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Effects of Virtual Instruction on Educators' Voices During the COVID-19 Pandemic

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Summary: Introduction. Resulting from the COVID-19 pandemic, professionals in the United States were mandated to work virtually from home to protect the health needs of the population. The shift in setting and ergonomic factors posed a threat to the vocal health of workers, and more specifically, to those whose professions inflict significant vocal load, such as educators. This study compared the symptoms of vocal tract discomfort and self-perceived voice handicap in full-time educators between face-to-face and virtual settings. Additionally, this study sought to identify relationships between specific environmental factors and levels of discomfort.

Methods. A cross-sectional research study was conducted by distributing an online survey to 223 individuals who identified as full-time educators. This survey collected data on vocal tract symptoms during both face-to-face and virtual instruction, environmental factors of virtual work setting, personal vocal health habits, and self-perceived voice handicap in each setting.

Results. In this sample population, the shift to a virtual work setting did not result in a significant increase in the number of vocal discomfort symptoms or an increase in vocal handicap. However, environmental factors such as air quality and water intake had the strongest correlation with levels of vocal tract discomfort.

Conclusion. It is beneficial to provide resources to full-time educators regarding the risk of voice disorders and the impact of environmental factors on vocal health.

Key Words: Virtual instruction−Voice handicap−Voice disorders−Vocal tract discomfort−High voice users −Environmental factors.

INTRODUCTION

In an effort to control the spread of the global COVID-19 pandemic, professionals across the United States were mandated to work from home on a state-by-state basis when possible and adopted entirely digital styles of working, otherwise known as telecommunication. A niche group of professionals whose occupation involved high vocal demands (eg, teachers, clergy, salespeople) sought out video and phone technologies that enabled continued communication of their professional material. While some jobs are contingent on being physically present in the workplace, countless occupations were forced to consider how work formerly performed in person could be transitioned to the digital space.

Before the pandemic, educators were already identified as a high-risk population for developing voice disorders.[1-3] In fact, the prevalence of voice disorders over one's lifetime was reported at 57.7% for teachers and 28.8% for non-teaching professionals.[4] However, as virtual work began, questions arose surrounding the quality of home offices and further risk of vocal health as educators left their classrooms. In fact, 43 of the 50 United States issued stay-at-home orders for their constituents in 2020 in response to the global pandemic.[5] Furthermore, USA Facts reported that within the first year of the pandemic, 65% of households with students transitioned to a virtual mode.[6] Between these statistics, the majority of teachers across the United States also shifted to virtual education.

Teachers and other occupational voice users apply a variety of techniques to perform their work effectively in person. Yet, these techniques were forced to be adapted or disregarded altogether during the shift to telecommunication and a digital platform. In this transition, many professionals likely found themselves questioning what elements of face-to-face work make their occupational performance successful. A home office may have been sufficient for those who worked independently and with little need for verbal collaboration, however, occupations of high voice use left controlled settings to make do with limited technology and questionable ergonomic factors in the home. Previous research has indicated the significance of ergonomic factors on influencing the phonatory and physiologic health of high voice users.[7] Thus, this modification in elements of work and setting can be influential on the vocal health of academic professionals across the country.

Despite having the technologies in place for occupational use, many professionals lacked control and consideration of key ergonomic factors in the home setting that could potentially lead to vocal discomfort. Access to laptops or desktop computers is not enough to transition the experience of face-to-face instruction to a virtual space. Digital lesson planning, voice amplification, and a strong internet connection are only a few considerations for educators when leading an online lesson.[8,9] Other significant elements that influence vocal health include posture/breath support, air quality, background noise, and acoustics.[10-12] There is an emerging body of research on the relationship between these elements and vocal health in response to the shift in

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workplace environment due to COVID-19 and the global pandemic.[10-12] Regarding breath support, Kishbaugh et al emphasized the difference for educators in standing for most lessons in the classroom to sitting at a desk when working virtually.[11] The researchers suggested investing in a standing desk or performing parts of lessons while standing to enhance breath support throughout the day of virtual work.[11] Additionally, education on proper breathing techniques (ie, diaphragmatic breathing) has been shown to positively influence vocal projection and could be beneficial for educators seeking to reduce vocal demand and improve overall vocal health.[13]

