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Original Article

Vocal fatigue perceived in remote working by teachers of different school grades during COVID-19 pandemic

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ABSTRACT

Objective: Teachers have an increased prevalence of voice disorders. The present study aimed to investigate the impact of remote teaching on perceived voice fatigue among Italian teachers of all grades during the lockdown due to the COVID-19 pandemic.

Method: s The participants were 195 female teachers (M_{age}=48.77; SD_{age}=9.61) in primary, secondary, and high schools. They completed the Vocal Fatigue Index (VFI) through an online survey. The tool includes 19 items grouped into three dimensions: tiredness of voice and avoidance of voice use (TA); physical discomfort (PD); and improvement of symptoms with rest (IS). The participants reported their perceived voice fatigue during remote teaching. They were also asked to provide data about voice fatigue as perceived in previous classroom teaching. The data were analyzed through two sets of independent one-way ANOVAs, with voice fatigue subscales as criterion variables and school grade as a between-subjects factor.

Results: The teachers involved in the study reported higher voice fatigue scores than vocally healthy adults from the general population. Primary school teachers showed higher voice fatigue during remote teaching than both secondary and high school teachers, specifically for the TA and PD dimensions, whereas no difference emerged for IS. The VFI scores of primary school teachers were similar to those of dysphonic individuals.

Conclusion: The results of the study confirm that primary school teachers are more vulnerable to developing voice disorders and suggest the need for specific vocal health interventions in case of prolonged remote work.

1. Introduction

School teachers are the largest category of professional voice users; they are at risk of developing voice disorders, which can cause physical discomfort and loss of working days [1–7]. The extensive use of a loud voice, which is often necessary in a crowded classroom, enhances the risk of developing phonotraumatic lesions of the vocal folds due to collision stress [8].

Even in the absence of a perceivable voice disorder, a relevant health issue for these professionals is voice fatigue, ascribed to the perception of vocal effort and laryngeal discomfort, which are commonly mitigated by voice rest and [9] by means of individual behavioral strategies [10]. Although a shared definition of voice fatigue is currently miss-

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ing, it should be considered a complex condition influenced by different underlying mechanisms across subjects and by individual characteristics [11–14].

Elementary school teachers are especially prone to developing voice disorders, with a prevalence of almost 70% over the years [15,16]; this phenomenon can be related to the high number of students per class and their young age, which pose challenges such as recruiting and maintaining pupils' attention on school tasks and talking in a noisy environment for a prolonged period of time.

In addition to job-related factors such as high vocal demand due to teaching in often noisy classroom environments, an additional risk factor for voice disorders and fatigue among teachers is psychological distress [5,17-21]. The relevance of this issue among teachers of all school grades emerged more clearly during the outbreak of the COVID-19 epidemic, a globally stressful condition leading to the disruption of citizens' daily lives. All teaching institutions were forced to adopt strategies aimed at continuing educational activities and, at the same time, granting safety and protection for students and school staff from contagion risks. Face-to-face classes were cancelled, and teachers of all school grades had to abruptly move their lessons online.

The substantial lack of previous training and experience with remote teaching, combined with infrastructure and equipment limitations, forced Italian teachers to invest a high amount of material, as well as physical and psychological resources, to face the professional challenges arising from such an unexpected situation. Teachers had to quickly attain a technological literacy level to adequately handle remote teaching. Although online lessons could be performed at home rather than in a noisy classroom, new issues emerged, such as the necessity to share home spaces and electronic equipment with other family members, including teachers' own children attending classes remotely. In this complex scenario, teachers had to face manifold challenges that could intensify voice fatigue [5]. These challenges include limited competence in handling technological platforms and devices; difficulty establishing appropriate communication patterns with pupils and in capturing their sustained attention through remote interactions; environmental and logistical problems related to family needs and a lack of privacy; and psychological distress linked to life restrictions, health risk perception, and work-family interferences.

The aim of this study was to investigate the impact of remote teaching on perceived voice fatigue among Italian school teachers of all grades during the COVID-19 outbreak and to analyze the relationship between school grade and level of perceived fatigue. A secondary aim was to examine how teachers' perceived voice fatigue is related to their experience with previous classroom teaching.

