Developing Educational Health Modules to Improve Vocal Wellness in Mask-Wearing Occupational Voice Users

*,†,‡Victoria S. McKenna, ‡Renee L. Gustin, ‡Rebecca J. Howell, *Tulsi H. Patel, *Mariah B. Emery, *Courtney L. Kendall, and §Nicholas J. Kelliher, *†‡§*Cincinnati, Ohio*

Summary: Objective. To develop educational modules to improve vocal wellness and optimize communication in mask-wearing occupational voice users.

Methods. Module development focused on identifying accurate, understandable, and actionable steps to improve vocal wellness in the workplace. We i) interviewed eight voice-specialized speech-language pathologists and researchers on current speech and voice recommendations for mask-wearers, ii) developed educational content using the standardized Patient Education Materials Assessment Tool (PEMAT), iii) assessed the ability of nine mask-wearing community members to learn educational content, and iv) compared behavioral, acoustical, and perceptual changes in four mask-wearing healthcare professionals following educational training.

Results. We created three educational modules that described key vocal health and communication strategies, including microphone amplification, postural alignment, clear speech, hydration, vocal naps, and vocal warm-ups. PEMAT scores were 96% and 93% on understandability and actionability, respectively. Mask-wearing healthcare professionals increased use of 4 out of the 6 strategies following educational training and were able to retain information at rates >90% at 1-week follow-up.

Conclusions. We developed a set of free-to-use educational modules to promote vocal wellness among mask-wearing occupational voice users (see VSMechLab.com). Future work should examine the impact of these strategies on voice measures in a larger group of mask-wearing community members.

Key Words: Acoustics−Adults−Voice−Education.

INTRODUCTION

Occupational voice users comprise a group of community workers that depend on verbal communication to effectively complete job tasks. It is estimated that occupational voice users make up approximately 45% of the work force[1] and are at an increased risk for developing voice problems[2,3] due to occupational vocal load. Other factors of stress and anxiety,[4,5] air quality,[6] and room acoustics[6,7] can exacerbate this risk. Further, if vocal overuse or misuse persists, benign vocal fold lesions (eg, vocal fold nodules) may develop.[8] These negative health effects not only impact the worker, but also the employer, as voice problems can result in absences from work and decreased participation in work-related activities.[9]

With the onset of COVID-19, many occupational voice users have the additional challenge of communicating through a face mask. Face masks attenuate high frequencies (>1kHz) from 3−12dB,[10,11] which impact speech intelligibility.[12] Further, previous research on healthcare workers—a subgroup of occupational voice users who report voice problems at rates of 50%−70%[13,14]—found that masks negatively impact communication and increase vocal symptoms.[15,16] Specifically, masked-speech increases self-perceived vocal effort when compared to unmasked speech, and reduces vowel articulatory range and relative fundamental frequency (RFF) offset cycle 10.[15] The authors speculated that the observed reduction in RFF offset cycle 10 reflected an increase in vocal effort and laryngeal tension,[17,18] and could be a marker of maladaptive compensations for masked communication challenges.

Despite these noted challenges, few of the masked occupational voice users reported using voice or communication strategies (eg, hand gestures) to offset communication problems.[16] Evidence suggests that lack of voice training is a contributing factor to voice disorders in teachers,[19] and that the implementation of preventative measures could decrease voice problems among occupational voice users.[20] In the past few years, there has been substantial growth in vocal health programs, particularly for teachers and performers.[21,22]

Due to the rise of social media (eg, YouTube), free educational content is more readily available than it once was. More than half of all adults in the US access health information via virtual platforms.[23] However, previous research indicates a discrepancy between the accessibility and the quality of information available, particularly for educational materials aimed to improve vocal health. For example, websites' quality and suitability (defined as "ease in understanding and acceptance, including learning stimulation and motivation")[24] were found to be acceptable when vocal hygiene, vocal health, and prevention of voice

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From the *Department of Communication Sciences and Disorders, University of Cincinnati, Cincinnati, Ohio; †Department of Biomedical Engineering, University of Cincinnati, Cincinnati, Ohio; ‡Department of Otolaryngology-Head & Neck Surgery, University of Cincinnati, Cincinnati, Ohio; and the §Department of Voice, College-Conservatory of Music, University of Cincinnati, Cincinnati, Ohio.
Address correspondence and reprint requests to Victoria McKenna, Department of Communication Sciences and Disorders, University of Cincinnati, 3225 Eden Ave, Cincinnati, OH 45267. E-mail: mckennvs@ucmail.uc.edu
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disorders materials were provided.[25,26] However, understandability was poor in websites devoted to the treatment of vocal nodules[27] and poor-to-adequate in websites pertaining to vocal fold paralysis.[28] Readability—or the ease in understanding written material—also varied across studies, with most studies finding that readability levels were too high for the general population.[27,28] Actionability (the ease of implementing behavioral changes) was shown to be adequate in an investigation into 150 YouTube videos on vocal health;[29] however, the content of those videos varied widely with most focusing on educational strategies and few describing the signs/symptoms of voice disorders, anatomy of the vocal mechanisms, or detailing voice assessments.

