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COVID-19 and Remote Learning: Predictive Factors of Perceived Improvement or Worsening of the Voice in Brazilian Teachers

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Summary: Objectives. Given the transformations in teaching modalities as a result of the COVID-19 pandemic, this study aimed to evaluate the factors associated with vocal self-perception during the pandemic and to investigate the ability of selected variables to predict changes in vocal self-perception in teachers with professional vocal demands during the investigated period.

Study design. Cross-sectional survey.

Method. A total of 1,126 teachers of both genders (ages 19–78 years, average 43.23 years) who were participating in remote teaching activities using their voice answered the online questionnaire. To characterize vocal changes (improvement, worsening or no change), the teachers' self-assessment of their voice quality was considered; the association between the variables reported in the questionnaire and vocal changes was analyzed, as was the capacity of these variables for predicting voice changes.

Results. Most of the teachers worked at a public school, reported having no previous voice changes or difficulties with their voice during online classes and indicated that they began to use their voice less often and with reduced intensity during the pandemic. Vocal demands were divided between teaching synchronous online classes, recording video lessons and participating in online meetings. Several variables were associated with voice improvement and worsening, and some had the capacity to predict voice changes: improvement in voice quality was associated with working in a public school or as an autonomous teacher, reduced voice use and, to a lesser extent, participating in online meetings, certain vocal habits and a reduction in vocal symptoms; worsening voice quality was associated with working in a private school, increased voice use, using the voice at a higher intensity, difficulty with the voice in online classes, vocal habits and vocal symptoms.

Conclusion. The context of remote education has changed the way teachers communicate during classes, and monitoring is necessary to ensure that necessary adaptations are made to preserve the voice and ensure effective communication.

Key Words: Coronavirus—Pandemic—Self-assessment—Signs and symptoms—Voice disorders—Voice—Teacher.

INTRODUCTION

The teaching profession has always placed great demands on professionals' voice and communication skills,¹ and it is associated with a high occurrence of vocal disorders.^{2–4} Work-related voice disorders develop due to factors related to the work organization, conditions of the physical environment and predisposing personal factors; in recent years, there has been an increase in work-related voice disorders in Brazil.⁵ A literature review on work and voice disorders found a large number of articles related to the voice in teachers; the research indicated a high prevalence of dysphonia and the association of such disorders with factors such as the presence of noise and heavy workloads.⁶

A recent systematic review and meta-analysis identified the main risk factors for dysphonia in teachers as the presence of upper respiratory tract diseases and high levels of

noise in the school; the study also showed that female teachers have a 1.6 times higher risk of dysphonia than male teachers and that professionals who drink coffee daily are 1.55 times more likely to have dysphonia than those who do not consume coffee or who consume it less frequently.⁷

The COVID-19 pandemic imposed several transformations on life and work routines, habits and social and leisure activities^{8,9} due to the social distancing adopted to stop the progression of the disease.¹⁰ The resulting social isolation led to drastic occupational changes throughout the world, particularly for teachers, who suddenly had to adapt all of their teaching activities to deliver them from their homes.^{8,11} There was virtually no time for this adaptation, and teachers had to develop virtual teaching activities to the best of their ability at that time.⁹ Their homes and computers became classrooms,¹² and it was necessary to adapt pedagogical practices at a time when everyone was very fearful about the future.¹¹

Teachers' psychological stress was higher during the transition to remote education than during the prepandemic period, and this increase in stress was correlated with the occurrence of vocal symptoms during the transition period, especially among teachers who had some previous level of psychological stress.⁹ Uncertainties, drastic changes,

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professional adaptations without preparation or previous training and the accumulation of household demands along with work demands can impact emotional and mental health and cause anxiety, sleep disorders and excessive physical tension.⁹ In addition, home office workers in different fields have reported increased vocal fatigue and musculoskeletal pain in the cervical region⁸ in addition to the development of dysphonia and vocal tract discomfort.¹⁰

For teachers, remote work can impact their overall health and can directly impair voice production and communication. This may be due to the need for increased concentration on improving communication during classes, long times spent in front of computer screens, prolonged use of headphones and new stimuli that demand their attention. This mental overload may have consequences for voice and communication.⁹

In Brazil, formal education is divided into private and public education. The greatest demand is concentrated in public schools, which educate approximately 80% of all students at different levels: early childhood education; basic education; elementary, middle and high school; and higher education. Public schools are administered at the federal, state and municipality level. The remaining students enrolled in the different levels of education attend private schools. Small regional variations in this proportion may occur. The government is not involved in the administration of private schools.

However, the National Education Program defines the curricular guidelines for all state teaching systems and networks as well as the pedagogical proposals for all public and private schools at the different education levels throughout Brazil.¹³

In both public and private schools, teaching took place in a classroom setting prior to the pandemic. In terms of technological resources, teachers and students in private schools generally have more resources and greater access to them than students in public schools. Consequently, given the pandemic situation, private schools started remote classes earlier than public schools did.¹⁴

Autonomous teachers have students of any age who may or may not be in an academic program. Classes can be offered for a set period of time and can cover different areas of knowledge, such as languages, arts, sports, etc. The student (or his or her guardian) is responsible for paying for such teaching, and the government is not involved in such contracts.

Distance learning (DL) existed in Brazil even before the pandemic. It was offered starting in 1940 in the form of radio correspondence courses, for which printed materials were sent by mail. Television allowed the emergence of telecourses, but with technological advances, especially the internet, DL has changed. It is estimated that before the pandemic, approximately 25% of courses were offered through DL.^{15,16} In 1996, this teaching modality became official, and it later became regulated.¹⁷ Both basic and higher education can be provided through DL, which is defined as an educational modality in which the means of

communication and information (in addition to trained personnel, access policies, and compatible forms of evaluation and monitoring) are mediators of the teaching and learning process.¹⁸ This definition reflects an evolution in the concept of distance learning, which, nowadays, takes into account the construction of more accessible methodologies and the qualification of professionals.¹⁹ This teaching modality is far removed from the emergency remote teaching that was proposed due to the pandemic.