2. Materials and methods

2.1. Procedure and participants

The study was conducted during the first wave of the COVID-19 pandemic in Italy by means of the Google Forms electronic platform. A cross-sectional web-based design was adopted. After receiving approval from the ethical committee of the University of Milan (59/20), potential participants were identified through authors' contacts and schools' secretaries. They were contacted through e-mail or smartphone messages and invited to fill out an online survey. Interested teachers were able to access and complete the survey only after online completion of an informed consent form. Teachers' anonymity was granted across all study phases.

The inclusion criterion was being currently employed as a teacher in a primary, secondary, or high school. All teachers used personal computers with internet access, cameras and internal microphones. The online lessons were performed live (never recorded), using an interactive learning approach, with methods and contents similar to the pre-pandemic face-to-face lessons.

Exclusion criteria were being a support teacher or currently not performing distance teaching activities.

A total of 317 teachers (91.2% females) completed the survey. They were divided into three groups according to school level: 152 (n=3 males) worked in primary schools, 93 (n=18 males) worked in secondary schools, and 72 (n=7 males) worked in high schools. Due to the notable gender imbalance within each school grade, males were excluded from subsequent analyses. Furthermore, to balance teacher numerosity within each school grade, a propensity score [11] matching procedure was implemented using SPSS V.26. After identifying the group with the lowest number of participants (high school, n=65) as the reference group, pairwise propensity score matching allowed for randomly selecting 65 teachers (balanced for age and job seniority) from primary and secondary schools. Consequently, a total of 195 female teachers (65 in each school grade) were included for the data analysis.

2.2. Research instruments

Information was collected about the participants' demographic and work-related attributes: age, gender, number of cohabiting persons, school grade, job seniority, workplace region, and hours per week spent in the classroom teaching before lockdown and in remote teaching during the COVID-19 pandemic.

The participants then completed the Vocal Fatigue Index (VFI) [14], reporting the level of voice fatigue they were experiencing during remote teaching. The VFI is a self-report questionnaire specifically developed and validated to identify individuals with vocal fatigue and to quantify and characterize perceived fatigue level. The tool comprises 19 items on 0–4 Likert-type scales, grouped into three dimensions: tiredness of voice and avoidance of voice use (TA; 11 items); physical discomfort (PD; 5 items); and improvement of symptoms with rest (IS; 3 items). Scores for each dimension are obtained by summing up the respective item values. For both TA and PD, higher scores correspond to greater severity, whereas for IS, lower scores indicate worse vocal fatigue, as a score of 7 or lower signals that symptoms have not improved with rest [14]. The reliability of the VFI in assessing voice fatigue has been proven in several studies [9,22,23].

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Table 1. Participants' demographic and work-related characteristics across groups.

Group	N	Age	N persons Cohabiting	Job seniority[c]	Remote teaching[d]	Classroom teaching[d]	Δ teaching [d,e]
		M (SD)[a]	Md[b] (range)	M (SD)[a]	M (SD)[a]	M (SD)[a]	M (SD)[a]
Primary school	65	48.14 (9.48)	1 (0-5)	20.34 (11.34)	17.85 (18.21)	21.55 (4.71)	-3.70 (17.97)
Secondary school	65	48.85 (10.77)	2 (0-5)	19.83 (12.70)	13.20 (8.85)	17.63 (2.47)	-4.43 (9.14)
High School	65	49.34 (8.57)	3 (0-5)	19.92 (10.29)	13.66 (5.95)[f]	17.38 (2.71)[f]	-3.71 (5.66)

N=Number of participants
[a] M=Mean, SD=Standard Deviation
[b] Md=Mode
[c] years
[d] Hours per week
[e] Difference between remote and classroom teaching
[f] One participant did not provide any answer

Each participant was also asked to fill out a second copy of the VFI, rating the level of fatigue perceived during regular classroom teaching before the pandemic. All teachers included in the study switched from face-to-face teaching during the pre-pandemic period to remote teaching during the pandemic. Therefore, we compared the levels of perceived vocal fatigue referring to the pre-pandemic period with those of the pandemic period in the same group of teachers.

