Influence of Noise Resulting From the Location and Conditions of Classrooms and Schools in Upper Egypt on Teachers' Voices

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Summary: Purpose. Teachers are professional voice users, always at high risk of developing voice disorders due to high vocal demand and unfavorable environmental conditions. This study aimed at identifying possible correlations between teachers' voice symptoms and their perception of noise, the location of schools, as well as the location and conditions of their classrooms.

Method. One hundred forty teachers (ages 21−56) from schools in Upper Egypt participated in this study. They filled out a questionnaire including questions about the severity and frequency of their voice symptoms, noise perception, and the location and conditions of their schools and classrooms. Questionnaire responses were statistically analyzed to identify possible correlations.

Results. There were significant correlations ($P < 0.05$) between voice symptoms, teachers' noise perception, and noise resulting from the location and conditions of schools and classrooms. Teachers experienced severe dysphonia, neck pain, and increased vocal effort with weekly or daily recurrence. Among the teachers who participated in the study, 24.2% felt they were always in a noisy environment, with 51.4% of the total participants reporting having to raise their voices. The most common sources of noise were from student activities and talking in the teachers' own classrooms (61.4%), noise from adjacent classrooms (52.9%), and road traffic (40.7%).

Conclusions. Adverse effect on teachers' voices due to noise from poor school and classroom conditions necessitates solutions for the future improvement of conditions in Egyptian schools. This study may help future studies that focus on developing guidelines for the better planning of Egyptian schools in terms of improved infrastructure and architecture, thus considering the general and vocal health of teachers.

Key Words: Teachers−Voice symptoms−Noise−School and classroom location−Classroom conditions.

INTRODUCTION

Noise, an unwanted sound occurring in the environment in which people live and work,[1] may predispose individuals to have a sense of annoyance or a negative evaluation regarding their environmental conditions.[2] In the past few decades, there have been several research studies conducted to better understand the effects of internal and external noise that prevails in schools and classrooms on student and teacher health, particularly on teachers' vocal conditions.[3−8] There are many sources of background noise inside and outside of classrooms. The predominant outdoor noises include those from automobiles, aircraft, road traffic,[9,10] industrial plants, and activities from school yards and grounds.[11] Indoor noises (also inside classrooms) are primarily from student activities and talking and noise from hallways during breaks between lessons.[9,12] Noise generated within school buildings, including those due to utilities (such as ventilation systems for heating/cooling) often intrudes inside classrooms from walls and partitions, and floor-to-ceiling assemblies.[11]

A good voice quality is essential for good communication with students, which can otherwise be hampered if teachers experience a voice problem. It has been reported that the vocal impairment of teachers (irrespective of whether it is a mild or severe voice problem) may have some detrimental effects on children's speech-processing ability, resulting in a negative educational effect.[13] An active classroom involves students and teachers conversing at least 60% of the time, pressing the need for a favorable listening environment that supports clear communication.[14] It was found that 13% of the active school teachers in southern Sweden self-reported voice problems.[15] A further serious consequence of this could be job dissatisfaction, disinterest in continuing the job, lack of self-esteem, and fatigue after work.[16] Vilkman has indicated "bad classroom acoustics" to be one of the threats to voice health.[16] In a study by Cutiva et al,[17] the authors systematically reviewed 23 publications and found that most of the studies reported teachers being at high risk of developing voice problems due to noisy classrooms. Noisy classrooms may cause teachers to raise their voices, leading to increased teacher stress and vocal fatigue.[18] Classroom acoustics are often overlooked, where noise, echoes, and reverberation typically interfere with the ability of the listeners to understand speech, thus increasing the vocal effort by teachers.[19] The influence of classroom acoustics on the vocal load of teachers has been documented objectively in recent studies.[6,20−27]

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The prevalence of voice disorders among Egyptian teachers is not in the limelight and is an overlooked matter. However, in a recent comprehensive study,[28] authors tried to investigate risk factors for voice disorders in Egyptian teachers of public schools. The dominant risk factors for poor vocal health in these teachers were overcrowded, loud, noisy, and misbehaved classroom environments, with the teachers having a poor awareness of vocal hygiene. In another Egyptian study,[29] authors compared self-reported voice symptoms and noise reports between public and private schools. They found that teachers working in public schools had more negative voice impacts and were susceptible to their voices failing by the end of their work day, which was also attributed to a larger number of students in the classroom and increased noise disturbances from nearby classes.

Over the years, Egyptian schools have been facing serious issues related to the planning of educational, technical, and architectural requirements.[30] Egyptian school buildings are constructed with inexpensive, local materials, leading to poor building conditions, especially in public schools.[31,32] Moreover, the distribution of school buildings does not follow any standard rule. Some schools are located close to other schools, while some districts in Egypt have no schools to serve the population at all. Based on a survey report, it is mentioned that most of rural Egypt has very few schools and lacks good infrastructure.[33] The location of schools is another problem in Egyptian cities. Most of the schools are located on main streets, near road traffic, or near railway lines, which is a vital factor that requires consideration.[34–37] All of these factors tend to increase noise levels in schools and classrooms, making it an extremely unfavorable working place that affects both teachers' vocal health and children's learning abilities.

The present study is a continuation of the study conducted by Abo-Hasseba et al.[29] Here we hypothesize that the location of a school and its classroom as well as classroom conditions may be a source of noise capable of harming teachers' voices, resulting in a hindrance to their teaching. We sought to identify if any correlations exist between the prevailing voice symptoms of teachers and the noise due to the inappropriate location and conditions of schools and classrooms.

AIM

The study aimed at identifying possible correlations between teachers' voice symptoms and their perception of noise, the location of schools, as well as the location and conditions of their classrooms.

