ELSEVIER

Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Self-Perceived Voice Handicap During COVID19 Compulsory Facemask Use: A Comparative Study Between Portuguese and Spanish Speakers

*Nuria Polo, and †Filipa M.B. Lã, *†Madrid, Spain

Summary: This study investigates self-perceptions of voice-related handicap as a function of facemask use in the general working population during the COVID19 outbreak, using the Voice Handicap Index (VHI). Each VHI item was answered twice in a row; the first answer referred to the condition of not wearing a facemask (henceforth, the *Without* condition) and the second to the condition of using a facemask (henceforth, the *With* condition). VHI scores were collected via *Google Forms* (Google, Mountain View, California), targeting 2 groups of speakers of different nationalities, Portuguese (n = 261) and Spanish (n = 297). A Wilcoxon test was carried out to compare VHI scores between *With* and *Without* conditions for each group of speakers; a Mann-Whitney *U* test was used to compare groups within each condition. Results suggested that VHI overall scores and scores for all dimensions were higher for the *With* condition, for both Portuguese and Spanish speakers. When comparing groups of speakers, Spanish speakers presented higher scores for functional and emotional dimensions, for both *With* and *Without* conditions. In addition, the overall score for the *Without* condition was higher for Spanish speakers. No differences between groups were found for the total VHI score for the *With* condition. When comparing overall VHI_{diff} between speakers, that is, the difference in the VHI total score between *With* and *Without* conditions, no significant differences could be found. Thus, a multiple regression analysis was carried out between the VHI_{diff} and the independent variables of interest: age, sex, smoking habits, professional occupation, nationality, facemask type and its hours of use. The resulting model providing the highest association suggested that 2.5% of the variation in overall VHI_{diff} total score could be associated with sex, smoking habits, and professional level. Female smokers who use their voices during prolonged hours at work (e.g., teachers, lawyers, sales people) presented a higher VHI total score when wearing a mask. Future voice-related health interventions should address preventive strategies towards speaking behaviors leading to vocal fatigue and vocal effort as a consequence of compulsory facemask use, especially with respect to female professional voice users who smoke.

Key Words: COVID19−Voice handicap index−Facemask use−Portuguese speakers−Spanish speakers.

INTRODUCTION

The use of facemasks to reduce the risk of airborne transmission of SARS-CoV-2 (COVID19) has been compulsory, from the begining of 2020 until, at least, most part of 2021, in public spaces in European countries.[1] The use of this personal protective equipment has been reported to affect oral communication in many ways, namely concerning speech intelligibility,[2] facial cues in human social interactions,[3] emotional reading[4] and voice production.[5]

Both surgical and filtering facepiece (FFP2) mask types seem to restrict speech intelligibility for listeners, especially in noisy environments and when speakers have a foreign accent.[6] The literature reports a reduction of about 3−12 dB in the frequency range between 2 and 8 kHz, with the FFP2 type, an European equivalent to the N95 facemasks wore in USA, offering the greatest attenuation.[5,7−10] According to recent studies, the low-pass filter effect of facemask use compromises the perception of several groups of phonemes, especially those with spectral peaks within 2−8 kHz, such as voiceless fricatives.[7] This effect seems particularly important when concerning languages rich in these type of consonants, such as Portuguese.[11]

Speech comprehension has also been reported to be impaired in association with facemasks due to the substantial reduction of visual cues in oral communication. For example, Maltese individuals perceive a reduction in voice clarity and intensity.[12] In addition, lip reading is not an option when wearing a facemask. This might constitute a substantial drawback not only for those who are hearing-impaired, but also for children during stages of language development and students in a classroom.[3,13,14]

Besides speech perception, voice production also seems to be affected by facemasks. Speakers report difficulties in coordinating breathing with speech when using N95 masks.[15] In addition to reports of lack of oxygen, voice projection and vocal fatigue have been pinpointed as major contributors to self-perceptions of vocal distress.[12] For example, in Brazil, individuals requiring facemask use during their professional activities report symptoms of vocal fatigue more commonly as compared to individuals who wear a facemask during

Accepted for publication August 2, 2021.
This research was supported by Atracción de Talento Investigador C. de Madrid (grant number 2018-T1/HUM-12172) and by UNED funding open access publishing.
From the *Department of Spanish Language and General Linguistics, Universidad Nacional de Educación a Distancia (UNED), Madrid, Spain; and the †Department of Didactics, School Organization and Special Didactics, Universidad Nacional de Educación a Distancia (UNED), Madrid, Spain.
Address correspondence and reprint requests to Nuria Polo, Department of Spanish Language and General Linguistics, Universidad Nacional de Educación a Distancia (UNED), Senda del Rey 7, 28040 Madrid, Spain. E-mail: nuriapolo@flog.uned.es
Journal of Voice, Vol. ■■, No. ■■, pp. ■■−■■
0892-1997
© 2021 The Authors. Published by Elsevier Inc. on behalf of The Voice Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)
https://doi.org/10.1016/j.jvoice.2021.08.003