Despite providing predominantly face-to-face classes before the pandemic, either at a home or in a specific location, many autonomous teachers—or "private teachers", as they are known—remained active during the pandemic by providing online access through synchronous or asynchronous classes. DL in Brazil was already showing signs of growth before the pandemic, and once the pandemic struck, this growth increased rapidly due to greater access to the internet and technologies, increased security of platforms and the higher confidence among users. It should be noted, however, that in the face of the pandemic, both professionals and students had to adapt quickly to remote emergency teaching without an established structure for DL.

Teachers who were not prepared for the effective use of voice and communication during their formal education also did not receive guidance and training on the use of voice for long periods during the transition to remote learning, nor did they receive information about resources related to adaptations of body posture, gestures, facial expressions and expressiveness when in front of a camera. The use of voice under these conditions can result in inadequate muscle adjustments that have impacts on voice production.⁸ Additionally, it is important to consider prepandemic factors associated with dysphonia, such as external noise that is difficult to control, that may be present in the home office.⁷ In contrast, other prepandemic factors associated with dysphonia, such as dust, classrooms with large numbers of students, considerable noise levels and exposure to violence,⁶ may be less present or even absent during remote learning.

A preliminary study investigated the self-perceptions of voice and communication of 1253 Brazilian teachers of both genders at different levels of education who started working from home due to the COVID-19 pandemic. Their main complaints were dry throat (43%), stress (27%) and a general feeling of fatigue (27%). Most of the participants indicated that they got few hours of sleep and little hydration, and almost all reported an accumulation of work and routine tasks at home. Most of these teachers did not consume alcoholic beverages, cigarettes and/or other drugs; however, 16.3% indicated that their consumption of these substances increased during the pandemic. Gastroesophageal reflux and respiratory diseases were the most frequently cited health problems. The teachers complained of hoarseness, voice failures and difficulties with technology during remote interactions, including classes, meetings and question-answering sessions. Nevertheless, most reported that their voices improved during the pandemic, and the main factors they attributed to this improvement were rest,

talking less and drinking water. For those who reported worsening of their voice, the main reasons were talking a great amount; stress, nervousness, tension or anxiety; and headphone use.²⁰

The in-depth analysis proposed in the present study is justified by the difficulties that were self-reported by the participants and motivated the development of support materials that could help to minimize the impacts of communication demands on teachers. The objective of this study was to evaluate the factors associated with vocal changes during the pandemic and to investigate the ability of the selected variables to predict vocal improvement and worsening during the pandemic among teachers who self-reported professional vocal demands during the investigation period.

MATERIAL AND METHODS

Study design

This was an exploratory, cross-sectional, observational study involving teachers from both public and private educational institutions as well as autonomous teachers.

Ethical aspects

The institution's Ethics Committee for Research Project Analysis approved this study (CAAE 32876820.8.0000.0068; study protocol number 4.127.673). All participants were volunteers who digitally signed the Free and Informed Consent Form.

Study participants

The inclusion criteria were teachers of any age and gender who taught at any education level (early childhood education, elementary and middle school, high school and university) regardless of their subject (generalist or specialist) and/or whether they taught private classes.

The exclusion criteria were as follows: teachers who were retired or did not work during the data collection period. Data were collected online using Google Forms between July and October 2020, during the COVID-19 pandemic.

The teacher's questionnaire was developed exclusively for this study using Google Forms ([supplementary material](#)). The questionnaire included exploratory questions that were designed to gather information relevant to this study. The objective was not to propose an evaluation protocol for the field, although the questionnaire could be used by other researchers from different countries for possible comparisons with linguistic adaptations and consideration of differences in educational systems among locations. This study collected a large amount of data, only some of which was analyzed for this article.

The researchers sent the first mailings about the study, which contained a link to the questionnaire, to teachers whom we knew via emails and messages on apps. In addition, we asked each member of the team to send the questionnaire to their network, following the snowball technique. Teachers who received the questionnaire were

permitted to pass it along to colleagues, which reinforced the snowball effect. After this initial step, the questionnaire was posted on social media; distributed through various media, such as newspapers, radio and websites; and shared with institutions that provide teacher training. This first stage of the study took place between July and October 2020, during the COVID-19 pandemic.

A total of 1,493 teachers answered the questionnaire; 240 questionnaires were excluded, most because of incomplete and duplicate answers, a small number because of an incorrect age (responses of 3 years old, 5 years old and 7 years old, which were likely the result of a typing error), and 19 for not consenting to their data being used for research (no reasons were provided for their nonconsent).

For this study, 127 teachers who indicated that they performed activities with no vocal demands (ie, those who produced written materials for regular distribution to distance students, did not perform school activities or were on vacation or sick leave) were also excluded.

The final sample consisted of 1,126 teachers who engaged in activities with vocal demands during the pandemic. The teachers indicated on the questionnaire that they performed at least one of the following activities: teaching synchronous online classes, recording video lessons, participating in online meetings, and answering students' questions synchronously online. These last two modalities were considered to have lower vocal demands than classes because they occur less frequently and involve multiple people, who take turns talking.

Among the participants, 932 (82.8%) were women, and 194 (17.2%) were men. Their ages were between 19 and 78 years (mean of 43.23 years). The mean length of teaching experience was 19.7 years. In terms of workplace setting, 631 (56%) worked at public educational institutions, 350 (31%) worked at private institutions, 64 (5.7%) worked at public and private schools, 25 (2.3%) were self-employed, and 56 (5%) worked at other types of institutions (nongovernmental organizations, philanthropic organizations, etc.). The participants were from 21 Brazilian states distributed throughout the five regions of Brazil, and many worked in more than one level of education (elementary school, middle school, early childhood education, high school, university) and in more than one type of service delivery setting (private classes, academies, technical education and postgraduate education). Twenty-six (2.3%) teachers reported having had COVID-19.

Data analysis

The software SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA) was used.

