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Lyberg Åhlander, Viveka

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221 00 Lund
+46 46-222 00 00

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Voice use in teaching environments
Speakers' comfort



LUND UNIVERSITY
Faculty of Medicine

Viveka Lyberg Åhlander
Department of Logopedics, Phoniatics & Audiology
Clinical Sciences, Lund University,
Lund, Sweden

“C’est toujours les voix qui restent, au final, c’est aussi par elle que ça commence. Une voix plus une oreille; deux fils de soie impalpables et un pavillon”.

At the end it’s the voices that remain, it’s also with them that everything starts. One voice and one ear; one auricle and two impalpable silken threads

Jean-Jacques Schuhl “Ingrid Caven”

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To my

‘fantastic four’

Arne, Elias, David and Samuel

.

TABLE OF CONTENTS

LIST OF PUBLICATIONS	1
ACKNOWLEDGMENTS	2
ABBREVIATIONS AND DEFINITIONS	5
THESIS AT A GLANCE	7
INTRODUCTION	9
Definition of voice problems and vocal load	11
Speakers' comfort	11
Voice use in teachers and environmental factors of vocal load	12
Inter-individual factors influencing voice load	17
Measuring voice and vocal load	18
Prevalence of voice problems in teaching staff	20
Summary of the introduction	24
SUBJECTS AND METHODS	26
Subjects	26
Methods	31
Examinations of voice, larynx and hearing	35
Study III: Recordings of voice	35
Study III: Voice Range Profile	35
Study IV: Field recordings, voice dosimetry	36
Study III Laryngeal examination and recording	37
Study III Audiometry	37
Registration of noise, room-acoustics and indoor air quality	37
Analyses of voice, larynx and hearing	38
Statistical methods	40
Ethical considerations	42
RESULTS	43

Study I	43
Study II	45
Study III	54
Study IV	55
GENERAL DISCUSSION	64
CONCLUSIONS	81
SVENSK SAMMANFATTNING	83
REFERENCES	85
APPENDIX	100
a) Voice Handicap Index- Throat	100
b) Questionnaire for study II	103

LIST OF PUBLICATIONS

This thesis is based on the studies reported in the following papers, referred to in the text by their respective Roman numerals.

- I Viveka Lyberg Åhlander, Roland Rydell, Jacqueline Eriksson, & Lucyna Schalén, Throat related symptoms and voice: Development of an instrument for self assessment of throat-problems. BMC Ear, Nose and Throat Disorders, 2010, 10:5. DOI: 10.1186/1472-6815-10-5.
- II Viveka Lyberg Åhlander, Roland Rydell, & Anders Löfqvist, Speaker's comfort in teaching environments: Voice problems in Swedish teaching staff. Journal of Voice, in press. Corrected proof, available online 26 March 2010. DOI: 10.1016/j.jvoice.2009.12.006.
- III Viveka Lyberg Åhlander, Roland Rydell, & Anders Löfqvist, How do teachers with self-reported voice problems differ from their colleagues with self reported voice health? Submitted for publication
- IV Viveka Lyberg Åhlander, David Pelegrín García, Roland Rydell, & Anders Löfqvist. Teacher's voice use in teaching environments: A field study using Ambulatory Phonation Monitor (APM). Manuscript.

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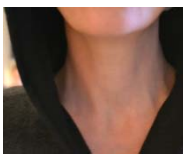
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ABBREVIATIONS AND DEFINITIONS

APM	Ambulatory Phonation Monitor.
BNL	Background Noise Level.
Cycle dose unit.	Number of vibratory cycles performed by the vocal folds per time unit.
F0	Fundamental of the voice, in Hz.
JCQ	Job Content Questionnaire.
LTAS	Long Time Average Spectrum.
RT	Reverberation Time, the time it takes for the sound level in a room to decrease by 60 dB after a continuous sound source has been shut off.
SMBQ	Shirom Melamed Burnout Questionnaire.
SPL	Sound Pressure Level, in dB.
SSP	Swedish Universities Scale of Personality.
STI	Speech Transmission Index, a well validated measure of the effect of a room on the transmitted speech. The STI varies from 0 (completely unintelligible) to 1 (perfect intelligibility).
ST _v	Acoustic Voice Support: the speaker's perception of the voice, related to both the direct sound from the mouth to the ears and the reflected sound from the room.
Time dose	Time phonated in percentage of the measured time.
UCL	Utrechtste Coping List.
VHI-T	Voice Handicap Index-Throat.
VPL	Voice Power Level, the source power in dB.
VPR	Voice Range Profile (synonymous to phonetogram), in dB and Hz.

THESIS AT A GLANCE

Study	Aim	Method	Results	Conclusion
I VHI-T 	To develop a rating scale for the self-assessment of throat related symptoms in relation to voice symptoms	Development of a subscale with 10 statements added to the Voice Handicap Index (VHI). Test-retest of two test-occasions with the VHI-T by 144 voice patients and 58 voice healthy controls. Comparison between patients and controls	Good correlation between the test-occasions. The scale discriminates between patients and controls. Cronbach's alpha for total VHI-T $r=0,90$ and for the throat-scale $r=0,87$.	The subscale with statements of throat-related symptoms together with the Voice Handicap Index forms the VHI-T. It proves to be a reliable and stable instrument for use in the clinic and in research.
II Prevalence of voice problems in teaching staff 	To explore how teaching staff rate their teaching environment in relation to the voice. To explore the prevalence of voice problems in Swedish teaching staff.	Cross-sectional cohort study. Questionnaires distributed to 22 schools. 487 questionnaires collected at collegial meetings. 467 analyzed. Teachers with self-assessed voice problems were compared to voice healthy teachers.	Voice problems were defined as 2-4 on the frequency based rating-scale (0-4). The teachers with voice problems rated aspects of room acoustic, back-ground noise and environment as more disturbing than their colleagues. The groups differed significantly for all voice items. Prevalence of voice problems found to be 13%.	Teachers suffering from voice problems react stronger to loading factors in the teaching environment, report more frequent symptoms of voice discomfort and are more absent from work due to voice problems.

III Etiology of voice problems in teachers 	To compare teachers with self-assessed voice problems to their voice healthy colleagues. To relate the self-assessed voice function to laryngeal function, voice quality; personality; psychosocial aspects and hearing.	Case-control design, prospective study. 31 teachers with voice problems from study II were compared to age, gender and school-matched colleagues. Recordings by high-speed digital imaging, voice recordings; voice range profile; audiometry; VHI-T and questionnaires on personality, coping and psychosocial aspects.	The groups differed for all statements of the VHI-T and the teachers with voice problems rated significantly longer times for vocal recovery.	The differences between teachers with voice problems and those without are not found in the vocal apparatus or within the individual. The individual's perception of voice problems seems to be a combination of the number of voice symptoms along with the time for vocal recovery.
IV Field study of voice use 	To investigate the vocal behavior and voice use in teachers with self-estimated voice problems and their voice healthy peers.	Case-control prospective field study. 14 teachers with voice problems from studies II & III were compared to age, gender and school matched colleagues. Measurements during a whole "school-day" were made with a voice accumulator, and a structured diary.	The teachers with voice problems behaved differently compared to their voice healthy peers. Time and cycle doses were significantly higher in this group. Also the F0 pattern related to both voice level and room acoustics differed.	The results suggest a higher voice load in teachers with voice problems and fewer possibilities for voice rest and recovery. Teachers with voice problems also show less flexibility in controlling the fundamental frequency in relation to the sound pressure level of the voice.

INTRODUCTION

“The teacher's voice needs to be effective in a variety of circumstances. The frequently heard suggestion that (out-of-work) actors might help teachers how to use their voices, ignores the fact that Equity (the British actors' union) would protest vociferously if any of its members had the daily voice load of the average teacher. Switching from one-to-one and small groups to whole-class, assembly, physical education and games situations, not to mention the acoustic delights of corridors and laboratories, teachers have to have 'adaptability' as one of their several middle names. They need a voice which projects well and appropriately in all these circumstances and which is also pleasant to listen to, even when being at its most authoritative. Warm and expressive voices, used in an imaginative way, draw pupils in and make them want to pay attention and listen. If such a voice has quality and liveliness, they will be motivated to attend, participate and learn.” (Hendy, 2009)

This web-citation captures well the demands that teachers, pupils and parents unconsciously put on the teacher's voice. The teacher-voice seems to be a tool, taken for granted, which is not asked for before it stops working or deviates from its normal function in some way. During the last decades, an increasing focus has been put on teachers' voice and the consequences of vocal problems. In 1996, Fritzell, presented a paper on voice and occupations, identifying teachers to be the most common occupational group at voice clinics, in relation to the percentage of the total number of teachers in the population at that time in Sweden. The prevalence of voice problems in Swedish teachers is, however, largely a substantial number of unrecorded cases since teachers rarely seem to seek help for their voice problems. Voice difficulties at work seem to be regarded as more of an individual problem, depending on the individual's innate capacities or voice use or “abuse”, than as an occupational hazard (Vilkman, 2000).

Three of the included papers in this thesis (*studies II-IV*) were initiated within the project of “Speakers' comfort and voice health in teaching environments”. The project aimed at investigated teachers' voice use in relation to the class-room acoustics, based on the hypothesis that the environment influences the way speakers regulate their voices. This is an intriguing perspective that has not been investigated earlier in relation to teachers' voice health. Vocal ergonomics is an area that has attracted increased research interest during the last decade (Vilkman, 2004). However, the awareness of the importance of knowledge in this area also in the voice clinic is more recent or maybe revived. The project “Speakers' comfort” was carried out in close cooperation with research colleagues at the Department of Acoustics at Denmark Technical University.