"essential activities."[16] These effects have been associated with changes in speaking habits. Slowing down speaking rate and increasing vocal loudness constitute examples of most frequently reported adaptative behaviours to facemask use.[17]

Habitual loud speech is well known to increase the risk of phonotrauma; however, such risk has not yet been completely understood with regard to facemask use during the pandemic. From a recent systematic review on adverse health effects of facemask use, effects on perceived vocal health are described to be assessed in only 1 study.[18] It was an investigation on the prevalence of self-perceived voice handicap during COVID19 outbreak in Chile, measured by means of the short version of the *Voice Handicap Index* (VHI-10). The results suggested that VHI-10 scores during COVID19 were higher in healthcare professionals as compared with pre-COVID19 scores for the general population.[19]

Voice impairment affects the quality of a person's life in many ways.[20] Besides the functional impact on working ability and employment opportunities, voice impairment can also affect social activities due to limited communication skills.[21−23] Such restrictions would also have a direct impact on a person's affective response to voice impairment.[24] The perceived impacts on functional, physical, and emotional domains are all assessed by the VHI;[25] therefore, it seems relevant to use this scale when investigating the long-term effects of facemask use on self-perceptions of voice handicap.

The present study aims at investigating self-perceptions of voice-related handicap as a function of compulsory facemask use during COVID19 outbreak. We hypothesize that speakers perceive a higher vocal handicap when using a facemask. As to date, voice-related handicap has been investigated mainly with respect to essential professionals; the current study includes all types of professions. In addition, because effects of facemask use differ across speakers[5] and across phonemes,[7] self-perceptions of voice-related handicap were compared between 2 populations of speakers, that is, Portuguese and Spanish.

MATERIALS AND METHODS

Participants and study design

A comparative observational descriptive study was carried out. Participants were recruited through the authors' preexisting personal contacts, via e-mail, social networks, and word of mouth. Inclusive criteria included: to be aged 18 or over, with no medically diagnosed hearing impairment, with no restrictions to understand nor give an informed consent and to be a native Portuguese/Spanish speaker. Only participants who provided a valid informed consent were included.

Data collection

Data was collected from the middle of October 2020 until the middle of January 2021. Validated versions of both Portuguese and Spanish VHI were used. This particular questionnaire was chosen because it is the most conventional self-filled form of assessing voice-related handicap.[26] In addition, it has been translated and validated into both Portuguese and Spanish languages.[27,28]

The same procedure was followed for both Portuguese and Spanish data collection. The VHI was anonymously filled in online, using *Google Forms* (Google, Mountain View, California). For each of the 30 items, participants chose the most appropriate answer concerning frequency of experience of a given voice description or voice effect on life, at the present moment, using a Likert scale (0: never; 4: always). This was repeated in 2 consecutive conditions: first, for the case of not wearing a facemask (henceforth, the *Without* condition) and, second, when wearing a facemask (the *With* condition). This order of presentation of items was followed to ensure that participants would have as a reference the more habitual speaking condition, that is, no facemask use.

Participants were also enquired about: (i) facemask type most frequently worn; (ii) total number of daily hours of use; and (iii) commonly associated discomfort. Other questions addressed general health, history of medically diagnosed voice pathologies, vocal hygiene routines, and sociodemographic information, such as age, sex, smoking habits, and professional occupation (see Supplementary material).

Statistical analysis

Both descriptive and inferential analysis were carried out; for nominal data, descriptive statistics included relative and absolute values. Normal distribution of continuous quantitative variables was inspected by a Shapiro-Wilk test; as a result, median and interquartile ranges were used to describe quantitative variables. For comparing VHI scores between conditions (that is, *With* and *Without*), a Wilcoxon test was carried out. A Mann-Whitney *U* test was performed to compare VHI scores between Portuguese and Spanish speakers, for both conditions. A stepwise multivariate-regression analysis was carried out to assess whether there was a statistical association between the difference in VHI overall scores for the *With* and for the *Without* conditions (henceforth, overall VHI_{diff}) and the independent variables of interest: age, sex, smoking habits, professional occupation, nationality, facemask type and its hours of use. Independent variables that were categorical were transformed into dummy variables, following the statistical recommendation described elsewhere.[29] All statistical analysis were carried out using SPSS version 24 (IBM Corporation, Armonk, NY).