For the question "How would you classify your voice?", teachers marked one of the options provided (great, good, regular, bad or terrible) for both before and during the pandemic (authors' note: for future studies, the questionnaire will be modified and we will use the terms very good, good, fair, poor, very poor; in this

article, the terms used in the questionnaire were kept, as it is included as [supplementary material](#)). We compared the options chosen for before and during the pandemic were compared and classified the result as improvement (when there was a change for the better of any magnitude, for example, from terrible to bad, regular to good, good to great, bad to good), worsening (when there was a change for the worse of any magnitude, for example, from great to good, good to regular, bad to terrible, great to regular, etc.) or no change (when the self-perception of the voice before and during the pandemic was the same).

The descriptive analysis considered measures of central tendency and variability. The inferential analysis verified the association between changes in vocal self-perception (improvement, worsening, equal) and other variables collected by the teacher questionnaire (gender, age, type of school, aspects related to voice use, vocal habits and life style, mental health, physical, mental or vocal fatigue/exhaustion, history of COVID-19, type of professional activities with vocal demand, comorbidities, overlapping of personal and professional tasks, vocal signs and symptoms).

For the analysis of categorical variables, Fisher's exact test was used, and when a statistically significant difference was detected, post hoc analysis was performed with the z test to compare proportions between rows. Except for the variable "type of school", in which the chi-square test was used.

The measures of central tendency and the dispersion of age and duration of activity were analyzed according to the observed voice changes. The three groups organized according to the observed voice change during quarantine were compared using one-way univariate analysis of variance with an independent factor since the sample was large enough to allow the direct use of parametric tests based on the central limit theorem. Both variables violated the assumption of homoscedasticity ($P \leq 0.05$, Levene's test); therefore, the Welch correction for P value was used. The Games-Howell test was used for post hoc analysis, and the effect size was calculated using the d coefficient.

From the associations found between vocal changes and information obtained from the questionnaire, the most relevant variables were selected to compose a multinomial logistic regression model to assess the possible predictive capacity of these variables in relation to vocal changes by calculating the odds ratio. The quality of model fit was evaluated using the chi-square test of the likelihood ratio (likelihood ratio chi-square test) and through the R^2 calculations of Cox-Snell and Nagelkerke. The independent variables were inserted into the model simultaneously in a single step, since the aim of the study was to explore possible predictors of vocal changes in the quarantine period and this method is indicated in situations where the influence of the variables is not well established. The significance level adopted was 5% ($P \leq 0.05$).

RESULTS

The descriptive data presented in [Tables 1, 2, 3](#) and [4](#) show that most of the teachers in the study worked at a public school, reported having no previous voice changes or difficulties with their voice during online classes and used their voice less often and less intensely during the pandemic. Their vocal demands were divided between synchronous online classes, recording video lessons and participating in online meetings. They rarely mentioned the presence of hearing loss, respiratory problems, gastroesophageal reflux and other diseases and smoking. On the other hand, approximately half of the participants reported allergic rhinitis. The participants often reported mental and physical exhaustion, followed by vocal exhaustion. The majority felt the impact of the pandemic on their mental health.

In the inferential analysis, some variables were statistically significantly associated with improvements in voice quality during the pandemic, and other variables had a statistically significant association with voice worsening ([Tables 1, 2, 3](#) and [4](#)).

There was no statistically significant difference between the groups with voice improvement and voice worsening in terms of age ([Table 5](#)). There was a difference in mean age between the worsening ($P = 0.014$, $d = 0.297$) and improvement ($P = 0.002$, $d = 0.215$) groups compared to the group without changes in voice quality; the group without changes had a higher mean age than the other two groups. The three groups were similar in terms of length of experience ([Table 5](#)).

The logistic regression model found that the predictor variables could effectively predict vocal change during the pandemic ($\chi^2 = 905.34$, $P < 0.001$). The factors that led to voice improvement: working in a public school or as an autonomous teacher, reduced use of the voice, using the voice at a lower intensity. In addition, the factors that led to worsening of voice include working at a private school, increased voice use, use of the voice at higher intensities, difficulty with voice use during online classes, among others ([Table 6](#)). Among the selected variables, those that were not statistically significant predictors of vocal change during the pandemic included gender, voice use outside of work, the adoption of new habits, mental exhaustion, physical exhaustion, vocal exhaustion, online effort, conducting real-time online classes, the production of written materials, stress and general fatigue ([Table 6](#)).

DISCUSSION

This exploratory study emerged from questions about the impact of emergency remote teaching on teachers' voices. On the one hand, there was a possibility that distance from the risks associated with the classroom environment, such as noise and dust, among others, could have a positive impact on teachers' voice. On the other hand, previously unknown factors emerged that could have a negative impact on teachers' voice and communication, such as adjusting to

TABLE 1.
Analysis of the Association Between Voice Changes and Sociodemographic and Voice-Use Variables

Variable	Category	Change in Voice								P
		Worsened		Equal		Improved		Total		
		N	%	n	%	N	%	n	%	
Gender	Female	108	11.59	529	56.76	295	31.65	932	82.77	0.004*
	Male	23	11.86	132	68.04	39	20.10	194	17.23	
Type of school	Public	38	6.02	360	57.05	233	36.93	631	56.04	<0.001*
	Private	71	20.29	217	62.00	62	17.71	350	31.08	
	Private lessons	9	36.00	10	40.00	6	24.00	25	2.22	
	Public and private	5	7.81	38	59.38	21	32.81	64	5.68	
	Other	8	14.29	36	64.29	12	21.43	56	4.97	
Previous vocal changes	No	105	13.80	526	69.12	130	17.08	761	67.58	<0.001*
	Yes	26	7.12	135	36.99	204	55.89	365	32.42	
Use of voice	Reduced	15	2.31	345	53.08	290	44.62	650	57.73	<0.001*
	Equal	12	5.61	171	79.91	31	14.49	214	19.01	
	Increased	104	39.69	145	55.34	13	4.96	262	23.27	
Loudness	Reduced	32	4.95	337	52.17	277	42.88	646	57.37	<0.001*
	Equal	29	8.63	258	76.79	49	14.58	336	29.84	
	Increased	70	48.61	66	45.83	8	5.56	144	12.79	
Use of voice outside work	No longer present	20	12.12	89	53.94	56	33.94	165	14.65	<0.001*
	Equal	82	9.65	512	60.24	256	30.12	850	75.49	
	Started to present	29	26.13	60	54.05	22	19.82	111	9.86	
Difficulties with voice in online classes	No	52	5.62	572	61.77	302	32.61	926	82.24	<0.001*
	Yes	79	39.50	89	44.50	32	16.00	200	17.76	
New habits	No	93	10.30	565	62.57	245	27.13	903	80.20	<0.001*
	Yes	38	17.04	96	43.05	89	39.91	223	19.80	
Microphone use	No	48	12.06	231	58.04	119	29.90	398	35.35	0.925
	Yes	83	11.40	430	59.07	215	29.53	728	64.65	

* Statistically significant at the 5% level ($P \leq 0.05$)

Pearson's chi-square test was performed for the variable "Type of the school"
 Fisher's exact test for other variables

the home teaching environment, lack of mastery of digital tools and pandemic-related stress.