Air quality can impact vocal health due to ventilation, temperature, and humidity amongst other factors.[12,14,15] In a study of Finnish schools, Patjas et al found that educators had better total air quality in the virtual work environment as opposed to face-to-face instruction.[12] The study also reported a decrease in symptoms of vocal discomfort when educators transitioned to virtual work.[12] Clearly, improved air quality in the home environment may not always be the case due to great variability across virtual work environments. To address this, researchers suggest comprehensive assessment of indoor air quality in the home and work settings to remove irritants and reduce the likelihood of vocal irritation for educational professionals.[12,14,15]

Background noise has been cited as the most disturbing factor affecting vocal performance during lecture time.[12] In a virtual class setting, background noise can be easily eliminated through the "mute" function offered on most if not all virtual meeting platforms. A microphone or headset with voice amplification may also further decrease the amount of vocal effort needed to lecture in an online setting.[8] Just as in the physical classroom, implementing classroom rules and physical elements that reduce vocal effort can make daily vocal demands more manageable and decrease vocal irritation in the virtual setting.

Lastly, acoustic properties of the setting where academic lecturing takes place may impact an educator's vocal health. For example, rooms where sound reverberates more have been shown to be associated with more vocal effort.[16] Other researchers have indicated a strong relationship between acoustic measurements of a settings and the vocal health of teachers.[17] Items such as drapes or curtains and carpeted floors tend to absorb background noise resulting in a quieter and more comfortable work environment and, subsequently, reduced vocal effort.[18,19] For teachers who have home offices with poor acoustics, their increased vocal load may further exacerbate symptoms of dysphonia. Recent research shows that many professionals found their virtual setting more acoustically desirable, likely due to decrease in background noise or the need to project less in a smaller room.[12]

Clearly, the need to control elements such as posture, air quality, background noise, and acoustics and their potential effect on vocal health for professional voice users is well established.[10-12] Likewise, professionals that are identified as having excessive vocal demands for their job, such as educators, are at a greater likelihood of developing voice disorders due to the nature of their work.[1-3] One of the most common voice disorders amongst high vocal use professionals is dysphonia. Several occupational and nonoccupational risk factors contribute to the development of dysphonia. Namely, the amount of vocal load one experiences as part of their occupation is a strong predictor of the presence of dysphonia.[20] Gender and age are two additional influential predictors of dysphonia, while workplace considerations previously discussed such as background noise and air quality are ergonomic elements that also increase the likelihood of a dysphonia.[12,15]

A voice disorder and the resultant dysphonia that may accompany it has been characterized by a change in voice that no longer meets the daily needs of an individual.[21] Along with the impact of voice disturbances on daily performance, researchers have questioned how else voice disorders impact people's lives. For example, researchers have evaluated the impact of dysphonia across the various subscales of general health (eg, physical functioning, social functioning, and mental health amongst others) and found that the presence of dysphonia negatively impacts all areas of overall health.[3,22] The impact of dysphonia on a person's overall health can be measured using the Voice Handicap Index (VHI).[23] The VHI-10 has been shown to be valid and reliable in numerous languages and includes 10 questions designed to evaluate how one's voice difficulties impact their personal life, social life, and income, as well as the feelings one experiences about their dysphonia and how others respond to their voice difficulties.[23] The primary areas of impact measured by the VHI-10 are divided into three domains: functional, physical, and emotional.[23] Research indicates a strong relationship between voice disorders and overall health, indicating that dysphonia and other voice disorders have the potential to negatively influence an individual's baseline quality of life and health-related quality of life.[23]

In recent years, the construct of vocal tract discomfort (VTD) has been introduced into the voice literature. Vocal tract discomfort is defined as a variety of uncomfortable sensations in the vocal tract even in the absence of dysphonia.[24] The construct was developed, in part, as a recognition that people may experience increased vocal load or vocal strain regardless of whether they are ultimately diagnosed with a voice disorder.[24] Compared to dysphonia, VTD can be considered the symptoms that precede and eventually lead to dysphonia if not appropriately managed.[20] The symptoms of VTD, as measured by the Vocal Tract Discomfort Scale (VTDS), includes eight items: burning, tightness, dryness, aching, tickling, soreness, irritable, and a lump sensation experienced in the throat.[25] Patients complete the questionnaire and identify the presence and frequency of those symptoms on a scale of zero (never) to six (always).[25] It is the exacerbation of these symptoms through overuse that may, ultimately, result in dysphonia and vocal fold damage for many professional voice users.[20]