RESULTS

Sample characteristics

From a total of 642 respondents, 301 (47%) were Portuguese and 341 (53%) were Spanish native speakers. For the purpose of assessing self-perceptions of voice-related handicap with respect to facemask use, only participants reporting absence of current medically diagnosed voice pathologies were included. This yielded a total of 261 and 297 Portuguese and Spanish participants, respectively (40.7% and 46.3% of the total Portuguese and Spanish respondents, respectively). For professional occupation, participants were grouped according to the classification system based on voice use and vocal demand described elsewhere.[30] This type of classification ranges from highly skilled professional voice users, such as singers (Level I), to professionals whose work does not depend on vocal quality (Level IV). Table 1 summarizes sample characteristics for the participants.

VHI scores

VHI scores (individual dimensions and overall), were non-normally distributed for both conditions (according to the Shapiro-Wilk normality test). Therefore, scores were compared between *With* and *Without* conditions using a non-parametric Wilcoxon signed-rank test. The results indicated that, for all dimensions and for the overall score, both Portuguese and Spanish speakers perceived higher voice-related handicap when using a facemask (see Table 2).

Given that VHI scores (dimensions and overall) were statistically different for both *With* and *Without* conditions in Portuguese and in Spanish populations, a Mann-Whitney *U* test was carried out to compare VHI scores between Portuguese and Spanish speakers in both conditions. The results suggest that, for the *Without* condition, Spanish speakers perceived a higher overall voice-related handicap as compared to Portuguese; however, this difference was not observed for the *With* condition (see Table 3).

When comparing overall VHI_{diff} between speakers, that is, the difference in the VHI total score between *With* and *Without* conditions, no significant differences could be found (Z = - 0.7; P= 0.484). The VHI mean total score for the *With* condition had a similar relative increase for both Portuguese (16%) and Spanish (17%) speakers. In addition, for both groups of speakers, dimensions showed similar VHI mean percent of increase: 6.55% to 7.57% for the functional dimension; 6.84% and 6.33% for the physical; and 2.74% and 3.23% for the emotional. For each dimension, the items receiving the highest score in the 0 to 4 frequency scale were similar in both Portuguese and Spanish populations (see Figure 1).

Given the above results, a multiple linear regression analysis was carried out using a dataset that included both Portuguese and Spanish overall VHI_{diff}. The result estimated 3 models (see Table 4). The first contained the independent variable profession (adjusted r^2 = 0.012); the second added the variable sex (adjusted r^2 of 0.019); and the third included the independent variables profession, sex and smoker (adjusted r^2 = 0.025). The third model provided the highest association, with 2.5 % of the variation in overall VHI_{diff} explained by type of profession, sex and smoking habits.

TABLE 1.
Summary of Participants Characteristics, Displayed Also by Nationality

Participants Without Vocal Pathology	Portuguese, n (%)	Spanish, n (%)	Total (n%)
Age			
Mean (SD)	44.8 (15.9)	40.3 (11.5)	42.39 (13.9)
Sex			
Male	97 (37.2)	79 (26.6)	176 (31.5)
Female	164 (62.8)	217 (73.1)	381 (68.3)
Prefer not to answer	0	1 (0.3)	1 (0.2)
Smoker			
Yes	52 (19.9)	56 (18.8)	108 (19.3)
No	209 (80.1)	241 (81.1)	450 (80.6)
*Professional occupation according to voice use and vocal demand**			
Level I	28 (10.7)	3 (1)	31 (5.6)
Level II	88 (33.7)	135 (45.5)	223 (40)
Level III	27 (10.3)	39 (13.1)	66 (11.8)
Level IV	103 (53.6)	89 (46.4)	192 (34.4)
Type of facemask			
Surgical	126 (48.3)	143 (48.1)	269 (48.2)
FFP2	16 (6.1)	69 (23.2)	85 (15.2)
Other	60 (23)	85 (28.6)	145 (26)
Combined use of different facemasks	59 (22.6)	0	59 (10.6)
Facemask use to work			
Yes	177 (67.8)	199 (67)	376 (67.4)
No	81 (31)	90 (30.3)	171 (30.6)
Daily facemask use in hours			
Mean (SD)	5.7 (6.8)	5.7 (3.2)	5.7 (5.2)

* Professional classification based on voice use and vocal demand proposed by Koufman & Isaacson (1991).