At present, we are not aware of any web-based health resource that explains the challenges of masked-based communication or provides vocal health strategies for mask-wearing occupational voice users. Therefore, the purpose of this project was to create educational content that was accurate, understandable, and actionable for mask-wearing community members and accordingly, fill a major gap in web-based educational content. We hypothesized that our content would meet established criteria of understandability and actionability via a standardized assessment tool. Further, we hypothesized that after viewing educational content, mask-wearing occupational voice users would be able to i) learn and retain information, ii) increase their ability to implement vocal health strategies into their workday, and iii) show a reduction in their degree of vocal symptoms, namely vocal effort and RFF, an acoustic indicator of laryngeal tension.

METHODS

This work was approved by the Institution Review Board at the University of Cincinnati and all participants provided informed consent prior to participation.

Establishing content accuracy

Eight expert voice professionals were interviewed over a virtual platform. Voice professionals included currently practicing speech-language pathologists (SLPs) who specialized in voice along with voice-based researchers. Their average duration of voice specialization was 14 years (range from 4−30 years). Voice professionals were asked questions regarding their perceptions of how masks impact communication and what strategies they currently implement to offset those communication challenges. Example questions for interviews with SLPs can be found in Appendix 1.

Four of the authors of this work (V.M, T.P., M.E., C.K.) independently reviewed notes taken during the eight interviews and informally extracted interview themes. These themes were based on the frequency of keywords noted during the interviews, such as effort, fatigue, loudness, dyspnea, etc. Figure 1 provides a word cloud of a themes extracted from the interviews. The authors then met as a group to discuss themes and come to a consensus on the most salient features of the interviews. We then combined the themes and perspectives from the interviews with previously established research on mask-based communication issues[15,16] to i) identify key challenges of mask-based communication, and ii) identify vocal and communication strategies to overcome these challenges.

Establishing module understandability

A total of 10 mask-wearing occupational voice users (4 male, 6 female, M = 29.2 years, range 21−53 years), were invited to view and provide feedback on drafts of the educational modules. Participant occupations included an engineer, grocery store worker, retail worker, medical student, SLP graduate student, pharmacist, coach, restaurant worker, property manager, and industrial project leader. Although this initial group included an SLP student, we decided that her knowledge of speech/voice might not reflect that of the general population and excluded her from further

FIGURE 1. Word cloud of themes from interviews with expert voice professionals on the impacts of masks on speech and voice. Words that are larger were discussed more frequently during the interviews.

analysis in this study. Therefore, our final group of mask-wearing workers that provided feedback on understandability included 9 participants (four male, five female).

The ability to learn module content was assessed via 11 questions (true/false, short answer, multiple choice). For a list of learning questions, please see Appendix 2. Next, participants completed a formalized assessment tool to evaluate the understandability and actionability of the print and audiovisual information: The Patient Education Materials Assessment Tool (PEMAT).[30] The PEMAT is a 26-item yes/no questionnaire with 19 of the questions focused on understandability and 7 focused on actionability. Example statements include: "The material uses common, everyday language," and "The material identifies at least one action the user can take." An answer of "yes" received one point, whereas an answer of "no" received 0 points. Items that did not apply were deemed "not applicable" and did not count against the scoring system. The total number of points were divided by the total number of questions to determine understandability and actionability scores. The criterion established by Shoemaker et al[30] of >70% was used to indicate adequacy of the training materials.

Final module content was developed with texts, animations, and real-life examples of how to implement the communication and vocal strategies. The educational modules depicted a healthcare worker, service worker, and classroom teacher as examples of occupational voice users now required to communicate while wearing masks. The modules also included a strategy-specific handout to assist in strategy implementation and carryover.

Assessing module actionability: pilot study of behavioral changes

We contacted 10 mask-wearing healthcare professionals from our previous study on the impact of masks on vocal health,[16] of which 5 enrolled in the current work (3 cisgender female, 2 cisgender male, M = 33.2 years, SD = 7.08 years). These professionals were recruited based on their previous reported vocal symptoms (increased vocal effort and dyspnea) during mask-based communication tasks, as well as using few compensatory strategies to offset communication and vocal challenges. Participants were free from illness on the day of testing, and had no history of speech, language, hearing, voice, or neurological disorders. All participants were non-smokers and non-vapers. Professionals included two physical therapists, an administrative assistant, a nurse, and an SLP who worked in the long-term care setting.