Multiple risk factors of VTD have been identified, including increased levels of stress and anxiety, presence of air pollution, specific personal habits (eg, water intake, smoking

history), and working as a teacher compared to other high voice-use professions.[26] The impact of a global pandemic on individuals' stress and anxiety levels as well as a shift in personal habits and work setting make the last 2 years of COVID-19 particularly influential in the world of vocal health. These elements have been independently identified as predictors of dysphonia, indicating that when they are exacerbated, an individual may develop dysphonia.[20] Similar to VTD, risk factors of dysphonia include psychological stressors, vocal vulnerability, and most relevant, general discomfort with phonation.[3,7,26] Vocal vulnerability is described by Deary and Miller as the result of 'intense vocal pressures'.[27] As previously reviewed, individuals in occupations of high voice use, including teachers, have more intense vocal pressures and thus, are at increased vocal vulnerability from the nature of their work when compared to other professionals who may not rely on their voice for their livelihood.

Prior to the global pandemic, there was naturally a paucity of research comparing the vocal demands of face-to-face work to virtual work, particularly with professional voice users. However, the pandemic has brought this issue to the forefront of vocal health. To date, there is a nascent body of research emerging from limited countries showing equivocal results. While these studies vary in populations addressed, data collected, and results gleaned, they each provide successful models of voice disorder analysis during this global pandemic and inspired the need to address these same questions within the United States.

In Finland, Patjas et al collected data on teachers' shift to virtual work following the change to virtual delivery for education.[12] Specifically, the researchers investigated participants' voice symptoms, environmental risk factors, and ability to complete their work according to setting. The authors used an abbreviated version of the VHI-10 to evaluate voice symptoms along with additional questions crafted by the researchers asking for the participants to elaborate on the frequency of symptoms, amount of vocal load needed for work, accompanying stress levels, acoustic properties of their working environment, and personal background information.[23] Results showed that less than half of the participants felt that the ergonomic factors at their face-to-face work settings were sufficient and that there was an overall decrease in reported voice problems following the shift to virtual work.[12] Participants also reported more suitable air quality amongst other improved ergonomic factors at their home setting. Ultimately, the authors concluded that virtual teaching may be a solution for educators in Finland who experience significant vocal discomfort symptoms when teaching in person.[12]

In Ireland, Kenny investigated the prevalence, onset, and severity of vocal discomfort and dysphonia of the general population in both virtual and face-to-face environments by using an online survey.[28] Questions on the survey included personal background information, amount of work conducted virtually throughout the day, ergonomic factors, and voice characteristics working face-to-face and working from home.[28] Contrary to Patjas et al, results in Ireland showed a slight increase in VTD symptoms and dysphonia following a shift to virtual work during COVID-19 lockdown.[12] This reported increase in vocal tract discomfort and dysphonia prevalence during lockdown suggested an association between virtual work settings and vocal health. Kenny concluded that workplaces and those working from home should be trained on equipment needed to maintain vocal health regardless of setting.[28]

In summary, the impact of the sudden shift to virtual work on teachers' voices is limited. Given the equivocal data available from a few select countries, additional studies are warranted, particularly for teachers in the United States. There is a need for this research as indicated above due to the high-risk teachers have of developing a voice disorder and the evidence that shifting workplaces also shifts a variety of factors that influence vocal health.

Specific research questions include: 1) what is the effect of virtual teaching on self-reported VTD symptoms and perceived vocal handicap for teachers in the United States; and 2) what environmental factors are associated with declining vocal health in both settings. This study hypothesized that teachers experience more vocal tract discomfort symptoms when working virtually compared to working face-to-face in a school environment.

Regarding clinical implications, the limited international data emphasize the need for training to conserve vocal health and the need for evaluation of environmental infrastructure in virtual settings as two qualifying consequences that are relevant to high voice users.[11,28-30] Training full-time educators on vocal hygiene and therapy techniques could reduce the number of high voice-use professionals who experience vocal tract discomfort that eventually develops into a voice disorder. Additionally, this information can make work less uncomfortable for professionals and introduce them to clinical support for their diagnosis and treatment.