2.3. Data analysis

The data were first inspected to detect missing values. Descriptive statistics of demographic characteristics were subsequently calculated for each group. One-way ANOVAs, or robust alternatives based on trimmed mean (10%), were employed together with the χ^2 test of independence to detect group differences in demographic features. Subsequently, Cronbach's alpha reliability indices and descriptive statistics of the VFI were calculated for each group, both for remote and classroom teaching; only α values >.69 were deemed acceptable. Levels of association among TA, PD, and IS were inspected, together with correlations among voice fatigue dimensions and sample demographic traits. In line with the literature [24], associations were interpreted as meaningful with coefficient values >|.30|. More specifically, values between |.31| and |.50| identified a low correlation, between |.51| and |.70| a moderate correlation, and above |.70| a high correlation between variables. VFI values reported by participants during remote teaching were compared through independent-samples t-tests with data from the measure validation study [14].

Subsequently, two sets of independent ANOVAs were employed. In the first set, TA, PD, and IS related to remote teaching were alternatively considered criterion variables, while group (primary, secondary, and high school) was treated as a between-subjects factor. When differences in group means were detected, post hoc pairwise comparisons were performed through Tukey's HSD test. The same procedure was used in the second set of ANOVAs, where TA, PD, and IS associated with classroom teaching were considered criterion variables, and group was considered a between-subjects factor.

The data were preliminarily checked for any ANOVA assumption violation: The presence of outliers and the normality of residuals' distribution were investigated for each between-subjects factor level. Moreover, Levene's test verified the homogeneity of variance. In the case of assumption violation, robust estimation techniques based on the trimmed mean (10%) were employed to corroborate parametric test results. Welch's method [24] allowed for robust hypothesis testing through the WRS2 R package.

3. Results

No missing data were detected in demographics or VFI; for work-related variables, one high school participant did not report the number of hours per week spent in the classroom or in remote teaching.

Table 1 displays the descriptive statistics for demographic and work-related variables. The participants were 195 women aged 24-67 (M_{age}=48.77; SD_{age}=9.61); the majority of them (66.7%) were working in Lombardy, the Italian region most severely affected by the pandemic. No group difference was detected for age ($F_{(2;\ 194)}$=0.25; p=.78), job seniority ($F_{(2;\ 194)}$=0.04; p=.96), number of persons cohabiting ($\chi^2_{(10)}$=9.50; p=.49), workplace region ($\chi^2_{(30)}$=43.7; p=.051), or difference in hours per week spent in remote teaching versus classroom teaching ($F_{(2;\ 92.22)}$=2.02; p=.13).

3.1. VFI descriptive statistics

Table 2 portrays the reliability indices and descriptive statistics for the three VFI factors across groups; columns on the right outline the scores reported by teachers when referring to classroom teaching. All α values ranged between .87 and .97, showing high to very high levels of internal consistency.

Table 3 shows the correlation levels among factors. In remote teaching, a high correlation level was found between TA and PD, whereas IS correlated moderately with the other two factors. The same correlation pattern was identified for classroom teaching.

In the global sample, voice fatigue dimensions showed negligible correlation with demographics and work-related variables. Meaningful (though low) levels of correlation emerged when school grade was taken into account. For primary school teachers, age was positively correlated both with TA (r=.47) and PD (r=.42) during remote teaching and with TA (r=.37) in classroom teaching. Moreover, TA was positively related to job seniority (r=.36) and number of persons