Participants attended two sessions held one week apart. Each session was at the end of their typical workweek. The average duration of hours worked during week 1 was 37.9 hours and during week 2 was 42.4 hours. On average, participants worked 9.4 hours on each day of testing. While at work, all participants reported wearing their masks 100% of the time, other than during their designated lunch break (30 minutes). The types of masks worn at work included simple masks, a cloth mask, and a KN95 mask.

During session 1, participants completed mask-based communication questions on a Likert scale (see Appendix 3 for a list of statements). A rating of 1 indicated that the participants "never" experienced the problem, whereas a 5 indicated that they "always" experienced the problem. Next, participants were surveyed about how frequently they employed communication and vocal strategies over their previous work week. Once again, a rating of 1 indicated that they "never" used the strategy, whereas a rating of five indicated they "always" used it.

Following these surveys, participants completed acoustic recordings without a mask in place. A headset microphone (MicroMic C555L) was placed 8.5 cm from the midline of the mouth at a 45° angle, attached to a handheld recorder (Zoom H4N). Data were acquired at 44.1 kHz and 16 bits. Participants read various prompts, including the Rainbow passage, sustained vowels (ie, /ɑ/, /i/, /u/), sentences, and vowel-consonant-vowel utterances (eg, /ifi/) for a duration of approximately five minutes. Upon completing the readings, participants made self-perceptual ratings of their vocal effort on a 100-mm visual analog scale (VAS) in which a score of 0 was anchored with "no effort" and a score of 100 was anchored as the "most effort."[17]

Finally, participants watched the educational modules, which were approximately 30 minutes in duration. Following the content viewing, participants answered the same 11 learning assessment questions that were used during module development (Appendix 2). All participants were provided a paper handout that included a summary of the communication and vocal health strategies as well as a self-monitoring log for personal use.

During session 2, participants re-completed the same Likert-based ratings from session one of how often they used compensatory strategies over the previous week. They also completed 11 learning retention questions to assess their ability to retain the educational content. Finally, acoustic recordings and self-perceptual ratings of vocal effort were captured using the same protocol described in session 1.

Data processing

Relative fundamental frequency (RFF). RFF is a short-term measurement extracted from voiced-to-voiceless phonemic transitions. Specifically, RFF requires a vowel-voiceless consonant-vowel utterance (eg, /ifi/) to capture small changes in vocal fold vibratory behavior during these transitions. We employed a semi-automated algorithm[31] to extract the last ten voicing cycles from the transition of the initial vowel into the voiceless consonant. These cycles are called *offset cycles* and are numbered from 1−10 with offset cycle 1 located closest to the midpoint of the vowel and offset cycle 10 located adjacent to the voiceless consonant. The reciprocal of the cycle period was calculated to determine the instantaneous fundamental frequency (f_0) of each cycle, which was then normalized to the f_0 value of RFF offset cycle 1 as this cycle is an estimate of f_0 during the approximate steady state of the vowel. Finally, f_0 cycle values were converted to semitones (ST), which standardizes values within and across speakers with varying vocal pitches.

RFF offset values that hover around 0 ST represent a zero-change from the vowel steady state during devoicing. Positive trending (or increasing) RFF values indicate faster vocal fold vibrations as the speaker transitions into a voiceless consonant, whereas negative trending (or decreasing) values represent slower vibrations compared to vowel steady-state. Typically, RFF offset values remain around 0 ST, indicating that vocal fold vibrational timing does not substantially change in the transition from a vowel to a voiceless consonant in vocally healthy speakers.[18]

Our analysis focused on RFF offset cycle 10, which has been shown to be sensitive to hyperfunctional vocal behavior[18] and levels of vocal effort.[17] In our previous work, RFF offset cycle 10 significantly decreased (became more negative) during masked speech compared to unmasked speech.[15] Moreover, RFF offset cycle 10 was also significantly lower following workday vocal loading in mask-wearing healthcare workers.[16] Therefore, we investigated RFF offset cycle 10 before and after the educational training with the hypothesis that RFF would improve (increase) after viewing the modules and return to levels of around 0 ST.

Vocal effort ratings. Ratings of vocal effort were manually measured using a ruler and transferred to an excel spreadsheet. Three months later, a blinded researcher re-extracted each measure and compared the new measures to the originals. All measurements were within 1 mm of the original measurement, and therefore, the original measurements were reported in this paper.

RESULTS

Module development

Our work resulted in the development of three educational modules, called the "Masks and Vocal Health: One Voice at a Time Educational Module Series." Module 1, or *Impact of Masks on Communication,* explains the importance of wearing a face mask to reduce COVID-19 transmission and identifies four ways masks impact communication. These include a loss of visual information, a reduction in sound clarity (muffling), a reduction in sound articulation (mumbling), and increased vocal effort and fatigue. Module 2, or *Communication Strategies and Vocal Protection for Mask Users,* introduces six strategies to optimize communication and vocal health while wearing masks. These strategies include microphone amplification,[32] postural alignment,[33] clear speech,[34] hydration,[35] vocal naps,[36] and vocal warm-ups.[37,38] See Table 1 for a brief explanation of each strategy. Module three, or *Implementing Vocal Wellness Strategies in the Workplace,* provides real-world examples detailing how various professionals (teachers, service workers, healthcare workers) can implement the strategies throughout their workday.