METHODS

Participants

Participants in this study were recruited using an online crowdsourcing platform, Amazon Mechanical Turk (AMT). In order to qualify for the survey, restrictions were set within the AMT platform requiring that all participants were working full-time at the time of the survey, identified as educators, and were above the age of 18 years. Participants were paid $1.50 for completion of the survey. The survey was available for a 3-month period on AMT and participants who responded to all survey questions were included in the final data analysis. The study was approved by the Institutional Review Board at Towson University in Towson, MD.

Survey instrument

The survey was an adapted version of the questionnaire used by Kenny and included two instruments used to

measure symptoms of vocal tract discomfort and self-perceived vocal handicap.[28] The VTDS rates the frequency and severity of eight different vocal tract sensations (ie, burning, tight, dry, aching, tickling, sore, irritable, and lump in the throat). This measure was developed to recognize the vocal health symptoms experienced by individuals who do not always have a voice disorder diagnosis.[31] Individuals indicate the frequency and intensity of each of these symptoms through a seven-point Likert scale.[31] Measures of frequency range from "never" to "always" while intensity scores range from "none" to "extreme". The VHI-10 was developed for individuals to elaborate on the psychosocial effects of their voice disorder or discomfort.[23] Items on the VHI-10 align with three subscales of health: functional, physical, and emotional.[23,32] These items were represented as statements about how one feels about their voice disorder and how it impacts their daily life. Patients selected their responses to 10 questions using a five-point Likert scaled that were labeled as and ranged from "always" to "never". Each of the participants responded to the VTDS and VHI-10 twice: once for their experience teaching face-to-face, and once following the shift to virtual instruction.

Similar to Kenny, additional items on the survey included questions regarding personal habits (water intake and smoking history) and work-related ergonomic factors.[28] The final version of this survey (see Appendix A) included the opportunity for participants to share open-ended responses to the VTDS by selecting "other" and manually entering a symptom they experienced but was not listed as one of the options.

Data analysis

Data were evaluated using SPSS for Windows.[33] The first hypothesis was addressed with a *t* test analysis to compare the overall mean of VHI responses for both in person and virtual work and to also compare the mean number of VTD symptoms experienced in both settings. The second research question was addressed by completing a Pearson-product moment correlation to analyze the relationship between environmental factors and the home setting.

RESULTS

A total of 223 educators responded to the survey (133 males, 90 females) with specific age breakdowns and instructional levels outlined in Table 1. Briefly, 82% of participants identified as teachers, 13% administrators, and 4% as 'other'. Overall, 65.9% of participants reported more than half of their workday is delivered virtually. Furthermore, 23% of respondents (n = 51) reported a previous diagnosis of a voice disorder while 35% of participants (n = 76) reported having previously received voice therapy. In addition, 75% of respondents indicated that they participate in other high voice-use pastimes. Tables 2 and 3 below outline the collection of responses about these diagnoses, activities, and water intake.

TABLE 1.
Participant Demographics

	n	%
Age (yrs)		
18-29	70	31.39
30-39	98	43.95
40-49	33	14.80
50-59	20	8.97
60+	2	0.09
Instructional level		
Elementary school	24	10.79
Middle school	43	19.28
High school	59	26.46
College or university	97	43.50

The first research question addressed the impact of teaching setting (face-to-face, virtual) on the presence of and number of VTD symptoms as well as self-perceived vocal handicap as measured by self-reported scores on the VHI-10.[23] Descriptive data shows that participants reported an average of 2.04 symptoms of vocal tract discomfort when working face-to-face and 1.96 symptoms when working virtually (Table 4). Across age brackets, these statistics were less than one standard deviation apart. Additionally, 41% of participants (n = 89) and 43% participants (n = 94) reported experiencing an average of one symptom on the VTDS in the face-to-face and virtual settings, respectively (Table 5 and Figure 1).

In addition to the number of symptoms reported by participants, Figure 2 shows the frequencies of each reported item. Within the face-to-face setting, dryness was the most commonly reported symptom (reported 57 times) followed by tightness (reported 32 times) and tickling of the throat (reported 28 times). Within the virtual setting, the most common symptom reported was dryness (reported 56 times), following by aching (reported 31 times) and tightness of the throat (reported 28 times).