MATERIALS AND METHOD

Participants

Of 200 invited teachers, 140 (85 females and 55 males) between ages 21 and 56 years (mean age = 35.8 years) from schools in Upper Egypt (Governorate of El-Minia) participated in this study. The schools were randomly selected, including both primary and preparatory grades, as well as both public and private school types. Of the 69 teachers from primary schools, 36 taught in public schools and 33 in private. Seventy-one teachers worked in preparatory schools, 34 of which taught in public schools and 37 in private schools. Teachers working in the public and private schools had an average of 17.9 and 7.4 years of teaching experience, respectively, with a total average of 12.3 years combining both groups.[29] Written consent was obtained from all teachers participating in the study.

Questionnaire

Teachers were asked to fill out a questionnaire regarding their demographic data, and the frequency and severity of voice symptoms (dysphonia, laryngeal pain, throat clearing, throat dryness, voice interrupted by the end of the day, and extra voice effort required to continue speaking) from the past 6 months. They were also asked about their school and classroom location and classroom conditions. The teachers also reported their perception on existing noise (and also the source of noise) at their workplace and how they felt about it:

(1) Demographic data: age, gender, type of school taught at, total years of teaching experience;
(2) Frequency of voice symptoms rated on a four-point rating scale (1 = no recurrence; 2 = monthly recurrence; 3 = weekly recurrence; 4 = daily recurrence);
(3) Severity of voice symptoms rated on a four-point rating scale (1 = none; 2 = mild; 3 = moderate; 4 = severe);
(4) Feeling of being in a noisy environment and having to raise their voices due to noise; both rated on a four-point rating scale (1 = always; 2 = sometimes; 3 = rarely; 4 = never);
(5) Location of schools (whether schools are located next to other schools, government offices and public sectors, and quiet streets with residential buildings or in open market areas);
(6) Location of classrooms (whether classrooms are located near or far from main traffic roads);
(7) Conditions of classrooms (approximate classroom area, number of students per class, number of windows in the classroom, the window and door material, any broken doors or windows, whether the windows and doors were closed during teaching, lighting/number of tube lights, the use of any ventilation, aeration, and insulation systems, and the presence of suspended ceilings based on a dichotomous response of yes/no).

Statistical analysis

Descriptive statistics were used to calculate percentages for the severity and frequency of voice symptoms and perception of noise. The percentage distribution was also calculated for other variables, namely noise sources, the location of schools and classrooms, and classroom conditions. The chi-squared test and Fisher's exact test (used when the chi-squared test assumption was violated by having more than 20% of cells with expected counts less than five) were used to find correlations between ordinal and nominal variables (ie, correlations between noise sources, the location of schools and classrooms, and the frequency and severity of voice symptoms). Goodman and Kruskal's Gamma was used to find correlations between

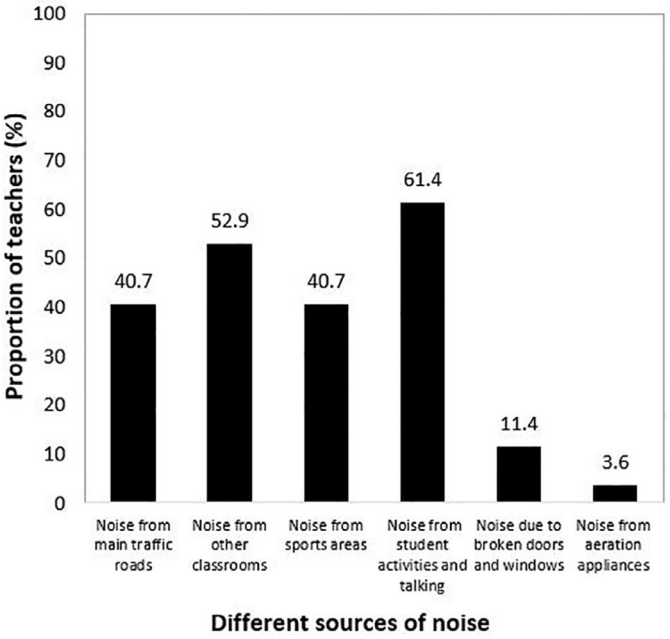

FIGURE 1. Percentage of teachers reporting noise from different sources.

ordinal variables (ie, correlations between the frequency and severity of voice symptoms and the perception of noise, voice raising, and classroom conditions). Additionally the Kruskal-Wallis test was used to compare the severity and frequency of voice symptoms for teachers with less and more than 2 and 12 years of teaching experience. The significance level was set at $P < 0.05$ for all statistical analyses. The statistical analyses were carried out using *SPSS 22* software (IBM SPSS Statistics v. 22 for Windows, Armonk, NY).

Compliance with ethical standards

Ethical approval to carry out this study was obtained from Minia University's ethical committee and from undergraduate educational authorities in Minia, Egypt.

RESULTS

Relationship between teachers' self-reported voice symptoms, noise sources, noise perception, and number of years of teaching experience

The percentage of teachers reporting noise from different sources is shown in Figure 1. A total of 82.8% of teachers reported noise from more than one source. Noise from student activities and talking in their own classrooms was the most frequent source of noise (61.4% of teachers) followed by noise from other neighboring classrooms (52.9%). The chi-squared test showed a significant association between frequent laryngeal or neck pain symptoms and noise from other classrooms ($\chi^2(3, N = 140) = 18.786$, $P < 0.001$). Of 44.8% of teachers who reported noise from neighboring classrooms, 13.5% reported experiencing daily recurrence and 9.4% experienced monthly recurrence of laryngeal pain (Table 1). The chi-squared test showed a significant association between increased voice effort to continue talking and noise from student activities and talking ($\chi^2(2, N = 140) = 7.281$, $P = 0.026$). Of 61.4% of teachers who reported noise due to student activities and talking in their own class, 11.4% reported always requiring increased vocal effort to continue talking for long durations, while 27.1% reported the need for extra vocal effort only sometimes as shown in Table 2.

The results of the frequency distribution of teachers' reports of feeling they were in a noisy environment and having to raise their voices due to noise are shown in Figure 2.

