

# Relationship Between Room Acoustics With Voice Symptoms and Voice-Related Quality of Life Among Colombian School and College Teachers During Online Classes in Times of COVID-19 Pandemic

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**Summary: Aim.** To determine the relationship between working conditions, especially room acoustics, with voice symptoms and voice-related quality of life among Colombian school and college teachers during online classes in times of COVID-19 pandemic.

**Method.** Exploratory cross-sectional study. Participants were thirty-two primary, secondary and university Colombian teachers, who were invited to fill in an online survey about working conditions and voice symptoms during online classes in times of COVID-19 pandemic. In the statistical analysis, four dependent variables and eight independent variables were defined. We used Generalized Linear Model with a Gamma distribution and Binary Logistic Regression to determine the association between voice with working conditions.

**Results.** High reverberation time and stress during online classes in times of the COVID-19 pandemic reduced slightly the VRQOL scores. For Factor 3 of the VFI, high reverberation time and months teaching online classes were associated at the multivariate analysis. Stress and years of experience were statistically associated with an increased odds of reporting hoarseness.

**Conclusion.** Similar to pre-COVID-19, teachers with online classes during the COVID-19 pandemic are affected by two work-related factors namely high reverberation time and stress. These two factors are increasing their likelihood of reporting hoarseness and having lower voice-related quality of life, which may confirm the relationship between reverberation, stress, and voice also during online classes. This highlights the need of implementing workplace vocal and mental health programs to decrease the occurrence of voice problems among teachers in times of and post-COVID-19 pandemic.

**Key Words:** Voice-related quality of life—Hoarseness—Voice breaks—Vocal fatigue index—Room acoustics.

## INTRODUCTION

Previous research has reported an increased likelihood of voice disorders among teachers<sup>1</sup> associated with work-related conditions such as high background noise levels, high reverberation times inside the classrooms, increased occupational vocal loads, and increased work-related stress.<sup>1-3</sup>

One of the most common voice symptoms is vocal fatigue, which have been reported associated with a high vocal load that usually improve after a period of rest (Hunter et al, 2020; Welham & Maclagan, 2003). Recently, a self-assessment instrument was designed to evaluate patients who are experiencing vocal fatigue from vocally healthy individuals. This instrument was called Vocal Fatigue Index (VFI) and contains 19 statements divided into three factors: (1) tiredness of voice and voice avoidance, (2) physical discomfort associated with voicing, and (3) improvement of symptoms with rest.<sup>4</sup>

On the other hand, voice disorders among teachers have important socio-economic consequences due to the

increased use of health services and work absenteeism, and the reduction of quality of life.<sup>5,6</sup> Different instruments have been designed to assess quality of life related with voice functioning, but one of the most commonly used is the Voice-Related Quality of Life (V-RQOL), which focuses on an integrated assessment of functioning in relation to individual and environmental factors. The VRQOL has been found a useful tool to assess the impact of voice disorders on general population and occupational voice users. In fact, previous research have reported a reduced V-RQOL score among teachers that reported poor acoustic conditions in their workplace.<sup>5</sup>

Due to COVID-19, professors working conditions changed because people were requested to stay at home to avoid the transmission of the disease, which implies changing the way people work, study and live. Among these changes, tele practice and online classes were adaptations recommended by governments, and implemented by schools and universities to continue teaching without increasing the risk of transmission of the COVID-19.

Although these changes had important effects on health conditions, to the best of the authors knowledge, there is limited evidence on the relationship between working conditions during online classes in times of COVID-19 pandemic with voice disorders,<sup>7,8</sup> and voice-related quality of life among teachers. Therefore, a cross-sectional study was designed among Colombian teachers to determine the relationship between working conditions, especially room

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acoustics, with voice symptoms and voice-related quality of life during online classes due to COVID-19 pandemic.

## METHOD

### Design and participants

The results presented in this manuscript were obtained from an exploratory cross-sectional study. Participants were thirty-two primary, secondary and university Colombian teachers, who were working at home and teaching their classes online. Participants were invited to fill in an online survey about working conditions (including room acoustics) and voice symptoms during online classes in times of COVID-19 pandemic. We used a convenience sampling and complied with the ethical principles outlined in the Declaration of Helsinki.