To determine if there were significant differences between the number of symptoms reported by mode of delivery (virtual vs. face-to-face), a *t* test for paired samples was calculated. The mean VTDS scores for face-to-face and virtual instruction were 2.04 (SD = 1.3) and 1.96 (SD = 1.27), respectively. The difference between the mean scores represents a 4% difference. Results showed no significant

TABLE 2.
Voice Disorder Diagnoses

Diagnosis	*n*	%
Nodules	28	54.90
Polyps	15	29.14
Muscle tension dysphonia	8	15.69
Other	0	0.00

TABLE 3.
Voice-Related Activities and Water Intake

Activity	*n*	%
Coaching	94	33.22
Regularly attending sportingevents	81	28.62
Singing/Choir	51	18.02
Other	1	0.36
None	56	19.78
Water intake		
A great deal	78	35.29
A lot	66	29.86
A moderate amount	60	27.15
A little	16	7.24
Not at all	1	0.45

TABLE 5.
Number of Symptoms Reported by Setting

Number of symptoms	Face-to-face		Virtual	
	n	%	*n*	%
0	1	.46	0	0
1	89	41.01	94	43.32
2	69	31.80	63	29.03
3	33	15.21	42	19.35
4	18	8.29	8	3.69
5	3	1.38	6	2.76
6	0	0	1	.46
7	1	.46	1	.46
8	3	1.38	2	.92

differences between number of symptoms reported based on mode of delivery, t (1, 214) = 1.114, P = 0.266. The first research question also addressed the impact of teaching setting on self-perceived voice handicap. The mean VHI-10 scores for face-to-face and virtual instruction were 1.54 (SD = 1.14) and 1.57 (SD = 1.15), respectively. This represents a 1.9% difference between the two mean values. To determine if there were significant differences in self-perceived vocal handicap by mode of teaching, a t test for paired samples was calculated and showed that these scores were not significantly different, t (1, 214) = -1.126, P = 0.262.

The second research question addressed the effect of work-related environmental factors in the home and their correlation to VTD symptoms and VHI-10 scores as reported by participants while working virtually. As noted earlier, the virtual working environment was targeted due to the majority of schools transitioning to work-from-home and the premise being that nearly all educators were in their home environment during data collection. While working from home, 62% of participants reported using good posture and 71% of participants reported having their computer monitor at eye level. Data on home air quality is outlined in Table 6 and shows that 46% of participants (n = 102) reported cold air quality and 39% (n = 88) reported dry air quality at home. The category 'none' was selected by 13% of participants (n = 29) indicating no issues present.

Other questions about participants' perception of their vocal health asked participants if there was an existing problem with their voice and to identify how their voice sounds since the transition to virtual instruction. Results showed that 46% (n = 99) of participants believed they had a "problem" with the sound of their voice before they began virtual work and that a minimum of one type of disordered voice quality (eg, hoarse, rough) was reported by an average of 15% of participants (n = 47). Finally, 15% (n = 47) of participants selected 'none of these' suggesting no voice issues with their current voice quality.

To determine the strength of relationship between risk factors of vocal health and virtual work, a Pearson-product moment correlation was calculated using the data collected on posture, eye level of the computer, air quality, water intake, self-report of currently smoking, presence of a voice disorders, and number of vocal activities to the scores from the VTDS and VHI-10 in the virtual teaching setting (Table 7).

The risk factors that had the strongest correlation with the number of VTD symptoms experienced virtually were air quality (r = .503), posture (r = -.39), and number of vocal activities (r = .356). The risk factors that had the strongest correlation with scores on the VHI-10 were number of vocal activities (r = .53), air quality (r = .509), and posture

TABLE 4.
Self-Reported Number of VTD Symptoms by Setting

Setting	*N*	Mean	*SD*
Face-to-face	215	2.04	1.296
Virtual	215	1.96	1.265

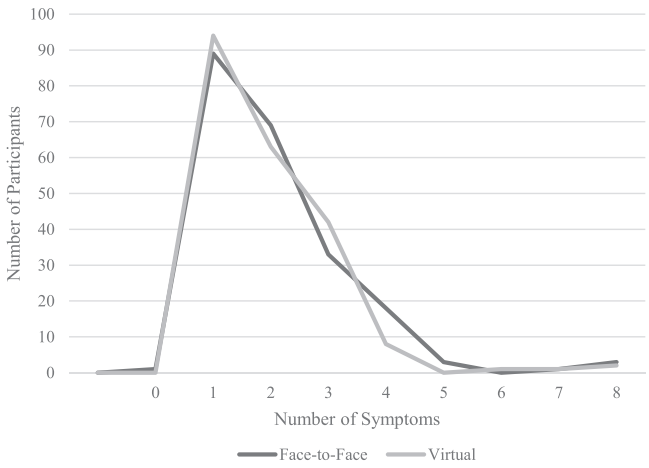

FIGURE 1. Number of vocal tract discomfort symptoms reported.

