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The Impact of Masking Habits on Voice in a Sub-population of Healthcare Workers

*Abdul-Latif Hamdan, *Christopher Jabbour, *Anthony Ghanem, and †Paola Ghanem, *Beirut, Lebanon, and †Baltimore, Maryland

Summary: Objective. To evaluate the impact of face masks on voice in a sub-population of healthcare workers, namely residents, medical students, and nurses, during the COVID-19 era.

Materials and Methods. A cross-sectional study was conducted in a large tertiary care center where a 23-items web-based questionnaire was conveyed to sub-population of healthcare professionals, namely residents, medical students, and nurses. The questionnaire included demographic data, type, and duration of mask use. Voice outcome measures included the Voice Handicap Index (VHI)-10 questionnaire and the visual analogue scale for vocal effort and vocal fatigue.

Results. A total of 178 participants answered the survey. One third had an abnormal score on the VHI-10 questionnaire, one third reported moderate to severe vocal fatigue, and 45% of the participants had moderate to severe vocal effort based on a visual analogue scale score. There was a significant association between the type of mask used and vocal fatigue ($P = 0.044$). No significant association was seen between the duration of mask used and the different voice outcome measures.

Conclusion. Masking habits during the COVID-19 pandemic were associated with a high prevalence of vocal fatigue, effort and abnormal VHI-10 score among residents, medical students, and nurses.

Key Words: COVID-19—Voice handicap Index (VHI-10)—Face mask—Vocal effort—Vocal fatigue.

INTRODUCTION

The novel 2019 coronavirus disease (COVID-19) has had considerable impact on human life and healthcare, with more than 200 million diagnosed cases worldwide and 4 million deaths to date.[1] In order to decrease transmission and reduce the disease burden among healthcare workers (HCW), the centers of disease control and prevention recommended the use of personal protective equipment (PPE), including face masks, respirators and face shields.[2] Various forms of face masks are currently used and these include surgical masks, cloth masks, N95 respirators and others. Surgical masks are recommended for routine care, whereas the use of N95 respirators has been advocated when performing high-risk aerosol generating procedures.[3] Due to the prolonged use of PPE, several adverse effects have been recorded, including discomfort,[4,5] dyspnea,[6,7] dizziness,[6] headaches[7,8] and most interestingly, voice disorders.[9,10]

The detrimental effects of face masks on speech and vocal effort have been thoroughly investigated.[11-14] McKenna et al compared acoustic and perceptual voice measures with and without face masks, and showed a significant reduction in relative fundamental frequency and vowel articulation index, in addition to a significant increase in perceived vocal effort and cepstral peak prominence.[11] In another study, Karakgouni showed that almost 50% of individuals who wear face masks report difficulty being heard by their peers, while 70% need a louder voice to overcome the physical barrier set by masks.[13] These results are congruent with the investigation by Pörschmann et al, who showed that face masks generate a loss in sound transmission, directly impairing speech intelligibility and voice radiation.[15] Similar findings were highlighted by Goldin et al, who demonstrated that different types of masks attenuate sound intensity ranging from 3 to 4 dB to 12 dB at high frequencies.[16]

All the above indicates that HCW who adhere to the PPE standard precautions and use various types of face masks are prone to phonatory disorders.[11] Resident physicians and nurses, as first responders in caring for patients in COVID-19 and other units, are particularly at a considerable risk in comparison to other healthcare workers. Similarly, medical students, although not commonly placed on COVID-19 patient care wards, still have repeated exposure to inpatient departments, placing them at an increased risk of contracting the disease.[17] The aim of our study is to investigate the impact of masking habits on phonation in this category of healthcare professionals, namely resident physicians, nurses, and medical students during the COVID-19 pandemic. The authors' hypothesis is that the use of face masks in healthcare workers leads to **vocal fatigue** and increase in vocal effort, which eventually manifests as phonatory handicap.

MATERIALS AND METHODS

A cross-sectional study was conducted at a large medical tertiary care center. After obtaining the Institutional Review Board approval, an anonymous web-based, self-administered 23-items questionnaire was conveyed to healthcare workers that include registered nurses, resident physicians

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From the *Department of Otorhinolaryngology Head and Neck Surgery, American University of Beirut Medical Center, Beirut, Lebanon; and the †Department of Medical Oncology, Johns Hopkins University, Baltimore, Maryland.

Address correspondence and reprint requests to Abdul-Latif Hamdan, Department of Otolaryngology, American University of Beirut, P.O. Box: 11-0236, Beirut, Lebanon. E-mail: ah77@aub.edu.lb

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and medical students during the COVID-19 outbreak. Consent was obtained from the participants by agreeing on the terms and conditions prior to filling the survey. The survey was solely voluntary, and participants were asked to fill general demographic information, including their working units, healthcare worker category, duration of mask use per day, mask type, simultaneous use of a face shield, history of smoking, previous manipulation of the larynx and history of radiation to the neck. The participants were excluded if they were older than 65 years of age in order to eliminate the adverse effect of aging on voice in our study group. Patients with a history of laryngeal surgery or manipulation, and patients with a history of neck irradiation were also excluded.

