated with the development of the PGS subtype ($p = .006$). However, previous studies have reported statistically insignificant higher incidences of both PGS and SGS among younger patients.[22,23] Although contradicting information exists regarding this result, research has demonstrated functional and

TABLE 3 Odds ratios (OR) and 95% confidence intervals (95% CI) for the development of airway stenosis and stenosis subtypes

	Airway stenosis		Posterior glottic stenosis		Subglottic stenosis		Tracheal stenosis		Vocal fold immobility		Posterior glottic granuloma	
	n = 204		*n* = 70		*n* = 48		*n* = 122		*n* = 16		*n* = 14	
Variable	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Age												
Univariate	–	–	–	–	–	–	–	–	–	–	–	–
Multivariate	1.01 (1.00–1.02)	.16	**1.03 (1.01–1.04)**	***.006***	0.993 (0.975–1.01)	.45	0.996 (0.983–1.01)	.58	1.00 (0.97–1.03)	.96	0.995 (0.961–1.03)	.75
BMI												
Univariate	**1.02 (1.00–1.01)**	***.02***	1.02 (0.993–1.04)	.17	1.02 (0.990–1.04)	.24	1.02 (0.971–1.01)	.25	1.03 (0.991–1.07)	.14	1.01 (0.965–1.06)	.67
Multivariate	0.962 (0.845–1.10)	.56	0.911 (0.776–1.07)	.25	0.907 (0.760–1.08)	.28	0.987 (0.863–1.13)	.85	0.927 (0.685–1.25)	.62	0.751 (0.496–1.14)	.18
Height (cm)												
Univariate	–	–	–	–	–	–	–	–	–	–	–	–
Multivariate	0.971 (0.917–1.03)	.32	0.954 (0.886–1.03)	.20	0.945 (0.871–1.03)	.17	0.992 (0.933–1.06)	.81	0.944 (0.814–1.10)	.45	0.941 (0.802–1.10)	.45
Weight (kg)												
Univariate	–	–	–	–	–	–	–	–	–	–	–	–
Multivariate	1.02 (0.975–1.07)	.37	1.04 (0.983–1.10)	.17	1.04 (0.978–1.11)	.21	1.01 (0.962–1.06)	.71	1.04 (0.939–1.15)	.46	1.10 (0.968–1.25)	.14
Length of admission (days)												
Univariate	–	–	–	–	–	–	–	–	–	–	–	–
Multivariate	1.01 (1.00–1.02)	.07	0.998 (0.989–1.01)	.65	1.00 (0.991–1.01)	.87	**1.01 (1.00–1.02)**	***.03***	0.984 (0.950–1.02)	.37	1.00 (0.984–1.02)	.84
Race												
Univariate	0.687 (0.337–1.40)	.30	0.490 (0.146–1.65)	.25	1.81 (0.713–4.63)	.21	1.07 (0.497–2.29)	.87	**6.06 (1.98–18.6)**	***.002***	0.900 (0.114–7.09)	.92
Multivariate	0.535 (0.249–1.15)	.11	0.504 (0.143–1.77)	.29	1.60 (0.601–4.25)	.35	0.773 (0.344–1.74)	.53	**6.07 (1.56–23.6)**	***.009***	0.444 (0.047–4.20)	.48
Male gender												
Univariate	–	–	–	–	–	–	–	–	–	–	–	–
Multivariate	1.27 (0.71–2.30)	.42	0.978 (0.427–2.24)	.96	1.33 (0.538–3.28)	.54	1.45 (0.755–2.77)	.27	0.727 (0.160–3.30)	.68	0.970 (0.150–6.27)	.10
Ethnicity												
Univariate	0.223 (0.026–1.93)	.17	-	-	1.58 (0.181–13.8)	.68	0.498 (0.058–4.31)	.53	5.38 (0.592–49.0)	.14	-	-
Multivariate	0.190 (0.021–1.68)	.14	-	-	1.56 (0.166–14.7)	.70	0.511 (0.057–4.61)	.55	4.75 (0.422–53.4)	.21	-	-
Rurality (RUCC codes 1–9)												
Univariate	0.956 (0.889–1.03)	.22	0.970 (0.878–1.07)	.55	0.929 (0.824–1.05)	.22	0.954 (0.879–0.104)	.26	0.836 (0.675–1.04)	.10	0.919 (0.742–1.14)	.44
Multivariate	1.02 (0.904–1.16)	.72	0.884 (0.743–1.05)	.17	1.05 (0.859–1.28)	.65	1.08 (0.949–1.24)	.23	1.34 (0.898–2.01)	.15	1.11 (0.800–1.55)	.52
Appalachian status												
Univariate	0.695 (0.479–1.01)	.06	1.28 (0.763–2.14)	.35	0.646 (0.354–1.18)	.16	**0.549 (0.360–0.836)**	***.005***	**0.278 (0.088–0.876)**	***.03***	0.337 (0.104–1.09)	.07
Multivariate	0.625 (0.344–1.14)	.12	2.13 (0.951–4.79)	.07	0.830 (0.321–2.15)	.70	**0.369 (0.191–0.713)**	***.003***	0.750 (0.126–4.45)	.75	0.231 (0.043–1.25)	.09