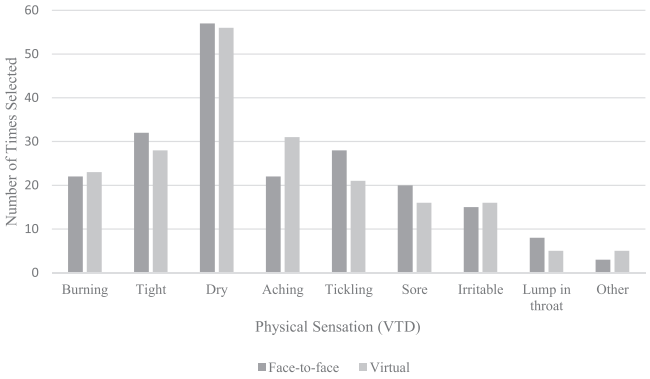

FIGURE 2. Frequency of vocal tract discomfort symptoms by setting.

(r = -.453). Correlation values between .10-.39 represent a weak correlation while those between .4-.69 represent a moderate correlation.[34]

DISCUSSION

Amidst the global pandemic, educators around the world were forced to embrace a shift to working virtually. In order to make this shift, professionals were responsible for reinventing their workspace, redesigning lesson plans, and gathering whatever materials necessary to effectively deliver virtual education – all in an abbreviated time frame. In recognition of the increased risk of voice disorders amongst teachers, this study was developed to shed light on the impact of virtual instruction on teachers' voices.[1-3] Overall, results showed that the shift to a virtual teaching setting did not result in a significant increase in the number of vocal discomfort symptoms or an increase in vocal handicap. Results do, however, shed light on the importance of the home working environment and its relationship to its impact on the vocal health of teachers. Each research question will be further discussed below.

Impact of work setting on VTDS and VHI-10

The first hypothesis focused on the impact of teaching setting on vocal tract discomfort and vocal handicap. Results showed no significant differences between the two work settings. It was particularly noteworthy that mean scores for both the VTDS and the VHI-10 were considerably low indicating that most teachers were not experiencing problems with their voice in either teaching setting. In fact, 72% of teachers reported only experiencing one or two of the symptoms on the VTDS in either setting. The four most common symptoms experienced in the classroom setting included dryness, tightness, tickling, and burning, while the most common symptoms experienced in the home setting were dryness, aching, tickling, and burning. These results closely follow the data gleaned from Kenny's study that suggested there was not a statistically significant difference in the number of voice-related symptoms experienced after the shift to virtual work.[28] Another similarity between this study and Kenny's is that participants indicated dryness and tightness as two of the most common vocal tract discomfort symptoms experienced in the home setting.[28] Both in this study and Kenny's, participants experienced an average of only a few symptoms of vocal tract discomfort.[28] Comparatively, Patjas et al found that there was a decrease in VTD symptoms when participants shifted to the home setting.[12]

TABLE 6.
Self-Reported Air Quality in the Home Setting

Air quality	*n*	%
Dry	88	39.22
Cold	102	46.15
Hot	71	32.12
Dusty	45	20.36
Damp or moldy	27	12.22
Chemical smell	7	3.17
None	29	13.12

Alternatively, the fact that approximately 20% of teachers reported a current disordered voice quality (ie, hoarse, rough/gravely, breathy) was indeed noteworthy given the much higher incidences reported earlier.[4] Before the pandemic, the prevalence of voice disorders, 57.7%, was over double the percentage of educators who identified vocal discomfort in this study.[4] Initially, this discrepancy suggests that educators as a population may be experiencing less vocal discomfort since working virtually. However, it is also possible that educators are simply less aware of the amount of voice discomfort symptoms they tolerate in the home setting. Relatedly, it is also possible that educators have normalized a baseline level of vocal discomfort, and expect it with their work, without reporting any impact on their lives. This may be supported by Roy et al which showed that while 57.7% of teachers experience voice disorders, the likelihood of reporting a voice problem was only 11%.[4] This may continue to be the case when combining this study's data with Roy's, suggesting that many educators who completed the survey may not be aware of their baseline vocal discomfort.[4] Clearly, more work is warranted to elucidate these potential discrepancies.