TABLE 1.
The Counts and Percentages of Teachers Reporting on the Frequency of Laryngeal or Neck Pain in Relationship to Noise From Neighboring Classrooms (N = 96 teachers)

	Noise From Neighboring Classroom		
Frequency of Laryngeal and Neck Pain	No	Yes	Total
No recurrence	11 (11.5%)	23 (24.0%)	34 (35.4%)
Monthly recurrence	14 (14.6%)	9 (9.4%)	23 (24%)
Weekly recurrence	18 (18.8%)	5 (5.2%)	23 (24%)
Daily recurrence	3 (3.1%)	13 (13.5%)	16 (16.7%)
Total	46 (47.9%)	50 (44.8%)	96 (100%)

TABLE 2.
The Counts and Percentages of Teachers Reporting on Increased Voice Effort in Relationship to Noise From Student Activities and Talking (N = 140 teachers)

	Noise From Student Activities and Talking		
Increased Voice Effort in Order to Continue Talking	No	Yes	Total
No voice effort	32 (22.9%)	32 (22.9%)	64 (45.7%)
Voice effort sometimes	13 (9.3%)	38 (27.1%)	51 (36.4%)
Voice effort always	9 (6.4%)	16 (11.4%)	25 (17.9%)
Total	54 (38.6%)	86 (61.4%)	140 (100%)

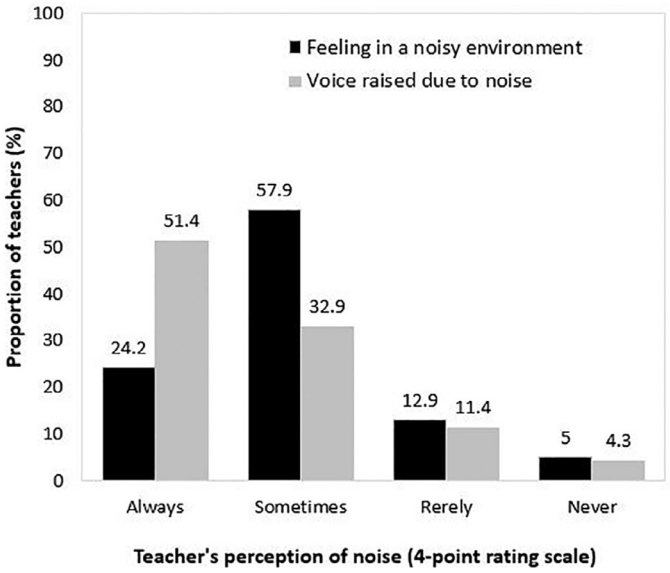

FIGURE 2. Frequency distribution of 140 teachers on their reports of feeling they were in a noisy environment and having to raise their voices due to noise.

A total of 57.9% of teachers reported feeling they were sometimes in a noisy environment, and 24.2% reported always feeling they were in a noisy environment. On the other hand, 51.4% of teachers reported always having to raise their voice due to noise, while 32.9% reported having to raise their voice only sometimes. Goodman and Kruskal's Gamma showed a very strong positive association between feeling they were in a noisy environment and raising their voices due to it ($G = 0.876$, $P < 0.001$). In addition, correlations were found between raising one's voice and the severity and frequency of voice symptoms (Table 3).

Comparing the severity and frequency of voice symptoms for teachers with less and more than 2 and 12 years of teaching experience

The Kruskal-Wallis test was used to compare the severity and frequency of voice symptoms for teachers with less and more than 2 years of teaching experience and for those with less and more than 12 years of experience. Of 140 teachers, 22 (15.7%) had 2 and less years, while 118 (84.3%) teachers had more than 2 years of teaching experience. No significant differences ($P > 0.05$) in the voice symptom reports between these two groups were found. However, a significant difference was found on the frequency of dysphonia ($\chi^2(1) = 4.602$, $P = 0.03$), frequency of laryngeal or neck pain ($\chi^2(1) = 3.998$, $P = 0.04$), and severity of voice interrupted at the end of the day ($\chi^2(1) = 10.371$, $P = 0.001$) between teachers with 12 and less years of teaching experience (71 teachers [50.7%]) and teachers with more than 12 years of teaching experience (69 teachers [49.3%]). The mean ranks of the Kruskal-Wallis test were higher for teachers with more than 12 years of teaching experience.

Relationship between voice symptoms and school location

Of 140 teachers, 84 (60%) reported their school to be located close to other schools, 33 (23.6%) reported being close to other government offices, and 23 (16.4%) reported their schools to be situated close to quiet streets with residential buildings. None reported their schools to be located near market areas. The results of Fisher's exact test show a significant relationship between the severity of dysphonia and school location ($P = 0.012$). Table 4 shows that the teachers in schools close to other schools had more severe symptoms than teachers located close to quiet streets; these experienced only mild symptoms of dysphonia.

Relationship between voice symptoms and classroom location

A total of 55.2% of teachers reported their classroom to be close to main traffic roads, while 44.8% reported it to be far from main traffic roads. The chi-squared test showed a significant correlation between classroom location and the frequency of laryngeal and neck pain ($\chi^2[3, N = 96] = 9.48$, $P = 0.02$). Here, however, reports of 44 teachers were missing, and only 96 teachers rated this variable, as shown in Table 5.

TABLE 3.
Goodman and Kruskal's Gamma Values and Significant *P* Values for Correlations Between Raising One's Voice Due to Noise and the Severity and Frequency of Voice Symptoms

Correlations Between		Type of Voice Symptom	Goodman and Kruskal's Gamma Value	Sig. (2-tailed) *P* value < 0.05
Raising voice due to noise	Severity of voice symptoms	Dysphonia	G = 0.327 (moderate)	*P* = 0.021
		Laryngeal or neck pain	G = 0.231 (weak)	*P* = 0.033
		Throat clearing	G = 0.298 (weak)	*P* = 0.007
		Interrupted voice at the end of the day with an inability to complete speech	G = 0.317 (moderate)	*P* = 0.031
	Frequency of voice symptoms	Throat clearing	G = 0.272 (weak)	*P* = 0.029
		Throat dryness	G = 0.239 (weak)	*P* = 0.042
	Increased voice effort in order to continue talking		G = 0.262 (weak)	*P* = 0.031

