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## Association Between e-Cigarette Vaping, Voice Quality and Vocal Cord Integrity Among Patients at the Quezon City General Hospital

### ABSTRACT

**Objective:** To determine the association between e-cigarette vaping, voice quality and vocal cord integrity among patients aged 19 years old and above at the Quezon City General Hospital based on the Filipino Voice Handicap Index (VHI), laryngoscopy, and GRBAS scale.

### Methods:

**Design:** Cross-Sectional Study

**Setting:** Tertiary Government Training Hospital

**Participants:** Ninety-eight (98) participants aged 19 years old and above with no previously known laryngeal illness who use e-cigarettes, completed the Filipino VHI, laryngoscopic evaluation, and GRBAS evaluation were recruited in the study.

**Results:** Out of 98 participants, 65.3% (64/98) and 34.7% (34/98) were current and past e-cigarette users, respectively, of which 30% (29/98) had abnormal laryngeal findings. Abnormal laryngeal findings were observed in 34.4% (22/64) and 20.6% (7/34) of current and past e-cigarette users, respectively, ( $p=.172$ ) which include erythema, edema or swelling, vascularity, and mucus in the vocal folds. Asthma ( $OR=145.1$ ,  $95\%CI=2.6-79.2$ ,  $p=.015$ ) and current smoking ( $OR=13.9$ ,  $95\%CI=1.6-17.1$ ,  $p=.016$ ) were significantly associated with abnormal laryngeal findings, while current smoking was significantly associated with higher GRBAS scores ( $\beta=0.5$ ,  $95\%CI=0.06-1.0$ ,  $p=.025$ ). Years vaping, pods and drops used, and nicotine content level were not significantly associated with abnormal laryngeal findings, GRBAS scores and VHI scores ( $p>.05$ ).

**Conclusion:** In this study, the prevalence of abnormal laryngeal findings was 30% among e-cigarette users which was higher among current e-cigarette users than past users. Concurrent cigarette smoking was a significant predictor of abnormal endoscopic findings and voice quality. Further research is recommended to substantiate the association of e-cigarette vaping with voice quality and laryngeal integrity.

**Keywords:** voice quality; vocal cord; larynx; smoking; vaping; e-cigarette; cigarette; voice handicap



In recent years, electronic cigarettes (e-cigarettes) and vaping gained popularity as a safer alternative to smoking,<sup>1</sup> especially for those who opted to quit smoking. With vaping, aerosol molecules deposited on the surfaces of the upper airways can have physiological effects on the oropharynx and vocal cords.<sup>2</sup> Inhaling the heated vapors from e-cigarettes cause mucosal burn to the epithelium and damage to the Reinke space, manifesting as erythema and ulcerative lesions on the vocal folds. These inflammatory reactions and ulcerations result in biochemical changes to the vocal fold properties which cause dysphonia.<sup>3</sup>

Using the terms “vaping,” “e-cigarette,” “dysphonia,” “voice,” “larynx,” and “vocal cord,” a search of HERDIN Plus, MEDLINE (PubMed and PubMed Central), the Directory of Open Access Journals (DOAJ), and Google Scholar found one local study on the association of e-cigarette use and dysphonia. This study by Dealino and Dela Cruz compared dysphonia in conventional cigarette smokers and e-cigarette users using the Filipino Voice Handicap Index (VHI) scores.<sup>4</sup> At present, sufficient concrete evidence on the effects of e-cigarette smoking, especially on vocal function and the vocal cords, is still lacking.

This study was initiated to investigate and gather more evidence on the possible effects of e-cigarettes on voice quality and vocal cord integrity through endoscopy, GRBAS scale and Filipino VHI in the local setting. The insights and results derived from this study, hopefully will help contribute to the current knowledge on the possible effects in the upper airway and guide clinicians to educate patients on e-cigarette use. Thus, the objective of this study was to determine the association between e-cigarette smoking, voice quality and vocal cord integrity based on laryngoscopic findings, GRBAS scale, and VHI scores.