### Data collection procedures

After giving written informed consent to participate in this study, teachers filled in a questionnaire that included 60 questions on four components: sociodemographic aspects ( $n = 3$ ), working condition (background noise, reverberation time, hours of online classes) ( $n = 18$ ), voice functioning ( $n = 10$ ), Voice-Related Quality of Life – VRQOL ( $n = 10$ ),<sup>9</sup> and the Spanish version of the Vocal Fatigue Index – VFI ( $n = 19$ ).<sup>10</sup> For stress assessment, participants answered the following question: "Stress is defined as a situation in which a person feels tense, restless, nervous, anxious or unable to sleep at night because his mind is preoccupied all the time. Do you feel this kind of stress at the moment?"<sup>11</sup> This item was scored in a five-point Likert scale going from "nothing" (1) to "a lot" (5). A Spanish translation of this question was adapted by Carrillo González and was used in this study.<sup>12</sup>

### Statistical analysis

Considering the objective of this study, four dependent variables and eight independent variables were defined. Two

out of four dependent variables were continuous variables (VRQOL and VFI), and two were dichotomous (Hoarseness and Voice Breaks). Among the independent variables, six were continuous (background noise, reverberation time, years of experience, numbers of students, months teaching online classes, and weekly hours of teaching online classes) and two were categorical (level of teaching and stress).

First, normality of the data was assessed by means of the Shapiro-Wilk test. Since data were not normally distributed, we used Generalized Linear Model (GLM) with a Gamma distribution to determine the association between VRQOL and VFI with working conditions during online classes. The magnitude of the association was expressed as the Beta, and its standard error (SE). In addition, we used Binary Logistic Regression to determine the association between Hoarseness and Voice Breaks with working conditions. The magnitude of the association was expressed as ORs, and its 95% Confidence Intervals (95% CI).

For the independent variables, those with a p-value no higher than 0.20 in the univariate analysis were included in the multivariate analyses in order to avoid residual confounding,<sup>13</sup> and were only retained if the p-value reached the conventional level of significance of 0.05. SPSS 24 software was used for statistical analysis.

## RESULTS

### Work-related factors of VRQOL during online classes in times of the COVID-19 pandemic

As shown in Table 1, at the univariate analysis, high reverberation time ( $B = -0.03$ ), level of teaching ( $B = -0.03$  for high schools;  $B = -0.11$  for primary school), stress ( $B = -0.02$ ), and years of experience ( $B = -0.01$ ) were statistically associated with decreasing of VRQOL scores. The multivariate analysis (including the four variables statistically significant at the univariate level) shows that high reverberation time and stress during online classes in times of the COVID-19 pandemic reduced slightly the VRQOL scores.

**TABLE 1.**  
Associated Factors of VRQOL Scores During Online Classes in Times of the COVID-19 Pandemic

Parameter	Univariate			Multivariate		
	BETA	SE	P-value	BETA	SE	P-value
High background noise	-0.01	0.01	0.64			
High reverberation time	-0.03	0.01	0.00	-0.02	0.01	0.04
Level of teaching (University)		REFERENCE			REFERENCE	
Level of teaching (High school)	-0.03	0.06	0.54	0.05	0.04	0.25
Level of teaching (Primary school)	-0.11	0.07	0.09	-0.07	0.05	0.17
Months teaching online classes	0.00	0.01	0.82			
Weekly hours of teaching online classes	0.00	0.00	0.24			
Stress*	-0.02	0.01	0.00	-0.02	0.01	0.00
Years of Experience*	-0.01	0.00	0.00	0.00	0.00	0.03
Number of Students	0.00	0.00	0.27			

**TABLE 2.**  
**Associated Factors of VFI Scores During Online Classes in Times of the COVID-19 Pandemic**

Parameter	VFI Factor 1			VFI Factor 2			VFI Factor 3					
	Beta	SE	P-value	Beta	SE	P-value	Beta	SE	P-value	Beta	SE	P-value
High background noise	0.02	0.06	0.74	0.05	0.06	0.36	-0.02	0.03	0.54			
High reverberation time	0.11	0.08	0.16	-0.03	0.06	0.61	-0.07	0.03	0.03	-0.07	0.03	0.01
Level of teaching (University)	REFERENCE			REFERENCE			REFERENCE			REFERENCE		
Level of teaching (High school)	0.41	0.35	0.24	0.66	0.27	0.01	-0.22	0.15	0.13			
Level of teaching (Primary school)	0.61	0.41	0.14	0.81	0.30	0.01	-0.27	0.17	0.12			
Months teaching online classes	0.04	0.08	0.64	0.10	0.07	0.14	0.12	0.03	0.00	0.11	0.03	0.00
Weekly hours of teaching online classes	0.01	0.01	0.33	0.01	0.01	0.41	0.01	0.01	0.43			
Stress	0.14	0.06	0.01	0.15	0.04	0.00	0.01	0.02	0.80			
Years of Experience	0.02	0.02	0.20	0.01	0.02	0.43	-0.01	0.01	0.28			
Number of Students	0.00	0.00	0.35	0.00	0.00	0.83	0.00	0.00	0.17			