TABLE 2.
Results of the Wilcoxon Sign-Rank Test, Comparing Dimensions and Overall Score for the VHI Between Conditions (ie, Facemask use, the *With* Condition and Non-use, the W*ithout* Condition), for Both Portuguese and Spanish Speakers

VHI Scores	Portuguese Speakers				Wilcoxon Signed-Rank Test	Spanish Speakers				Wilcoxon Signed-Rank Test
	Without		*With*			*Without*		*With*		
	Mdn	IQR	Mdn	IQR		Mdn	IQR	Mdn	IQR	
Functional	3	4	11	10	*z* = -13.366*	5	6	13	10	*z* = -14.465*
Physical	3	5	11	13	*z* = -13.081*	3	6	11	12	*z* = -14.098*
Emotional	0	2	3	7	*z* = -9.977*	1	4	4	6	*z* = -11.095*
Total	7	10	25	29	*z* = -13.465*	10	12	28	25	*z* = -14.558*

* Statistical significance ($P < 0.001$).
Abbreviations: IQR, interquartile range; Mdn, median.

TABLE 3.
Summary Results of the Mann-Whitney *U* Test Comparing VHI Dimensions and Overall Scores Between Portuguese and Spanish Speakers

VHI scores	*Without*	*With*
Functional	U = - 2.947; P= 0.003*	U = -3.415; P = 0.001*
Physical	U = - 0.250; P= 0.803	U = -0.742; P = 0.458
Emotional	U = - 4.172; P < 0.001*	U = -2.910; P = 0.004*
Total	U = - 2.710; P = 0.007*	U = -1.679; P = 0.093

* Statistical significance ($P < 0.005$).

DISCUSSION

The current investigation concerned self-perceptions of voice-related handicap associated with compulsory facemask use during COVID19 pandemic outbreak, between October 2020 and January 2021. As the impact of facemask use on phonation may differ across speakers[5] and across phonemes,[7] 2 populations of non-dysphonic speakers were investigated, that is, Portuguese and Spanish, using the respective validated translations of the VHI.[27,28] All responses were obtained online, following previous recommendations on the benefits of using online surveys during outbreaks of rapidly evolving infectious diseases.[31]

For both populations of speakers, all VHI items were investigated for both *Without* and *With* facemask use conditions, the latter assessed by adding "when wearing a

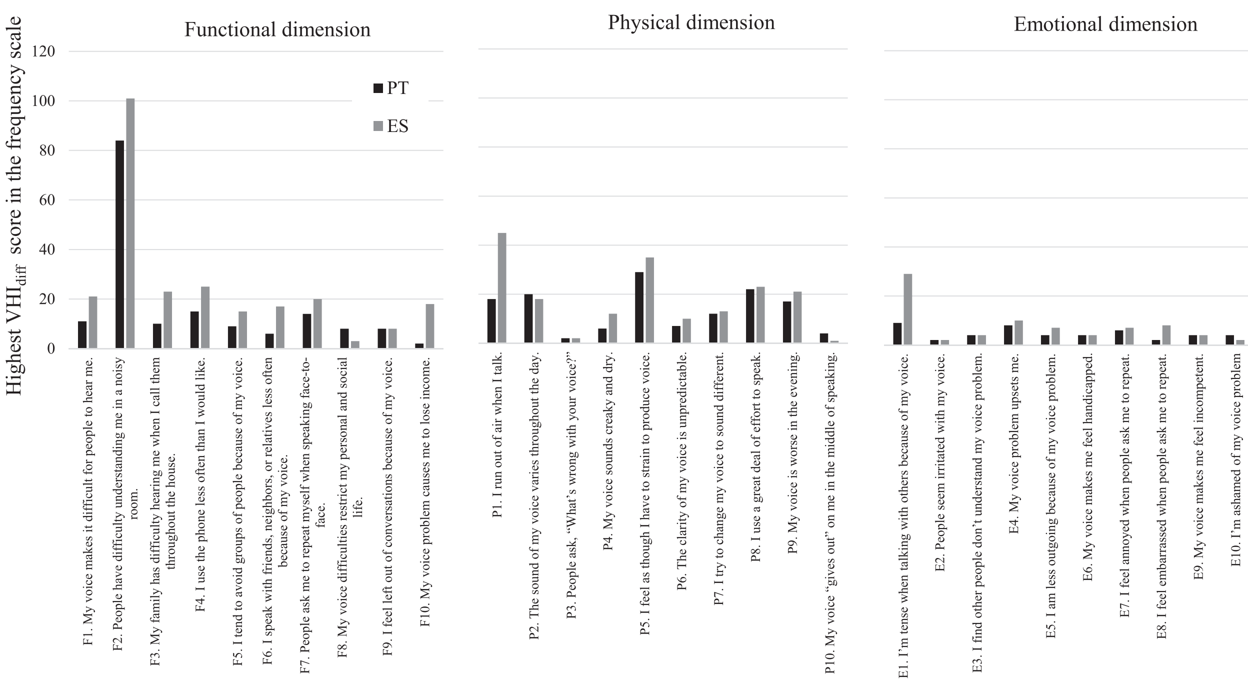

FIGURE 1. Distribution of ratings of the highest score in the 0 to 4 frequency scale (0: never; 4: always) used in VHI_{diff} for both Portuguese (black) and Spanish (grey) speakers. The left most graph corresponds to score 4 for each item presented in the functional dimension, whereas middle and most right graphs correspond to physical and emotional dimensions, respectively.