## METHODS

With Quezon City General Hospital Institutional Ethics Review Board approval (2023.May 6.1400. Plumo CR.VAPING-8), this cross-sectional study was conducted at the Quezon City General Hospital ENT Out-Patient Department from May 12, 2023 to February 18, 2024. Prospective participants were patients aged 19 years old and above who had used and currently used e-cigarettes and sought consultation in the Department of Otorhinolaryngology – Head and Neck Surgery. Excluded were patients with upper respiratory tract infection in the past 3 months, tuberculosis, autoimmune disease, voice abuse, vocal cord lesions, or any pharyngo-laryngeal disease or malignancy, and those who underwent head and neck surgery, radiotherapy and/or chemotherapy.

At least 98 participants were needed based on a 17.3% prevalence of voice impairment among e-cigarettes users<sup>4</sup> with 95% confidence interval, and 7.5% margin of error. This was deemed sufficient for a two

tailed logistic regression analysis to detect at least a significant odds ratio of 2.0 with 95% confidence interval and 80.0% power. Quota sampling was employed wherein consecutive participants eligible for inclusion were recruited to participate in the study until the needed sample size was met.

Baseline demographic and clinical data were collected including age, sex, comorbidities, use of cigarettes, frequency and duration of e-cigarette use, type of e-cigarette nicotine system used (e.g. pods for pod systems, liquid for vaporizers, etc.), and nicotine content level.

The sample population was divided into two groups, current and past e-cigarette users, for comparison. Current e-cigarette users were defined as those who currently used e-cigarettes at the time of data collection, while past e-cigarette users were those who discontinued using e-cigarettes one month prior to data collection. This division was done to determine whether discontinuation of vaping or e-cigarette would have effects on the voice and vocal cords compared to those using e-cigarettes recently.

History-taking and physical examination were done by the primary author which included palpation of the neck and visualization of the oropharynx and larynx with emphasis on the vocal cords and dysphonia.

Participants answered the Filipino Voice Handicap Index questionnaire and the scores were recorded by the primary author using Microsoft® Excel for Microsoft 365 MSO Version 2505 Build 16.0.18827.20102 (Microsoft Corp., Redmond WA, USA). The Filipino Voice Handicap Index (VHI) is a reliable subjective tool for identifying vocal dysfunction by measuring psychosocial handicap through a validated questionnaire consisting of 30 statements of reactions to and experiences on voice disorders.<sup>5</sup>

Afterwards, the primary author asked participants to read an excerpt from a summary of *Ang Ibong Adarna*<sup>6</sup> inside a separate room with minimal noise, recording these using the Voice Recorder App of a Samsung Galaxy S21 Ultra 5G SM-G998BZKGPL Android Smartphone (Samsung Electronics Co., Ltd., Seoul, Korea), and transferred to a Lenovo IdeaPad Flex 5 14ITL05 82HS0089AU 11th Gen Intel(R) Core(TM) i5-1135G7 @ 2.40GHz 2.42 GHz (Lenovo Group Limited, Beijing, China). The voice recordings were encoded with numbers and were blindly evaluated by a board-certified laryngologist from the Philippine Academy of Laryngobronchoesophagology and Phoniatrics (PALP) using the GRBAS scale. Ten to 20 recordings were evaluated for 2-3 hours a day, two days a week every third month. The GRBAS scale has 5 parameters: (G)rade, (R)oughness, (B)reathiness, (A)sthenia, and (S)train, and has 4 categories: normal or 0, slight or 1, moderate or 2, and severe or 3.<sup>7</sup>

Video laryngoscopy was performed by the primary author using a Medeasys 70-degree, 4mm x 18cm rigid endoscope (China) to evaluate

the appearance of the vocal cords, using a WDR-U200MB Mini HD Digital Camera S200-MB (China). The video recordings were saved into the same Lenovo laptop and labeled with different numbers by the primary author. These were then blindly evaluated by the same board-certified laryngologist. The encoded numbers were different to ensure that the laryngologist was blinded separately to the voice recordings and video laryngoscopy to avoid bias. Erythema, edema or swelling, vascularity, and mucus in the vocal folds and laryngeal structures were graded using the nonvibratory observations rating system used by Sample.<sup>8</sup> The ratings were 0 – normal, 1 – mild, 2 – moderate, and 3 – severe. Data gathered was entered into the same Microsoft 365 Excel database by the primary author for analysis.