TABLE 4.
The Counts and Percentages of Teachers Reporting on the Severity of Dysphonia in Relationship to School Location Categories (N = 140 teachers)

	Location of Schools			
Severity of Dysphonia	Close to Other Schools	Close to Government Offices and Public Sectors	Close to Quiet Streets With Residential Buildings	Total
No dysphonia	19 (13.6%)	6 (4.3%)	1 (0.7%)	26 (18.6%)
Mild dysphonia	19 (13.6%)	14 (10%)	14 (10%)	47 (33.6%)
Moderate dysphonia	35 (25%)	11 (7.9%)	8 (5.7%)	54 (38.6%)
Severe dysphonia	11 (7.9%)	2 (1.4%)	0 (0%)	13 (9.3%)
Total	84 (60%)	33 (23.6%)	23 (16.4%)	140 (100%)

Relationship between voice symptoms and classroom conditions

Teachers reported an average classroom area of 27.3 m^2, with an average class size of 36 students. Results of Spearman rank-order correlations showed a significant correlation between the class size and the severity of throat dryness ($r = 0.18$, $P = 0.033$). The average number of windows per classroom was four with an average of eight tube lights per classroom. When asked about broken and fixed/unbroken doors and windows, 2 teachers reported broken windows, 56 (40%) reported broken doors, and 84 (60%) reported unbroken doors. All the teachers reported to have wooden doors in their classroom with 132 (94.3%) reporting windows made of only glass and 8 (6%) reporting windows made of both wood and glass. A weak but significant positive correlation was also found using Goodman and Kruskal's Gamma ($G = 0.257$, $P = 0.024$) between the frequency of dysphonia and the absence of closed doors and windows during teaching. From Table 6 it is clear that the largest number of teachers reported the doors and windows to be closed during teaching only sometimes. Of these 12 teachers (10.5%) had daily and 14 (12.3%) had monthly recurrence of dysphonia.

There were no suspended ceilings or sound insulators used in any of the classrooms (eg, insulated walls, window curtains, or carpeted floors). Regarding the use of ventilators and other aeration appliances, 129 (92%) teachers reported using fans, while 11 (8%) reported not using any type of ventilators or aeration appliances in their classrooms.

Relationship between school type and school location

There was a significant and strong correlation between school location and type of school ($\chi^2[6, N = 140] = 99.071$, $P < 0.001$), with Cramer's V value being 0.595. Table 7 shows the distribution of school types by school location category as reported by 140 teachers. All public schools (N = 70) were situated close to other schools, while only 10% of private schools were close to other schools. Among

TABLE 5.
The Counts and Percentages of Teachers Reporting on the Frequency of Laryngeal and Neck Pain in Relationship to Classroom Location (N = 96 teachers)

	Location of Classroom		
Frequency of Laryngeal and Neck Pain	Close to Main Traffic Roads	Far From Main Traffic Roads	Total
No recurrence	17 (17.7%)	17 (17.7%)	34 (35.4%)
Monthly recurrence	10 (10.4%)	13 (13.5%)	23 (24%)
Weekly recurrence	19 (19.8%)	4 (4.2%)	23 (24%)
Daily recurrence	7 (7.3%)	9 (9.4%)	16 (16.7%)
Total	53 (55.2%)	43 (44.8%)	96 (100%)

TABLE 6.
The Counts and Percentages of Teachers Reporting on the Frequency of Dysphonia in Relationship to Open/Closed Status of Doors and Windows During Teaching (N = 114 teachers)

Frequency of Dysphonia	Doors and Windows Closed During Teaching?				
	No	Rarely	Sometimes	Always	Total
No recurrence	6 (5.3%)	10 (8.8%)	24 (21.1%)	6 (5.3%)	46 (40.4%)
Monthly recurrence	3 (2.6%)	2 (1.8%)	14 (12.3%)	3 (2.6%)	22 (19.3%)
Weekly recurrence	3 (2.6%)	3 (2.6%)	9 (7.8%)	7 (6.1%)	22 (19.3%)
Daily recurrence	2 (1.8%)	2 (1.8%)	12 (10.5%)	8 (7%)	24 (21.1%)
Total	14 (12.3%)	17 (14.9%)	59 (51.8%)	24 (21.1%)	114 (100%)

TABLE 7.
Distribution of School Types by School Location Category

Type of School	Location of School			Total
	Close to Other Schools	Close to Government Buildings	Close to Quiet Streets With Residential Buildings	
Primary public	36 (25.7%)	0 (0%)	0 (0%)	36 (25.7%)
Primary private	6 (4.3%)	19 (13.6%)	8 (5.7%)	33 (23.6%)
Preparatory public	34 (24.3%)	0 (0%)	0 (0%)	34 (24.3%)
Preparatory private	8 (5.7%)	14 (10%)	15 (10.7%)	37 (26.4%)
Total	84 (60%)	33 (23.6%)	23 (16.4%)	140 (100%)

the private schools, 16.4% were situated close to quiet streets with residential buildings.

DISCUSSION

This study aimed at identifying correlations between teachers' voice symptoms and their noise perception, noise resulting from the location of schools, and the location and conditions of classrooms. These sources of noise are often not investigated, particularly in terms of the negative impact they can have on a teacher's voice. We also sought to find out if years of teaching experience had an effect on the severity and frequency of voice symptoms.