TABLE 3 (Continued)

	Airway stenosis		Posterior glottic stenosis		Subglottic stenosis		Tracheal stenosis		Vocal fold immobility		Posterior glottic granuloma	
	n = *204*		*n* = *70*		*n* = *48*		*n* = *122*		*n* = *16*		*n* = *14*	
Distance to hospital (mi)												
Univariate	**0.996 (0.992–0.999)**	***.02***	0.998 (0.993–1.00)	*.32*	0.995 (0.988–1.00)	*.10*	0.996 (0.992–1.00)	*.06*	**0.980 (0.964–0.996)**	***.01***	0.990 (0.977–1.00)	*.14*
Multivariate	0.996 (0.991–1.00)	*.07*	0.995 (0.987–1.00)	*.19*	1.00 (0.987–1.00)	*.28*	0.998 (0.993–1.00)	*.34*	0.978 (0.949–1.01)	*.15*	0.994 (0.976–1.01)	*.55*
Median household income ($)												
Univariate	1.00 (0.999–1.00)	*.85*	1.00 (1.00–1.00)	*.49*	1.00 (1.00–1.00)	*.35*	1.00 (1.00–1.00)	*.71*	1.00 (1.00–1.00)	*.09*	1.00 (1.00–1.00)	*.84*
Multivariate	1.00 (1.00–1.00)	*.70*	1.00 (1.00–1.00)	*.38*	1.00 (1.00–1.00)	*.43*	1.00 (1.00–1.00)	*.65*	1.00 (1.00–1.00)	*.12*	1.00 (1.00–1.00)	*.42*

Note: Statistically significant results have been bolded with the *p* values italicized.

anatomical differences of the airway that develop with age that increase susceptibility to airway compromise.[24,25] In the context of healthcare disparities, the elderly's anatomical predisposition to the development of airway pathology may be a future consideration when monitoring patients after a tracheostomy or intubation.

Obesity is a well-documented comorbidity associated with the development of AS.[1,6,13,26] However, past research has attributed these results to various factors with the most common being an increase in endotracheal tube size for obese patients. In this study, increases in BMI across all weight classes were moderately associated with the development of generalized AS on univariate analysis ($p = .02$). Although there may exist an increasing prevalence of AS among obese patients due to differing treatment modalities, these results indicate that any increase in BMI may increase susceptibility to AS. Additionally, in this study, increases in BMI were not statistically associated with increases in intubation/tracheostomy tube size on simple linear regression ($p = .16$). However, this result may vary from past literature due to the influence of BMI being analyzed continuously. Future work on this topic is, therefore, required to determine the exact association between BMI and AS.