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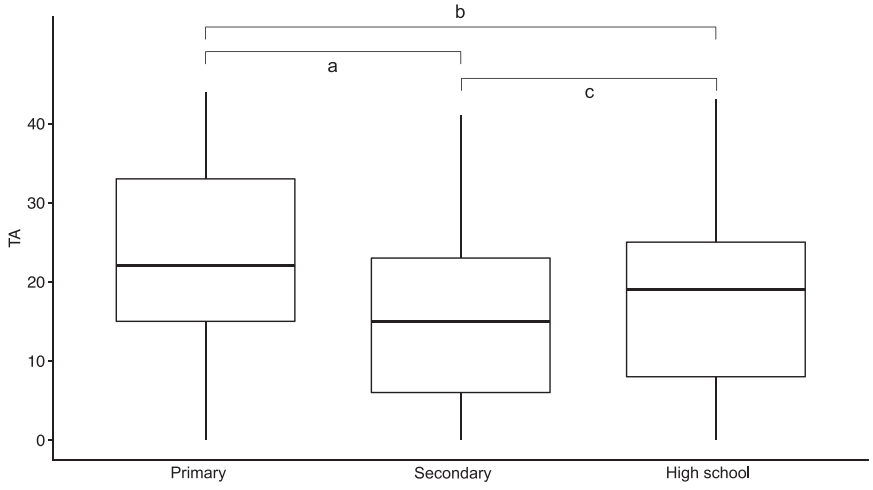
Table 2. Descriptive statistics and reliability indices of VFI factors across groups.

		Remote Teaching			Classroom Teaching		
Group	N	TA M (SD) [α] [a]	PD M (SD) [α] [a]	IS M (SD) [α] [a]	TA M (SD) [α] [a]	PD M (SD) [α] [a]	IS M (SD) [α] [a]
Primary school	65	22.65 (11.61) [.96]	9.46 (5.45) [.93]	8.15 (3.36) [.90]	20.97 (11.63) [.97]	8.06 (5.45) [.92]	7.91 (3.40) [.94]
Secondary school	65	15.58 (11.31) [.96]	6.51 (5.40) [.87]	7.65 (4.18) [.95]	17.72 (11.73) [.96]	6.72 (5.61) [.90]	7.53 (3.72) [.93]
High School	65	17.35 (11.20) [.95]	6.38 (5.09) [.90]	8.03 (3.22) [.89]	18.78 (10.14) [.95]	6.41 (4.79) [.88]	8.35 (3.28) [.97]

N=Number of participants; TA= Tiredness of voice and avoidance of voice use; PD=Physical discomfort; IS= Improvement of symptoms with rest
[a] M=Mean, SD=Standard Deviation, α=Cronbach alpha.



Note. a: p=.001 ; b: p=.02 ; c: p=.65.

Fig. 1. Post hoc pairwise group comparisons of tiredness of voice and avoidance of voice use during remote teaching.
Note. a: p=.001; b: p=.02; c: p=.65

Table 3. Pearson's correlation indices among VFI factors.

	Remote Teaching			Classroom Teaching		
N=65	TA	PD	IS	TA	PD	IS
TA	*1*	*.77***	*.58***	*1*	*.77***	*.62***
PD		*1*	*.51***		*1*	*.53***
IS			*1*			*1*

N=Number of participants; TA= Tiredness of voice and avoidance of voice use; PD=Physical discomfort; IS= Improvement of symptoms with rest
** p<.01

cohabiting (r=-.31), and PD was correlated with hours per week spent in remote teaching (r=.33). Among secondary school teachers, in remote teaching, the sole meaningful relationship was observed between PD and the number of persons cohabiting (r=-.36), while age was negatively correlated with both TA (r=-.36) and PD (r=-.41) in classroom teaching.

VFI values in remote teaching (Figs. 1-3, Table 2) were compared through independent-samples t-tests using data from the index validation study [24]. Teachers from all school grades reported higher VFI values than vocally healthy participants from the general population examined by Nanjundeswaran [24]. In particular, primary school teachers reported higher TA ($t_{(133)}$=11.67, p<.001), PD ($t_{(133)}$=11.57, p<.001) and IS ($t_{(133)}$=3.65, p<.001); secondary school teachers had higher TA ($t_{(133)}$=7.11, p<.001), PD ($t_{(133)}$=7.37, p<.001) and IS ($t_{(133)}$=2.61, p=.01); and high school teachers perceived higher TA ($t_{(133)}$=8.38, p<.001), PD ($t_{(133)}$=7.56, p<.001) and IS ($t_{(133)}$=3.52, p=.001).