### Work-related factors of VFI during online classes in times of the COVID-19 pandemic

As shown in Table 2, stress was associated with Factor 1 (tiredness of voice and voice avoidance) and Factor 2 (physical discomfort associated with voicing) of the Vocal Fatigue Index. For Factor 3 (improvement of symptoms with rest), high reverberation time ( $B = -0.07$ ) and months teaching online classes ( $B = 0.11$ ) were associated at the multivariate level.

### Work-related factors of hoarseness during online classes in times of the COVID-19 pandemic

Table 3 shows that teachers who reported high reverberation time ( $OR = 2.22$ ), stress ( $OR = 1.36$ ), and years of experience ( $OR = 1.10$ ) increased the likelihood of reporting hoarseness during online classes in times of the COVID-19 pandemic. The multivariate analysis shows that only stress ( $OR = 2.29$ ) and years of experience ( $OR = 1.26$ ) remain

statistically associated with an increased odds of reporting hoarseness.

### Work-related factors of voice break during online classes in times of the COVID-19 pandemic

Table 4 shows that high reverberation time ( $OR = 2.49$ ) and stress ( $OR = 1.58$ ) were statistically associated with an increased likelihood of reporting voice break. However, this relationship did not remain at the multivariate level.

## DISCUSSION

This cross-sectional study aimed to determine the relationship between working conditions, specially, room acoustics with voice symptoms and voice-related quality of life among Colombian school and college teachers during online classes due to COVID-19 pandemic. Three main results were found. First, high reverberation time and stress during online classes in times of the COVID-19 pandemic reduced

**TABLE 3.**  
**Associated Factors of Hoarseness During Online Classes in Times of the COVID-19 Pandemic**

Parameter	Univariate Analysis				Multivariate Analysis			
	OR	L 95% CI	U 95% CI	P-value	OR	L 95% CI	U 95% CI	P-value
High background noise	1.08	0.81	1.46	0.59				
High reverberation time	2.22	1.18	4.17	0.01	1.75	0.93	3.28	0.08
Stress*	1.36	1.01	1.85	0.05	2.29	1.00	5.26	0.05
Years of Experience*	1.10	1.01	1.21	0.03	1.26	1.01	1.57	0.05
Number of Students	1.01	1.00	1.02	0.22				
Months teaching online classes	1.08	0.76	1.56	0.66				
Weekly hours of teaching online classes	1.05	0.98	1.13	0.15				
Level of teaching (University)	REFERENCE				REFERENCE			
Level of teaching (High school)	7.78	0.80	76.09	0.08	4.47	0.15	136.43	0.39
Level of teaching (Primary school)	0.74	0.10	5.49	0.77	0.02	0.00	1.77	0.09

**TABLE 4.**  
**Associated Factors of Voice Break During Online Classes in Times of the COVID-19 Pandemic**

Parameter	Univariate Analysis				Multivariate Analysis			
	OR	L 95% CI	U 95% CI	P-value	OR	L 95% CI	U 95% CI	P-value
High background noise	1.37	0.99	1.91	0.06	1.33	0.77	2.28	0.31
High reverberation time	2.49	1.27	4.90	0.01	3.43	0.98	12.03	0.06
Stress	1.58	1.08	2.30	0.02	1.56	0.87	2.81	0.14
Years of Experience	1.07	0.99	1.15	0.09	0.98	0.82	1.17	0.83
Number of Students	1.00	0.99	1.01	0.61				
Months teaching online classes	0.83	0.56	1.22	0.34				
Weekly hours of teaching online classes	1.04	0.97	1.11	0.23				
Level of teaching (University)			REFERENCE				REFERENCE	
Level of teaching (High school)	5.14	0.81	32.77	0.08	1.95	0.12	33.15	0.64
Level of teaching (Primary school)	6.86	0.63	74.19	0.11	30.95	0.49	1942.46	0.10

slightly the VRQOL scores. Second, high reverberation time and months teaching online classes were associated with Factor 3 of the Vocal Fatigue Index. Third, stress and years of experience were statistically associated with an increased odds of reporting hoarseness.