Vilkman (2000), summarizing relevant studies that have investigated subjective complaints among teachers, conclude that the majority of teachers have experienced vocal problems, one tenth suffer from severe problems, and 5% have experienced problems so severe that their working ability is questionable. Verdolini & Ramig, (2001) estimated the costs for sick-days and treatment in US teachers to \$2,5 billion. Teachers have reported that their work performance is affected by their voice capacity and vocal problems (e.g. Roy, Merrill, Gray, & Smith, 2005; Russell, Oates, & Greenwood, 1998; Sapir, Keidar, & Mathers-Schmidt, 1993) and there are findings indicating that the pupils' understanding is negatively influenced by the teacher's unhealthy voice (Rogerson & Dodd, 2005).

The need for training teachers' voices has been discussed for a long time (J. M, 1915; Winter, 1915). However, the attention has been focused on the individual's work and not on other factors that may help or hinder voice use. The work environment has been examined more closely since factors of *vocal loading* have been identified as major contributors to voice problems in occupations with high vocal demands (Vilkman, 2004). In some countries, such as Sweden, there is as yet no legislation concerning voice load. There are, however, recommendations concerning voice use in relation to background noise (Swedish dep. of work-environment and occupational health, 2009).

Although much today is known about teachers' voices and voice use, only a few studies have taken into account the teachers' opinion of their work-environment. Even fewer have explored the teachers' actions in the work environment. Moreover, the work environment, i.e. the classroom's air-quality and acoustics, has often been discussed and acknowledged to contribute to the vocal load, but these factors are seldom investigated when the teacher is teaching.

The main purpose of the present thesis was thus, to investigate the voices and the voice use of teaching staff in their teaching environment and to explore the prevalence of voice problems in Swedish teachers. Additional aims were:

- To explore the teachers' ratings of aspects of their working environment that can be presumed to affect the vocal behavior and the voice.
- To measure the teachers' voice use in relation to some of those factors.
- To clinically assess the voice function in the teachers with self-rated voice problems and to compare it to their vocally healthy colleagues.
- To compare the teachers, one main objective was to develop and assess a self-rating instrument for the rating of throat-related problems in relation to the voice.

The following sections introduce and define aspects of the teachers' voice, vocal loading and, the prevalence of voice problems.

Definition of voice problems and vocal load

“Voice problems” is a concept used throughout this thesis. It has been defined by Colton, Casper, & Leonard (2006) to comprise subjective symptoms that may be summarized as: difficulties in phonation, deviant voice quality and/or physical pain or sensation related to voice use. Vilkmán (2004) also adds the aspect of [subjective] vocal endurance as a core aspect of occupational voice problems.

Vocal/voice load is today indisputably acknowledged as one of the major causative factors of voice problems perceived by teachers. As defined by Vilkmán (2004), the term “voice load” links occupational demands on the voice to the “physical, corporeal nature of voice production” (Vilkmán, 2004, p 222). Vocal loading may be seen as a process, ranging from vocal warm-up, via fatigue to voice rest and vocal recovery. “Vocal fatigue” is highly subjective and has been defined by Vintturi (2001) in healthy subjects to include physiological, perceptual or subjective changes. During warm-up, the phonation subjectively becomes more effortful (Vintturi, Alku, Sala, Sihvo, & Vilkmán, 2003), there is a rise of the fundamental (F0) and the sound pressure level (SPL) (Laukkanen, Ilomäki, Leppanen, & Vilkmán, 2008; Rantala, Vilkmán, & Bloigu, 2002; Vintturi et al., 2001b), and the phonation becomes more hyperfunctional (Löfqvist & Mandersson, 1987; Rantala, Paavola, Korkko, & Vilkmán, 1998). There is a gender difference, since females report more vocal effort than males (Södersten, Ternström, & Bohman, 2005; Vintturi et al., 2003), and more vocal fatigue (e.g. Russell et al., 1998; Vintturi et al., 2003).

Speakers' comfort

One of the core concepts in this thesis is “Speakers' comfort” that ties together the voice use and the speaker's subjective perception of the voice. It is defined as the subjective impression that talkers have when they feel that their vocal message reaches the listener effectively [with no or low vocal effort]. In this subjective impression, experienced while hearing and perceiving one's own voice, some attributes play important roles: the voice-support provided by the room and the speech intelligibility along with the sensory-motor feedback from the phonatory apparatus (Payà Ballester, 2007).

Voice use in teachers and environmental factors of vocal load

Voice use

Prolonged voice use has traditionally been considered to be one of the most causative factors in functional voice disorders. Measurement of phonation-time *i.e.* the percentage or the time spent phonating in relation to the total measured time, has been performed in groups with anticipated high occupational voice load. Masuda, Ikeda, Manako, & Komiyama (1993) reported a phonation time of 20% in kindergarten teachers, Titze, Hunter, & Svec (2007) a phonation time of 23% in teachers, and in a recent study Hunter & Titze (2010) found phonation times as high as 30%, +/-11%. Södersten, Granqvist, Hammarberg, & Szabo, (2002) reported a phonation-time of 16.9% in pre-school teachers. These measures should be compared to the voicing percentages of 7% (Masuda et al., 1993) and 5% (Ohlsson, Brink, & Löfqvist, 1989) in subjects with no, or lower, occupational vocal demands. Teachers thus have a higher phonation time than individuals with a lesser occupational voice load. However, there are no field studies comparing the voice use in groups of teachers with and without voice problems.

Rest and recovery

High phonation time causes the vocal folds to collide more frequently. During an equally long period of time, females' vocal folds collide more often than the males' due to the higher fundamental frequency of the voice. Hence, a female teacher with a fundamental frequency of 200 Hz, spending 20% of her teaching (6 hrs) phonating would experience 864 000 collisions of the vocal folds during one work-day (Hunter & Titze, 2009; Roy et al., 2004). Roy et al., (2004) reason that the more frequent reports of vocal fatigue in females than in males are due the higher frequency of collisions of the vocal folds.

McCabe & Titze, (2002) developed a conceptual, behavioral model of vocal fatigue and voice recovery. The model describes how phonatory effort, *i.e.* "central fatigue", leads to compensatory functional changes (e.g. greater adduction of the vocal folds), which lead to alterations of neuromuscular processes and changes of the lamina propria (e.g. prevention of a stable blood circulation, and organic micro-changes). These alterations result in non volitional changes of voice quality, *i.e.* "peripheral fatigue", increasing the phonatory effort, further leading to increased central fatigue, etc. Based on the outcomes of a therapy based on this model, performed in four teachers with vocal fatigue, McCabe & Titze, (2002) suggest that vocal recovery occurs in two phases. The first, short time recovery, occurs during the first 1-2 hours after voice load as a constant process independent

of the rated level of fatigue. The second, long-time recovery, takes several days and is hypothesized to correlate to recovery of the lamina propria. The occurrence and distributions of pauses during the day may thus be crucial for the possibility of recovery. The importance of pauses, both long and short ones, has been identified in relation to voice recovery after vocal load (Carroll et al., 2006; Hunter & Titze, 2009; Titze et al., 2007; Vintturi et al., 2001a). Short pauses occur during breathing and swallowing (Vintturi et al., 2001a). Vinturri et al. (2001b) concluded that the SPL level in male voices dropped significantly during and after voice rest and that their voices changed toward a less hyperfunctional quality. Changes in female voices were not as significant but the glottal closure was improved which can be interpreted as signs of improved vocal function.

The time it takes to recover from temporary voice problems has traditionally been on the clinical checklist for the case history of patients with voice dysfunction. A difference between males' and females' self-rated vocal recovery was reported by Russell et al. (1998) who found female teachers to need significantly longer recovery times than men for voice symptoms occurring at the time of the study. In a study comparing day-care center staff to nurses Sala, Laine, Simberg, Pentti, & Suonpaa, (2001) found the teachers to rate their voice symptoms to last significantly longer than the nurses did. The findings of Sala et al., (2001) are in line with those of Bermudez de Alvear, Baron, & Martinez-Arquero, (2011) who showed a long duration for recovery to be a high odds factor in determining voice disorders in teachers. Thus, rest during the day seems important to prevent voice problems.

Background noise

Speaking in background noise is a factor of vocal load (Vilkman, 2004; Södersten et al., 2005). The Lombard effect (Lane & Tranel, 1971) describes the influence of noise on the voice function. The speaker automatically raises the sound pressure level and changes the spectral contents of the voice signal as the noise level increases. The background noise level in classrooms is usually high, also during instruction, as shown by Pekkarinen & Viljanen (1991). Pekkarinen, Himberg, & Pentti (1992) reported that 40% of the teachers compared to 23% in a group of nurses found the background noise disturbing often or very often, and that the noise from inside the classroom was considered more disturbing than the noise coming from the outside. Södersten et al., (2005) investigated the rise of F0 and SPL due to background noise in vocally healthy subjects. They showed that the speaker increases the SPL and F0 and prolongs the phonation time when exposed to noise (due to prolonged speech), especially continuous noise. In addition, the voice quality changed towards a more hyperfunctional phonation pattern, there was an increase of instability and roughness, and a decrease of vocal fry. In that

study, females also reported less success in making themselves heard and using greater effort to do so. In a companion study, Ternström, Bohman, & Södersten (2006) measured the spectral balance, *i.e.* the ratio of energy in the frequency bands 2-6 kHz and 100-1000 Hz. (This measure was used as a simpler substitute for spectrum slope). Ternström et al. (2006) found the spectrum balance to increase with SPL but only up to a “saturation point” that occurred 6-8 dB below the personal maximum SPL. Above this point that occurred at individual voice SPL:s (average 93,2 dB for females and 97,4 for males) the increase stopped. They concluded that the normalized SPL minus the saturation point (voice SPL-SPL_{sat}) could better predict the individual rating of vocal strain than the SPL alone, at least in the male subjects. Ternström et al (2006) argue that the saturation point ideally might be an indication of an individual hazard strain limit.