Thus, this study compared aspects related to voice use before and during the pandemic, and evaluated the factors associated with vocal changes during the pandemic and investigated the ability of the selected variables to predict those vocal changes. Decreasing the prevalence of dysphonia among teachers depends on the ability to identify risk factors.⁷ Any proposed action should identify the variables that need to be controlled, regardless of whether classes take place in person, remotely or in both modalities concurrently.

The pandemic caused experts from various fields to address issues that arose from the new context. Thus, investigations of factors that may interfere with the changed communication demands associated with working from home are necessary and urgent.⁸

The study population consisted of teachers who indicated that they faced vocal demands while working from home during the pandemic. There was greater proportion of female teachers than male teachers among the participants; the distribution was similar to that reported in another study²¹ but was comparable with the distribution of women

in Brazilian education according to the 2017 School Census.²² The risk of dysphonia for female teachers is 1.6 higher than that for male teachers.⁷ A better understanding of gender differences in the occurrence of dysphonia in teachers and possible related aspects will be one of the outcomes of this study.

Although this study's participants included teachers from five different regions of Brazil who worked in public, private and autonomous schools and who taught different subjects at different levels of education, it is important to consider the possible effect of the snowball technique on the composition of the sample.

The prevalence of perceived voice alterations prior to the pandemic (32%) was similar to that reported in a recent study of people who were working remotely during the pandemic¹⁰ and reinforces the high risk of dysphonia in this professional group. Although most of the participants did not report previous vocal changes, the proportion that did was higher than that reported in Behlau et al³ and Devadas et al²¹; those authors reported values close to 50% in the literature but emphasized that comparisons are difficult to make due to difference in methodologies. Teachers with vocal disorders are four times more likely to take sick leave

TABLE 2.
Analysis of the Association Between Voice Changes and Variables Related to Lifestyle, Vocal Signs and Symptoms and Mental Health

Variable	Category	Change in Voice								P
		Worsened		Equal		Improved		Total		
		N	%	n	%	N	%	n	%	
Smoking	No	119	11.29	617	58.54	318	30.17	1054	93.61	0.186
	Yes	12	16.67	44	61.11	16	22.22	72	6.39	
Increased consumption of alcohol/drugs	Does not consume	56	11.27	279	56.14	162	32.60	497	44.14	0.104
	No	46	10.31	273	61.21	127	28.48	446	39.61	
Pandemic affected mental health	Yes	29	15.85	109	59.56	45	24.59	183	16.25	0.083
	No	21	7.95	165	62.50	78	29.55	264	23.45	
Mental exhaustion	Yes	110	12.76	496	57.54	256	29.70	862	76.55	0.001*
	No	9	4.59	123	62.76	64	32.65	196	17.41	
Physical exhaustion	Yes	122	13.12	538	57.85	270	29.03	930	82.59	<0.001*
	No	16	5.26	188	61.84	100	32.89	304	27.24	
Vocal exhaustion	Yes	114	14.04	468	57.64	230	28.33	812	72.76	<0.001*
	No	21	3.32	384	60.76	227	35.92	632	56.13	
Greater online effort	Yes	110	22.27	277	56.07	107	21.66	494	43.87	<0.001*
	No	20	3.57	325	57.93	216	38.50	561	49.82	
Hoarseness	Yes	111	19.65	336	59.47	118	20.88	565	50.18	<0.001*
	Stopped	17	5.20	108	33.03	202	61.77	327	29.04	
Dry throat	Equal	82	10.98	539	72.16	126	16.87	747	66.34	<0.001*
	Appeared	32	61.54	14	26.92	6	11.54	52	4.62	
Sore throat	Stopped	10	3.52	116	40.85	158	55.63	284	25.22	<0.001*
	Equal	85	11.60	495	67.53	153	20.87	733	65.10	
Breathiness	Appeared	36	33.03	50	45.87	23	21.10	109	9.68	<0.001*
	Stopped	14	4.95	111	39.22	158	55.83	283	25.13	
Vocal fatigue	Equal	93	11.79	525	66.54	171	21.67	789	70.07	<0.001*
	Appeared	24	44.44	25	46.30	5	9.26	54	4.80	
Voice loss	Stopped	1	2.08	17	35.42	30	62.50	48	4.26	<0.001*
	Equal	117	11.15	634	60.44	298	28.41	1049	93.16	
Throat clearing	Appeared	13	44.83	10	34.48	6	20.69	29	2.58	<0.001*
	Stopped	10	3.95	90	35.57	153	60.47	253	22.47	
Habit of yelling	Equal	88	10.81	549	67.44	177	21.74	814	72.29	<0.001*
	Appeared	33	55.93	22	37.29	4	6.78	59	5.24	
Habit of speaking loudly	Stopped	11	5.14	74	34.58	129	60.28	214	19.01	<0.001*
	Equal	99	11.29	576	65.68	202	23.03	877	77.89	
Stress	Appeared	21	60.00	11	31.43	3	8.57	35	3.11	<0.001*
	Stopped	5	4.50	30	27.03	76	68.47	111	9.86	
General fatigue	Equal	107	11.04	610	62.95	252	26.01	969	86.06	<0.001*
	Appeared	19	41.30	21	45.65	6	13.04	46	4.09	
Water consumption	Stopped	10	5.49	68	37.36	104	57.14	182	16.16	<0.001*
	Equal	116	12.42	590	63.17	228	24.41	934	82.95	
Coffee consumption	Appeared	5	50.00	3	30.00	2	20.00	10	0.89	<0.001*
	Stopped	24	6.33	170	44.85	185	48.81	379	33.66	
Hours of sleep	Equal	78	11.11	478	68.09	146	20.80	702	62.34	0.157
	Appeared	29	64.44	13	28.89	3	6.67	45	4.00	
Increased consumption of alcohol/drugs	Stopped	5	3.11	56	34.78	100	62.11	161	14.30	<0.001*
	Equal	86	10.14	542	63.92	220	25.94	848	75.31	
Pandemic affected mental health	Appeared	40	34.19	63	53.85	14	11.97	117	10.39	<0.001*
	Stopped	10	4.98	76	37.81	115	57.21	201	17.85	
Vocal exhaustion	Equal	90	10.87	527	63.65	211	25.48	828	73.53	<0.001*
	Appeared	31	31.96	58	59.79	8	8.25	97	8.61	
Greater online effort	Reduced	29	10.74	144	53.33	97	35.93	270	23.98	0.143
	Equal	75	11.87	385	60.92	172	27.22	632	56.13	
Mental exhaustion	Increased	27	12.05	132	58.93	65	29.02	224	19.89	0.653
	Reduced	31	12.30	141	55.95	80	31.75	252	22.38	
Physical exhaustion	Equal	80	11.24	419	58.85	213	29.92	712	63.23	0.157
	Increased	20	12.35	101	62.35	41	25.31	162	14.39	
Vocal exhaustion	Reduced	10	9.71	53	51.46	40	38.83	103	9.15	0.157
	Equal	88	11.31	472	60.67	218	28.02	778	69.09	
Greater online effort	Increased	33	13.47	136	55.51	76	31.02	245	21.76	0.157