Learning and PEMAT scores

The average learning accuracy of the nine mask-wearing occupational voice users for the 11-learning questions was 97% (range of 82%−100%). The formalized 26-item PEMAT, yielded an average score of 96% (range 94%−100%) for understandability and 93% (range 60%−100%) for actionability. These understandability and actionability scores were considered "adequate," exceeding the established criterion of >70%.[30]

Acoustical, perceptual, and behavioral results

Of the five mask-wearing healthcare professionals enrolled in the actionability portion of the study, only four completed both sessions. See Table 2 for participant demographics. Participants were able to learn and retain module content at an accuracy of greater than 90%.

Figure 2 provides a summary of the impact of masks on communication and vocal symptoms during the workday gathered in session 1 for all five participants. Data from our previous study with these same participants are provided for comparison.[16] Results indicate that participants continued to experience masked-based communication challenges, many of which are comparable to earlier in the pandemic. The overall average Likert rating (out of a possible 5 points) for our previous research with these five participants was 3.16, whereas the average was 2.94 in the present study.

TABLE 1.
Voice and Communication Strategies Provided to Mask-Wearing Occupational Voice Users

Strategy	Description
Microphone amplification	A small microphone that is worn on the head or pins to the shirt with a speaker at the belt
Postural alignment	Relax neck and shoulders; make sure ears are aligned over the shoulders
Clear speech	Overaticulation of the speech sounds; Open the mouth wide, move the tongue freely and speak slowly
Hydration	Drink 8 glasses of 8-oz of water (64 oz total) per day
Vocal naps	Scheduled, intentional blocks of silent time to rest the vocal mechanism (5-minutes once per hour, or 10-minutes 2 − 3 times throughout the day)
Vocal warm-ups	Humming at a comfortable pitch and volume for 3 − 5 minutes; vary the pitch up and down to comfortable levels

TABLE 2.
Participant Demographics for Behavioral Actionability Assessment

Participant	Age	Gender	Occupation	Mask Type	Mask use Day of Testing (Week 1)	Mask Use Day of Testing (Week 2)	Learning-Check Score (Week 1)	Learning Retention Score (Week 2)
P01	24	F	SLP	KN95	8 hours	8.5 hours	100%	91%
P02	27	M	PT	Simple	10.5 hours	9.5 hours	100%	100%
P03	44	F	Admin	Simple	9.5 hours	10.5 hours	91%	91%
P04	35	F	Nurse	Cloth	9 hours	–	100%	–
P05	35	M	PT	Simple	8.5 hours	7.75 hours	100%	100%

Note. SLP, speech-language pathologist; PT, Physical therapist; Admin, administrative assistant. –, designates no information as participant did not complete the second assessment.

Specific improvements (ie, lower Likert ratings) were noted for the statements “it is difficult for people to hear me” and “it is harder for me to catch my breath when talking,” with improvements of at least half a point on the scale. Participants also had a reduction in the amount of effort to talk; however, it continued to be high overall with a rating of “sometimes-to-almost always” (M = 3.80). There was an increase in tiredness at the end of the workday (M = 3.20), but essentially no change in the need to repeat themselves more or the frequency of using hand gestures to be understood. Participants also reported that they “rarely-to-never” remove their masks to communicate (M = 1.40), an improvement from earlier in the pandemic (M = 2.00).

Participants reported that they used four of the six suggested strategies more frequently in session 2 compared to session 1, including hydration, postural alignment, vocal naps, and vocal warm-ups (see Figure 3). Improvements ranged from an increase of 0.75−1.50 rating points (M = 1.06, SD = 0.31) on the five-point scale. There was no change in microphone use, in which all participants reported “never” using the strategy, as well as no appreciable change in the strategy for clear speech, as it remained consistently used “sometimes” (difference < 0.5 points). We calculated the effect size for all six strategies combined via Cohen’s *d*,[39] defined as (μ_1-μ_2)/pooled SD, yielding a medium effect size of $d = 0.66$. When we eliminated microphone amplification and clear speech and focused on the four strategies that showed increased use, the effect size increased to $d = 0.91$, indicating a large difference between sessions 1 and 2. Participants’ raw scores can be found in Appendix 4.