Moreover, Lindström, Persson Waye, Södersten, McAllister, & Ternström, (2011) showed that there is a large variation in vocal behavior due to noise exposure. Thus, it is important to study voice use in real life to further understand the vocal behavior and detect possible individual differences in voice use and in the management of vocal load.

Voice and room acoustics

Every experienced talker knows the need to adapt to the acoustics of the room, although this adaptation is probably unconscious in most speakers. The influence of the room acoustics on the voice is a factor often mentioned, but seldom studied in relation to the development of voice disorders. Pekkarinen & Viljanen, (1991) concluded that many Finnish classrooms were too reverberant resulting in reduced intelligibility, which may cause the speaker to use more effort when speaking. On the other hand, Black, (1951) concluded that speakers talk louder in highly absorptive rooms than in more acoustically “live” rooms.

Kob, Behler, Kamprolf, Goldschmidt, & Neuschaefer-Rube, (2008) studied teachers with different voice status acting in different rooms and found that teachers with voice problems were more affected by the acoustic properties of the room than their voice healthy colleagues. Furthermore, Brunskog, Gade, Payá-Bellester, & Reig-Calbo (2009) studied voice healthy subjects in different rooms and found that the speaker changes the level of the voice (VPL) in relation to the room acoustics, which is related to the size of the room. Brunskog et al (2009) also found a correlation between the vocal behavior of the speaker and the speaker's rating of how comfortable the room was to talk in.

Lacking a measure describing the speaker's perception of the room acoustics, earlier investigations of voice and room acoustics, have used measures that focus

on the listeners' perspective, such as the reverberation time or the Speech Transmission Index (see Kuttruff, 2009). For examining the effect of the room acoustics on the voice use, one useful starting point is the results by Brunskog et al. (2009) who studied speakers' preference for room-acoustical properties providing a good speaker's comfort. Based on that study, Brunskog & Pelegrín García (2010) and Pelegrín García, (2011) introduced the measure of *Acoustic Voice Support* to cover the speaker's perspective. In a laboratory study with 14 subjects Pelegrín García, Smits, Brunskog, & Jeong, (2011) found that the speakers' changes of the voice level were induced by the room and also were related to the *Acoustic Voice Support* given by the room.

The *Acoustic Voice Support* is a measure describing the speaker's perception of the voice in a room. The *Voice Support* is a measure based on the two properties of the *impulse response* that describe the airborne acoustic path between the mouth and the ears. The two properties are the *direct sound* that travels from the mouth to the ears, and the *indirect sound* that is reflected to the speaker from the boundaries of the room. Thus, the *Acoustic Voice Support* is the ratio between the energy of the reflected sound (E_r) and the energy of the direct sound (E_d), see Equation 1.

$$STV = 10 \log \frac{E_r}{E_d}$$

The *Acoustic Voice Support* ranges from -18dB to -5dB in normal rooms and differs from the traditionally used measures by the way in which it takes the producers' perception of the sound into account.

Noise

The tolerance for noise depends on individual factors, such as general tolerance, hearing capacity, and hearing impairment. The perception of noise depends mainly on the loudness, frequency and spectral characteristics of the noise (AFS2005:16). The same noise may thus be perceived differently by different individuals and under different circumstances. Teaching premises are of special interest for noise regulation, since noise might mask the speech and reduce the intelligibility of the spoken message. The Swedish recommendation for maximum daily exposure to background noise in rooms used for teaching is 35dB (AFS2005:16).

Most speakers intuitively try to regulate the voice to get across to the listener both as a result of the Lombard effect and also due to the distance to the listener. The latter has been examined by Pelegrín-García, Smits et al. (2011) who showed that

the speakers raise their vocal power when the distance to the listener increases, at a rate of 1.5~2dB per doubling of the distance. The measurements were performed in four rooms: an anechoic chamber, a reverberation room, a long narrow corridor, and a lecture room and at 1,5 m, 3 m, 6m and 12 m away from the listener. Somewhat different results were obtained by Traunmüller & Eriksson (2000) who showed the increase to be 4,6dB for a doubled distance at 7,5 ; 37,5 and 187,5 m, in subjects speaking/shouting outdoors at distances up to 187 m. According to Pelegrín-García, Smits et al., (2011) the differences in SPL might be ascribed to differences in instructions and also to the fact that when the sound is not reflected by any boundaries (as outdoors and in an anechoic chamber), the speaker raises the SPL. This indicates that auditory cues are important in the regulation of the voice level and underlines the importance of exploring hearing capacity in studies of voice use.

Air quality

Patients diagnosed with functional voice disorders often report that “dry air” and poor air quality are troublesome for their voices. A number of authors have concluded from laboratory experiments that both systemic hydration and ambient humidity levels affect the phonation, (e.g. Leydon, Sivasankar, Falciglia, Atkins, & Fisher, 2009; Sivasankar & Leydon, 2010; Verdolini, Titze, & Fennell, 1994; Vintturi et al., 2003). As an example, Vintturi et al. (2003) reported higher phonatory effort in females in low ambient humidity. Geneid et al. (2009) reported provoked subjective vocal reactions to air quality in a provocation test. Lyberg Åhländer, Malm, & Schalén (2009) investigated subjective complaints and analyses of voice changes after exposure to saline solution/methacholine in subjects reporting reactions to different irritants in their working environment, comparing them to voice healthy subjects. The frequency of subjective complaints was equal in both groups for both substances. However, there was a qualitative difference in the character of the symptoms: the patients complained of throat, vocal, and nasal symptoms whereas the controls complained exclusively of nasal symptoms. However, there is a lack of field studies using air-quality measurements.

Stress and psychological factors

Stress is considered to be one of the factors that may add to the subjective perception of voice load (Vilkman, 2004). Teachers commonly work in a stressful environment with high vocal and psychological demands and a large number of students. Gassull, Casanova, Botey, & Amador (2010) concluded in a recent study that teachers with voice problems were highly reactive to stress.

There is an increasing number of studies linking psychological factors to functional dysphonia (e.g. Baker, 2010; Deary, Wilson, Carding, & Mackenzie, 2003a; Yiu, 2002). These factors include higher levels of anxiety, lower levels of sense of control, quality of life, and coping (Deary et al., 2003a; McAleavy, Adamson, Hazlett, Donegan, & Livesey, 2008; Roy, Bless, & Heisey, 2000a). Roy, Bless, & Heisey, (2000b) found that the majority of people with functional dysphonia were introverts. Andersson & Schalén, (1998) noted that interpersonal conflicts related to family and work were one important contributing factor in psychogenic voice disorders. It is therefore often argued that personality and the psychosocial environment influences voice disorders in teachers, but there are only a few studies that have investigated this relationship (Gassull et al., 2010; Gotaas & Starr, 1993; Kooijman et al., 2006; McAleavy et al., 2008; Pekkarinen et al., 1992). In analogy with Gotaas & Starr (1993), the group of teachers answering to a questionnaire survey by McAleavy et al. (2008) rated presence of “trait anxiety”, assessed with the State Trait Anxiety Inventory ([STAI] Spielberger, Gorsuch, & Lushene, (1970). Pekkarinen et al., (1992) did not find any significant correlation between the personality profile (defined as introversion-extroversion) and vocal symptoms between teachers and nurses, which is in analogy with the findings of Kooijman et al., (2006) from a questionnaire study in 1878 teachers. To summarize, there is still a need to investigate the role of stress and psychological factors in relation to voice disorders in general, and specifically in teachers. However, it seems that the personality profile is not as important as anxiety and stress coping.

Inter-individual factors influencing voice load

Gender

The results by Roy et al., (2004) indicated that being a female and being between 40-59 years of age were positively associated with having experienced a voice problem. Females are more at risk for developing voice disorders (Baker, 2010; Fritzell, 1996; Morton & Watson, 1998; Russell et al., 1998; Vilkmán, 2004). Females are more often affected by vocal loading (Pekkarinen et al., 1992; Russell et al., 1998). One reason is the doubled frequency of vocal fold collisions that occur due to the higher fundamental frequency of the female voice (Titze et al., 2007). There is a gender difference of the distribution and concentration of Hyaluronic Acid in the vocal folds, and the possible damping effects of this on the collision force is debated (Lebl, Martins, Nader, Simoes Mde, & De Biase, 2007; Schweinfurth & Thibeault, 2008).