TABLE 4.
Summary of Unstandardized and Standardized Multiple Regression Coefficients for the 3 Models Obtained When Testing the Statistical Association Between the Difference of VHI Overall Score With and Without Facemask Use

		Unstandardized Coefficients		Standardized Coefficients		
	Model	B	Std. Error	Beta	*t*	*P*
1	(Constant)	18.114	1.092		16.589	0.000*
	Profession	4.747	1.723	0.116	2.755	0.006*
2	(Constant)	11.354	3.200		3.548	0.000*
	Profession	4.598	1.718	0.113	2.677	0.008*
	Sex	4.044	1.800	0.095	2.247	0.025*
3	(Constant)	19.211	4.989		3.851	0.000*
	Profession	4.380	1.716	0.107	2.553	0.01*
	Sex	4.094	1.795	0.096	2.281	0.023*
	Smoker	-4.350	2.124	-0.086	-2.049	0.041*

* Statistical significance ($P < 0.005$).

facemask" at the end of each VHI item. Such procedure was followed to provide respondents with the same and the most habitual reference for self-perception of voice-related handicap that is, the *Without* condition. This could be understood as a possible methodological limitation. However, this seems not to be the case. The overall mean VHI scores for the *Without* condition are in agreement with previously reported VHI overall scores for both Portuguese and Spanish non-dysphonic populations.[27,28] The Portuguese participants showed a mean overall VHI score of 11.4 (± 13.8), which is closed to the 10.5 (± 1.8) reported by Guimarães & Abberton (2004). For the Spanish population, participants reported a mean overall VHI score of 13.2 (± 12.8), which is also closed to the 8.1 (± 9.8) reported by Núñez-Batalla et al. (2007).[28] The higher standard deviations found in our results could be explained by the substantial higher number of non-dysphonic participants (n = 261, as compared to the 56 previously studied Portuguese speakers; and n = 297, as compared to the 38 previously investigated Spanish speakers).

The overall mean VHI scores for the *With* condition showed values similar to those reported by previous studies when assessing self-perceived voice handicap in dysphonic voices. According to Guimarães & Abberton (2004), VHI overall scores in dysphonic Portuguese voices are 34.4 (± 3.2), a value comparable to the one found in the present investigation for the *With* condition (30.8 ± 21.62). For Spanish speakers, according to Núñez-Batalla et al. (2007),[28] dysphonic voices can have an overall VHI score between 40.9 and 48.2, depending on whether the dysphonia is organic or functional. In the present investigation, overall mean VHI scores for the *With* condition were below these values; however, given that the studied population did not have a dysphonic voice, one may argue that 33.77 (± 22.47) corresponds to a high perceived voice-related handicap.

Previous studies have found that effects of facemask use may vary according to speakers.[5] In order to investigate this, comparisons of effects of facemask use in 2 different populations of speakers, that is, Portuguese and Spanish, were made. Results suggested significant differences between these 2 groups except for the physical dimension for the *Without* condition. For the *With* condition, differences were also found except for the physical dimension and the overall total scores. These results were not surprising. First, it is well document that VHI scores are different for Portuguese and Spanish speakers.[27,28] Second, the physical dimension failed to show significant differences because questions concerned voice production rather than aspects of communication and social interactions. These are reflected in the other 2 dimensions of the VHI, and are clearly more dependent on the cultural background of the respondent.