Referring to section "Relationship between teachers' self-reported voice symptoms, noise sources, noise perception, and number of years of teaching experience" of the results, teachers reported noise to be sourced mainly from student activities and talking in their own classrooms (61.4% of teachers), as well as noise from neighboring classrooms (52.9%). This also had a negative effect on their frequent recurrence of laryngeal or neck pain (13.5% of teachers) (Table 1) and their need to exert extra vocal effort to continue talking for longer durations due to the noise in their own classrooms (11.4% of teachers reporting always and 27.1% reporting sometimes) (Table 2). In today's education system, students are encouraged to discuss and verbalize ideas and thoughts during active classroom situations, which may lead to increased levels of classroom noise.[36,38] The teachers then strain their voices and often speak aloud to discipline their students, which then leads to voice illnesses in these teachers, particularly due to vocal loading for long periods without any voice rests.[38] These voice problems may become aggravated when there is also noise from adjacent classrooms adding to the total noise, particularly when there are thin walls or partitions (made of poor acoustic insulation material) separating the classrooms. This leads to poor classroom acoustical quality, which is a common problem in Egyptian schools.[39,40]

Teachers also reported feeling they were in a noisy environment (57.9% of teachers reported sometimes and 24.2% reported always, from Figure 2) and had to raise their voices due to this noise (51.4% of teachers reported always and 32.9% reported sometimes, from Figure 2), which is related to a well-known phenomenon called the "Lombard effect."[41] This is a reflexive behavior of the speaker who involuntarily increases his/her vocal intensity and fundamental frequency due to noise, thus coping with the constraints posed by the noise on the reception of acoustic signal (in this case, the speaker's own voice). Due to the increase in vocal loudness and pitch, there is increased vocal effort,[42] vocal loading, vocal fatigue, and teacher stress.[18] In a study by Kristiansen et al,[6] authors reported a 0.65 dB(A) increase in vocal load with per dB(A) increase in noise level in classrooms, with teachers raising their voices 61% of the time. Speaking with a raised voice and increased vocal load seemed to cause dysphonia, laryngeal and neck pain, and throat dryness with frequent throat clearing among the teachers. These teachers also reported not being able to maintain their speaking at the end of the day and exerting much vocal effort to continue talking. These findings are evident from Table 3, where significant, weak to moderate correlations were obtained between the raising of voice due to noise and the severity and frequency of different voice symptoms.

Considering the section "Comparing the severity and frequency of voice symptoms for teachers with less and more than 2 and 12 years of teaching experience," we compared voice symptoms in teachers with different years (less and more than 2 and 12 years) of teaching experience. From the results of the previous study by Abo-Hasseba et al[29] on the same study population, it was found that teachers working in the public schools had an average of 17.9 years of teaching experience, while those working in private schools had an average of 7.4 years of teaching experience with a total average of 12.3 years of teaching experience combining both school types. They also reported that no significant differences were found between public and private teachers for the severity and frequency of voice symptoms. In the present study as well, no significant difference in the severity and frequency of voice symptoms was found between groups with less and more than 2 years of teaching experience, probably due to the smaller sample size of the group with teaching experience of 2 years and less (only 15.7% teachers). However, considering the total average of 12.3 years of teaching experience combining both school types,[29] we sought to compare the severity and frequency of voice symptoms for the teachers with 12 and less versus more than 12 years of teaching experience. It was found that teachers with more than 12 years of teaching experience had significantly higher scores on frequency of dysphonia, laryngeal or neck pain, and severity of voice interrupted at the end of the working day. The more the years of teaching,

the more the teachers are exposed to unfavorable environmental conditions, particularly teaching in a noisy classroom for many years without any appropriate voice use and vocal hygiene. Literature also proves that a long job tenure (longer years of teaching) may be a crucial factor to the development of long-standing pharyngeal and laryngeal abnormality and hyperfunction signs in teachers due to long-term exposure to noise.[43,44]

Considering school site (the section "Relationship between voice symptoms and school location"), a school that is located in a busy and noisy area (eg, near traffic or an industrial area) is highly unfavorable for both learning and working conditions. The World Health Organization, in their document titled "Information series of school health-Document 2," define a health-promoting school as "one that constantly strengthens its capacity as a healthy setting for living, learning and working,"[45] This document provides guidelines for selecting a school site by considering the potential environmental risk in terms of a school's location, including the risk of noise. In the present study (Table 4), about 60% of teachers reported their schools were located close to other schools. Of these teachers, 13.6% reported having mild, 25% reported having moderate, and 7.9% reported having severe dysphonia. A total of 23.6% of teachers had schools located close to other government buildings (such as government banks, passport offices, and directorate service offices, which are very crowded and noisy). A significant association was found between the school location and the severity of dysphonia in these teachers. When two or more schools or other noisy government offices are situated close to each other, there is an additive effect on the total noise generated from nearby schools and public sectors. Only 16.4% of teachers reported their schools to be situated close to quiet streets with residential buildings, which may be a more favorable environment. However, even these teachers reported having mild to moderate dysphonia, which may be due to unawareness or poor vocal hygiene and improper use of voice. Another factor may be teaching without breaks (no voice rest), as seen in 61% of teachers in the previous study[29] conducted on the same study population. When schools are located in a quiet residential area with more trees and plants around, the trees are able to absorb some of the sound, thus reducing noise levels. The acoustic benefits of trees and plants in attenuating noise have been very well known for many years.[46] Currently, there have been actions taken to promote "Green Schools" by the U.S. Green Building Council[47] in order to construct school buildings that provide a healthy environment for the improved performance of teachers and students. In Egypt, schools are mostly located adjacent to other schools or in noisy environments. In a most recent Egyptian study,[48] authors provide guidelines and selection procedures for the appropriate planning of school sites, taking into consideration geographical, environmental, educational, technical, and safety aspects.