In regard to our first result, our findings are in line with previous research that suggest that teachers that reported poor acoustic conditions inside their workplaces have lower V-RQOL scores ( $B = -4.99$ ).<sup>5,14</sup> De Souza<sup>14</sup> suggest that this association may be explained by the effect of poor acoustic conditions on voice functioning, which may also affect teacher's quality of life. Our results suggest that even though room acoustic conditions were different during online classes due to COVID-19 pandemic because teachers were teaching (1) at home where the design and acoustics were for living and not for teaching, and (2) online, which implies different vocal demands; self-perception of high reverberation time (echo) influences the perception of voice related quality of life.

Concerning our second result on the association between high reverberation time and months of teaching online with Factor 3 of the Vocal Fatigue Index (improvement of symptoms with rest), it seems likely that perceiving poorer room acoustic conditions during longer periods of time reduced the perception of recovery of vocal fatigue. One explanation for this result is that teachers who consider their environment with higher reverberation time and have been exposed to this condition for longer time may have been also exposed to higher vocal effort during their occupational voice use during the online classes. Therefore, either they are having shorter periods of vocal rest, or they are having longer "cumulative" vocal effort, which hampers their recovery of the symptoms; and this is the reason they score higher on the Factor 3 of the VFI.

Concerning our third result, stress and years of experience were statistically associated with an increased odds of reporting hoarseness. Previous studies have reported the association between individual and work-related factors with the occurrence of voice disorders among teachers.<sup>2,6,15</sup>

We found that teachers with more experience were more likely to report hoarseness, compared with teachers with less experience, during the online classes in times of COVID-19 pandemic. This result is in disagreement with previous research that report no significant association between voice problems and years of experience in face-to-face classes.<sup>16,17</sup> One explanation for this disagreement is the definition of voice disorders; Bruck Marçal and Padilha measured voice disorders in general, whereas we measured a specific symptom (hoarseness). A second explanation is related with the change of the working conditions. Since participating teachers in Padilha's and Bruck Marçal's studies were working inside schools (face-to-face classes) and our participants were home working. From our results, it seems likely that teachers with longer in-person teaching experience are more used to work under in-person conditions (noise, reverberation, temperature, number of students, voice use, etc.), and changing to online classes may cause stress and also increase the likelihood of reporting hoarseness. The United Nations Educational, Scientific and Cultural Organization (UNESCO) called this phenomenon *coronateaching*, which is defined as a socio-educational phenomenon with psycho-emotional implications due to the high amount of information received through educational and digital platforms, as well as the frustration of not knowing-how use these digital resources.<sup>18</sup> Therefore, occupational voice use during online classes when having extensive experience in in-person teaching, as well as high stress levels, seems to perceive a high vocal demand response among teachers, and therefore increased hoarseness.

This study has a couple of limitations. First, we had a small sample size, which hampers the generalization of our results. Unfortunately, we were not able to recruit a considerable number of teachers due to mobility restrictions and quarantines during COVID-19 pandemic. Second, our results rely exclusively in self-reports, which may overestimate the reported associations. However, considering that during COVID-19, teachers were not allowed to go to the educational institutions (including labs) and researchers

were not able to go to participants' homes, self-reports were considering a valuable instrument to collect information about the participants' perceptions. Third, concerning the stress assessment, the item allowed to evaluate stress in general; therefore, it could be associated either to the pandemic or to the fact that teachers were teaching in a non-optimal environment; however, both aspects are determining the way teachers were working in a macro (pandemic context) or micro (distractions in the environment) levels. Future studies are needing to characterize better the relationship between stress (general and work-related) and voice disorders among teachers.

In conclusion, similar to pre-COVID-19, teachers with online classes during the COVID-19 pandemic are affected by two work-related factors namely high reverberation time and stress. These two factors are increasing their likelihood of reporting hoarseness and having lower voice-related quality of life, which may confirm the relationship between reverberation, stress, and voice also during online classes. This highlights the need of implementing workplace vocal and mental health programs to decrease the occurrence of voice problems among teachers in times of and post-COVID-19 pandemic.

#### CONFLICT OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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