Self-reported voice outcome measures included the validated Voice Handicap Index (VHI)-10 questionnaire, with a score >11 considered abnormal,[18] and a self-reported degree of vocal fatigue and effort measured using a visual analogue scale (VAS) out of 10 points, stratified into the following categories: VAS of 1-3 (mild), 4-7 (moderate) and 8-10 (severe).

Frequencies and means (± standard deviation) were used to describe categorical and continuous variables, respectively. We analyzed the data using repeated Analysis of Variance (ANOVA) to compare the means of voice outcome measures within the different categories of masking habits (duration of mask use and type of mask). All analyses were conducted using Statistical Package for the Social Sciences (SPSS) version 25 software package. A two-tailed *P*-value <0.05 was considered as statistically significant.

TABLE 1.
Demographics

		n (%)
Gender	Female	106 (59.6)
	Male	72 (40.4)
Age group (yrs)	18-25	53 (29.8)
	26-35	103 (57.9)
	36-45	15 (8.4)
	46-55	4 (2.2)
	56-65	3 (1.7)
Smoking	Yes	51 (28.7)
	No	127 (71.3)
Working unit	COVID	23 (12.9)
	Non-COVID	155 (87.1)
Healthcare worker category	Resident physicians	77 (43.3)
	Nurses	64 (35.9)
	Medical students	37 (20.8)
Type of mask	Cloth	3 (1.7)
	Surgical	131 (73.6)
	N95	4 (2.3)
	Surgical + N95	38 (21.3)
	Surgical + Cloth	2 (1.1)
Duration of mask use (hrs)	1-4	1 (0.6)
	5-9	104 (58.4)
	9-12	55 (30.9)
	13-15	13 (7.3)
	>15	5 (2.8)

RESULTS

Demographic data

A total of 1,463 healthcare workers were invited to participate in this study by filling a web-based survey. A total of 178 participants (12.6%) agreed to participate. The types of masks used were divided into five categories which included: cloth, surgical, N95, surgical + N95 and surgical + cloth masks. Data on the duration of mask use in hours was also collected and categorized as follows: 1-4, 5-9, 9-12, 13-15 and more than 15 hours. **Please refer to** Table 1 **for demographic data and the participants' baseline characteristics.**

Voice outcome measures: VHI-10, vocal fatigue, and vocal effort

Sixty participants (33.7%) had an abnormal VHI-10 score (above 11). When looking at the degree of vocal fatigue, one third of the respondents had moderate to severe vocal fatigue based on the VAS. Around two thirds, 66.3% (n = 118) of the participants fell in the mild range, while one third 30.3% (n = 54) fell in the moderate range, and 3.4% (n = 6) in the severe range. Similarly, with regards to the self-reported degree of vocal effort, 45% had moderate to severe vocal effort based on the VAS. Around 55% (n = 98) of participants fell in the mild range, 38.76% (n = 69) in the moderate range, and 6.18% (n = 11) in the severe range. The mean scores for the VHI-10, VAS for vocal fatigue and effort are summarized in Table 2.

Association between voice outcome measures, type, and duration of mask use

There was a significant association between the type of face mask used and the degree of vocal fatigue ($P = 0.044$). Participants who wear surgical masks or a combination of surgical mask plus a N95 respirator had higher scores of vocal fatigue in comparison to those who wear a cloth mask, N95 respirator or a combination of cloth and surgical masks (Table 3). On the other hand, there was no significant association between the type of mask used and VHI-10 score ($P = 0.168$), or the degree of vocal effort ($P = 0.214$). In addition, no significant association was found between the

TABLE 2.
Mean ± Standard Deviation of the Different Voice Outcome Measures (VHI, voice handicap index; VAS, visual analogue scale out of 10)

	Mean ± SD	95% CI
VHI-10	9.42 ± 0.97	8.45-10.4
VAS-vocal fatigue	3.05 ± 0.32	2.73-3.37
VAS-vocal effort	3.62 ± 0.35	3.27-3.97

TABLE 3.
Mean ± Standard Deviation of the Visual Analogue Scale (VAS) Score on Vocal Fatigue Based on the Different Types of Masks Used ($P = 0.044$).

	n	Mean ± SD	95% CI
Cloth	3	1.33 ± 0.577	-0.1-2.77
Surgical	131	3.17 ± 2.281	2.77-3.56
N95	4	1.25 ± 0.5	0.45-2.05
Surgical + N95	38	2.74 ± 1.605	2.21-3.26
Surgical + Cloth	2	6 ± 0	6-6

duration of wearing a mask and VHI-10 score ($P = 0.363$), vocal effort ($P = 0.387$) and vocal fatigue ($P = 0.955$).