* Statistically significant at the 5% level ($P \leq 0.05$)
 Fisher's exact test for other variables

TABLE 3.
Analysis of the Association Between Voice Changes and Variables Related to the Presence of Comorbidities

Variable	Category	Change in Voice								P
		Worsened		Equal		Improved		Total		
		N	%	n	%	N	%	n	%	
Gastroesophageal Reflux	No	98	12.36	477	60.15	218	27.49	793	70.43	0.042*
	Yes	33	9.91	184	55.26	116	34.83	333	29.57	
Respiratory problems	No	112	11.55	577	59.48	281	28.97	970	86.15	0.373
	Yes	19	12.18	84	53.85	53	33.97	156	13.85	
Rhinitis	No	60	10.24	375	63.99	151	25.77	586	52.04	0.001*
	Yes	71	13.15	286	52.96	183	33.89	540	47.96	
Allergies	No	80	10.68	470	62.75	199	26.57	749	66.52	0.001*
	Yes	51	13.53	191	50.66	135	35.81	377	33.48	
Hearing loss	No	124	12.10	601	58.63	300	29.27	1025	91.03	0.253
	Yes	7	6.93	60	59.41	34	33.66	101	8.97	
Other diseases	No	124	11.79	618	58.75	310	29.47	1052	93.43	0.799
	Yes	7	9.46	43	58.11	24	32.43	74	6.57	
COVID history	I don't know	36	9.89	214	58.79	114	31.32	364	32.33	0.060
	No	87	11.82	434	58.97	215	29.21	736	65.36	
	Yes	8	30.77	13	50.00	5	19.23	26	2.31	

* : statistically significant at the 5% level ($P \leq 0.05$)
 Fisher's exact test for other variables

TABLE 4.
Analysis of the Association Between Voice Changes and Variables Related to Aspects of Professional Activity

Variable	Category	Change in Voice								P
		Worsened		Equal		Improved		Total		
		N	%	n	%	N	%	n	%	
Synchronous online classes	No	24	4.61	285	54.70	212	40.69	521	46.27	<0.001*
	Yes	107	17.69	376	62.15	122	20.17	605	53.73	
Recording of video lessons	No	83	13.56	357	58.33	172	28.10	612	54.35	0.066
	Yes	48	9.34	304	59.14	162	31.52	514	45.65	
Online meetings	No	41	22.53	95	52.20	46	25.27	182	16.16	<0.001*
	Yes	90	9.53	566	59.96	288	30.51	944	83.84	
Production of written material	No	74	15.91	275	59.14	116	24.95	465	41.30	<0.001*
	Yes	57	8.62	386	58.40	218	32.98	661	58.70	
Answering questions	No	84	11.08	461	60.82	213	28.10	758	67.32	0.114
	Yes	47	12.77	200	54.35	121	32.88	368	32.68	
Other school activities	No	118	11.26	616	58.78	314	29.96	1048	93.07	0.306
	Yes	13	16.67	45	57.69	20	25.64	78	6.93	
Caring for children	No	80	13.84	343	59.34	155	26.82	578	51.33	0.016*
	Yes	51	9.31	318	58.03	179	32.66	548	48.67	
Supporting children in school tasks	No	102	13.33	452	59.08	211	27.58	765	67.94	0.008*
	Yes	29	8.03	209	57.89	123	34.07	361	32.06	
Home care	No	11	18.64	41	69.49	7	11.86	59	5.24	0.003*
	Yes	120	11.25	620	58.11	327	30.65	1067	94.76	
Caring for other members of the household	No	102	12.85	474	59.70	218	27.46	794	70.52	0.017*
	Yes	29	8.73	187	56.33	116	34.94	332	29.48	

* Statistically significant at the 5% level ($P \leq 0.05$)
 Fisher's exact test for other variables

TABLE 5.
Descriptive Values and Comparative Analysis of Individuals With Different Levels of Voice Change by Age and Length of Experience

Variable	Group	n	Average	DP	Median	Min.	Max.	P
Age (years)	Voice worsened	131	41.00 [39.13. 42.80]	11.90	40.00 [40.00, 40.00]	18.00	74.00	<0.001 ^{*,†}
	No change	658	44.18 [43.38. 45.00]	10.70	44.00 [42.00, 45.00]	21.00	78.00	
	Voice improved	334	41.88 [40.84. 42.90]	9.45	41.00 [40.50, 42.00]	19.00	67.00	
Length of experience (years)	Voice worsened	131	15.61 [13.84, 17.38]	11.42	13.00 [11.00, 15.00]	1.00	50.00	0.227 [†]
	No change	661	16.56 [15.82, 17.33]	10.32	15.00 [15.00, 15.00]	1.00	49.00	
	Voice improved	334	15.46 [14.46, 16.41]	9.18	15.00 [12.00, 16.59]	0.00	45.00	

* Statistically significant at the 5% level ($P \leq 0.05$)

† Value adjusted with the Welch correction for violation of the homoscedasticity assumption ANOVA one-way univariate analysis of variance.