Length of admission was positively associated with TS on multivariate analysis ($p = .03$). Increased duration of admission not only produces a significant financial burden for patients,[27] but these results indicate that prolonged intubation may lead to worse healthcare outcomes in the future. However, length of admission was additionally statistically associated with a number of airway comorbidities that may have necessitated prolonged airway interventions or prolonged length of stay such as chronic obstructive pulmonary disease ($p = .03$), obstructive sleep apnea ($p < .001$), bronchitis ($p < .001$), and pneumonia ($p < .001$) on multiple logistic regression. Healthcare disparities relating to the development and treatment of airway diseases have been well documented in the past.[28]

This study additionally demonstrated an increased odds of black patients developing VFI on univariate analysis ($p = .002$) and multivariate analysis ($p = .009$) compared to Caucasian patients. AS has previously been demonstrated to be more prevalent among black children due to their increased risk of being born prematurely or undergoing endotracheal intubation.[18] However, in the context of our study, all patients were older than 18 and, therefore, had anatomically developed airways; additionally, previous tracheostomy placement was an exclusion criterion. VFI has also been shown to be more common among black patients in the context of laryngeal cancer due to decreased laryngeal preservation with chemoradiation.[29] There are several explanations for this finding between race and AS incidence. First, researchers have previously recommended prolonged observation and follow-up on patients after prolonged tracheostomy to reduce the risk of AS; however, previous studies have demonstrated racial differences in post-discharge utilization of healthcare after trauma.[30] Secondly, sociodemographic factors such as insurance quality, access to care, healthcare literacy, and transportation may influence a patient's decision to seek care, and these barriers are increasingly prevalent among black communities.[31–33] Because of the small sample size in the VFI subgroup, the result may be statistically obscured and should be scrutinized appropriately. However, the outcome does align with previously demonstrated disparities among the black community and, therefore, warrants future analysis by healthcare providers. One unique observation was the association of race with the development of VFI and the lack thereof in the other AS subcategories. A possible explanation is the neurogenic etiology of VFI's leading to vocal fold paralysis. Previous studies have demonstrated an increase rate of VFI among black and Hispanic patients due to an increased incidence of recurrent laryngeal nerve bifurcations in this population.[34,35] This variation has been linked to increased rates of VFI if a branch is considered to be the entire nerve, resulting in increased risk to the additional branch(es).[36] The VFI cohort was selected specifically from the MICU to reduce procedure or trauma-related injuries to the airway, but not all procedures can be excluded that put the recurrent laryngeal nerve at risk. Alternatively, it is known that the endotracheal tube and intubation itself can lead to paralysis of the recurrent laryngeal nerve.[37]

Similar to many rural populations in the United States, patients from Appalachian communities have demonstrated numerous barriers to healthcare.[38,39] Of note, these obstacles exist within an otolaryngology setting and have previously been demonstrated to impede access to care.[3,40] In this study, Appalachian populations demonstrated decreased odds of developing TS on both univariate analysis ($p = .005$) and multivariate analysis ($p = .003$) in addition to decreased odds of developing VFI on univariate analysis ($p = .03$). However, we initially hypothesized that Appalachian populations would demonstrate increased incidences of AS due to their higher association with comorbidities such as obesity,[41] increased use of tobacco products,[42] and an increased incidence of general airway disease.[43] These results seem to elucidate an additional barrier to healthcare for the Appalachian population, namely that they are less likely to present for reevaluation and be diagnosed with AS compared to non-Appalachian patients. Distance to the hospital has previously been a demonstrated barrier to timely otolaryngology diagnosis for Appalachian populations.[3] In this study, patients from Appalachian and non-Appalachian communities had a mean distance to the hospital of 90.0 miles (SD 45.2) and 30.3 miles (SD 61.4), respectively. Additionally, patients from both rural and Appalachian communities have been shown to perceive their communities as not lacking in access to healthcare. Wilson et al. appropriately point out that healthcare utilization must be contextualized based on the given community to assess perceptions and cultural factors that may influence a patient's decision to seek care.[44] Similarly, these results seen in Appalachia are supported by the decreased odds of developing AS and VFI as driving distance to the hospital increases. Patients had a 4.4% lower odds of being diagnosed with AS for every 10-mile increase in driving distance to the hospital ($p = .02$) and a 20% lower odds of being diagnosed with VFI for every 10-mile increase in driving distance to the hospital ($p = .01$) on univariate analysis. Although increased facilities and medical infrastructure may be necessary to improve the delivery of otolaryngology care, future research should look to determine possible cultural differences or perceptions of health and wellness to explain why certain populations may delay seeking care.