When correlating voice symptoms and classroom location and conditions (the sections "Relationship between voice symptoms and classroom location" and "Relationship between voice symptoms and classroom location"), all teachers who reported their classrooms to be close to main traffic roads (55.2%) experienced daily (7.3%), weekly (19.8%), and monthly (10.4%) recurring frequency of laryngeal or neck pain (Table 5). Voice symptoms such as laryngeal pain, throat clearing, and throat dryness may be attributed to excess vocal loading, vocal fatigue, and speaking in a raised voice (or increased loudness) for continuous long periods.[49–51] The possible reasons for excess classroom noise due to road traffic could be due to the finding that only 51.8% of teachers reported doors and windows in their classroom to be closed only sometimes while teaching, while in 14.9% of teachers reported that they were closed rarely and in 12.3% they were never closed (Table 6); additionally, 40% of teachers reported broken doors, which might have aggravated the noise levels in classrooms. Sound insulation windows with monolayer or two double-hollow glass layers should be used, as they attenuate external noise (road traffic noise) up to 32 and 24 dBSPL, respectively.[52] Such considerations to school classrooms may help teachers to preserve good vocal health, as they reduce vocal loading resulting from noise. Road traffic noise is the primary type of troublesome external noise.[9]

About 92% of teachers reported using fans as a ventilation system. There was also an average of eight tube lights inside every classroom. Noise from ventilation systems (fans in this study) and power lines are all sources of low-frequency noise. The low-frequency noise (20–200 Hz) usually emitted by heating-ventilation and air-conditioning systems occurs due to less attenuation of these unwanted sounds by walls and floors.[53,54] The presence of this low-frequency noise is a reason for the reported unpleasantness and annoyance of noise in humans.[55,56] For reducing low-frequency internal noise, the installation of thick cotton curtains and porous floor carpets, which may decrease up to 2.4–4.5 dB of internal noise, should be considered.[11,57]

Communication through spoken language is essential for students learning in an active classroom, but when there are 30–40 students (average of 36 students in this study) accommodated in one class, their loud verbalizations may increase noise levels in the classrooms. Overcrowded classrooms are a reason for elevated stress in teachers, who find it very difficult to maintain control and teach efficiently. This may cause teachers to use their voices in a strained manner, affecting their vocal health. In a study conducted by Munier and Farrell,[58] they reported teachers with a class size greater than 30 to have more frequent voice problems than those teaching fewer students. A similar result was seen in a study where teachers of larger class sizes had a threefold increased risk of having voice symptoms.[59] Due to the increased Egyptian population and the mandatory rule of the state to provide education to all children 6 years and older, schools enroll students into classrooms of more than 40–50 students,[28,60,61] the implications of which require further consideration, including the need for class size standards in Egyptian schools.

Lastly we also sought to identify associations between school type and the location of schools. We found that all public schools (N = 70, which are government funded) are situated closer to other schools, as compared with private schools, which are located closer to other government buildings (23.6%) and quiet streets with residential buildings

(16.4%, Table 7). Also, it was found here that teachers working in public schools had more voice and throat symptoms and more often felt they were in a noisy environment than teachers working in private schools, as seen in the previous study conducted by Abo-Hasseba et al[29] on the same study population. This study also mentions that public schools are overcrowded when compared with private schools, which may be one reason for the poor voice quality in public school teachers. Moreover, the public schools located close to other schools may have an additive external noise effect in the public school classrooms, causing these teachers to have a higher degree of voice problems.

The present study advocates considering noise from inappropriate school and classroom locations and poor classroom conditions to be causative factors for the prevalence of voice symptoms in teachers of Egyptian schools. This study, which is based on teacher self-reports, encourages future studies measuring internal and external noise levels of Egyptian schools to consider these factors. This would further bring about useful applications for the improved planning of new Egyptian schools and/or the renovation of existing schools. This improved planning may be in terms of location and infrastructure for improved classroom conditions with optimum acoustical quality similar to those recommended by standards in the United States.[11,62] Such an initiative would be conducive for both teachers' vocal health and a better learning place for students.

CONCLUSION

This study showed that noise resulting from inappropriate school and classroom locations and poor classroom conditions had moderate to severe repercussions on a teacher's voice. This requires attention and necessitates solutions for the future improvement of Egyptian schools and classrooms. Significant correlations between voice symptoms and inappropriate environmental conditions suggest that teachers' vocal conditions are very vulnerable to undesirable environments, including factors not typically considered to have an effect. Teachers reported feeling they were in a noisy environment most of the time and had to raise their voice due to this noise, thus straining their vocal organ. This study forms a base for future studies that could be conducted in Egyptian schools, focusing on recommending appropriate architecture and infrastructure standards that consider the health of teachers and students. The present study suggests the need for designing schools in a better way so as to achieve a positive and successful work/learning environment. Also, it suggests that teachers should be provided with vocal training programs to overcome undesirable environmental conditions and use their voices appropriately in this vocally demanding occupation.