RFF offset cycle 10 values improved slightly from -0.49 ST in session 1 to -0.24 ST in session 2 (see Figure 4). There seemed to be a reduction in overall variability with a trend towards values closer to 0 ST for session 2. The effect size for the difference in RFF offset 10 values from session 1 to session 2 was small with $d = 0.25$. Participants continued to report minimal levels of vocal effort at the end of their work week with an average rating of 13.0 mm in session 2, compared to 11.8 mm in session 1. An effect size was not calculated for these ratings as the difference between them was deemed negligible.

DISCUSSION

The goal of this work was to develop free, web-based educational modules for mask-wearing occupational voice users. We wanted to provide strategies to help make masked communication less taxing to occupational voice users and

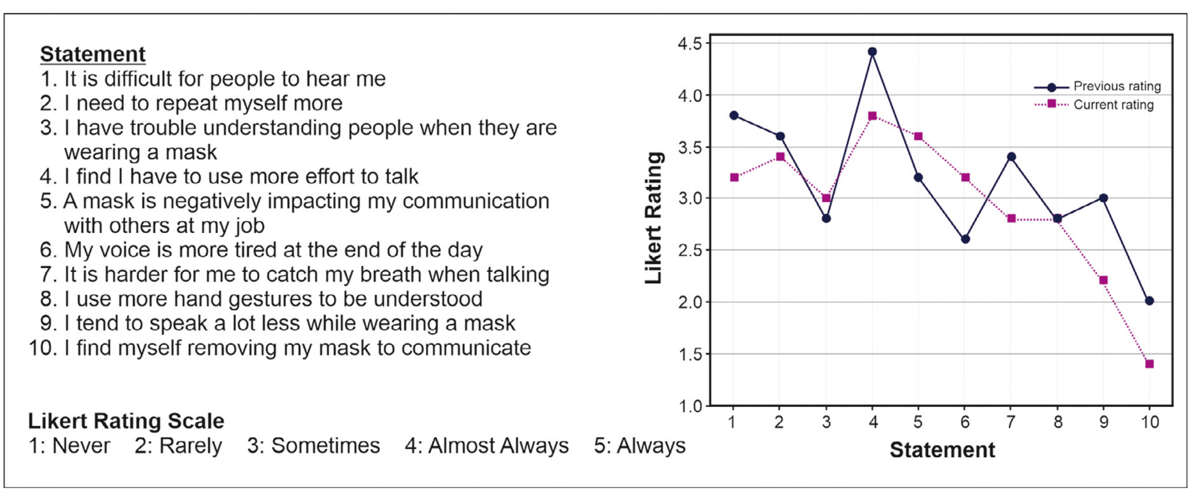

FIGURE 2. Statements and averaged responses for five participants who enrolled in the actionability assessment. All participants completed the same ratings approximately 6-months prior,[16] which are visualized here as a comparison. Note: Statements have been modified for space. See Appendix 3 for the complete list of statements.

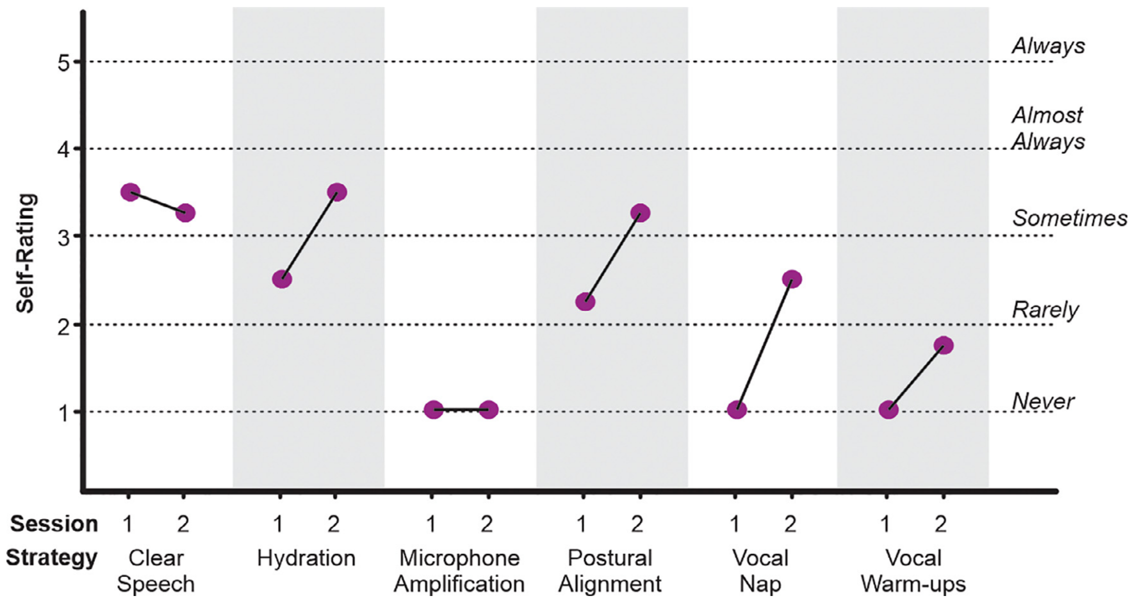

FIGURE 3. The frequency of strategy use made on a 5-point Likert Scale. The mean is plotted for the participants (n = 4) who completed both actionability assessment sessions. Session 1 ratings were taken prior to receiving training and session 2 was assessed 1 week later after training.

reduce the need to remove the mask to effectively communicate. We created three educational modules that were based on our three major objectives: accuracy, understandability, and actionability. The content could be viewed in just under 30 minutes and included an educational handout to supplement the audiovisual information.