Age

Age is a factor that has been discussed, but not established, as an influencing factor on voice disorders in teachers. Roy et al., (2004) concluded that females in the age-range of 40-59 years were more likely to have a history of voice problems, a result in line with the findings of Russell et al., (1998) who reported more voice problems in teachers 50 years or older. On the other hand, in a recent study by Bermudez de Alvear et al. 2011) assessing the prevalence of and risk factors for voice disorders in 2103 teachers, age did not turn out as a significant risk factor for voice disorders. Similar findings were made Kooijman, Thomas, Graamans, & de Jong, 2007) who could not find any correlation between the amount of complaints and age in a group of 1875 teachers. However, there are some indications, based on the results by Kooijman et al. (2007), that teachers complain more of voice problems early in their career. Similar to gender and age, years of teaching was also a factor identified by Roy et al., (2004) to be related to a history of voice problem. This might indicate that it is more important to focus on the number of years in teaching, which of course does not always co-vary with age, due to possible earlier occupations, and maternity-leaves.

Hearing

A prevailing problem in teaching staff is tinnitus and hearing impairments. However, little, if any, attention has been drawn to hearing in teachers in relation to voice production and voice problems. Most probably, the hearing capacity is crucial for the perception of one's own voice, not least in relation to the room-acoustics. Thomas, de Jong, Cremers, & Kooijman, (2006) found that 30% of 457 female teacher students considered their decrease in hearing to negatively influence on their voice. Gotaas & Starr, (1993) found that 35 teachers with signs of vocal fatigue had significantly more problems from their ears compared to a voice healthy control group.

Measuring voice and vocal load

Clinical investigations of voice problems

Patient-reported symptoms together with laryngostroboscopy or high speed imaging and perceptual analysis of the voice are considered to be the cornerstones for the evaluation of voice in logopedic and phoniatic practice (Carding, Wilson, MacKenzie, & Deary, 2009; Dejonckere, 2000). A number of instruments for self-rating of voice problems have been developed for use in the voice clinic. The Voice Handicap Index ([VHI], Jacobson et al., 1997) along with the shortened

VHI: VHI-10 (Rosen, Lee, Osborne, Zullo, & Murry, 2004); the Voice Activity and Participation Profile ([VAPP], Ma & Yiu, 2001); the Voice-Related Quality of Life ([VrQoL], Hogikyan, Wodchis, Terrell, Bradford, & Esclamado, 2000); the Voice Outcome Survey ([VOS], Glicklich, Glovsky, & Montgomery, 1999) and the Voice symptom scale (Deary, Wilson, Carding, & MacKenzie, 2003b) are all designed for measuring perceived handicap and quality of life, and perceived limitations of participation and activity. Of these, the Voice Handicap Index is by far the most widely spread and it has been translated and tried for stability in a number of languages.

Measurement of throat related problems

Symptoms related to the throat, such as frequent throat clearing, irritated throat, and sensation of globus are frequently reported by patients suffering from voice disorders. Of these symptoms, frequent throat clearing, dry throat, and sensation of globus are commonly reported symptoms in studies of teachers' voices (e.g. Munier & Kinsella, 2008; Simberg, Sala, Vehmas, & Laine, 2005; Smith et al., 1998; Yiu, 2002). These symptoms are, however, not specific and may be due to a multitude of underlying disorders. In the area of voice, throat symptoms may be interpreted either as the *cause* of functional voice disturbances but they may also be interpreted as a *consequence* of voice load or vocal behavior. Apart from vocal behavior, non-specific mucosal hyperreactivity (Lyberg Åhlander et al., 2009), laryngo-pharyngeal reflux (Ross, Noordzji, & Woo, 1998), allergy (Geneid et al., 2009), and mass lesions in the throat region are often considered as causative factors. Thus, throat related problems seem a rather common concern both in patients referred to voice clinics as well as in teachers (e.g. Munier & Kinsella, 2008; Simberg et al., 2005; Smith et al., 1998; Yiu, 2002).

Three self-assessment scales exist, designed to measure throat problems in specific diagnoses: the Glasgow and Edinburgh Throat Scale, designed for the evaluation of globus (Deary, Wilson, Harris, & Macdougall, 1995), the Reflux Symptom Index ([RSI] Belafsky, Postma, & Koufman, 2002) and the Pharyngeal Reflux Symptom Questionnaire ([PRSQ], Andersson Ryden, Ruth, Möller, Finizia, Titze et al., 2009), which specifically addresses reflux. However, none of these comprise more than single voice related issues and there is thus a need for an instrument that includes both throat- and voice symptoms.

Field studies of voice use

During the last decades, a number of research groups have tried to understand teachers' daily voice use based on the hypothesis that the daily vocal behavior might differ from what can be seen in laboratory or clinical settings. Jonsdottir,

Laukkanen, & Vilkmán, (2002); Lindström, Ohlsson, Sjöholm, & PerssonWaye (2010); Ohlsson et al., (1989); Rantala et al., (1998); Rantala & Vilkmán, (1999); Rantala et al., (2002), and Södersten et al., (2002), among others, studied the vocal behavior of subjects at their work place. Hunter & Titze, (2010) also included the study of non-occupational time. Parameters that have been covered are fundamental frequency, sound pressure level, and phonation (or speaking) time.

Several different methods to study the vocal behavior outside of the laboratory have been developed during the years (Airo, Olkinuora, & Sala, 2000; Buekers, Bierens, Kingma, & Marres, 1995; Cheyne, Hanson, Genereux, Stevens, & Hillman, 2003; Granqvist, 2003; Lindström, et al., 2010; Masuda et al., 1993; Ohlsson et al., 1989; Popolo, Svec, & Titze, 2005; Svec, Popolo, & Titze, 2003; Szabo, Hammarberg, Granqvist, & Södersten, 2003). These devices have used various techniques. The ones in use today are based on accelerometers that estimate fundamental frequency and sound pressure level from skin vibrations. Using this technique, it is possible to track the speaker's voice also in noisy environments without recording the background noise or the spoken message.

Vocal doses

Based on the measures provided by a voice accelerometer, Titze, Svec, & Popolo, (2003) and Svec et al., (2003) have defined vocal dose measures for various aspects of the speaker's voice. Among the doses, two are applied in this thesis: *The time dose* is defined as the total duration of phonation, *i.e.*, the total cumulated time and the percentage of this time spent phonating. *The cycle dose* is the total number of vibratory cycles during a period of time. The cycle dose is similar to the Vocal Loading Index (VLI) originally introduced by Rantala & Vilkmán, (1999). These dose measures are useful in assessing and comparing teachers' voice use in the class-room or at the teachers' spare time.

Prevalence of voice problems in teaching staff

During the last decades, the prevalence of voice problems in teaching staff has received increasing attention. A large number of authors have studied the prevalence of voice problems in teachers, mostly in cross-sectional questionnaire surveys (e.g., Gotaas & Starr, 1993; Kooijman, Thomas, Graamans & de Jong, 2007) and in some cases by telephone interviews (Roy et al., 2004; Roy et al., 2005), see Table 1. Some authors have also included comparisons to a group with expectedly lower vocal demands (Ohlsson, Järvholm, & Löfqvist, 1987; Pekkarinen et al., 1992; Sala et al., 2001; Sliwinska-Kowalska et al., 2006; Smith, Gray, Dove, Kirchner, & Heras, 1997). However, up till today the prevalence of voice problems in Swedish teaching staff is largely unknown.

Table 1. Summary of studies investigating the prevalence of voice problems in teachers.

Author	Voice problems, prevalence %			N	Response rate, %	Method	Comparisons
	During career	During past 12 months	Current				
<i>Bermudez de Alvear et al., 2011</i>			59	282	28	Questionnaire	
<i>de Medeiros, et al., 2008</i>			15	2103	86	Questionnaire	
<i>Gotaas & Starr, 1993</i>	80		28 (1/month) 12 (1/week)	250	48	Questionnaire Perceptual analysis Anxiety rating	Teachers with vocal fatigue/teachers without vocal fatigue
<i>Kooijman et al., 2007</i>	58,6	34,4	17,5	1775	31	Questionnaire VHI	
<i>Lee, Lao, & Yu., 2010</i>		69,9		498	70	Questionnaire	
<i>McAleavy et al., 2008</i>		67		217	29	Questionnaire Anxiety rating	
<i>Munier & Kinsella, 2008</i>			27	304	55	Questionnaire	
<i>Pekkarinen et al., 1992</i>		80	12	478	-	Questionnaire	Nurses
<i>Roy et al., 2004</i>	58 (during lifetime)		11	2531	87-95	Telephone interview	Non-teachers
<i>Roy et al., 2005</i>	29,9 (during lifetime)		6,6	1326	87-95	Telephone interview	Non-teachers

<i>Russell et al., 1998</i>	19	16	1186	75	Questionnaire	
<i>Sala et al., 2001</i>	54 (1 symp) 37 (>2 symp)		370	95	Questionnaire Laryngeal exam	Nurses
<i>Sapir et al., 1993</i>	26 (1-2 symp) 33 (≥3symp)	22 (1-2 symp) 52 (≥3symp)	237 F	40	Questionnaire	Teachers with < 2 symptoms
<i>Simberg et al., 2005</i>		5/20	478/2 41	80/5 6	Questionnaire	Teachers at two occasions
<i>Sliwinski a-Kowalska et al., 2006</i>	69		425 F	-	Questionnaire Larygological examination	Non-teachers
<i>Smith et al., 1997</i>		14,6	242	95	Questionnaire	Non-teachers
<i>Smith, Lemke et al., 1998</i>		20 (1symp) 30 (>2 symp)	774	65	Questionnaire	Non-teachers

Prevalence is used to measure the disease burden in a population and the duration for the disease measured (Rothman, 2002). The time-spans used to decide the prevalence of voice problems in a teacher cohort vary between studies and thus make them more difficult to compare. The time-spans defined by Russell et al., (1998) have been used by some authors: career prevalence (incidence of symptoms during the career), year prevalence (incidence of symptoms during the past 12 months), and point prevalence (incidence of symptoms at the day of the survey). The point prevalence for voice problems in teachers has been reported to range from 6,6% (Roy et al. 2005) to 59% (Bermudez de Alvear et al. 2010) and the career prevalence to range between 19% (Russell et al. 1998) to 80% (Gotaas & Starr, 1993), see Table 1.