There are limitations to this study that may impede the generalizability of the results. The generalizability of this study is somewhat limited to a MICU patient population that is rural by majority and seeks medical assistance from a large tertiary medical facility. Primarily, the small sample size increases the possibility of error and decreases the overall power of the study. The nature of a retrospective cohort study also introduces inherent limitations that may limit this study's ability to highlight any causal relationship. However, this information may be used to inform more rigorous studies in the future. Moreover, the utilization of zip-code information to localize patients to a region introduces possible errors by analyzing the patient in the context of their geographic group and not as an individual with patient-specific information. Although this method is less problematic when used to determine patients' rural status and Appalachian status, a possible error is introduced when approximating household income and driving distance to the hospital. Nonetheless, this information helped identify specific at-risk groups based on the geographic location that may rationalize future research on the effect of sociodemographic factors on the development of AS. Finally, this study is limited by the fact that we do not include in the univariate and multivariate models every factor associated with the development of AS in the literature. This study, however, sought to specifically analyze sociodemographic factors and physical factors that may contribute to the development AS and expand upon the known contributing factors. Future studies should both incorporate these variables in additional analysis and gather more patient-specific data to expand knowledge on the topic and improve patient outcomes while minimizing harm in at-risk populations.

5 | CONCLUSION

Sociodemographic factors may contribute to the development of stenosis after intubation or tracheostomy placement. Associated risk factors include age, BMI, length of admission, race, Appalachian status, and distance to the medical center. Recognition of high-risk patient populations may help improve overall otolaryngological outcomes and reduce the development of adverse complications in the future.