A major goal of our project was to ensure participants without any background in speech or voice sciences could understand the educational materials. Online voice materials generally have low understandability (eg, <60% on the PEMAT);[27,28] however, our formalized assessment yielded an adequate understandability rating of 96%. We also found that mask-wearing occupational voice users were able to learn the material at an accuracy level of 97%. In fact, mask-wearing healthcare providers learned and retained the information for at least one week's time at levels greater than 90%. With these findings, we are confident that the content is understandable to a wide-range of occupational voice users.

We used the findings from our previous investigations[15,16] and the themes from the interviews with the voice-specialized professionals to develop six vocal and communication recommendations: microphone amplification, postural alignment, clear speech, hydration, vocal naps, and vocal warm-ups. Most of the recommendations fell under the umbrella of *vocal hygiene strategies,* which are commonly part of vocal prevention and treatment programs. The research and educational literature is replete with recommended vocal hygiene strategies to help prevent or improve voice disorders. For example, a systematic review combined the results of seven studies to investigate the impact of systemic hydration on vocal quality.[35] The authors determined that hydration was an easy, cost-effective solution to vocal symptoms that could be incorporated into any vocal hygiene program. The low cost and ease of implementation of this strategy as well as others made these ideal recommendations for web-based content, especially for people in the general community.

Microphone amplification was the only high-cost strategy recommended in the series. Microphone amplification is one of the most common recommendations for teachers to overcome the challenges of communicating in large rooms and in background noise.[32,40,41] For instance, Roy et al[42] randomized groups of teachers to employ vocal hygiene, microphone amplification, or no strategy over six weeks of the school year. The authors determined that both vocal hygiene and microphone amplification strategies resulted in fewer vocal symptoms compared to the control group. However, microphone amplification seemed to have an added benefit of increased adherence and improvements in ease of voice production when compared to the vocal hygiene group. In the present study, microphone amplification was not used by any healthcare provider (Likert rating equivalent to 1). It may be that the cost associated with microphone-based strategies is prohibitive to their use or that amplification was not appropriate for the specific professional environments examined in our work.

Nevertheless, we saw an increase in four of the six strategies in our post-training session with a large effect size. The participants increased their use of vocal rest, vocal warm-ups, hydration, and postural alignment by an average of 1.06 Likert points. At the same time, their degree of vocal effort remained unchanged (M = 11.8 mm at session 1, M = 13.0 mm at session 2), though the variability of the group's effort decreased while the entire group moved closer to "0" rating on the VAS. Likewise, there was a concurrent increase in RFF offset cycle 10 (M = -0.49 ST at session 1,

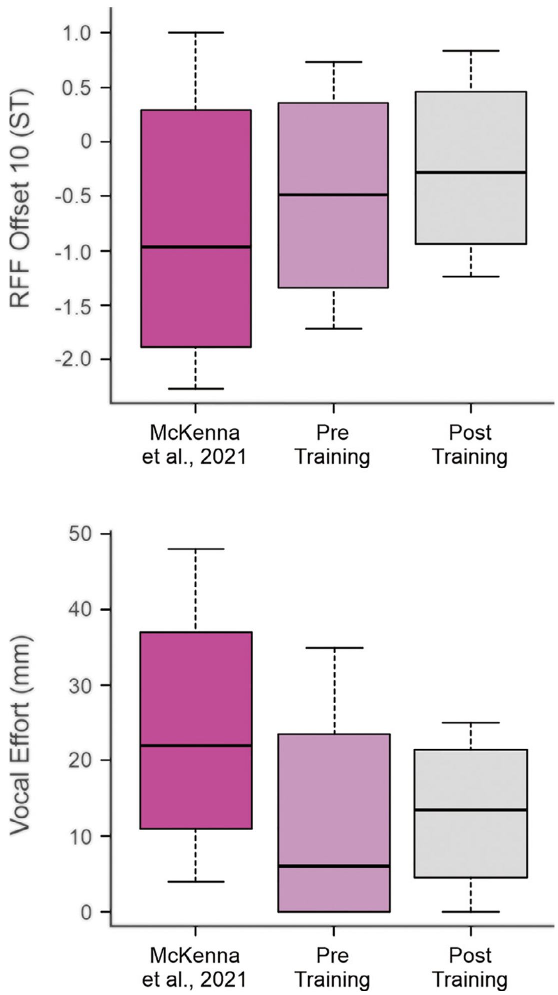

FIGURE 4. Pre- and post-training data from the four participants who completed the behavioral actionability assessment. Our previous work completed 6-months prior with the same participants is presented as a comparison.[16]

M = -0.24 ST at session 2) and reduction of overall range toward 0 ST. The directionality of change in vocal effort and RFF offset cycle 10 are overall positive, indicating an improvement in vocal effort and a reduction in laryngeal tension, though the effect size was small.