Patient characteristics were summarized using means with standard deviations for continuous variables and frequencies with percentages for categorical variables. Chi-square test and Fisher Exact test were used to compare patient characteristics between those with and without laryngeal findings. Simple and multiple logistic regression analysis was used to determine the association between factors that may be related to the laryngeal findings. Simple and multiple linear regression analysis were used for the VHI and GRBAS scores. STATA version 14.0 (StataCorp LLC, College Station, TX, USA), was used for data analysis and a p-value of <.05 was considered significant.

**RESULTS**

Out of 105 recruited participants, a total of 98 were included. Seven participants were excluded because of incomplete data. The ages of the participants ranged from 19 to 59 years old with a mean age of 30.6 years old. Majority were males (74.5%). Out of 98 participants, 65.3% (64/98) and 34.7% (34/98) were current and past e-cigarette users, respectively, and 29.6% (29/98) had abnormal laryngeal findings. The comorbid conditions were hypertension (11.2%), asthma (4.1%), and diabetes mellitus (3.1%). Using Chi-square test, asthma was significantly higher among those with abnormal laryngeal findings (10.3%) than those without (1.5%); [df=1, X<sup>2</sup>=4.1, p=.042]. (Table 1)

The number of years of vaping ranged from 0.5 to 7 years with a mean duration of 2.7 years while the number of years of cigarette smoking ranged from 1 to 38 years with a mean duration of 7.5 years. The number of pack-years ranged from 0.05 to 19 pack-years with a mean of 3 pack-years. Among the 64 current e-cigarette users, 26.6% (17/64), 21.9% (14/64), and 51.6% (33/64) were non-smokers, past smokers, and current smokers, respectively. Among the 34 past e-cigarette users, 23.5% (8/34), 38.2% (13/34), and 38.2% (13/34) were non-smokers, past smokers, and current smokers, respectively.

Out of 98 participants, 46.9% (46/98) were current smokers, 27.6% (27/98) past smokers, and 25.5% (25/98) non-smokers. Among the

46 current smokers, 71.7% (33/46) and 28.1% (13/46) were past and current e-cigarette smokers, respectively, and 39.1% (18/46) were found with abnormal laryngeal findings. Among the 27 past smokers, 51.9% (14/27) and 48.1% (13/27) were past and current e-cigarette smokers, respectively, and 11.1% (3/27) were found with abnormal laryngeal findings. Among the 25 non-smokers, 32% (8/25) and 68% (17/25) were past and current e-cigarette smokers, respectively, and 32% (8/25) were found with abnormal laryngeal findings. Using Chi-square test, concurrent smoking was significantly higher among those with abnormal laryngeal findings (62.1%) than those without (40.6%) [df=2, X<sup>2</sup>=6.5, p=.039]. (Table 2)

The mean number of years vaping was 2.3 and 2.4 among those with and without laryngeal findings, respectively. The mean number of