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CONFLICT OF INTEREST

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REFERENCES

1. Bird Y, Lemstra M, Rogers M, Moraros J. The relationship between socioeconomic status/income and prevalence of diabetes and associated conditions: a cross-sectional population-based study in Saskatchewan, Canada. *Int J Equity Health*. 2015;14:93. doi:10.1186/s12939-015-0237-0
2. Barnett M, Hixon B, Okwiri N, et al. Factors involved in access and utilization of adult hearing healthcare: a systematic review. *Laryngoscope*. 2017;127(5):1187-1194. doi:10.1002/lary.26234
3. Bush ML, Hardin B, Rayle C, Lester C, Studts CR, Shinn JB. Rural barriers to early diagnosis and treatment of infant hearing loss in Appalachia. *Otol Neurotol*. 2015;36(1):93-98. doi:10.1097/MAO.0000000000000636
4. Bush ML, Kaufman MR, McNulty BN. Disparities in access to pediatric hearing healthcare. *Curr Opin Otolaryngol Head Neck Surg*. 2017;25(5):359-364. doi:10.1097/MOO.0000000000000388
5. Urban MJ, Wojcik C, Eggerstedt M, Jagasia AJ. Rural-urban disparities in otolaryngology: the state of Illinois. *Laryngoscope*. 2021;131(1):E70-E75. doi:10.1002/lary.28652
6. Dang S, Shinn J, Campbell B, Garrett G, Wootten C, Gelbard A. The impact of social determinants of health on laryngotracheal stenosis development and outcomes. *Laryngoscope*. 2020;130(4):1000-1006. doi:10.1002/lary.28208
7. Hanlon K, Boesch RP, Jacobs I. Subglottic stenosis. *Curr Probl Pediatr Adolesc Health Care*. 2018;48(4):129-135. doi:10.1016/j.cppeds.2018.03.007
8. Almanzar A, Danckers M. Laryngotracheal stenosis. *StatPearls*. StatPearls Publishing; 2021 http://www.ncbi.nlm.nih.gov/books/NBK554561/
9. Kastanos N, Miró RE, Perez AM, Mir AX, Agustí-Vidal A. Laryngotracheal injury due to endotracheal intubation: incidence, evolution, and predisposing factors. A prospective long-term study. *Crit Care med*. 1983;11(5):362-367.
10. Dane TEB, King EG. A prospective study of complications after tracheostomy for assisted ventilation. *Chest*. 1975;67(4):398-404. doi:10.1378/chest.67.4.398
11. Stauffer JL, Olson DE, Petty TL. Complications and consequences of endotracheal intubation and tracheotomy: a prospective study of 150 critically ill adult patients. *Am J med*. 1981;70(1):65-76. doi:10.1016/0002-9343(81)90413-7
12. Norwood S, Vallina VL, Short K, Saigusa M, Fernandez LG, McLarty JW. Incidence of tracheal stenosis and other late complications after percutaneous tracheostomy. *Ann Surg*. 2000;232(2):233-241. doi:10.1097/00000658-200008000-00014
13. Li M, Yiu Y, Merrill T, Yildiz V, de Silva B, Matrka L. Risk factors for posttracheostomy tracheal stenosis. *Otolaryngol Head Neck Surg*. 2018;159(4):698-704. doi:10.1177/0194599818794456
14. Wu X, Su ZZ, Hu LJ, et al. Analysis of the risk factors causing tracheal stenosis after tracheotomy for mechanical ventilation in 560 patients. *Zhonghua Er bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2007;42(11):839-842.
15. Gelbard A, Francis DO, Sandulache VC, Simmons JC, Donovan DT, Ongkasuwan J. Causes and consequences of adult laryngotracheal stenosis. *Laryngoscope*. 2015;125(5):1137-1143. doi:10.1002/lary.24956
16. Bibas BJ, Cardoso PFG, Salati M, et al. Health-related quality of life evaluation in patients with non-surgical benign tracheal stenosis. *J Thorac Dis*. 2018;10(8):4782-4788. doi:10.21037/jtd.2018.07.80
17. Yin LX, Padula WV, Gadkaree S, et al. Health care costs and cost-effectiveness in laryngotracheal stenosis. *Otolaryngol Head Neck Surg*. 2019;160(4):679-686. doi:10.1177/0194599818815068
18. Johnson RF, Isaiah A. Laryngeal stenosis among hospitalized children: results from a nationwide cross-sectional survey. *Laryngoscope Investig Otolaryngol*. 2018;3(3):244-248. doi:10.1002/lio2.153
19. Rural-Urban Continuum Codes. USDA Economic Research Service. United States Department of Agriculture. 2021. https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx
20. Kentucky. Appalachian Counties Served by ARC. Appalachian Regional Commission, 2021. https://www.arc.gov/appalachian-counties-served-by-arc/
21. U.S. Census Bureau. American Community Survey - Median Income in the Past 12 Months (in 2019 Inflation-Adjusted Dollars). 2021. https://data.census.gov/cedsci/table?t=Income%20and%20Earnings&g=0400000US21%24860000&y=2019&tid=ACSST5Y2019.S1903&hidePreview=true
22. Collins AM, Chorath K, Simpson CB. Subglottic stenosis: An evaluation of an elderly treatment-seeking population. *Laryngoscope*. 2019;129(5):1155-1158. doi:10.1002/lary.27495
23. Hillel AT, Karatayli-Ozgursoy S, Samad I, et al. Predictors of posterior glottic stenosis: a multi-institutional case-control study. *Ann Otol Rhinol Laryngol*. 2016;125(3):257-263. doi:10.1177/0003489415608867
24. Hiramatsu T, Kataoka H, Osaki M, Hagino H. Effect of aging on oral and swallowing function after meal consumption. *Clin Interv Aging*. 2015;10:229-235. doi:10.2147/CIA.S75211
25. Johnson KN, Botros DB, Groban L, Bryan YF. Anatomic and physiopathologic changes affecting the airway of the elderly patient: implications for geriatric-focused airway management. *Clin Interv Aging*. 2015;10:1925-1934. doi:10.2147/CIA.S93796
26. Halum SL, Ting JY, Plowman EK, et al. A multi-institutional analysis of tracheotomy complications. *Laryngoscope*. 2012;122(1):38-45. doi:10.1002/lary.22364
27. Di Fusco M, Shea KM, Lin J, et al. Health outcomes and economic burden of hospitalized COVID-19 patients in the United States. *J med Econ*. 2021;24(1):308-317. doi:10.1080/13696998.2021.1886109
28. Gaffney AW, Himmelstein DU, Christiani DC, Woolhandler S. Socioeconomic inequality in respiratory health in the US from 1959 to 2018. *JAMA Intern med*. 2021;181(7):968-976. doi:10.1001/jamainternmed.2021.2441
29. Hou WH, Daly ME, Lee NY, Farwell DG, Luu Q, Chen AM. Racial disparities in the use of voice preservation therapy for locally advanced laryngeal cancer. *Arch Otolaryngol Head Neck Surg*. 2012;138(7):644-649. doi:10.1001/archoto.2012.1021
30. Chun Fat S, Herrera-Escobar JP, Seshadri AJ, et al. Racial disparities in post-discharge healthcare utilization after trauma. *Am J Surg*. 2019;218(5):842-846. doi:10.1016/j.amjsurg.2019.03.024
31. Osborn CY, Cavanaugh K, Wallston KA, et al. Health literacy explains racial disparities in diabetes medication adherence. *J Health Commun*. 2011;16(sup3):268-278. doi:10.1080/10810730.2011.604388
32. Syed ST, Gerber BS, Sharp LK. Traveling towards disease: transportation barriers to health care access. *J Community Health*. 2013;38(5):976-993. doi:10.1007/s10900-013-9681-1