Abbreviations: SD, standard deviation; Min., minimum; Max., maximum

TABLE 6.
Multinomial Logistic Regression Model for Predicting Voice Change During the Pandemic Considering Only Individuals Who Taught Synchronous Online Classes

Variable	Category	Worsened			Improved		
		b	Odds Ratio	P	b	Odds Ratio	P
Intercept	-	-3.45	-	<0.001*	-4.47	-	<0.001*
Female gender	-	0.22	1.25 [0.58. 2.69]	0.571	0.48	1.61 [0.96. 2.71]	0.074
Type of school	Private	0.80	2.22 [1.06. 4.64]	0.033*	-0.14	0.87 [0.53. 1.44]	0.592
	Private lessons	1.14	3.11 [0.62. 15.56]	0.167	1.76	5.82 [1.24. 27.21]	0.025*
	Public and private	0.02	1.02 [0.24. 4.30]	0.978	0.39	1.48 [0.70. 3.15]	0.305
	Other	-1.05	0.35 [0.09. 1.39]	0.136	-0.17	0.84 [0.34. 2.09]	0.710
Voice alteration	-	-0.40	0.67 [0.31. 1.47]	0.321	1.39	4.02 [2.76. 5.85]	<0.001*
Use of voice	Minor	-0.01	0.99 [0.35. 2.79]	0.988	0.74	2.11 [1.22. 3.62]	0.007*
	Greater	1.54	4.68 [2.04. 10.70]	<0.001*	-0.44	0.64 [0.28. 1.46]	0.294
Vocal intensity	Minor	-0.04	0.96 [0.46. 2.01]	0.909	0.98	2.65 [1.71. 4.12]	<0.001*
	Greater	1.45	4.26 [1.97. 9.21]	<0.001*	-0.02	0.98 [0.36. 2.66]	0.971
Use of voice outside work	Minor	0.85	2.35 [0.97. 5.70]	0.059	0.08	1.08 [0.67. 1.75]	0.747
	Greater	0.67	1.95 [0.91. 4.18]	0.085	0.28	1.33 [0.67. 2.65]	0.417
Difficulty with voice in online classes	-	1.24	3.44 [1.72. 6.89]	<0.001*	-0.22	0.80 [0.44. 1.45]	0.466
New habits	-	0.41	1.51 [0.76. 2.98]	0.235	0.29	1.34 [0.87. 2.06]	0.186
Mental exhaustion	-	0.11	1.11 [0.36. 3.46]	0.853	-0.12	0.89 [0.52. 1.52]	0.661
Physical exhaustion	-	0.41	1.51 [0.60. 3.76]	0.381	0.08	1.08 [0.68. 1.72]	0.745
Vocal exhaustion	-	0.03	1.03 [0.46. 2.32]	0.946	-0.27	0.76 [0.50. 1.16]	0.210
Online work	-	-0.08	0.92 [0.44. 1.96]	0.836	-0.28	0.75 [0.52. 1.09]	0.136
Real-time online classes	-	-0.60	0.55 [0.24. 1.28]	0.167	-0.21	0.81 [0.52. 1.25]	0.334
Online meetings	-	-1.01	0.36 [0.17. 0.79]	0.011*	-0.70	0.50 [0.28. 0.88]	0.016*
Production of written material	-	-0.26	0.77 [0.41. 1.45]	0.422	-0.01	0.99 [0.67. 1.46]	0.960
Routine activities	Caring for children	0.32	1.37 [0.67. 2.82]	0.388	0.21	1.23 [0.77. 1.98]	0.386
	Supporting children with school tasks	-1.11	0.33 [0.14. 0.76]	0.009*	-0.04	0.96 [0.58. 1.59]	0.883
	Home care	-0.77	0.46 [0.15. 1.41]	0.175	0.56	1.75 [0.65. 4.68]	0.267
	Caring of other family members	-0.76	0.47 [0.24. 0.92]	0.029*	0.21	1.24 [0.85. 1.80]	0.273
Vocal habits	Stopped	0.82	2.26 [1.07. 4.79]	0.033*	0.75	2.12 [1.41. 3.18]	<0.001*
	Began	1.14	3.14 [1.48. 6.66]	0.003*	0.08	1.09 [0.43. 2.74]	0.860
Vocal signs/symptoms	Stopped	-0.37	0.69 [0.37. 1.29]	0.246	1.94	6.97 [4.14. 11.72]	<0.001*
	Began	2.34	10.34 [5.43. 19.68]	<0.001*	-0.13	0.88 [0.53. 1.45]	0.606
Stress	Stopped	-0.01	0.99 [0.25. 3.88]	0.985	0.26	1.29 [0.75. 2.22]	0.356
	Began	0.33	1.39 [0.59. 3.28]	0.447	-0.07	0.94 [0.41. 2.11]	0.872
General fatigue	Stopped	0.72	2.06 [0.69. 6.12]	0.194	0.17	1.19 [0.73. 1.94]	0.492
	Began	-0.07	0.94 [0.38. 2.30]	0.886	-0.78	0.56 [0.16. 1.29]	0.139

* Statistically significant at the 5% level ($P \leq 0.05$)

$r^2 = 0.56$ (Cox-Snell), 0.67 (Nagelkerke). $\chi^2(66) = 919.23$, $P < 0.001$

than other teachers and have difficulty maintaining their careers.⁷

Most of the teachers in the study worked at public schools. In Brazil, public institutions initiated online activities at a later date than private institutions at the early childhood, primary and secondary education levels. In addition, at public institutions other than universities, these activities were less intense, which may explain why most university professors reported less use of voice and lower intensity of voice use during the pandemic and a consequent perception of improved voice quality.²⁰