The reported percentages of prevalence are quite variable. The variation may partly depend on differences in methods and definitions of the core questions and

concepts as pointed out by Mattiske, Oates, & Greenwood (1998) and Russell et al., (1998). Furthermore, explanations to the varying prevalence might be the variation in response rates, shown in Table1, and also the gender differences. The studies comprising both male and females show a somewhat lower prevalence (e.g., Russell et al., 1998). To summarize, based on the results of the prevailing studies, between 19-80% of teachers have sometimes experienced voice problems during their lives or careers. The reported prevalence varies between studies, which may be due to the studied groups. However, these variations might also be due to the way the investigations have been performed.

Objective findings of voice disorders in teachers

Voice problems are sometimes associated with deviations of laryngeal morphology, with objectively measurable changes of voice quality or vocal capacity. Objective measurements of the larynx and of voice quality have been made by some authors specifically in teachers. A small number of studies also include instrumental, acoustical analyses. The number of findings of laryngeal deviations varies between the studied groups. Urrutikoetxea, Ispizua, & Matellanes (1995) examined 1 046 teachers and found structural deviations in 20,8%. Ilomäki et al. (2009) found severe organic changes in 14% of the 78 pre-school teachers investigated. Sala et al. (2001) made organic findings in 29% of 262 teachers compared to 7% in a control group of nurses.

Perceptual and acoustical analyses of voice quality differences between teachers, and between teachers and groups with lesser voice demands, show them to be small, rated to a low grade (Gotaas & Starr, 1993), or lacking (Ohlsson et al., 1987). Ohlsson et al. (1987) compared a group of teachers with a group of nurses and found no differences between the groups in their Long Time Average Spectras (LTAS), voice quality, or Voice Range Profiles. Gotaas & Starr (1993) compared teachers experiencing vocal fatigue with teachers who did not, and concluded that the groups differed only on “vocal fatigue days” and then only during the later part of the day. Voice quality differences between teacher groups were, however, reported by Tavares & Martins (2007), who found the ratings of Grade, Roughness and Breathiness to be higher in a group of teachers with more vocal complaints. Nevertheless, the majority of studies have been unable to establish a connection between the clinical findings and the subjective symptoms.

Absence from work due to voice problems

Teachers stay at home from work due to their voice problems more often than individuals with lesser occupational voice load. Smith et al. (1997) and Smith et al. (1998) found that >20% of the investigated teachers but none of the

investigated non-teachers had missed schooldays due to voice problems. Sapir et al. (1993) concluded that 32% of the teachers with >3 vocal symptoms and 14% of the teachers with 1-2 symptoms had had days of sick-leave due to vocal problems. Similar numbers are reported by Russell et al. (1998) and de Medeiros et al., (2008), who found that 38,7% and 30% of the teachers in their surveys had stayed at home due to voice problems. In spite of the high frequency of days off work due to voice problems, teachers do not seem to seek professional help to a comparable extent. In the study by Smith et al. (1998), 14% of the teachers had sought professional help. As discussed by Smith et al. (1998) the reasons for this discrepancy need to be further explored.

Summary of the introduction

Definitions of core concepts

- Vocal load links occupational demands on the voice to voice production.
- Voice problems are defined as difficulties in phonation, deviant voice quality and/or physical pain or sensation related to voice use. Vocal endurance may be added to this definition.
- Speakers' comfort is the connection between the voice use and the speaker's subjective perception of the voice in relation to the room and the listeners.

Voice use in teachers and environmental factors of vocal load

- Teachers' voice use is characterized by long phonation times, by few possibilities to rest the voice, and a constant need to talk in the presence of background noise. The acoustical properties of the teaching environments influence how the teachers use their voice. Many class-rooms have been found to have too long reverberation times. The air quality of the room has not been investigated in field studies in teachers, but laboratory investigations show that the air-quality of the room probably influences on the voice of the speaker. Stress and anxiety are acknowledged as factors of voice load in teachers, but personality factors don't seem to be crucial.

Inter-individual factors influencing on voice load

- Female gender, >50 years of age and years of teaching have been identified as important risk factors for developing a voice disorder.
- Hearing has not been investigated in relation to the voice in teachers.

Measuring voice load

- Clinical investigations of voice and larynx have been made in some studies of teachers' voice. The results are rather inconclusive and the relation to the subjective assessments of voice problems is not clear.
- Symptoms related to the throat are often reported among voice patients. Throat related problems have not commonly been investigated in relation to the voice.
- Field studies of voice use have been performed by a number of authors and seem very informative about the daily voice use. Varying devices for field measurements have been used. The devices used today are microprocessors that estimate aspects of the voice function from an accelerometer glued to the skin of the neck.
- Voice doses are computed by the voice accelerometers. The doses used in this thesis are the *time dose*, *i.e.* the percentage of the measured time spent phonating, and the *cycle dose*, *i.e.* the total number of vibratory cycles during a period of time.

Prevalence and consequences of voice problems

- The measured prevalence of voice problems vary depending on the investigation, the method, and the definition of the duration of the time for the measurement. The reports of point-prevalence vary between 7-59% and the career, or life prevalence, varies between 19-80%.
- Voice problems have been reported to negatively affect the work situation in teachers. Teachers stay at home due to voice problems more often than individuals with no occupational voice demands, and some even consider change of occupation.

SUBJECTS AND METHODS

The studies in this thesis aim at investigating teachers' voices and voice use, both the teachers' own ratings of the voice and their teaching environment, their voice use in vivo and the individual prerequisites for the voice use (*studies II-IV*). For this purpose, an existing self-assessment instrument for the voice VHI (Jacobson et al., 1997) was translated and assessed with an added subscale for the self-estimation of throat problems (*study I*).

Subjects

Study I developed a self-assessment instrument for symptoms from the throat and voice. Data were collected from 239 subjects (169+70 patients and controls). *Study II* explored the prevalence of voice problems in teaching staff and investigated their ratings of their voice and teaching environment. Data from 467 teachers were analyzed. *Study III* closer explored possible differences between 31 teachers with self-assessed voice problems and their 31 age and gender matched voice healthy colleagues; the participants were recruited from the population in *study II*. From the 31 pairs from *study III*, the voice use in 14 teachers with voice problems and their 14 voice healthy colleagues were measured in field conditions in *study IV*, examining their voice use during school-days. Figure 1 presents a flow chart of the subjects included in the studies.

Study I: patients and controls

Study I developed a self-assessment instrument for symptoms from throat and voice and assessed it for stability and reliability. Self-rating questionnaires, covering voice with an added subset of questions on throat problems (VHI-T), from a total of 169 (23+144) patients and 70 (12+58) voice healthy controls were analyzed during two validation phases. All patients were consecutive patients referred to the department of voice and speech disorders at Lund University Hospital. Inclusion criteria for both phases were that the responders had to be older than twelve years and competent to complete the questionnaire without help. The *first phase* of the data collection served mainly to develop a new subscale of questions on symptoms related to the throat. The *second phase* served to assess the complete questionnaire VHI-T for stability and reliability. Here, the results and discussions of *study I* are thus based on the data collected during the second phase. For the sake of completeness, the description, the data collection for *phase one* is described below but is not further discussed.

The *first phase* of the test-retest procedure included 40 consecutive patients with voice problems (20 patients diagnosed with phonastenia and 20 with diagnoses of

benign lesions of the vocal folds), and 20 voice-healthy controls from the orthopedic out-ward clinic. The two questionnaires were completed and returned in due time by 23 patients (16 F:7 M, median age 54 yrs, range:25-71) and 12 controls (5F:7M, median age 39, range: 21-71). Thus, due to late or no return of the second questionnaire, 17 patients and eight controls were excluded.

For the *second phase* questionnaires were collected from 262 persons, 156 patients and 106 voice-healthy controls. Twelve patients and 48 controls were excluded due to incomplete questionnaire, late, or no, return of the second questionnaire. *Study I* thus reports data from 144 patients (98F:46M median age 53, range: 13-79) and 58 controls (31F:27 M, median age 60,5, range: 15-80) .Table 2. The responders were assigned to four patient groups and one group of controls. *Phonastenia* (n=20 defined by vocal fatigue as a cardinal symptom, without any pathological laryngeal findings, with or without subjective hoarseness); *benign lesions of the vocal folds* (n=41; 17 polyps; 6 cysts; 5 each of nodules and sulcus glottidis; 3 papillomas; two each of vascular dilatation in the mucosa, or atrophy of the vocal folds, and one granuloma); *neurological laryngeal motility disorder* (n=20; 18 cases with unilateral paresis of the vocal folds, and two cases with spasmodic dysphonia); *benign goitre* (N=41; all referred to the clinic for pre-surgery control), and patients referred for *throat problems* as cardinal symptoms (N=22), not themselves complaining of voice problems. As in phase 1, the Control group (N=58) consisted of out-ward patients from the orthopaedic clinic, all reporting voice health and no former contact with voice clinicians. Table 2 presents demographic data for the participants according their diagnose.