Compared to individuals with dysphonia described by Nanjundeswaran [14], primary school teachers did not differ for TA ($t_{(168)}$=-1.10, p=.27) and IS ($t_{(168)}$=0.88, p=.38) and reported higher PD ($t_{(168)}$=2.95, p=.004); secondary school teachers had lower TA values ($t_{(168)}$=-5.43, p<.001) and did not differ for PD ($t_{(168)}$=-0.45, p=.65) and IS ($t_{(168)}$=-0.11, p=.91); high school teachers reported lower TA values ($t_{(168)}$=-4.37, p<.001) and did not differ for PD ($t_{(168)}$=-0.61, p=.54) and IS ($t_{(168)}$=0.65, p=.52).

3.2. Tiredness of voice and avoidance of voice use

In remote teaching, no significant outliers were found in any cell of the one-way ANOVA with TA as the criterion variable. The results from the Shapiro-Wilk tests showed marginal deviation from normality in the residual distribution for high school teachers (W=0.96, p=.03). A stronger deviation was instead observed for secondary school teachers (W=0.94, p=.004). Based on visual inspection of associated Q-Q plots and Levene's test results ($F_{(2,192)}$=0.15, p=.86), parametric tests were deemed appropriate.

Analysis of variance showed a significant main effect of group on TA ($F_{(2,192)}$=6.78, p<.001). Post hoc analyses using Tukey's HSD indicated that TA levels were higher among primary school teachers than among both secondary (p=.001) and high school (p=.02) teachers. No differences in TA were found between secondary and high school teachers (p=.65) (Table 2,Fig. 1).

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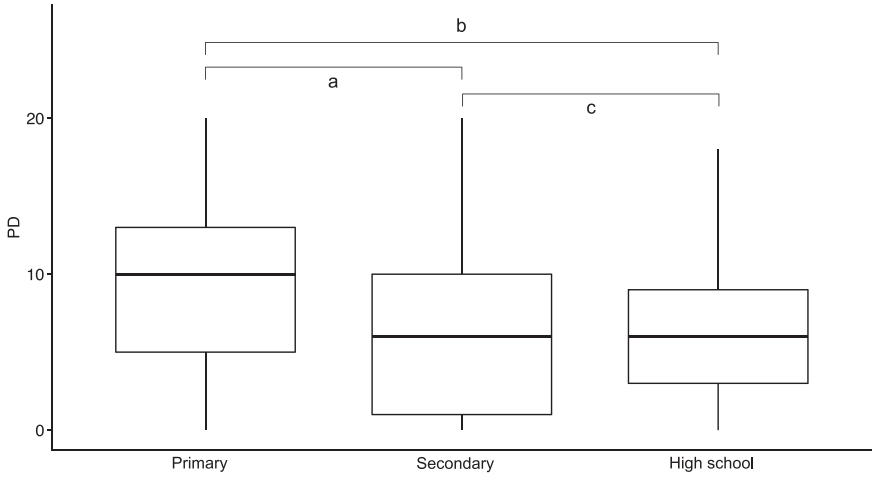

Note. a: p=.005 ; b: p=.003 ; c: p=.99;

Fig. 2. Post hoc pairwise group comparisons of physical discomfort during remote teaching.
Note. a: p=.005; b: p=.003; c: p=.99

For classroom teaching, only marginal deviation from normality was observed in the residual distribution for secondary school teachers (W=0.96, p=.04). Visual inspection of associated Q-Q plots and Levene's test results ($F_{(2,192)}$=1.03, p=.36) suggested parametric test employment. The results from the one-way ANOVA did not show any significant main effect of group on TA associated with classroom teaching ($F_{(2,192)}$=1.42, p=.24).