**Table 1.** Demographic profile

	Overall (N=98)	With laryngeal findings (n=29, 29.6%)	Without laryngeal findings (n=69, 70.4%)	t-value	X <sup>2</sup> value	p-value
Age (mean, SD)	30.6±7.5	30.5±6.7	30.9±9.3	-0.23	-	.8197
Sex						
Male	73 (74.5)	20 (69.0)	53 (76.8)	-	0.66	.416
Female	25 (25.5)	9 (31.0)	16 (23.2)			
Comorbidities						
Hypertension	11 (11.2)	2 (6.9)	9 (13.0)	-	0.77	.499
Diabetes mellitus	3 (3.1)	2 (6.9)	1 (1.5)	-	2.04	.208
Asthma	4 (4.1)	3 (10.3)	1 (1.5)	-	4.1	.042
Cancer	0 (0.0)	0 (0.0)	0 (0.0)	-	n/a	n/a
Others	6 (6.1)	1 (3.5)	5 (7.3)	-	0.51	.667
Cigarette smoker						
Past	27 (27.5)	3 (10.3)	24 (34.8)	-	6.5	.039
Never	25 (25.5)	8 (27.6)	17 (24.6)			
Current	46 (46.9)	18 (62.1)	28 (40.6)			
E-Cigarette smoker						
Years vaping (mean, SD)	2.4±1.8	2.3±1.2	2.4±1.8	0.25	-	.799
Pods used per week (mean, SD)	1.8±1.9	1.6±1.3	1.8±2.2	0.64	-	.523
Drops used per day (mean, SD)	0.8±2.6	0.8±2.7	0.8±2.2	0.02	-	.982
Nicotine content level (mean, SD)	3.9%±1.7	3.6%±1.8	4.0%±1.7	0.87	-	.387

Independent t-test was used for continuous variables, Chi-square test was used for sex and cigarette smoker, Fisher's test for comorbidities



Pods used per week was 1.6 and 1.8 among those with and without laryngeal findings, respectively. The mean number of drops used per day was 0.8 among those with and without laryngeal findings. Finally, the mean nicotine content level was 3.6% and 4.0% among those with and without laryngeal findings, respectively.

Based on the nonvibratory observations rating scale used in laryngoscopy, the total scores ranged from 4 to 16. The mean scores were 7.7 and 6.9 among current and past e-cigarette users, respectively. Out of 98 participants, the laryngoscopic findings in decreasing order were: mild vocal fold (VF) mucus in 71 (72.5%), mild arytenoid edema in 56 (57.1%), mild VF edema in 48 (49%), mild arytenoid erythema in 45 (45.9%), mild ventricular fold erythema in 45 (45.9%), mild VF varices in 30 (30.6%), mild VF discoloration in 25 (25.5%), moderate VF mucus in 21 (21.4%), and moderate arytenoid edema in 16 (16.3%). The prevalence of abnormal laryngeal findings among those with current and past e-cigarette use were 34.4% (22/64) and 20.6% (7/34), respectively, with no significant difference between the two groups using Chi-square test [df=1,  $X^2=2.02$ ,  $p=.172$ ]. Among the 17 non-smokers who currently used e-cigarettes, 100% had abnormal laryngoscopic findings, 94% (16/17) of which had VF mucus. On multivariable logistic regression analysis, years vaping [adjusted OR=1.0, 95%CI=0.7-1.3,  $p=.872$ ], pods used per week [adjusted OR=0.9, 95%CI=0.6-1.4,  $p=.608$ ], drops used per day [adjusted OR=0.9, 95%CI=0.7-1.1,  $p=.350$ ], and nicotine content level used [adjusted OR=1.9, 95%CI=0.2-2.5,  $p=.512$ ] were not significantly associated with abnormal laryngeal findings. (Table 3)

Based on the GRBAS scale, the total scores ranged from 0 to 4. The mean scores were 1.2 and 1.3 among current and past e-cigarette users, respectively. Seventy-nine (79) out of 98 participants (80.6%) scored mild for roughness, 1 (1%) moderate for roughness, 10 (10.2%) mild for breathiness, 19 (19.4%) mild for asthenia, and 9 (9.2%) mild for strain. There was no significant difference between current and past e-cigarette users with regards to the mean GRBAS scale scores using Fisher Exact test ( $t=0.65$ ,  $p=.519$ ). Among the 17 non-smokers who currently used e-cigarettes, 70.6% (12/17) scored mild for roughness with negligible scores in other parameters. Based on multivariable linear regression analysis, concurrent smoking was significantly associated with higher GRBAS scores [adjusted  $\beta=0.5$ , 95% CI=0.06-1.0,  $p=.025$ ]. Years vaping [adjusted  $\beta=-0.05$ , 95% CI=-1.2-1.1,  $p=.930$ ], pods [adjusted  $\beta=-0.06$ , 95% CI=-11.6-10.5,  $p=.990$ ], drops [adjusted  $\beta=0.03$ , 95% CI=-0.04-1.1,  $p=.374$ ], and nicotine content level used [adjusted  $\beta=-7.1$ , 95% CI=-18.0-4.3,  $p=.221$ ] were not significantly associated with GRBAS scores. (Table 4)