Table 2. Demographic data for the five groups of patients with voice disorders and one group of voice healthy controls. (Study I)

	Phonastenia	Benign lesions	Neurolog. disorders	Throat	Benign goitre	Controls
N	20	41	20	22	41	58
F:M	15:5	30:11	12:8	11:11	30:11	31:27
Median Age (range)	52 (18-69)	45 (13-74)	56 (26-76)	58 (20-73)	48 (19-79)	60,5 (15-80)

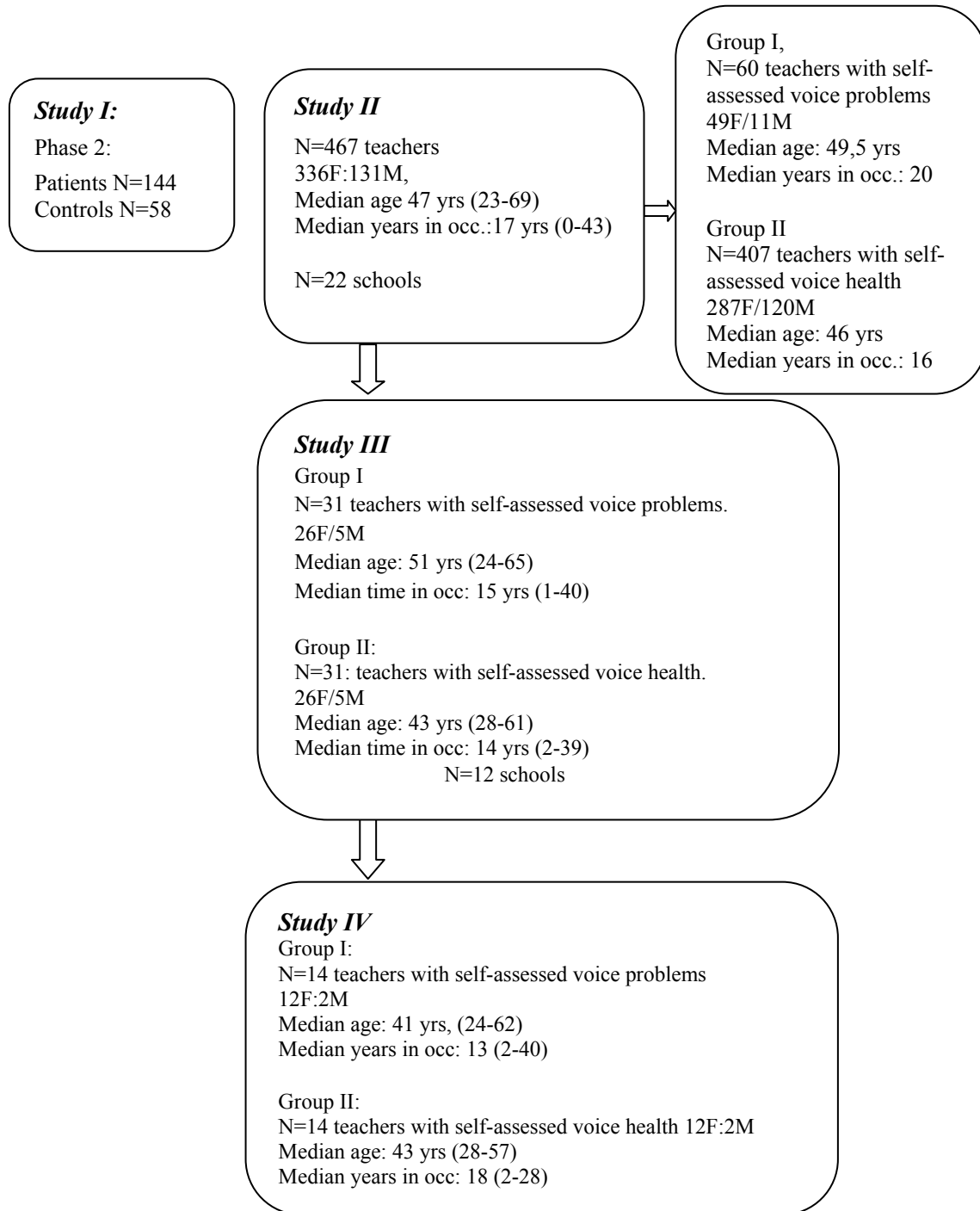


Figure 1. Flowchart of participants in studies I-IV

Study II: subjects and schools

Study II is an epidemiology study with cross-sectional design that explored the prevalence of voice problems in teaching staff and investigated their ratings of their voice and teaching environment. For this purpose, a questionnaire was distributed to 487 teachers at their collegial meetings. Nine of the questionnaires were excluded due to incomplete data. In addition, eleven questionnaires were excluded since they had mistakenly been given to teacher-students who had participated in the collegial meetings where the questionnaire was distributed. Data from a total of 467 responders (336F:131 M, median age 47, range: 23-69) were thus finally included in *study II*. Only a small number of the teachers were current smokers: 36/467 subjects, while 158 had given up smoking during a period of 0->10 years. The median number of years in the occupation was 17 years, range: 0-43. Thirty percent of the teachers: 146/467 did not report any main subject in teaching, rather being general teachers, specialized in certain age-groups. The largest group reporting a main subject were teachers teaching language (20%), followed by natural sciences (11%), and social sciences (9%). Teaching staff at all levels were included, except pre-school teachers at pre-schools and day-care-centres, and teachers at specialised, vocational high schools, due to the large variety of the teaching premises, see Table 3 for the distribution of teaching levels. The teachers were accessed via the headmasters of 53 randomly selected schools in the region. The choice of geographical area was based on a uniform distribution of air pollution, and on an equivalent population density. Participation was accepted by 22 schools. The questionnaire was completed by 73% of all the teachers of all the included schools. Visits to distribute and collect the questionnaire were mainly made from January to April 2009.

A permission to distribute the questionnaire was obtained from the headmaster of each school. The teachers were informed about the study at regular, pre-scheduled, compulsory collegial meetings at each school. The questionnaire was distributed, completed, and collected during one and the same meeting. The teachers completed the questionnaire anonymously. If, however, a teacher was interested in continued participation in the project, contact information was obtained on a voluntary basis. All teachers participating at the conferences answered the questionnaire.

Table 3. Teaching level of 467 teachers (Study II)

Teaching level	N teachers
Junior+intermediate school	203
Secondary school	108
High school	156

Based on the ratings of statement 32 “I have voice problems”, the participants were divided into two groups. *Group I* (N=60) consisted of teachers suffering from voice problems sometimes, often, or always. *Group II* (N=407) included teachers who reported never or only occasionally having voice problems. There were no significant differences between the groups for gender (*Group I* 80%F:20% M, *Group II* 71%F: 29M), age (*Group I* Md=49,5, *Group II* Md=46), smoking (*Group I* 10%, *Group II* 7%), or years of occupation (*Group I* Md=20, *Group II* Md=16), as shown by a chi square test.

Study III: subjects and matching of subjects and controls

Study III is prospective with a case-control design and examined the etiology of voice problems in teachers by more closely exploring possible differences between 31 teachers with voice problems and their 31 age and gender matched voice healthy colleagues. All participants were recruited among the teachers from *study II*. Planned continuation of the project was explained and 220 of the teachers were interested in further participation: n=41 who had rated themselves as suffering from voice problems and n=179 who had estimated no voice problems in *study II*. The teachers with self-assessed voice problems were matched for age and gender with voice healthy colleagues from the same schools. Ten subjects with voice problems were excluded: one due to lack of a gender matched control at his school; two smoking subjects since it was not possible to find a smoking control at the school; one subject was not possible to reach and six subjects declined to participate due to lack of possibility or interest. Finally, two paired groups of teachers were formed: *Group I* (N=31, 26F:5M) included teachers with self-assessed voice problems, with a median age of 51 years (range 24-65) and a median time in occupation of 15 years (range 1-40); *Group II* (N=31, 26F:5M) included teachers without voice problems with a median age of 43 years (range 28-61) and median time in occupation of 14 years (range 2-39). The pairs came from 12 of the 22 schools in *study II*. A paired samples t-test revealed significant differences in age between the groups: *Group I* (M=48,7, Sd=10,7) and *Group II* (M=44,6, Sd 9,9) $t(30)=2,503$, $p=0,018$. There were no significant differences between the groups for time in occupation as shown by a paired samples t-test.

Study IV subjects and controls

Study IV is prospective, has a case-control design, and investigated the voice use during a typical school day in teachers with voice problems and their voice healthy school colleagues, measured with a voice accumulator (Ambulatory Phonation Monitor, APM) and a structured diary. For *study IV*, N=28 teachers were recruited among the 62 participants in *study III*. The pairs worked at the schools with the

highest frequency of matched pairs, 3 schools, and formed two groups: Group I: teachers with self-assessed voice problems (N=14, 12F:2M median age: 41, range: 24-62), and Group II: teachers without voice problems (N=14, 12F:2M median age: 43, range: 28-57). Median years in occupation: Group I: 13, range 2-40 and Group II: 18, range: 2-28. The groups did not differ for age or years in occupation as shown by a paired t-test.