3.3. Physical discomfort

In remote teaching, no significant outliers were found in any cell of the ANOVA with PD as the criterion variable. The results of the Shapiro-Wilk tests showed strong deviation from normality in the distribution of residuals for secondary (W=0.92, p<.001) and high school (W=0.92, p<.001) teachers, and primary school teachers showed only marginal deviation (W=0.96, p=.04). Q-Q plot inspection further corroborated this evidence. No violations of variance equality assumption were found ($F_{(2,192)}$=0.19, p=.83). Due to assumption violations, robust estimation techniques were employed, together with parametric techniques, to test the significance of the ANOVA main effect.

Similar to the TA outcomes, when parametric tests were employed, a significant main group effect on PD was found ($F_{(2,192)}$=6.98, p=.001). Tukey's HSD post hoc analyses showed that primary school teachers reported significantly higher levels of PD than secondary (p=.005) and high school (p=.003) teachers. No differences were noted between secondary and high school teachers' PD levels (p=.99) (Table 2,Fig. 2).

The results were confirmed by robust tests: a significant main effect was found for group ($F_{(2,103.5)}$=6.97, p=.001). Confidence intervals from post hoc robust pairwise comparisons also confirmed that the PD values of primary school teachers were significantly higher than those of both secondary school teachers (95% CI [0.76, 5.99]) and high school teachers (95% CI [1.06, 6.03]). No differences were found between secondary and high school teachers' PD levels (95% CI [-2.25, 2.59]).

For classroom teaching, significant deviations from normality were found in the residuals' distribution for primary (W=0.95, p=.02), secondary (W=0.92, p<.001) and high school (W=0.94, p=.005) teachers, while no violations of variance equality assumption were found ($F_{(2,192)}$=1.37, p=.26). Neither parametric ($F_{(2,192)}$=1.78, p=.17) nor robust ($F_{(2,\ 103.55)}$=1.71, p=.18) tests resulted in a significant main effect of group on PD associated with classroom teaching.

3.4. Improvement of symptoms with rest

No significant outliers were found in any cell of the ANOVA with IS in remote teaching as the criterion variable. The Shapiro-Wilk tests and Q-Q plots, however, showed strong deviation from normality in the residuals' distributions for primary (W=0.91, p<.001), secondary (W=0.86, p<.001) and high school teachers (W=0.92, p<.001). No violation of homogeneity of variance assumption was detected ($F_{(2,192)}$=2.31, p=.10). Due to assumption violations, robust estimation techniques were employed to support evidence from parametric tests. No significant effect of group on IS was observed with either parametric techniques ($F_{(2,192)}$=0.35, p=.71) or Welch's robust alternative ($F_{(1,102.08)}$=0.18, p=.84) (Table 2,Fig. 3).

For classroom teaching, strong deviation from normality in the residuals' distributions for primary (W=0.91, p<.001), secondary (W=0.90, p<.001) and high school (W=0.88, p<.001) teachers was found. The homogeneity of variance assumption was not violated ($F_{(2,192)}$=0.55, p=.57). No significant effect of group on IS in classroom teaching was observed through parametric tests ($F_{(2,192)}$=0.90, p=.41) or Welch's robust alternative ($F_{(2,\ 103.68)}$=0.81, p=.44).

4. Discussion

The worldwide disruption of daily work and social routines by the first wave of the COVID-19 pandemic made

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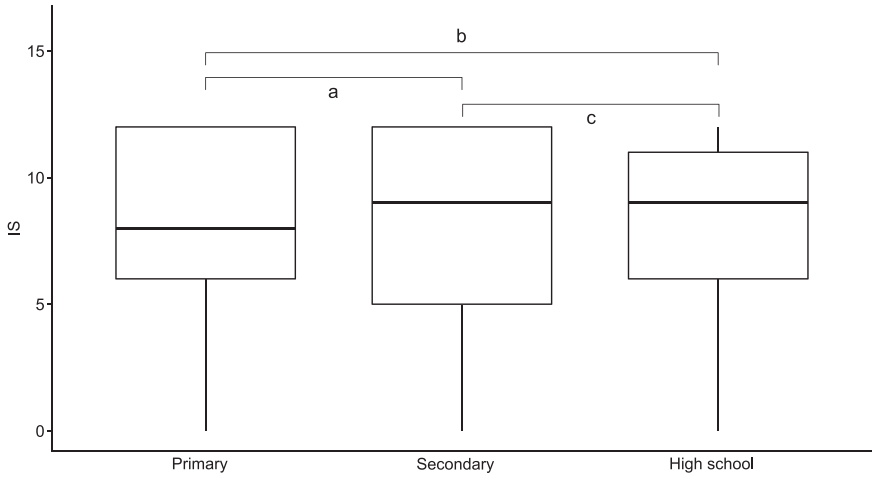