To analyze the psychosocial impact of shifting to a virtual work setting, this study also collected data using the VHI-10.[23] Participants' mean VHI-10 scores were 1.54 and 1.57 in the face-to-face and virtual work setting, respectively. Typically, the normal mean is 2.83 and values above 10 indicates an abnormal voice.[35] As individuals in this study reported a mean response lower than the previously collected average, this data indicates that no participants in this study were experiencing dysphonia resulting from any identified vocal discomfort. Participants in Patjas et al reported a decrease in self-perceived voice handicap following the shift to virtual work.[12] From both the current study and Patjas et al, it appears that the apparent lack of vocal

TABLE 7.
Correlation of Environmental Risk Factors with VTD and VHI-Scores

		Posture	Eyelevel	Air quality	Water intake	Smoking	Voice disorder	Vocal activities
VTDS-virtual	*r*	−.390	−.154*	.503†	.134*	−.070	−.205*	.356†
	P	0.566	0.024	0.000	0.050	0.307	0.002	0.000
VHI-virtual	*r*	−.453†	−.115	.509†	.293†	−.307†	−.405†	.530†
	P	0.000	0.093	0.000	0.000	0.000	0.000	0.000

* = $P \leq 0.05$
† = $P \leq 0.001$

tract discomfort and perceived handicap may be closely related.[12] That is, results of the current study showed that participants experienced an average of the same number of symptoms (VTDS) across settings, and subsequently near the same perception of voice handicap (VHI-10). Comparatively, participants in Patjas et al indicated that fewer symptoms of discomfort in the home setting led to lower scores on the VHI.[12] While participants did not indicate an equal number of symptoms across settings in Patjas et al, there was a suggested relationship between the number of symptoms experienced and self-perceived voice handicap similar to this study.[12]

Relationship between work setting and outcome measures

The second research question addressed the relationship between the home working environment (including other factors related to vocal hygiene) and scores on the VTDS and VHI-10. Correlational analyses showed multiple significant and weak to moderate relationships among many of these factors and scores on the VTDS and VHI-10 in the virtual teaching setting. A large percentage of teachers reported less than ideal air quality in the home working environment, including dry (39%), damp/moldy (12%), and interestingly, a cold home working environment (46%). Past research on the relationship between air quality and voice disorders has suggested that poor air quality demonstrates an increased likelihood of developing laryngitis.[15] Additionally, a 2021 study in Finland collected data on the indoor air quality of work settings and found that the worse air quality, the more complaints employees reported, as well as an increased likelihood of developing voice disorders.[36] This was the only element in this study participants deemed less than desirable, since most participants reported good posture, water intake, and no smoking history. As dryness was the most common reported air quality in the home, this potentially suggests that adequate water intake may not be enough to maintain vocal health. Overall, the current results align with previous research which emphasized the need for evaluation of air quality in work settings due to the likelihood of vocal tract discomfort development.[12,14,15]

One additional component of the study that merits attention is the issue of hydration. It is well known that proper hydration plays an important role in maintaining vocal hygiene.[37,38] Yet, while 65% of teachers reported drinking either 'a lot' or 'a great deal' of water, 34% of teachers reported only drinking 'a moderate amount' or 'a little'. Since the importance of hydration on vocal hygiene is well established, this may speak to the importance of educating teachers on proper vocal hygiene, including improved hydration.

Finally, numerous teachers reported also participating in other high-vocal activities such as coaching (33%), attending sporting events (29%), and singing/choir (18%). Participation in these events may be related to the presence of the disordered voice qualities discussed above. Such results again may speak to the importance of proper vocal hygiene, particularly for high-use vocal professionals such as teachers. In fact, there is a plethora of research showing that providing education to vocal professionals does improve vocal health and can even change teachers' vocal behaviors.[39-41]

In sum, the importance of identifying how the virtual work setting impacted educators' voices during the global pandemic is necessary to evaluate how different settings compare and what environmental factors may be influential in maintaining vocal health. Not only is this research responsive to the sudden shift in work style across the world, but it also invites specialists to support academic professionals who may require treatment for their vocal health. Likewise, this shift to virtual work and changes in professional habits and routines may continue for decades to come. As work and education not previously thought possible in a home or virtual setting has made these adjustments, the United States may continue to embrace virtual schooling and work as technological advances persist. Studies evaluating the global shift to virtual education have emphasized the likelihood that digitization will continue to transform the future of education by improving access and collaboration efforts on an international level and be used to supplement or potentially replace traditional face-to-face education settings.[9,42,43] COVID-19 has accelerated the development of digital workspaces on an international level and treatment for high voice use professionals should be made accessible and familiar when there is a relationship between workplace setting and vocal health.