Given these results, the difference in the overall VHI score between *With* and *Without* conditions was calculated for the whole sample of speakers. The results indicated a significant increase in VHI scores (ie, more self-perceived voice handicap with regard to facemask use) for all dimensions and total score for the *With* condition with no differences found between groups. This increase was within the magnitude of 6.55%−7.57% for functional, 6.84% and 6.33% for physical, and 2.74% and 3.23% for emotional dimensions, and between 16% and 17% for the overall VHI score, in Portuguese and Spanish speakers, respectively. Thus, one may argue that the effects of facemask use are more pronounced with regard to verbal communication. This assumption can be corroborated by the distribution of ratings for the highest score in the 0 to 4 frequency scale (0: never; 4: always). The VHI_{diff} was higher for the item "People have difficulty understanding me in a noisy room" (functional dimension) in both Portuguese and Spanish speakers. This item was also reported to be the one receiving higher VHI ratings of frequency in health professionals when wearing a facemask.[19] Increased values of VHI scores when using a facemask can be associated with higher vocal fatigue and vocal effort,[19] both symptoms associated with louder speech in noisy environments. The results of this investigation suggested that such symptoms may be extendable also to other professionals besides healthcare workers. This is not surprising, bearing in mind that the COVID19 has forced the use of facemasks during all professional and daily life activities, in both Portugal and Spain.

Previous investigations suggest that effects of facemask use on the voice may vary across phonemes.[7] In addition, type of mask and total daily time of use can also contribute to higher VHI-10 scores.[19] The results of the present study seem to point at a different direction. No statistical association was found between VHI_{diff} scores and nationality, type of facemask and daily hours of facemask use. Instead, factors that could predict higher differences between *With* and *Without* conditions were sex, professional level and smoking habits. Being a female level II professional (i.e., a teacher, public speaker, politician, call center worker, sales person, judge or lawyer), who smokes, seems to be associated with a higher self-perception of voice-related handicap when wearing as compared to not wearing a facemask. These results are in accordance to previous literature. First, it is well documented that being a female increases the risk of developing a voice-related health problem.[32] Voice pathologies are more common in females than in males: 46.3% as compared to 36.9%, respectively.[33] Research suggests that anatomical and histological differences could account for this higher incidence in females. Females have shorter vocal folds, that vibrate almost twice as fast than male vocal folds.[32] Although the smaller vibrating amplitude of female vocal folds may protect them from being exposed to a higher risk of damage due a higher number of vibrations,[32] female vocal folds have less hyaluronic acid in the layers of the vocal folds more exposed to collision forces.[34] This, in addition to the smaller concentrations of collagen found in female's lamina propria,[34] expose women to a higher risk of a voice disorder as compared to men.[32] Also, the complexity of the endocrinological female reproductive system can account for a higher exposure to risk of vocal problems as compared to men.[32,34] For example, sex steroid hormonal variations during puberty, the menstrual cycle, pregnancy, and menopause have been pinpointed as life stages during which vocal changes may occur.[35,36] Possible explanations include (i) similarities found between the histological response of the mucosa of the vocal folds and the mucosa of the cervix to sex hormones,[37−39] and (ii) the presence of sex steroid hormonal receptors at different sub-units of the vocal folds.[40] Second, professionals that require extended periods of voice use, such as teachers, are also exposed to higher risks of vocal hazards.[41] Finally, a recent systematic review on effects of smoking on voice revealed substantial alterations to voice function.[42] In the current investigation, we found that female smokers were particularly more sensitive to alterations to their voices as compared to males. This result seems to corroborate previous findings suggesting that answering the VHI helps female smokers to become more aware of the potential risks of smoking to vocal health.[43]

CONCLUSIONS

The present investigation contributes to the understanding of self-perceptions of voice-related handicap with regard to facemask use. Speakers, independently of being Portuguese or Spanish, perceive a higher handicap when wearing a facemask. Being a female smoker who requires extended periods of voice use seems to contribute to higher self-perceptions of voice handicap. With the prolonged compulsory use of facemask use in most European countries, modifications to speaking behaviors are expected. To guarantee maintenance of vocal health during compulsory facemask use at work, future voice-related health interventions should be considered. These should address preventive strategies towards the development of speaking behaviors that may lead to vocal fatigue and vocal effort, targeting particularly those who required prolonged use of voice at work.

CONFLICT OF INTEREST

None.

ACKNOWLEDGMENTS

The authors would like to acknowledge all participants who took time to respond the questionnaire. They would also like to thank the time spent by Diego Ardura in providing advice concerning statistical analysis, the program Atracción de Talento Investigador de la Comunidad de Madrid, Proyecto 2018-T1/HUM-12172, allowing co-author FL to dedicate time to this research project, and UNED, for funding open access publishing, and to the project MASCARA UNED-Santander from Vicerrectorado de Internacionalización (2021/2022).

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at doi:10.1016/j.jvoice.2021.08.003.