The VHI total scores ranged from 0 to 26 with a mean score of 6.6 and 5.6 for current and past e-cigarette users, respectively. There was no significant difference in the mean VHI scores between current and

**Table 2.** Outcomes of participants who use e-cigarettes

	Overall (N=98)	Current E-Cigarette User (n=64, 65.3%)	Past E-Cigarette User (n=34, 34.7%)	t-value	$X^2$ value	p-value
With laryngeal findings	29 (29.6)	22 (34.4)	7 (20.6)	-	2.02	.172
GRBAS scale	1.2±0.9	1.2±0.9	1.3±0.9	0.65	-	.519
VHI scores	6.2±7.5	6.5±8.5	5.5±5.1	-0.63	-	.530

Independent t-test was used for continuous variables, Chi-square test was used for laryngeal findings

**Table 3.** Factors associated with positive endoscopic findings

	Univariate analysis		Multivariate analysis	
	Odds Ratio (95% CI) 1.0 (0.9 to 1.1)	t-value	Adjusted Odds Ratio (95% CI)	Adjusted p-value
Age	1.0 (0.9 to 1.1)	0.737	1.0 (0.9 to 1.1)	0.658
Sex				
Male	Reference	-	Reference	-
Female	1.7 (0.2 to 3.7)	0.364	1.6 (0.5 to 4.9)	0.389
Comorbidities				
Hypertension	0.1 (0.02 to 2.8)	0.191	0.1 (0.04 to 2.8)	0.184
Diabetes mellitus	38.9 (0.8-145.2)	0.078	31.9 (0.8-132.4)	0.068
Asthma	122.1 (2.7-59.1)	0.021	145.1 (2.6-79.2)	0.015
Others	0.2 (0.02-2.1)	0.227	0.5 (0.05-5.1)	0.557
Cigarette smoker				
Past	Reference	-	Reference	-
Never	9.2 (0.1-98.7)	0.290	9.5 (0.1-88.6)	0.480
Current	13.9 (1.7-17.1)	0.016	13.9 (1.6-17.1)	0.016
E-Cigarette smoker				
Years vaping	1.0 (0.7-1.3)	0.882	1.0 (0.7-1.3)	0.872
Pods used per week	0.9 (0.7-1.2)	0.707	0.9 (0.6-1.4)	0.608
Drops used per day	0.9 (0.7-1.1)	0.330	0.9 (0.7-1.1)	0.350
Nicotine content level	1.9 (0.2-2.2)	0.211	1.9 (0.2-2.5)	0.512

past e-cigarette users using Fisher Exact test ( $t=-0.63$ ,  $p=.530$ ). Among the 17 non-smokers who currently use e-cigarettes, the prevalence of dysphonia was 58.8% (10/17) using the VHI scores, and 5.9% (1/17) using a cut-off score of 18. Based on multivariable linear regression analysis, years vaping [adjusted  $\beta=-0.3$ , 95% CI=-1.3-0.7,  $p=.761$ ], pods per week [adjusted  $\beta=0.1$ , 95% CI=-0.8-1.0,  $p=.812$ ], drops per day [adjusted  $\beta=-0.3$ , 95% CI=-0.9-0.4,  $p=.221$ ], and nicotine content level used [adjusted  $\beta=20.7$ , 95% CI=-81.3-142,  $p=.688$ ] were not significantly associated with VHI scores. (Table 5)