Methods

Questionnaires

Studies I-IV: Voice Handicap Index-Throat (VHI-T)

Study I assessed the reliability of a Swedish adaption of the Voice Handicap Index and also developed and tested a subscale on symptoms from the throat. The VHI was first published by Jacobson et al., in 1997 (Jacobson et al. 1997) and covers three different domains of voice problems: physical, functional, and emotional. There are thirty statements, ten in each domain. The statements are phrased in the way the patients normally would express themselves. The occurrence of symptoms are estimated on a frequency-based scale (0=Never, 1=Almost Never, 2=Sometimes, 3=Almost Always, 4= Always). The added throat scale was kept in the same format with ten statements (Table 4). The new questionnaire was named VHI-Throat (VHI-T). The VHI-T was used in full in *study III*. (Appendix). The VHI-T with some modifications was used for the questions on voice and vocal symptoms in *studies II* and *IV*.

Table 4. Ten statements of the Throat subscale in Swedish (English translation within brackets)

Statement
1 Jag är torr i halsen (<i>My throat is dry</i>)
2 Jag måste harkla mig (<i>I need to clear my throat</i>)
3 Jag har mycket slem i halsen (<i>I have a lot of phlegm in my throat</i>)
4 Jag känner att det sitter något i halsen (<i>It feels as if something is stuck in my throat</i>)
5 Det svider i halsen (<i>My throat is burning</i>)
6 Jag känner ett tryck utanpå halsen (<i>I feel a pressure on the outside of my throat</i>)
7 Det känns som om jag har en klump i halsen (<i>It feels like a lump in my throat</i>)
8 Jag är irriterad i halsen (<i>I have an irritation in my throat</i>)
9 Jag har ont i halsen (<i>I have a sore throat</i>)
10 Jag har rethosta (<i>I have a dry cough</i>)

Study II: Screening questionnaire

A screening questionnaire was developed for *study II* to assess the teachers' ratings of their working environment and also to estimate the prevalence of voice problems in teachers. The questionnaire covered 52 items in three domains: 1) background information; 2) room acoustics, perception of noise levels and other issues related to the environment: items 1-13; 3) voice problems, vocal behaviour and statements about skills in voice use: items 14-32. Items in part 1 were answered by yes/no or by a description using free text. The items in part 2 were statements, e.g., "The air in the classroom is dry", which were rated on a scale from 0 to 4, where 0=completely disagrees and 4= completely agrees. The items in part 3 were statements, e.g., "I have to clear my throat", which were rated on a frequency-based scale from 0 to 4, in accordance with the scale in the Voice Handicap Index (Jacobson et al. 1997). Two statements were considered to be "index-statements": #1: "The classroom acoustics help me talk comfortably" and #32: "I have voice problems". The questionnaire was tested in a pilot study of 63 teachers, all permanent staff of one high school. A reference group attached to the project (experts in occupational and environmental medicine, voice, acoustics, and representatives of the teachers' unions, and building proprietors) also made comments. The validity of the questions was also discussed by a group of experienced teachers representing the different teaching levels included in the study. Based on the pilot study and the feedback, the questionnaire was revised into its final form. (Appendix).

Study III: Questionnaires on work, burnout, coping and personality

Aspects related to work were measured with *the Job Content Questionnaire (JCQ)*. The JCQ is a self-administrated instrument designed to measure social and psychological characteristics of work according to the high demand/low control model of job strain development and covers issues relevant to work demands such as decision making, social interaction, support at the work-place etc.(Job Content Questionnaire center, Karasek et al. 1998).

The 26 questions, rated on a four-graded rating scale (1=disagrees completely, 4=agrees completely), comprise the dimensions of job control, job demands, and job support. The job demands, control, and support variables are further dichotomized into high and low categories, based on current means from a large population study (Lindeberg et al. 2010).

JCQ has been widely used for research with at least 70 publications available up to date, however only two in teachers (Azlihanis, Naing, & Aziah, 2006; Brown, James, & Mills, 2006), and none in relation to voice problems. The JCQ has been translated and assessed for stability in 23 languages until today (Job Content Questionnaire center).

Burnout or exhaustion disorder

To investigate the possible symptoms of burnout *the Shirom-Melamed Burnout Questionnaire (SMBQ)* was used (Shirom, 1989). A frequently discussed problem in society today is burnout or exhaustion disorders (Swedish National Board of Health and Welfare [Socialstyrelsen] 2003). Melamed et al., (1999) cite the definition by Shirom, (1989) of burnout “as the chronic depletion of an individual’s coping resources” (Melamed et al., 1999, p 1). Melamed further characterizes burnout by the constellation of emotional exhaustion, physical fatigue, and cognitive weariness. This syndrome does not overlap with any other clinical syndromes such as depression or anxiety (Shirom, 1989), and it is conceptually distinct from a temporary state of fatigue, which passes after a resting period. The SMBQ is a self-administered instrument and consists of 22 questions rated on a frequency based eight graded rating scale (0-7). The overall burnout index is computed as the mean value of four subscales comprising cognitive weariness, emotional and physical exhaustion, tension, and listlessness.

Coping

The Utrechtse Coping List, ([UCL] Scheurs, van de Willege, Brosschot, Tellegen, & Graus (1993) in its short form with 22 questions was used to investigate coping with stressful situations. The individual’s coping with stressful situations has

earlier been discussed as a cause of voice problems (Gassull et al., 2010). Coping strategies have also been shown to reveal how patients with voice disorders deal with the pressures of vocal disabilities (Epstein, Hirani, Stygall, & Newman, 2009). Meulenbroek, Thomas, Kooijman, & de Jong (2010) used the longer version of the UCL to investigate voice problems in teacher students. The subscales used in *study III* were passive avoidance, depressive reactions, and active reactions.

Personality

Baker (2008) notes that the role of personality for the origin of voice problems has long been of great interest and various measuring methods have been used to investigate this issue. To investigate the possible role of personality in this population of teachers, the two subscales “Psychic Trait Anxiety” and “Adventure seeking” from the *Swedish Universities Scale of Personality* ([SSP], Gustavsson et al. 2000) were used, providing a rough estimate of the commonly used dimensions of neuroticism and extraversion, respectively. The SSP items were rated on a four-grade scale, ranging from “does not apply at all” to “applies completely”.

Study III: General questionnaire on teaching- and voice related aspects during teaching.

For *study III* a short questionnaire was developed to cover facts about the student group (group size, native tongue and the language(s) of the students) and teaching circumstances (posture, distance to students), voice problems during teaching (frequency of voice problems, time for voice recovery, if problems occur with or without a simultaneous cold), and teaching environment (changes made in teaching style or teaching environment due to voice problems, smell in classroom).

Study IV: Voice-diary

For *study IV*, a diary was developed for the teacher to complete during the day on which they were recorded with the Ambulatory Phonation Monitor to track the activities of the teacher. The teachers were asked to identify a “typical school-day” to avoid days with many conferences.

The diary had two sections. The first consisted of nine questions on general information: the number and grade of the students taught, the teaching activities, the distance to and noise-level of students along with one question on voice hygiene (intake of water during the lesson). The second part consisted of nine questions on voice aspects and one on stress, rated on a categorical scale (not at all, partly, moderately, and very much). The subjects were instructed to complete

the diary after each lesson. The voice part was completed on three occasions: after the first lesson, after lunch, and just after the removal of the APM.

Studies I-IV: Subjective voice assessment

Subjective voice-assessment was used in all studies. In *studies I, III-IV* the ratings were made with a visual analogue scale (100 mm with “no voice problems” and “maximal voice problems” at the endpoints). In *study II*, the subjective rating was one of the statements in the questionnaire: “I have voice problems” (item 32). In *study I* the VA-scale was to be filled out together with the whole VHI-T questionnaire, on the first occasion before the clinical examination. Similarly, in *study III* the subjective voice assessment was performed while filling out the VHI-T questionnaire. In *study IV*, the assessment with the VA-scale was performed at three occasions during the day, after the first lesson, after lunch, and just after the removal of the APM.

Examinations of voice, larynx and hearing

Study III: Recordings of voice

For the recordings in *study III*, the voice signal was digitized at 16 kHz with 16 bit resolution, recorded in a sound-proof booth during the reading of a standard text (Nordanvinden och Solen: the Northwind and the Sun) using Soundswell Core 4.0 + Soundswell Voice 4.0, (Hitech Development AB, Täby, Sweden) and a head-worn microphone (MkE2 Sennheiser, www.sennheiser.com), placed 30 cm from the mouth. Due to a change of computer equipment, five of the voices were recorded on MiniDisc (Sony MDS-101) with the same microphone.

Study III: Voice Range Profile

In *study III*, a maximum phonetogram (Voice Range Profile, VRP) was performed with the teacher standing in front of a laptop computer and recorded on a real-time phonetograph Phog 2.5 (Hitech Medical, Täby Sweden) with a head-worn microphone (AKG C420) at a distance of 7 cm from the lips. According the guidelines by the European Union of Phoniaticians (Dejonckere et al., 2001), the signal was corrected to equal 30 cm distance from the mouth. The teachers phonated with glissandos on the vowel /a/ trying to cover as large an area as possible in frequency and SPL with connected contours. The teachers started at a habitual fundamental frequency gliding downwards to the softest phonation and thereafter, keeping as soft phonation as possible, working upwards through the frequency range towards the highest possible frequency. The procedure was then

repeated in loud voice. When this was completed, the teacher was asked to fill out blank spots and try to “connect” the contours. The teachers were free to take the time they needed to complete the VRP. The glissando was practiced a few times before the recording started.