REFERENCES

1. Leung CC, Lam TH, Cheng KK. Mass masking in the COVID-19 epidemic: people need guidance. *Lancet*. 2020;395:945. https://doi.org/10.1016/S0140-6736(20)30520-1.
2. Bottalico P, Murgia S, Puglisi GE, et al. Effect of masks on speech intelligibility in auralized classrooms. *J Acoust Soc Am*. 2020;148:2878–2884. https://doi.org/10.1121/10.0002450.
3. Giovanelli E, Valzolgher C, Gessa E, et al. Unmasking the difficulty of listening to talkers with masks: lessons from the COVID-19 pandemic. *Iperception*. 2021;12. https://doi.org/10.1177/2041669521998393.
4. Carbon CC. Wearing face masks strongly confuses counterparts in reading emotions. *Front Psychol*. 2020;11:1–8. https://doi.org/10.3389/fpsyg.2020.566886.
5. Nguyen DD, McCabe P, Thomas D, et al. Acoustic voice characteristics with and without wearing a facemask. *Sci Rep*. 2021;11:1–11. https://doi.org/10.1038/s41598-021-85130-8.
6. Yi H, Pingsterhaus A, Song W. Effects of wearing face masks while using different speaking styles in noise on speech intelligibility during the COVID-19 pandemic. *Front Psychol*. 2021;12:2449.
7. Maryn Y, Wuyts FL, Zarowski A. Are acoustic markers of voice and speech signals affected by nose-and-mouth-covering respiratory protective masks? *J Voice*. 2021. https://doi.org/10.1016/j.jvoice.2021.01.013.
8. Corey RM, Jones U, Singer AC. Acoustic effects of medical, cloth, and transparent face masks on speech signals. *arXiv*. 2020:2371. https://doi.org/10.1121/10.0002279.
9. Pörschmann C, Lübeck T, Arend JM. Impact of face masks on voice radiation. *J Acoust Soc Am*. 2020;148:3663–3670. https://doi.org/10.1121/10.0002853.