**Table 4.** Factors associated with GRBAS scores

	Univariate analysis		Multivariate analysis	
	Regression coeff (95% CI)	t-value	Adjusted Regression coeff (95% CI)	Adjusted p-value
Age	-0.2 (-0.03- 0.01)	0.237	-0.2 (-0.04- 0.01)	0.246
Sex				
Male	Reference	-	Reference	-
Female	-0.02 (-0.2- 0.3)	0.957	-0.02 (-0.4- 0.4)	0.922
Comorbidities				
Hypertension	0.01 (-0.7- 0.7)	0.972	0.01 (-0.7- 0.7)	0.972
Diabetes mellitus	0.02 (-1.1- 1.1)	0.973	0.02 (-1.1- 1.1)	0.974
Asthma	-0.1 (-1.1- 0.9)	0.859	-0.1 (-1.1- 0.9)	0.859
Others	0.03 (-0.7- 0.9)	0.917	0.04 (-0.7- 0.8)	0.907
Cigarette smoker				
Past	Reference	-	Reference	-
Never	0.03 (-0.5- 0.7)	0.873	0.04 (-0.5- 0.6)	0.873
Current	0.5 (0.07- 2.0)	0.125	0.5 (0.06- 1.0)	0.025
E-Cigarette smoker				
Years vaping	-0.05 (-1.2- 1.1)	0.933	-0.05 (-1.2- 1.1)	0.930
Pods used per week	-0.07 (-11.9- 12.5)	0.994	-0.06 (-11.6- 10.5)	0.990
Drops used per day	0.03 (-0.03- 0.1)	0.373	0.03 (-0.04- 0.1)	0.374
Nicotine content level	-7.2 (-19.0- 4.4)	0.325	-7.1 (-18.0- 4.3)	0.221

**Table 5.** Factors associated with VHI scores

	Univariate analysis		Multivariate analysis	
	Regression coeff (95% CI)	t-value	Adjusted Regression coeff (95% CI)	Adjusted p-value
Age	-0.05 (-0.3- 0.2)	0.710	-0.07 (-0.3- 0.2)	0.700
Sex				
Male	Reference	-	Reference	-
Female	0.2 (-3.4- 3.9)	0.891	0.2 (-3.1- 3.9)	0.891
Comorbidities				
Hypertension	3.5 (-2.5- 9.5)	0.244	3.7 (-2.7- 9.7)	0.222
Diabetes mellitus	-1.0 (-10.4- 8.5)	0.844	-1.0 (-10.1- 8.7)	0.835
Asthma	-0.5 (-9.3- 8.2)	0.904	-0.7 (-9.2- 8.2)	0.902
Others	1.3 (-5.3- 7.9)	0.692	1.3 (-7.3- 7.9)	0.683
Cigarette smoker				
Past	Reference	-	Reference	-
Never	-3.3 (-7.9- 1.3)	0.159	-3.4 (-7.9- 2.3)	0.179
Current	-1.9 (-5.8- 2.1)	0.350	-1.9 (-7.8- 2.2)	0.364
E-Cigarette smoker				
Years vaping	-0.3 (-1.3- 0.7)	0.560	-0.3 (-1.3- 0.7)	0.761
Pods used per week	0.1 (-0.8- 1.0)	0.824	0.1 (-0.8- 1.0)	0.812
Drops used per day	-0.3 (-0.9- 0.4)	0.441	-0.3 (-0.9- 0.3)	0.221
Nicotine content level	19.3 (-79.3- 118)	0.698	20.7 (-81.3- 142)	0.688

**DISCUSSION**

Our study showed no significant difference between past and current e-cigarette use with regards to voice quality measured by GRBAS scale and VHI scores. Of the 17 non-smokers who currently used e-cigarettes, 100% had abnormal laryngoscopic findings and three-quarters had mild roughness on GRBAS scale. Endoscopic findings showed vocal fold (VF) mucus, arytenoid edema, VF edema, arytenoid erythema, and ventricular fold erythema, with 30.6% prevalence of abnormal laryngeal findings among e-cigarette users.