Closely aligned with international suggestions, the current research suggests that it is necessary for full-time educators to be instructed on their potential risk of developing a voice disorder, the relationship between VTD and voice

disorders, and modifications teachers and other vocal professionals can make to their personal life and work environment to improve their overall vocal health.

Relationship between vocal activities and outcome measure scores

A post-hoc analysis was performed to further analyze the vocal health of individuals with notably high vocal load. Assessment of participants' VTDS responses (n = 10) who reported engagement in all three high voice-use activities (singing in choir, coaching, regularly attending sporting events) was measured with a *t* test analysis, t (1, 9) = -1.709, $P = 0.122$. Unsurprisingly, this small sample size of particularly high voice users reported an average of 4.40 (SD = 2.6) symptoms of VTD. Compared to the average scores of all 223 participants, those who engage in multiple high voice-use activities experience approximately two more symptoms of VTD on average.

VHI scores for these same participants were measuring using a second *t* test analysis and scored an average of 2.98 (SD = .680) on the VHI-10 in a virtual setting, t (1, 9) = 0.093, $P = 0.928$. While the average VHI-10 score of this sample does not qualify as a voice disorder, the score is more reflective of the previous average VHI-10 scores collected on the general population when compared to the larger sample average indicated in this study. These results further detail the relationship between excessive voice use and suggest that the more an educator uses their voice outside of the classroom, the more VTD symptoms and perceived voice handicap they will experience. Future research should include a larger sample size of high voice users to elucidate this relationship.

Limitations

The first limitation that needs to be addressed is the fact that the survey was developed with the assumption that the majority of schools in the United States had switched to a virtual platform. This assumption was based on anecdotal data at the time and later, supported by Census data. This assumption did not account for those who remained teaching face-to-face throughout the entirety of the pandemic. However, no participants indicated this in the free response portions of the survey. The second limitation involves the fact that data was collected on the environmental factors in the home setting and not in the school setting. Because most educators were teaching from the home setting, this data was likely more accurate than asking the educators to reflect on the environmental factors of their former face-to-face work setting. However, this makes it hard to determine how the factors compare across settings, and instead only allows for data on the home setting. Future research should include the comparison between work settings to better elucidate the impact of environmental conditions on vocal health. Additionally, there was no data collected in this study regarding Covid diagnoses and how Covid may have independently impacted participants' voices. An assumption was made that participants responded to survey questions with a general overview of their experience teaching in each setting *over time* compared to a moment in time, such as a 2-3 week period with a positive Covid diagnosis. Finally, face masks have become another element of concern in the vocal health of educators since the start of the pandemic. This survey did not evaluate the use of facemasks, since the questions were associated with pre-pandemic working face-to-face without masks and then virtual work in a home setting with the assumption that individuals did not wear facemasks when lecturing virtually. However, recent studies comparing VTD in person with and without masks has revealed that face masks are associated with an increase in vocal discomfort, especially for educators and those who use their masks for professional activities.[44] Future research should include this issue as a potential factor in vocal outcomes.

CONCLUSIONS

This study revealed that educators experienced the same levels of vocal tract discomfort working face-to-face before the pandemic and working virtually at home. Educators reported an average of 1.5 vocal tract discomfort symptoms in either setting. The four most common VTD symptoms were the same across settings as well, with only one difference: *tightness* was one of the most common symptoms when working face-to-face, while it was replaced by *aching* when working virtually. Furthermore, research showed similar VHI-10 scores when reflecting on their time working virtually and face-to-face. For this reason, environmental factors and personal habits should be evaluated across settings to reduce any vocal discomfort and prevent future voice disorders. Clinically, results support the notion that educators should be provided support techniques for vocal health and an overview of the vocal risk factors in both the school and virtual settings.

DECLARATION OF COMPETING INTEREST

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at doi:10.1016/j.jvoice.2022.08.012.

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