10. Goldin A, Weinstein BE, Shiman N. How do medical masks degrade speech perception? *Hear Rev*. 2020;27:8–9.
11. Cruz-Ferreira M. Illustrations of the IPA: European Portuguese. *J Int Phon Assoc*. 1995;25:90–94.
12. Martin GM, Desira M, Zarb C. Mask-wearing during the Covid-19 pandemic in the Maltese context : attitudes, beliefs, perceptions and behaviour. *Xjenza Online*. 2020:48–59. https://doi.org/10.7423/XJENZA.2020.2.01.
13. Atcherson SR, Mendel LL, Baltimore WJ, et al. The effect of conventional and transparent surgical masks on speech understanding in individuals with and without hearing loss. *J Am Acad Audiol*. 2017;28:58–67. https://doi.org/10.3766/jaaa.15151.
14. Tenenbaum EJ, Sobel DM, Sheinkopf SJ, et al. Attention to the mouth and gaze following in infancy predict language development. *J Child Lang*. 2015;42:1173–1190. https://doi.org/10.1017/S0305000914000725.
15. Lee HP, Wang DY. Objective assessment of increase in breathing resistance of N95 respirators on human subjects. *Ann Occup Hyg*. 2011;55:917–921. https://doi.org/10.1093/annhyg/mer065.
16. Ribeiro VV, Dassie-leite AP, Pereira EC, et al. Article in press Effect of wearing a face mask on vocal self-perception during a pandemic. *J Voice*. doi:10.1016/j.jvoice.2020.09.006.
17. Saunders GH, Jackson IR, Visram AS. Impacts of face coverings on communication: an indirect impact of COVID-19. *Int J Audiol*. 2020;0:1–12. https://doi.org/10.1080/14992027.2020.1851401.
18. Kisielinski K, Giboni P, Prescher A, et al. Is a mask that covers the mouth and nose free from undesirable side effects in everyday use and free of potential hazards? *Int J Environ Res Public Health*. 2021;18. https://doi.org/10.3390/ijerph18084344.
19. Heider CA, Álvarez ML, Fuentes-López E, et al. Prevalence of voice disorders in healthcare workers in the universal masking COVID-19 era. *Laryngoscope*. 2021;131:E1227–E1233. https://doi.org/10.1002/lary.29172.
20. Behlau M, Madazio G, Moreti F, et al. Efficiency and cutoff values of self-assessment instruments on the impact of a voice problem. *J Voice*. 2016;30. https://doi.org/10.1016/j.jvoice.2015.05.022. 506.e9-506.e18.
21. Ma EP, Yiu EM. Voice activity and participation profile : assessing the impact of voice disorders on daily activities. *J Speech, Lang Hear Res*. 2016;44:511–524.
22. Benninger MS, Ahuja AS, Gardner G, et al. Assessing outcomes for dysphonic patients. *J Voice*. 1998;12:540–550. https://doi.org/10.1016/S0892-1997(98)80063-5.
23. Epstein R, Hirani SP, Stygall J, Newman SP.How do individuals cope with voice disorders ? Introducing the voice disability coping questionnaire. J Voice. 23:209-217. doi:10.1016/j.jvoice.2007.09.001.
24. Smith E, Verdolini K, Gray S, et al. Effects of voice disorders on quality ot life. *J Med Speech Lang Pathol*. 1996;4:223–244.
25. Jacobson BH, Johnson A, Grywalski C, et al. The Voice Handicap Index (VHI): development and validation. *Am J Speech-Language Pathol*. 1997;6:66–69. https://doi.org/10.1044/1058-0360.0603.66.
26. Helidoni ME, Murry T, Moschandreas J, et al. Cross-cultural adaptation and validation of the voice handicap index Into greek. *J Voice*. 2010;24:221–227. https://doi.org/10.1016/j.jvoice.2008.06.005.
27. Guimarães I, Abberton E. An investigation of the voice handicap index with speakers of Portuguese: preliminary data. *J Voice*. 2004;18:71–82. https://doi.org/10.1016/j.jvoice.2003.07.002.
28. Núñez-Batalla F, Corte-Santos P, Señaris-González B, et al. Adaptación y validación del índice de incapacidad vocal (VHI-30) y su versión abreviada (VHI-10) al español. *Acta Otorrinolaringol Esp*. 2007;58:386–392. https://doi.org/10.1016/S0001-6519(07)74954-3.
29. Field A. Discovering Statistics Using SPSS. London: SAGE Publications; 2005. 2nd ed.
30. Koufman JA, Isaacson G. The spectrum of vocal dysfunction. *Otolaryngol Clin North Am*. 1991;24:985–988.
31. Geldsetzer P. Use of rapid online surveys to assess people's perceptions during infectious disease outbreaks: a cross-sectional Survey on COVID-19. *J Med Internet Res*. 2020;22:1–13. https://doi.org/10.2196/18790.
32. Hunter EJ, Tanner K, Smith ME. Gender differences affecting vocal health of women in vocally demanding careers. *Logop Phoniatr Vocol*. 2011;36:128–136. https://doi.org/10.3109/14015439.2011.587447.
33. Roy N, Merrill RM, Gray SD, et al. Voice disorders in the general population : prevalence, risk factors and occupational impact. *Laryngoscope*. 2005;115:1988–1995. https://doi.org/10.1097/01.mlg.0000179174.32345.41.
34. Butler JE, Hammond TH, Gray SD. Gender-related differences of hyaluronic acid distribution in the human vocal fold. *Laryngoscope*. 2001;111:907–911.
35. Lã FMB, Sundberg J. Pregnancy and the singing voice: reports from a case study. *J Voice*. 2012;26:431–439. https://doi.org/10.1016/j.jvoice.2010.10.010.
36. Lã FMB, Polo N. Fundamental frequency variations across the menstrual cycle and the use of an oral contraceptive pill. *J Speech, Lang Hear Res*. 2020;63:1–11. https://doi.org/10.1044/2020_jslhr-19-00277.
37. Perelló J, Comas J. Etude de la cytology exfoliative du larynx. *Acta-Rhino- Laryngol Belgica*. 1959;13:194–198.
38. Abitbol J, Abitbol P, Abitbol B. Sex hormones and the female voice. *J Voice*. 1999;13:424–446. https://doi.org/10.1016/S0892-1997(99)80048-4.
39. Abitbol J, de Brux J, Millot G, et al. Does a hormonal vocal cord cycle exist in women? Study of vocal premenstrual syndrome in voice performers by videostroboscopy-glottography and cytology on 38 women. *J Voice*. 1989;3:157–162. https://doi.org/10.1016/S0892-1997(89)80142-0.
40. Kirgezen T, Sunter AV, Yigit O, et al. Sex hormone receptor expression in the human vocal fold subunits. *J Voice*. 2017;31:476–482. https://doi.org/10.1016/j.jvoice.2016.11.005.
41. Roy N, Merrill RM, Thibeault S, et al. Prevalence of vocie disorders in teachers and the general population. *J Speech, Lang Hear Res*. 2004;47:281–293.
42. Byeon H, Cha S. Evaluating the effects of smoking on the voice and subjective voice problems using a meta-analysis approach. *Sci Rep*. 2020;10:1–23. https://doi.org/10.1038/s41598-020-61565-3.
43. Tafiadis D, Tatsis G, Ziavra N, et al. Voice data on female smokers : coherence between the voice handicap index and acoustic voice parameters. *Med Sci*. 2017;4:151–163. https://doi.org/10.3934/medsci.2017.2.151.