To completely alleviate symptoms of vocal effort and tension, participants may have needed to use the strategies more often. The participants reported behavioral modifications in four of the six domains, but the degree to which they used all of the strategies was only "rarely" to "sometimes" (M = 2.54 at session 2). To facilitate follow-through, they were provided a two-page handout that reviewed the recommendations, provided example goals, and tracked overall vocal symptoms; however, they were not specifically instructed to use the handout and were not told that that they would be assessed on their knowledge, frequency of strategy use, or symptoms at a later date. Therefore, our outcomes reflect what consumers of health-education may do when independently presented with the information and when relying on their own internal motivation to implement strategies. Although this was an ecologically valid approach to understanding typical behaviors when users were provided community-based educational materials, participants may have shown better outcomes if they were encouraged or instructed to use the self-monitoring log.

The relatively low level of vocal effort during masked-speech before training could have been due to the type of mask worn by the participant. Three of the four participants wore simple, disposable masks, whereas only one wore a KN95 mask. It is well established that N95 masks have significantly larger impacts on speech acoustics[11,15,43,44] and intelligibility,[12,45] compared to disposable masks. We suspect that healthcare providers who wear N95 masks may have a greater need for vocal health materials and be more motivated to employ strategies. A follow-up study could not only include N95 mask wearers, but also those that don additional personal-protective equipment such as face shields, to understand how additional barriers impact vocal habits.

Limitations and future directions

Although our results were positive overall, the behavioral actionability assessment should be interpreted with caution as there were only four participants who completed both sessions, precluding a formalized statistical analysis. In order to provide guidance for follow-up studies, we completed a sample size estimation using G-Power (ver 3.1) based on changes in self-reported strategy use across sessions. A non-parametric Wilcoxin signed-rank test analysis for matched samples and the more conservative estimate of effect size from all six strategies, revealed that an enrollment of 24 participants should be able to detect significance at $P < 0.05$ and power = .80.

Although the content was developed based on feedback from mask-wearing occupational voice users across several professions, the behavioral assessment solely enrolled healthcare professionals who had previously reported elevated levels of vocal effort early-on in the pandemic. Healthcare professionals are at risk for developing voice problems,[13,14] but they are often categorized as moderate voice users whose jobs usually require one-to-one communication.[1,19] Therefore, enrollment of participants across many different professions would be beneficial to determine whether the preliminary findings generalize to all mask-wearing occupational voice users. Further, a longitudinal study over several weeks, or months, is necessary to understand how learning, retention, and behavioral changes influence the development of voice problems in this population.

The proposed strategies were not an exhaustive list of recommendations because we did not want to overwhelm the participants with too much information. One voice-specialized interviewee recommended a face mask bracket—a small piece of plastic that is placed over the mouth and inside the mask—which is thought to increase breathability and improve lip/jaw movements. This could be beneficial to some speakers as face masks have been shown to reduce articulatory vowel space.[15] However, a bracket was not recommended in our modules because it was not a common theme across interviews. Moreover, the use of gestures and non-verbal communication (other than texting) were not incorporated into our modules due to a lack of emphasis during the interviews, but could be investigated as a potential strategy in the future. Finally, determining which strategies are more likely to be used across specific professions could help refine the recommendations. Future work could include more in-depth participant interviews as part of the study design to understand reasons behind implementing certain strategies over others.

CONCLUSION

We developed educational modules as a free resource for mask-wearing occupational voice users. Modules were vetted for accuracy, understandability, and actionability. In a small pilot study (n = 4), participants showed that they could learn and retain module information (>90%) as well as implement behavioral changes. Specifically, participants increased their use of hydration, postural alignment, vocal naps, and vocal warm-ups, by an average of approximately 1 Likert-rating point. However, levels of vocal effort remained unchanged at the end of the workday, possibly due to the need to implement strategies more often. Next steps of this work should include a larger number of mask-wearing occupational voice users and consider additional work-related communication barriers, such as personal protective equipment and social distancing.