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REFERENCES

1. Levak K, Horvat M, Domitrovic H. *Effects of Noise on Humans*. ELMAR, 2008. 50th International Symposium. Vol 1: IEEE. 2008 333−336.
2. Guski R, Felscher-Suhr U, Schuemer R. The concept of noise annoyance: how international experts see it. *J Sound Vib*. 1999;223:513–527. https://doi.org/10.1006/jsvi.1998.2173.
3. Cutiva LCC, Puglisi GE, Astolfi A, et al. Four-day follow-up study on the self-reported voice condition and noise condition of teachers: relationship between vocal parameters and classroom acoustics. *J Voice*. 2017;31:120.e1–120.e8. https://doi.org/10.1016/j.jvoice.2016.02.017.
4. Durup N, Shield BM, Dance S, et al. Teachers' voice parameters and classroom acoustics—a field study and online survey. *J Acoust Soc Am*. 2017;141:3540. https://doi.org/10.1121/1.4987482.
5. Rantala LM, Hakala S, Holmqvist S, et al. Classroom noise and teachers' voice production. *J Speech Lang Hear Res*. 2015;58:1397–1406. https://doi.org/10.1044/2015_JSLHR-S-14-0248.
6. Kristiansen J, Lund SP, Persson R, et al. A study of classroom acoustics and school teachers' noise exposure, voice load and speaking time during teaching, and the effects on vocal and mental fatigue development. *Int Arch Occup Environ Health*. 2014;87:851–860. https://doi.org/10.1007/s00420-014-0927-8.
7. Ilomäki I, Leppänen K, Kleemola L, et al. Relationships between self-evaluations of voice and working conditions, background factors, and phoniatric findings in female teachers. *Logoped Phoniatr Vocol*. 2009;34:20–31. https://doi.org/10.1080/14015430802042013.
8. Thibeault SL, Merrill RM, Roy N, et al. Occupational risk factors associated with voice disorders among teachers. *Ann Epidemiol*. 2004;14:786–792. https://doi.org/10.1016/j.annepidem.2004.03.004.
9. Shield B, Dockrell JE. External and internal noise surveys of London primary schools. *J Acoust Soc Am*. 2004;115:730–738. https://doi.org/10.1121/1.1635837.
10. Harght P, Coffeen RC. Comparing classroom acoustics in green and nongreen schools. *J Acoust Soc Am*. 2008;124:2588. https://doi.org/10.1121/1.4783209.
11. ANSI.S12.60-2002. *American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools*. Melville, NY: Acoustical Society of America. 2002:1–36.
12. Koszarny Z, Goryński P. Exposure of schoolchildren and teachers to noise at school. *Rocz Panstw Zakl Hig*. 1990;41:297–310.
13. Rogerson J, Dodd B. Is there an effect of dysphonic teachers' voices on children's processing of spoken language? *J Voice*. 2005;19:47–60. https://doi.org/10.1016/j.jvoice.2004.02.007.
14. Nelson P. The changing demand for improved acoustics in our schools. *Volta Rev*. 1999;101:23–31.
15. Åhlander VL, Rydell R, Löfqvist A. Speaker's comfort in teaching environments: voice problems in Swedish teaching staff. *J Voice*. 2011;25:430–440. https://doi.org/10.1016/j.jvoice.2009.12.006.
16. Vilkman E. Voice problems at work: a challenge for occupational safety and health arrangement. *Folia Phoniatr Logop*. 2000;52:120–125. https://doi.org/10.1159/000021519.
17. Cutiva LCC, Vogel I, Burdorf A. Voice disorders in teachers and their associations with work-related factors: a systematic review. *J Commun Disord*. 2013;46:143–155. https://doi.org/10.1016/j.jcomdis.2013.01.001.
18. Tiesler G, Oberdörster M. Noise—a stressor? Acoustic ergonomics of schools. *Build Acoust*. 2008;15:249–261.
19. Berg FS, Blair JC, Benson PV. Classroom acoustics: the problem, impact, and solution. *Lang Speech Hear Serv Sch*. 1996;27:16–20. https://doi.org/10.1044/0161-1461.2701.16.
20. Bottalico P, Astolfi A, Hunter EJ. Teachers' voicing and silence periods during continuous speech in classrooms with different reverberation times. *J Acoust Soc Am*. 2017;141:EL26–EL31. https://doi.org/10.1121/1.4973312.
21. Puglisi GE, Astolfi A, Cantor Cutiva LC, et al. Four-day-follow-up study on the voice monitoring of primary school teachers: relationships with conversational task and classroom acoustics. *J Acoust Soc Am*. 2017;141:441–452. https://doi.org/10.1121/1.4973805.