Another important factor is that there were few smokers among the participants. Smoking has deleterious effects on the vocal fold mucosa and impacts voice production.²³

Vocal demands were divided between synchronous online classes and recording video lessons, in addition to participating in online meetings. Each of these modalities has its own specific vocal demands. The participants rarely mentioned the presence of hearing loss, respiratory problems and gastroesophageal reflux, which can negatively impact the voice.^{7,21} On the other hand, approximately half of the participants reported allergic rhinitis. Diseases of the upper respiratory tract are associated with voice disorders,⁷ and allergic rhinitis can increase the likelihood of voice problems by twofold.²¹

Psychological stress is one of the main factors associated with vocal symptoms in teachers.^{4,9,10} Additionally, some of the teachers in this study reported experiencing vocal exhaustion. Because their voice is fundamental to their profession, teachers' stress may increase as they notice vocal symptoms and/or difficulties with communication.⁹ Teachers with poor voice quality have worse quality of life.¹ Therefore, addressing the well-being of teachers will prevent further adverse effects of this global crisis.¹¹

The analysis of predictive variables showed that the presence of voice changes before the pandemic increased the likelihood of vocal improvement during the pandemic (OR = 4.02; 95% CI 2.76–5.85). One hypothesis for this finding may be related to the fact that teachers with a history of voice changes may more easily perceive improvement than those who rated their voices as excellent or good during the prepandemic period.²⁰ In addition, these teachers may have benefited more from the switch to a physical environment with less dust and noise and/or organizational changes. Nevertheless, a recent study identified a 28% incidence of dysphonia among professionals who were working remotely during the pandemic,¹⁰ which reinforces the need for follow-up with these professionals.

Teachers who worked in private schools had approximately twice the likelihood of vocal worsening (OR = 2.22; 95% CI 1.06–4.64) than teachers in public schools. As mentioned, private schools initiated remote activities before public schools did and offered a higher volume of online classes, which led to greater vocal demand. It is possible that universities were an exception, and this hypothesis can be examined as the study continues.

In turn, autonomous teachers, who may work with individuals or small groups, were more likely to show vocal improvement (OR = 5.82; 95% CI 1.24–27.21) than teachers in public schools. While public school teachers experienced vocal improvement because they were teaching less than those in private schools, autonomous teachers may have had less work, and therefore, taught fewer classes than teachers in public schools. This scenario can be explained by the economic uncertainties that led to reductions in spending.

The hypothesis that voice improvement was the result of teaching fewer classes was also corroborated by the finding that a reduction in voice use (OR = 2.11; 95% CI 1.22–3.62) doubled the likelihood of vocal improvement, as did the use of the voice at lower intensities (OR = 2.65; 95% CI 1.71–4.12). In parallel, increased voice use (OR = 4.68; 95% CI 2.04–10.70) quadrupled the likelihood of vocal worsening, as did use of the voice at higher intensities (OR = 4.26; 95% CI 1.97–9.21). Thus, the direct interference of vocal demand and voice intensity was found to predict the self-perceived improvement or worsening of the voice. Vocal hyperfunction in habitual speech results in many sensations of discomfort in the vocal tract, especially in teachers with dysphonia due to muscle tension.²⁴ Teachers who use increased vocal intensity have more vocal symptoms.⁹ Among professionals who were working from home during the pandemic, worsening of vocal hyperfunction has been observed, along with increased vocal intensity and effort, which led to worsening of the voice.¹⁰

Experiencing voice difficulties during online classes (OR = 3.44; 95% CI 1.72–6.89) tripled the likelihood of worsening of the voice. This result reinforces the importance of structuring home offices to ensure adequate working conditions and the need for specific vocal training.^{9,10} Teachers who work from home have increased pain in the neck, back and shoulders and vocal fatigue related to inadequate posture when speaking due to improvised ergonomics.⁸ A higher occurrence of dysphonia was observed during the pandemic among teachers who adopted inadequate body postures and used incorrectly positioned computers while working.¹⁰ Teachers, who are accustomed to standing for long periods, spend more time seated when working from home, and poor posture impairs respiratory support and increases muscle tension and tension in the voice.¹² The teacher-camera interaction can impact prosody and intonation because under such conditions, speech is more monotonous and unilateral, which can also lead to greater vocal effort.¹²

Participation in online meetings doubled the likelihood of vocal improvement (OR = 2.78; 95% CI 1.26–5.88) and decreased the likelihood of vocal worsening (OR = 2.00; 95% CI 1.13–3.57). Participation in online meetings requires less from the phonation system than teaching does. Although participation in meetings is an activity that involves vocal demands, when teachers are in meetings, they are teaching less, and this seems to be a protective factor for their voices.

Helping children with school tasks (OR = 3.03; 95% CI 1.31–7.14) and caring for other family members (OR = 2.12; 95% CI 1.08–4.16) reduced the likelihood of vocal worsening. It is possible that teachers who were able to reconcile these tasks with their work routine taught fewer classes and consequently spent less time using their voice. Further exploration of this issue is intended as this study continues.

Not indulging in certain habits related to voice use (OR = 2.26; 95% CI 1.07–4.79) doubled the likelihood of both vocal worsening and vocal improvement (OR = 2.12; 95% CI 1.41–3.18). Starting these habits (OR = 3.14; 95% CI 1.48–6.66) increased the likelihood of vocal worsening. These contradictory relationships may be based on whether the changes were for the better (positive habits, such as drinking more water), which would contribute to the improvement of voice quality, or for the worse (negative habits, such as clearing the throat), which negatively affect the voice. Recently, two structured training programs for teachers involving vocal hygiene concepts, explanations of the anatomy and physiology of voice production and clarifications of healthy and unhealthy vocal behaviors and habits were found to be effective.^{25,26} Such training provides valuable information to teachers, and professional monitoring can support them in implementing and maintaining these positive changes. Interventions that combine guiding content with training in vocal practices are even more effective for improving the voice quality and vocal self-assessment of teachers, even when applied for a short period of time.²⁷