Note. a: p= .70; b: p= .98; c: p= .82;

Fig. 3. Post hoc pairwise group comparisons of improvement of symptoms with rest during remote teaching.
Note. a: p= .70; b: p= .98; c: p= .82

online teaching the only strategy to grant continuity of formal education for the country's young generations. In Italy, all school grades were forced to abruptly interrupt classroom teaching; online teaching remained mandatory until the end of the school year, and required a paramount effort from teachers and school staff.

Overall, our findings confirm that voice fatigue is a central health issue for school teachers compared with the general population [25,26]. More specifically, the scores of TA reported by all groups of teachers were more than three times higher than those detected by Nanjundeswaran et al. [14] among vocally healthy individuals, and were consistent with the findings of regular classroom teaching [9]. A similar pattern was noted for PD, as the values reported by all groups were significantly higher than those reported by healthy individuals [14]. Moreover, primary school teachers had TA scores that were not different from those of dysphonic subjects described by Nanjundeswaran et al. [14], whereas secondary and high school teachers had significantly lower TA scores. Therefore, the results of our study confirm that, even during the shift to remote teaching, elementary school teachers have a higher risk of voice disorders, emphasizing once again the relevance of voice fatigue as a professional health issue for this specific category [15,16,21,27]. These findings are not surprising, as teachers of the younger classes are subjected to high vocal demand due to the pupils'age and being in charge of teaching most subjects of the students' program, without any habilitative vocal training [21,27].

The IS score of all groups was above the cutoff value of 7 [14], indicating that vocal fatigue was reduced with voice rest, as could be expected in an unselected sample of teachers without known voice pathologies (an IS score $\leq$ 7 suggests risk for dysphonic disorders).

In contrast with our results, a study by Patjas et al., conducted on 121 primary and secondary school teachers across Finland, suggested that better acoustics and indoor air quality in distance teaching could have a positive impact on voice health [28].

Another study by Nemr et al., which included 1,126 Brazilian teachers, showed that a voice improvement may occur with the shift to remote learning, although some factors, such as increased voice use, use of the voice at higher intensities and difficulty with voice use during online classes are predictors of vocal worsening [29].

Regarding the relationship of participants' demographic and work-related variables with vocal fatigue, negligible levels of association were found in the global sample. In particular, age and teaching seniority were not related to VFI scores, in contrast with a previous study showing a positive association between perceived vocal fatigue and teachers' age, with the highest effect detected at 40-45 years for all VFI dimensions [22].

The condition of considerable vocal load implies a high risk of developing voice disorders with loss of workdays, or even the risk of leaving the field of teaching, due to unbearable fatigue [15]. The reported results show that forced remote teaching due to the COVID-19 pandemic did not reduce this risk, highlighting the necessity of promoting vocal hygiene preventive programs. In accordance with our results, a study by Kenny [30] showed that the condition of forced home-working by online and telephone communications during the COVID-19 pandemic could itself be a risk factor for the development of voice disorders for other professionals, as illustrated by an increased prevalence of self-reported dysphonia and vocal tract discomfort. Furthermore, teaching while staring at a screen, without continuous and direct eye contact, could result in a monotonous and one-sided instruction that promotes students' attention loss and leads to vocal abuse over time [31].