22. Astolfi A, Carullo A, Pavese L, et al. Duration of voicing and silence periods of continuous speech in different acoustic environments. *J Acoust Soc Am*. 2015;137:565–579. https://doi.org/10.1121/1.4906259.
23. Durup N, Shield B, Dance S, et al. An investigation into relationships between classroom acoustic measurements and voice parameters of teachers. *Build Acoust*. 2015;22:225–241.
24. Hunter EJ, Bottalico P, Graetzer S, et al. Teachers and teaching: speech production accommodations due to changes in the acoustic environment. *Energy Procedia*. 2015;78:3102–3107. https://doi.org/10.1016/j.egypro.2015.11.764.
25. Åhlander VL, García DP, Whitling S, et al. Teachers' voice use in teaching environments: a field study using ambulatory phonation monitor. *J Voice*. 2014;28:841.e5–841.e15. https://doi.org/10.1016/j.jvoice.2014.03.006.
26. Bottalico P, Astolfi A. Investigations into vocal doses and parameters pertaining to primary school teachers in classrooms. *J Acoust Soc Am*. 2012;131:2817–2827. https://doi.org/10.1121/1.3689549.
27. Pelegrín-García D, Brunskog J. Speakers' comfort and voice level variation in classrooms: laboratory research. *J Acoust Soc Am*. 2012;132:249–260. https://doi.org/10.1121/1.4728212.
28. Bolbol SA, Zalat MM, Hammam RA, et al. Risk factors of voice disorders and impact of vocal hygiene awareness program among teachers in public schools in Egypt. *J Voice*. 2017;31:251.e9–251.e16. https://doi.org/10.1016/j.jvoice.2016.07.010.
29. Abo-Hasseba A, Waaramaa T, Alku P, et al. Difference in voice problems and noise reports between teachers of public and private schools in Upper Egypt. *J Voice*. 2017;31:508.e11–508.e16. https://doi.org/10.1016/j.jvoice.2016.10.016.
30. AboulKheir AE. *Consideration of primary school design standards with reference to Egyptian schools [doctoral dissertation]*. 1967. https://doi.org/10.3929/ethz-a-000089241.
31. Ibrahim N. Efforts for improving buildings conditions in public schools in Egypt: SWOT analysis of two governmental renovation programs; 2017. [master thesis] American University in Cairo. Available at: http://dar.aucegypt.edu/handle/10526/4977. Accessed March 27, 2018.
32. El Baradei M, El Baradei L. Needs assessment of the education sector in Egypt; 2004. ZEF Bildungsstudie, Cairo. Available at: https://www.zef.de/fileadmin/webfiles/downloads/projects/el-mikawy/egypt_final_en.pdf. Accessed March 27, 2018.
33. Hamdy A. Survey of ICT and education in Africa: Egypt Country Report; 2007. Available at: http://www.infodev.org/infodev-files/resource/InfodevDocuments_399.pdf. Accessed March 27, 2018.
34. Ali SA. Investigation of the dose−response relationship for road traffic noise in Assiut, Egypt. *Appl Acoust*. 2004;65:1113–1120. https://doi.org/10.1016/j.apacoust.2004.06.007.
35. Ali SA. Railway noise levels, annoyance and countermeasures in Assiut, Egypt. *Appl Acoust*. 2005;66:105–113. https://doi.org/10.1016/j.apacoust.2004.06.005.
36. Ali SA. Study effects of school noise on learning achievement and annoyance in Assiut City, Egypt. *Appl Acoust*. 2013;74:602–606. https://doi.org/10.1016/j.apacoust.2012.10.011.
37. Zaki GR. Assessment of ambient noise levels in the urban residential streets of Eastern Alexandria, Egypt. *J Egypt Public Health Assoc*. 2012;87:96–103. https://doi.org/10.1097/01.EPX.0000421367.39770.52.
38. Martin S, Darnley L. *The Teaching Voice*. 2 ed. London: Whurr; 2004.
39. Awad HS, Farag HH, Hanafi MA, et al. *Architectural acoustics in educational facilities: An empirical study on university classrooms in Egypt*. Proceedings of Meetings on Acoustics 164ASA. Vol 18: ASA. 2012. 015002. https://doi.org/10.1121/1.4772593.
40. Herrera L. Participation in school upgrading: gender, class and (in) action in Egypt. *Int J Educ Dev*. 2003;23:187–199. https://doi.org/10.1016/S0738-0593(02)00013-5.
41. Lombard E. Le signe de I'elevation de la voix, Annals Maladiers Oreille. *Larynx Nez Pharynx*. 1911;37:101–119.
42. Lee J, Ali H, Ziaei A, et al. The Lombard effect observed in speech produced by cochlear implant users in noisy environments: a naturalistic study. *J Acoust Soc Am*. 2017;141:2788–2799. https://doi.org/10.1121/1.4979927.
43. Augustyńska D, Kaczmarska A, Mikulski W, et al. Assessment of teachers' exposure to noise in selected primary schools. *Arch Acoust*. 2010;35:521–542. https://doi.org/10.2478/v10168-010-0040-2.
44. Bronder A. Study of phenomenon of voice disorders in the population of teachers and the prevention rules. [doctor's thesis]. Institute of Occupational Medicine and Environmental Health in Sosnowiec, Sosnowiec, Poland. 2003.
45. *World Health Organization*. The physical school environment: an essential element of a health-promoting school; 2004. Available at: http://www.who.int/iris/handle/10665/42683. Accessed March 27, 2018.
46. Van Renterghem T, Botteldooren D, Verheyen K. Road traffic noise shielding by vegetation belts of limited depth. *J Sound Vib*. 2012;331:2404–2425. https://doi.org/10.1016/j.jsv.2012.01.006.
47. Gordon DE. Green schools as high performance learning facilities; 2010. National Clearinghouse for Educational Facilities. Available at: http://files.eric.ed.gov/fulltext/ED512700.pdf. Accessed March 27, 2018.
48. Moussa M, Mostafa Y, Elwafa A. School site selection process. *Procedia Environ Sci*. 2017;37:282–293. https://doi.org/10.1016/j.proenv.2017.03.059.
49. Vintturi J, Alku P, Sala E, et al. Loading-related subjective symptoms during a vocal loading test with special reference to gender and some ergonomic factors. *Folia Phoniatr Logop*. 2003;55:55–69. https://doi.org/10.1159/000070088.
50. Laukkanen A-M, Järvinen K, Artkoski M, et al. Changes in voice and subjective sensations during a 45-min vocal loading test in female subjects with vocal training. *Folia Phoniatr Logop*. 2004;56:335–346. https://doi.org/10.1159/000081081.
51. Laukkanen A-M, Kankare E. Vocal loading-related changes in male teachers' voices investigated before and after a working day. *Folia Phoniatr Logop*. 2006;58:229–239. https://doi.org/10.1159/000093180.
52. Zhai G, Zhang B. The design of ventilation and sound insulation window. *Noise Vib Control*. 2004;1:014.
53. Berglund B, Hassmen P, Job RS. Sources and effects of low-frequency noise. *J Acoust Soc Am*. 1996;99:2985–3002. https://doi.org/10.1121/1.414863.
54. Waye KP, Rylander R, Benton S, et al. Effects on performance and work quality due to low frequency ventilation noise. *J Sound Vib*. 1997;205:467–474. https://doi.org/10.1006/jsvi.1997.1013.
55. Leventhall G, Pelmear P, Benton S. A review of published research on low frequency noise and its effects; 2003. Available at: http://westminsterresearch.wmin.ac.uk/4141/1/Benton_2003.pdf. Accessed March 27, 2018.
56. Baliatsas C, van Kamp I, van Poll R, et al. Health effects from low-frequency noise and infrasound in the general population: is it time to listen? A systematic review of observational studies. *Sci Total Environ*. 2016;557:163–169. https://doi.org/10.1016/j.scitotenv.2016.03.065.
57. Zhisheng L, Dongmei L, Sheng M, et al. Noise impact and improvement on indoors acoustic comfort for the building adjacent to heavy traffic road. *Chin J Popul Resour Environ*. 2007;5:17–25. https://doi.org/10.1080/10042857.2007.10677482.
58. Munier C, Farrell R. Working conditions and workplace barriers to vocal health in primary school teachers. *J Voice*. 2016;30:127.e31–127.e41. https://doi.org/10.1016/j.jvoice.2015.03.004.
59. Thomas G, Kooijman P, Cremers C, et al. A comparative study of voice complaints and risk factors for voice complaints in female student teachers and practicing teachers early in their career. *Eur Arch Otorhinolaryngol Head Neck*. 2006;263:370–380. https://doi.org/10.1007/s00405-005-1010-6.
60. *Egypt*. World data on education; 2012. Available at: http://www.ibe.unesco.org/fileadmin/user_upload/Publications/WDE/2010/pdf-versions/Egypt.pdf. Accessed March 27, 2018.
61. Ministry of Education. *National strategic plan for pre-university education reform in Egypt 2007/08−2011/12*. Cairo. 2007.
62. American National Standards Institute/Acoustical Society of America. *S12.60-2009/Part 2 American National Standard Acoustical Performance Criteria DR, and Guidelines for Schools, Part 2: Relocatable Classroom Factors*. Melville, NY: Acoustical Society of America. 2009.