The cessation of vocal symptoms considerably increased the likelihood of vocal improvement (OR = 6.97; 95% CI 4.14–11.72), whereas the onset of vocal symptoms (OR = 10, 34; 95% CI 5.43–19.68) further increased the likelihood of vocal worsening. As these are intrinsically related factors, it was expected that teachers with less hoarseness, dry throat, and breathiness, among other symptoms, would consider their voices better, and conversely, those who observed these symptoms would consider their voices worse. A study of Israeli teachers during the transition from face-to-face teaching to synchronous online teaching observed the following main symptoms: vocal fatigue, the need to drink water very often, effortful voice production, hoarseness, pain or irritation in the throat and a frequent need to clear the throat or cough.⁹ Teachers may experience various symptoms of vocal fatigue ranging from mild physical discomfort to the need for vocal rest to the need to avoid vocal communication. Effective coping strategies must consider these specificities.²⁸

One limitation of this study was the possibility of bias in the participants' responses when reporting data prior to the pandemic,⁸ given that they were asked to rely on their memory of a time that was particularly complex for all. Although some aspects of working from home were better in terms of the impact on teachers' voices, other factors were worse and had an even stronger negative impact than usual on the voice.

Before the pandemic, work in the classroom placed a great demand on teachers' voices¹; working from home presents different and relevant vocal demands. Additionally, these changes in demands occurred rapidly; thus, there is a need to improve the adaptations made for remote education.²⁹ Remote teaching, unlike distance education, is a temporary and emergency approach to teaching that was implemented so that classes could continue during the pandemic to reduce educational losses.³⁰ Synchronous and asynchronous online classes delivered via distance education were a reality in several countries before the pandemic.³¹ Analyses of how these practices were implemented and the impact of training teachers in communication and voice use could provide information that can be adapted to the pandemic period.

In addition, the pandemic has accelerated humanity's path toward a future in which interactions mediated by information and communication technologies should continue to be provided in some postpandemic contexts, and a focus on the professional voice should be part of this scenario.¹² The monitoring of teachers becomes even more important in the current reality in several countries, including Brazil, where mixed teaching practices comprise concomitant online and classroom work. This modality presents even more challenges in ensuring that teachers maintain effective and healthy vocal communication.¹² This is because under these circumstances, teachers must not only be present in the two scenarios but must also integrate them, while at the same time adhering to strict health safety rules, such as physical distancing and mask use. Studies have shown that prolonged speaking while wearing a mask can lead to vocal fatigue and hinder speech intelligibility and breathing-speech coordination,³² increase pain in the laryngeal region,⁸ promote increased vocal intensity and decrease F3.³³ These data reinforce the need to monitor teachers with the aim of better adapting workplaces in terms of both equipment and organization and providing training for better communication in this new format to prevent dysphonia.^{9,10}

For this study, the authors produced two videos as support materials for Brazilian teachers and made them available to the participants and to the Brazilian public. Video 1 provided guidance regarding voice and communication in the context of remote online classes and was released in 2020 during data collection. Video 2 followed from video 1 and was prepared after analyzing the responses to the teacher questionnaire²⁰; it provided voice and communication guidelines for remote and face-to-face teaching.

During this complex time characterized by increases in the number of people infected in some countries, such as Brazil, and decreases in cases in countries where mass vaccination is a reality, different scenarios for the education process are being developed. In this context, the voice and communication health of teachers, the protagonists in this process, should be tirelessly investigated so that experts can offer teachers the best of their expertise.

It is important to emphasize that this study analyzed only part of the data that were collected. Other studies are being conducted on the differences between male and female teachers, teachers who have contracted COVID-19, and the qualitative analysis of the open questions, among other topics.

As a possible sampling bias, the snowball effect in the dissemination of the research should be considered, which may have grouped teachers from the same schools and with similar realities. This is somewhat attenuated when the participation of teachers from five different regions of the country is observed, from different levels of education and types of school. In addition, the results related to the OR of vocal worsening should also be considered with caution, since the sample number of people with voice worsening in this study (N = 131) was slightly below that established in the literature for regression studies (N = 200) using this number of variables.³⁴

Regarding the questionnaire, some questions about vocal habits, vocal quality and vocal health could have been accompanied by the definitions of the terms to improve the teachers' understanding. The same applies to the term laryngopharyngeal reflux, even though this is a common term for Brazilians. The "regular" classification in the questionnaire refers to the concept of regular used in Brazil, which is an attribute between bad and good, similar to "fair". Some data may be underestimated because teachers often consider their voice good, even in the presence of dysphonia, which they consider inherent to the profession.

Among the clinical implications of the study are that many of these teachers will seek professional help, and it is important for clinicians to be aware of possible vocal alterations resulting from the pandemic context. Moreover, based on these results, guidelines on vocal care were sent to all of the participants in the form of videos. A continuation of the present study that is currently under development will record the voices of these teachers remotely and update the data, because in Brazil, at the time this article was being finalized, in-person teaching was resumed simultaneously with remote teaching, and new impacts will arise from this new context.

CONCLUSION

Teachers' self-reported prevalence of voice disorders during the pre-pandemic period was high, although voice improvement occurred with the shift to remote learning.

Several factors were associated with vocal changes during the pandemic. The predictors of voice improvement were working at a public school or as an autonomous teacher, reduced voice use, using the voice at a lower intensity, participating in online meetings, stopping some vocal habits and adopting others and not presenting vocal symptoms. The predictors of vocal worsening were working at a private school, increased voice use, use of the voice at higher intensities, difficulty with voice use during online classes, failure

to adopt some vocal habits and the adoption of others and presenting vocal symptoms.

AUTHOR CONTRIBUTIONS

KN, MSZ: the study's conception and design, data acquisition, data analysis and interpretation, article drafting, revising for key intellectual content, final approval of the version submitted; VCA, GAM, ITS, RSG: data organization, support in the data analysis, final approval of the version submitted.

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CONFLICT OF INTEREST

None.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at [doi:10.1016/j.jvoice.2021.08.010](https://doi.org/10.1016/j.jvoice.2021.08.010).

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