This study has several limitations. The first is the gender homogeneity of the sample, which included only women. However, across countries, the vast majority of teachers are women (over 80% in Italy), especially in primary and sec-

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ondary schools. Regardless of seniority and duty similarity, female teachers are more prone to developing vocal fatigue than males due to anatomical and functional reasons, such as a higher frequency of vibration of the vocal folds, that predispose them to phonotrauma [9,32,33]. Hence, information collected among female teachers could provide more significant results in studies aimed at analyzing the relationship between voice load and perception of vocal fatigue.

A second limitation of this study is represented by the lack of information about the participants' clinical history as concerns smoking habits, previous vocal fold pathologies and eventual laryngological evaluations. Notwithstanding, the primary aim of this work was explorative in nature, consisting of the investigation of the relationship between the online teaching mode imposed by the COVID-19 emergency and the perception of voice fatigue in a sample derived from the general Italian population of teachers, without specific selection constraints.

Furthermore, there are other possible sources of bias, including the different amount and frequency of water intake or the rest time between classes, which were not investigated.

A further limitation consists of retrospectively gathering data about voice fatigue perceived during classroom teaching, potentially biased by a comparative evaluation with the current online teaching experience. Nevertheless, the data about classroom teaching were a secondary aim of this study, which was focused on remote teaching conditions. Finally, it is important to underline that the drastic measures taken by the Italian government to contain the spread of COVID-19, such as the use of face masks, social distancing, limited travel, the impossibility of practicing group sports, the closure of restaurants, stadiums and museums, had a negative impact on people's psycho-physical health, often exacerbated by emotional distress due to SARS-CoV-2 infection, mandatory quarantine or death of family members [34]. In this dramatic context, the psychological profile of Italians was prone to high levels of stress, anxiety and fear, and could have contributed to the perceived vocal fatigue in remote working.

5. Conclusion

The present study investigated perceived vocal symptoms among primary, secondary and high school teachers during the mandatory transition to remote teaching during the COVID-19 global public health emergency. Comparisons among the three school grades demonstrated differences in vocal fatigue perception, highlighting the critical condition of fatigue perceived by elementary school teachers.

These findings may offer suggestions for vocal health interventions aimed at preventing phonotraumatic behaviors and the consequent vocal symptoms among teachers of all school grades, especially of primary school as in this specific category voice fatigue was similarly higher both during in-person and remote teaching. In light of the fundamental educational and social role played by teachers during the ongoing COVID-19 pandemic, preventive programs could help them avoid the chronicity of symptoms that might be the cause of workday loss and persistent voice disability. The use of the VFI as a diagnostic tool among teachers performing distance teaching might favor the early identification of vocal fatigue and could be a valuable follow-up means to evaluate the efficacy of vocal health interventions performed for prevention and/or treatment.

Author contributions

GC: substantial contributions to the conception, design, acquisition, interpretation of data for the work; drafting the work; final approval of the version to be published; agreement to be accountable for all aspects of the work.

LN: substantial contributions to the conception, design, acquisition, interpretation of data for the work; drafting the work; final approval of the version to be published; agreement to be accountable for all aspects of the work.

GB: revising the work critically for important intellectual content; giving final approval of the version to be published; agreement to be accountable for all aspects of the work.

LN: revising the work critically for important intellectual content; giving final approval of the version to be published; agreement to be accountable for all aspects of the work.

MA: revising the work critically for important intellectual content; giving final approval of the version to be published; agreement to be accountable for all aspects of the work.

LP: revising the work critically for important intellectual content; giving final approval of the version to be published; agreement to be accountable for all aspects of the work.

ADF: substantial contributions to the conception, design, acquisition, analysis and interpretation of data; drafting the work; giving final approval of the version to be published; agreement to be accountable for all aspects of the work.

Author agreement

All authors have approved the manuscript and agree with its submission

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Declarations of Competing Interest

The authors declare that they have no conflicts of interest/competing interests.

Ethics approval

The present retrospective study was conducted according to the World Medical Association's Declaration of Helsinki and was approved by the ethical committee of the University of Milan (59/20).

Consent to participate

Written informed consent was obtained.

Consent for publication

Written informed consent was obtained.

Availability of data and materials

The source data are available on request.

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