DISCUSSION

Our study displays key findings regarding the effects of face mask use on voice in a sub-population of healthcare workers, namely resident physicians, nurses, and medical students. The results of this investigation showed that nearly one third (33.7%) of our participants had a VHI-10 greater than 11, a figure that is higher than the figure of 26.24% reported by Heider et al in their study on the prevalence of voice disorders in healthcare workers at large.[12] In our study, the prevalence of participants with a voice disorder is also higher than that reported in the general population (7.6%).[18] Similarly, the mean VHI-10 was elevated (9.42 ± 0.97 (95% CI 8.45-10.4) compared to the mean score previously reported in healthcare workers (7.92; 95% CI 6.98-8.85).[12] This increase in VHI-10 score is in alignment with the increase in vocal fatigue and effort in our study population. The mean self-reported (VAS) score for vocal fatigue was found to be equal to 3.05 ± 0.32 (95% CI 2.73-3.37) with one third of the respondents reporting moderate to severe vocal fatigue. Similarly, the mean self-reported score for vocal effort was equal to 3.62 ± 0.35 (95% CI 3.27-3.97), with around 45% of respondent falling in the moderate to severe range.

These findings suggest that resident physicians, nurses, and medical students are subject to vocal **fatigue** and distinctively need to put more vocal effort in comparison to healthcare workers in general. This can be ascribed to several factors. One factor is the attenuation of high frequencies in individuals wearing face masks**,** as they have been shown to act as acoustic filters and physical barriers for phonation and speech.[11,15,16,19] Although the N95 respirators offer a superior form of protection, it has been suggested that they hinder sound transmission by 12 dB to 18 dB between 3 kHz and 7 kHz, when compared to surgical masks which hinder sound transmission by 4 dB to 6 dB.[15] Nevertheless, no significant association was found between the duration of mask use and the different voice outcome measures. The lack of statistical significance can be attributed to a low response rate of 12.6%, a recall bias by the participants when filling the survey and the lack of a comparison arm. Another reason for the increase in vocal effort, fatigue and VHI-10 score is the environmental **noise level**, which is considered a health hazard associated with a large number of morbidities among which is dysphonia.[20] Measures of sound levels on general wards, telemetry floors and ICU units have been found to be above average. These figures range from 44.6 dB to 55.1 dB in non ICU wards and 56.1 dB to 60.3 dB in ICU units,[21] **which are values higher than those set by the World health organization (WHO) guidelines for hospital settings (35 dB in settings where patients are being treated or monitored).**[22] In order to surpass noise pollution that is set by the hospital environment, we presume that HCW in general and residents, nurses and medical students in particular, adjust their phonatory behavior aiming to correct vocal intelligibility. The increase in phonatory effort can eventually lead to voice disorders. Auditory feedback also plays a paramount role in modulating the pitch and loudness of the speaker. It has been suggested by Schenck et al that smoothed cepstral peak prominence (CPPS) is influenced by both loudness shifts and pitch shifts, which may be coupled to a mechanism that enhances speech audibility under states of altered acoustic feedback.[23] Therefore, a decrease in acoustic feedback is associated with an increase in the fundamental frequency and vocal intensity, which in turn lead to an increase in phonatory effort.[24]

The increase in vocal fatigue and effort is commensurate with the high prevalence of abnormal VHI-10 among the participants of our study group. Based on the review of Titze et al,[25] the collision forces between the vocal folds during vocalization is one of the major stresses of phonation. An increase in phonatory effort, which is the clinical correlate of the phonatory threshold pressure, that is the pressure needed to set the vocal folds in vibration, is associated with an increase in intraepithelial stress, particularly at the "striking zone," that is the mid-portion of the membranous vocal fold.[26] The increase in contact pressure secondary to an increase in "vocal loading" is in turn associated with alteration in vocal fold microvascular pressure, hence leading to submucosal lesions.[26,27] Another contributing factor to the high prevalence of VHI-10 and VAS findings is the high prevalence of smokers in our study group. Nearly 28.65% of our participants have a history of smoking, compared to 16% of healthcare workers in the US,[28] and a 31% prevalence within the Lebanese population in 2011.[29] This may also explain the higher number of participants complaining of voice disorders in our study.

LIMITATIONS

This investigation has multiple limitations. One is the subjective nature of the voice outcome measures which are based on the participants' self-reported perception of vocal symptoms, second is the lack of validation of the VAS, and third is absence of laryngeal examination. In addition, participants were not screened for hearing loss or history of otologic

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disorders, which may aggravate the degree of vocal effort and vocal fatigue in the setting of mask use. Finally, the analysis was not stratified according to smoking status, which also may have had a confounding effect on the results.

CONCLUSION

This study highlights the high impact of masking habits on voice in resident physicians, nurses, and medical students. The results of this investigation showed that this sub-population is at an increased risk of having vocal fatigue, high vocal effort and abnormal VHI-10 score.

DECLARATION OF COMPETING INTERESTS

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