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APPENDIX 1. INTERVIEW QUESTIONS WITH VOICE-SPECIALIZED SPEECH-LANGUAGE PATHOLOGISTS

1. What do you notice about your own voice throughout the day since wearing a mask when seeing your patients?
2. Do you experience increased vocal fatigue from wearing a mask?
3. What is your number one strategy you employ to offset vocal fatigue caused by mask use during a vocally demanding day?
4. Do you feel that masks have influenced typical vocal hygiene habits?

4a). What specific workplace activities do you encounter that make it difficult to practice good vocal health?

4b) What do you see as barriers and facilitators to implementing vocal hygiene programs for mask-wearing workers?

5. Are there specific patient populations or interactions in which you find they have more difficulty understanding you?

5a) What communication strategies have you implemented to improve other's ability to understand while you are wearing a mask?

6. Have you noticed other staff members using strategies to improve communication while wearing masks?

The next set of questions regards patient care:

7. What are the most common complaints you hear from your patients about wearing a mask all day?
8. What do you think it is about voicing through the mask that is resulting in patients' reports of increased vocal symptoms?
9. Have you noticed any specific/particular muscle tension patterns arise and/or changes to breathing patterns in your patients since their introduction of daily mask use?
10. Is there any particular strategy or recommendation that you find has been most helpful to your patients to make them the most vocally successful while wearing a mask at work?
11. If you could make one recommendation to improve vocal health in those who are required to wear masks throughout the day, what would it be?

APPENDIX 2. QUESTIONS TO ASSESS LEARNING OF EDUCATIONAL CONTENT FOR MASK-WEARING OCCUPATIONAL VOICE USERS

Module 1: ***Impact of Masks on Communication***

1. Please answer "True" or "False." Droplets and aerosols are spread during speaking and breathing.
2. Please identify two ways masks impact communication.
3. Which of the following is a sign of vocal fatigue?
   A). Vocal effort
   B). Throat pain/discomfort
   C). Running out of air while talking
   D). All of the above

Module 2: ***Communication Strategies and Vocal Protection for Mask Users***

1. Why is our speech mumbled when wearing a mask?
   A). Because we cannot see our own faces anymore
   B). Because the mask itches

C). Because masks restrict the movement of the lips, tongue, and jaw
D). Because masks make it hard to breathe
2. The feeling of having to push the voice or yell is known as:
A). Vocal warm-up
B). Vocal cool down
C). Vocal nap
D). Vocal effort
3. Please answer “True” or “False.” Mask removal increases the likelihood of COVID-19 transmissions through droplets and aerosols.
4. Please answer “True” or “False.” Mask-wearing community members tend to remove their masks to improve their communication.

Module 3: ***Implementing Vocal Wellness Strategies in the Workplace***

1. Please answer “True” or “False. I can use all of the strategies across various work settings.
2. Please answer “True” or “False. Texting and non-verbal communication can be used during a vocal nap.
3. What are the benefits to using a microphone?
A). It increases vocal volume
B). It can be used in large spaces
C). It can reduce vocal fatigue
D). All the above
4. Which of the following can help improve you voice and communication?
A). Hydration
B). Body posture
C). Drinking warm liquids (coffee, tea)
D). A and B
E). B and C

APPENDIX 3. COMPLETE LIST OF STATEMENTS TO ASSESS THE IMPACT OF MASKS ON COMMUNICATION IN THE WORKPLACE

1. Wearing a mask makes it difficult for people to hear me
2. Wearing a mask causes me to need to repeat myself more
3. I have trouble understanding people when they are wearing a mask
4. I find I have to use more effort to talk while wearing a mask
5. Wearing a mask is negatively impacting my communication with others at my job
6. I feel that my voice is more tired at the end of the day when I wear a mask
7. Wearing a mask makes it harder for me to catch my breath when talking
8. I find myself using more hand gestures so I can be understood while wearing a mask
9. I find I tend to speak a lot less while wearing a mask
10. I find myself removing my mask to communicate when I am at work

APPENDIX 4. RAW DATA FOR PARTICIPANTS WHO COMPLETED BOTH BEHAVIORAL ACTIONABILITY ASSESSMENTS (N=4), RATINGS ARE MADE ON A FIVE-POINT LIKERT SCALE

		Participant (P) and Session (S)							
		P01		P02		P03		P05	
		S1	S2	S1	S2	S1	S2	S1	S2
Strategy	Microphone amplification	1	1	1	1	1	1	1	1
	Postural alignment	1	3	3	5	3	3	2	2
	Clear speech	4	3	4	4	3	3	3	3
	Hydration	2	4	4	4	3	4	1	2
	Vocal naps	1	3	1	3	1	3	1	1
	Vocal warm-ups	1	3	1	1	1	2	1	1
	Summary M(SD)	1.67 (1.21)	2.83 (0.98)	2.33 (1.51)	3.00 (1.67)	2.00 (1.10)	2.67 (1.03)	1.50 (0.84)	1.67 (0.82)

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