A study by Dealino and Dela Cruz showed no significant difference between the Filipino VHI scores of e-cigarette users and smokers.<sup>4</sup> In the same study, the prevalence of dysphonia was 84% and 88% in cigarette smokers and e-cigarette users, respectively, while prevalence of vocal impairment was 17.31%. In our study, the prevalence of dysphonia in e-cigarette users was relatively lower at 68% based on VHI, while prevalence of vocal impairment was 10%. Hence, both studies showed a relatively high prevalence rate of dysphonia of 88% and 68% among e-cigarette smokers. In our study, although 68% had dysphonia, only a third showed laryngeal abnormalities.

A study by Tuhanoğlu *et al* revealed that increased secretion impacts the acoustic properties of the voice in the smoking group and to a lesser degree to the e-cigarette group. Secretion tends to be lower in e-cigarette users because of more vapor and less toxins than traditional cigarettes.<sup>9</sup> In a study by Chung *et al.*, e-cigarettes with nicotine may compromise mucociliary clearance, producing increased airway secretions.<sup>10</sup> In our study, vocal fold mucus was observed in 94% of the participants. Studies showing less detrimental effects of e-cigarettes does not necessarily mean that vaping has no potentially harmful sequelae. Sample reported that although there was no significant correlation between the use of e-cigarettes and abnormal acoustic measurements, however, there was a significant correlation with vocal fold varices, edema, and abnormal phase symmetry.<sup>8</sup>

Acute e-cigarette exposure may compromise lung function with prompt adverse physiologic effects after short-term use comparable to cigarette smoking.<sup>11</sup> E-cigarette aerosols induce oxidative stress and inflammatory response in human lung epithelial cells<sup>12</sup> while acute and chronic exposure may lead to dry pharynx and cough<sup>13</sup> with cytotoxic effects to oropharyngeal and laryngeal tissue. Furthermore, there are studies suggesting that e-cigarettes may increase the risk of cancer.<sup>14</sup> A recent study by Herzog showed that both traditional and e-cigarette use may elicit epigenetic effects such as DNA methylation linked to carcinogenesis and may be predictive of lung cancer.<sup>15</sup>—Moreover, studies by Lungova *et al.* and Bozzella *et al.* showed that vaping had toxic effects especially on the vocal fold mucosal health and airway protection.<sup>2,16</sup>



Chemical epithelium damage occurs when cells are exposed to e-cigarettes, brought about by a malfunction in lipid metabolism and ineffective removal of lipid or solvent particles that collect in the cytosol and intercellular spaces.<sup>2</sup> Nicotine and flavorings added to e-liquids to improve the taste and/or experience of vaping may produce abnormal lipid-laden macrophages associated with lung injury.<sup>17</sup> It causes vocal fold epithelial injury which may affect the integrity of apical cells, mucin production and clearance, and immune responses.<sup>2</sup>

Limitations of our study follow: The sample population was divided into current and past e-cigarette users who incidentally smoked conventional cigarettes, and only 17% used e-cigarettes alone. The study may have yielded good correlation and better causal relationship if current e-cigarette users had been selected. An additional number of laryngologists may be included in future studies to validate the results with considerations for inter-observer variability since the interpretation or analysis of endoscopic findings

and GRBAS scores may vary and may be influenced by subjective perception.

A multicenter trial is recommended including both hospitals and communities to generate reliable data. Future studies should include participants who use e-cigarettes exclusively and compare them with non-users of both conventional and e-cigarettes. Videostroboscopy may be done to provide a more detailed and accurate assessment of the voice and vocal cord mobility. Endoscopy should be performed on e-cigarette smokers who complain of dysphonia to evaluate the vocal folds to institute early intervention.

In conclusion, the prevalence of abnormal laryngeal findings among e-cigarette users was 30%, which was higher in current e-cigarette users than among past users. Concurrent cigarette smoking was a significant predictor of abnormal endoscopic findings and voice quality. Further research is recommended to substantiate the association of e-cigarette vaping with voice quality and laryngeal integrity.

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