33. Lillie-Blanton M, Hoffman C. The role of health insurance coverage in reducing racial/ethnic disparities in health care. *Health Aff*. 2005;24(2):398-408. doi:10.1377/hlthaff.24.2.398
34. Fontenot TE, Randolph GW, Friedlander PL, Masoodi H, Yola IM, Kandil E. Gender, race, and electrophysiologic characteristics of the branched recurrent laryngeal nerve. *Laryngoscope*. 2014;124(10):2433-2437. doi:10.1002/lary.24631
35. Plowman EK, Chheda N, Anderson A, et al. Vocal fold mobility impairment after cardiovascular surgery: incidence, risk factors, and sequela. *Ann Thorac Surg*. 2021;112(1):53-60. doi:10.1016/j.athoracsur.2020.07.074
36. Beneragama T, Serpell JW. Extralaryngeal bifurcation of the recurrent laryngeal nerve: a common variation. *ANZ J Surg*. 2006;76(10):928-931. doi:10.1111/j.1445-2197.2006.03899.x
37. Shin YH, An DA, Choi WJ, Kim YH. Unilateral vocal cord paralysis following a short period of endotracheal intubation anesthesia. *Korean J Anesthesiol*. 2013;65(4):357-358. doi:10.4097/kjae.2013.65.4.357
38. Shell R, Tudiver F. Barriers to cancer screening by rural Appalachian primary care providers. *J Rural Health*. 2004;20(4):368-373. doi:10.1111/j.1748-0361.2004.tb00051.x
39. Elnicki DM, Morris DK, Shockcor WT. Patient-perceived barriers to preventive health care among indigent, rural Appalachian patients. *Arch Intern med*. 1995;155(4):421-424. doi:10.1001/archinte.1995.00430040097012
40. Bush ML, Osetinsky M, Shinn JB, et al. Assessment of Appalachian region pediatric hearing healthcare disparities and delays. *Laryngoscope*. 2014;124(7):1713-1717. doi:10.1002/lary.24588
41. Holben DH, Pheley AM. Diabetes risk and obesity in food-insecure households in rural Appalachian Ohio. *Prev Chronic Dis*. 2006;3(3):A82.
42. Schoenberg NE, Huang B, Seshadri S, Tucker TC. Trends in cigarette smoking and obesity in Appalachian Kentucky. *South med J*. 2015;108(3):170-177. doi:10.14423/SMJ.0000000000000245
43. Stellefson M, Wang MQ, Balanay JAG, Wu R, Paige SR. Latent health risk classes associated with poor physical and mental outcomes in workers with COPD from central Appalachian U.S. states. *Int J Environ Res Pub Health*. 2020;17(18):6798. doi:10.3390/ijerph17186798
44. Wilson SL, Kratzke C, Hoxmeier J. Predictors of access to healthcare: what matters to rural Appalachians? *Glob J Health Sci*. 2012;4(6):23-35. doi:10.5539/gjhs.v4n6p23

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