Study IV: Field recordings, voice dosimetry

In *study IV*, the teachers were registered with the Ambulatory Phonation Monitor 3200 vers. 1.04 (APM) (APM, KayPentax New Jersey, USA), Figure 2. The APM uses an accelerometer to measure the skin vibrations of the neck that occurs during phonation (Cheyne et al., 2003). Based on these vibrations, the APM software estimates the phonation duration, fundamental frequency (in Hz), sound pressure level (in dB), and vocal doses (Hillman, Heaton, Masaki, Zeitels, & Cheyne, 2006). The APM does not register ambient noise (Hillman et al., 2006) and does not register the spoken message. Good accuracy has been shown for the APM’s estimation of F0 and phonation duration as compared to recordings with traditional microphones (Hillman et al., 2006). Hillman et al. (2006) also show a reliable estimation of the sound pressure level with an average error of 3.2 dB (SD 6 dB).

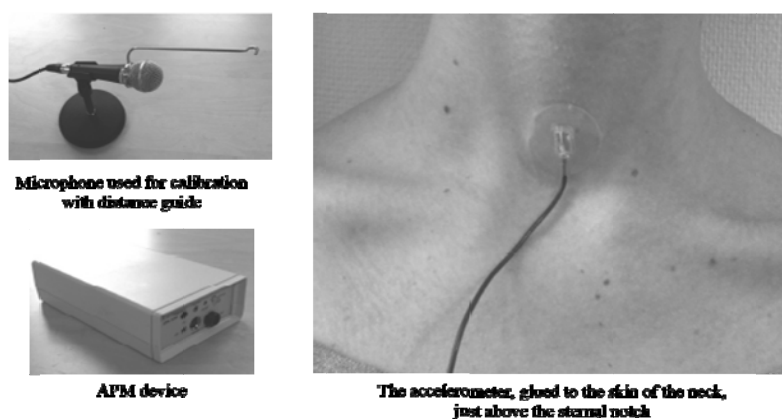


Figure 2. The Ambulatory Phonation Monitor

APM procedure

The teachers were asked to identify a “typical school-day” to avoid days with many conferences. Before the workday started, the APM accelerometer was glued to the subject’s neck, just above the sternal notch. The cable, connecting the accelerometer and the APM device, was taped to the back of the neck and thread under the clothes, exiting the garments at waist level. The APM was calibrated following the manufacturer’s recommendations. The teacher stood or sat in front

of the calibration microphone, with the distance guide (15 cm) resting on the upper lip. The subject was then instructed to phonate on the vowel /a/ from the softest to the loudest phonation possible. The APM device was thereafter put in a waist-bag. The APM was worn by the teacher during the workday and preferably also after work hours.

Study III Laryngeal examination and recording

The teachers underwent examination of the larynx and vocal folds with a 70 degree rigid laryngoscope. A digital documentation system was used, HRES Endocam (Wolf, Germany). First, high resolution mode was used for evaluation of organic lesions, adduction and abduction. In high-speed mode 2000 frames/s were recorded for male subjects and 4000 frames/s for female subjects. These recordings were used to evaluate mode and symmetry of vibration at the glottic level. Kymograms were calculated at the mid portion of the membranous vocal fold. The examinations were performed without local anesthetic in 56/62 subjects, but in six cases, three subjects and three controls Xylocain spray was used (1-3 doses of 10 mg each). All examinations were performed by one phoniatician who was unaware of which group each participant belonged to.

Study III Audiometry

For the audiometry, the equipment used was a GSI16 (Grason-Stadler Inc.) audiometer together with one pair of Telephonics TDH-39P supra-aural earphones with MX-41/AR cushions. The equipment was calibrated in accordance with IEC 60318-3 (IEC, 1998c) and ISO 389-1 (ISO, 2003). Test stimuli were pure tones of 1-2 seconds duration (35 ms rise and fall times). The following test order was used: 1000, 1500, 2000, 3000, 4000, 6000, 8000, 500, 250 and 125 Hz. Audiometry was conducted in accordance with ISO 8252-1 (ISO, 1989) using the manual descending technique (-10/+5 dB). The threshold was defined as the lowest level where three responses had been recorded. The test was performed in a double-walled soundproof booth (complying with the maximum permissible ambient sound pressure level as specified in ISO 8252-1) during one session (ISO 8253-1).

Registration of noise, room-acoustics and indoor air quality

Study IV

Simultaneously with the APM recordings, the noise and voice levels at the teacher's position were measured with a sound level meter Svantek, mod. SV-102.

The signals were picked with a lapel microphone at a distance of 15 cm from the teacher's mouth. The sound level meter was placed in the same waist-bag as the APM box. The acoustic properties of the classrooms were evaluated with the following acoustic parameters *background noise level*, *reverberation time*, *speech transmission index*, *sound strength* and *room support* while the classrooms were empty, due to logistics. Additionally, the geometrical dimensions of the room were measured.

The air humidity, room temperature, and the carbon dioxide (CO₂) contents of the air were simultaneously measured during the work-hours with an indoor air quality measuring device: Q-Trak IAQ Monitor Model 8550, TSI Inc, USA, analyzed with Trak Pro Data Analysis Software.

Analyses of voice, larynx and hearing

Study III: Perceptual rating of voice quality

The voice recordings with a total duration of app. 45 s each were organized into three differently randomized "lists" so that all 62 voices were presented in different order on each list. A panel of three experienced voice-pathologists rated all voices in consensus on a Visual Analogue Scale (VAS) which was presented through the Spruce listening test: Judge 2.0 (Hitech Medical, Täby Sweden). The voices were judged for five parameters, defined according to Hammarberg (2000): hyperfunction, breathiness, vocal fry, hard glottal onsets, and instability. In addition, Grade of Voice Disorder was estimated with the GRBAS scale (Hirano, 1981). The choice of parameters was limited by the number of parameters possible to present in the software application. The judges were given written information with instructions to listen to each voice at a maximum of three times. They were also instructed not to return to a voice that already had been rated. The judges were further instructed to comment on other aspects than those listed in the Judge application, and in such cases add the comments to a protocol.

Study III: Analyses of voice measurements: F0 and SPL

For *study III*, The sound-files were explored in Soundswell Voice™ and the fundamental frequency was calculated for each voice. A long-time average spectrum (LTAS) was made to obtain information on the voice source, in particular the tilt of the source spectrum (Löfqvist & Mandersson, 1987). For the analysis, silence and periods of unvoiced sounds were eliminated. For the latter, a comparison was made of the spectral levels below and above 1 kHz. If the lower frequency band dominated a frame, this frame was retained as voiced; otherwise, it

was discarded. The ratio of energy in the frequency bands 0-1kHz and 1-5 kHz was calculated. This measure provides information on the tilt of the source spectrum, *i.e.*, how rapidly the amplitude of the higher partials decreases. The second one was the energy in the frequency band 5-8 kHz. A large amount of energy in this band can be a sign of noise due to an incomplete glottal closure (Hanson, Stevens, Kuo, Chen, & Slifka, 2001).

Study IV: Vocal doses

The measures used in *study IV* were the mean F0 and SPL values of any chosen period, computed by the APM software. The APM software also returns three doses, of which the *time-* and *cycle dose* were used in this study. The *time dose* is the total duration of phonation, *i.e.*, the total cumulated time and the percentage of this time spent phonating (see Cheyne et al., 2003 for further information about the APM microprocessor's identification of phonation); *the cycle dose* is the total number of oscillatory periods of the vocal folds over time. The cycle dose is thus sensitive to F0 and accordingly higher in individuals with a higher speaking pitch. (Svec et al., 2003).

Study III: Larynx

The recordings were coded and randomized. The final evaluation of the recordings was made in consensus by two experienced phoniatricians unaware of the grouping of the subjects. Following clinical practice, the guidelines by the Committee on Phoniatrics of the European Laryngological Society (ELS) (Dejonckere et al., 2001), and suggestions by Kendall (2009) for high-speed imaging, a protocol was constructed to assess the following:

- The morphological structure of the vocal folds.
- Asymmetry of posterior larynx: The position of the corniculate tubercles during phonation and rest.
- The symmetry of abduction and adduction of the vocal folds
- The activity of the false vocal folds.
- The degree and type of glottal opening at maximal closure.
- The propagation and amplitude of the mucosal wave of the right and left vocal fold separately.
- The symmetry and periodicity of vocal fold vibration of the right and left vocal fold separately.
- The phase difference/periodicity: variations in the vibratory cycle, possibly causing asymmetrical closure.
- The Open Quotient in percent of the glottal cycle (time of open phase/time of vibratory cycle).

The glottic open phase and phase difference were assessed from kymograms. All parameters were judged on a four-point scale (0, no deviance; 3, severe deviance) except for the degree of glottal closure which was judged on a six point rating scale according to Södersten & Lindestad (1990), and the pattern of glottal closure which was also categorized according Södersten & Lindestad (1990):

- A: spindle shaped incomplete closure, with closure at the vocal processes.
- B: spindle-shaped incomplete closure at the posterior third of the folds, with closure at the vocal processes.
- C: spindle-shaped incomplete closure at the anterior third of the folds, with closure at the vocal processes.
- D: incomplete closure at the posterior and the anterior thirds of the folds, closure at the vocal processes and at the middle of the membranous portion (“hourglass”).

To assess inter rater reliability; eight randomly selected recordings were analyzed twice.

Study III: Voice Range Profile (phonetogram)

The analysis of the VRP followed the procedure described in Ma et al. (2007). Four boundary points were analyzed for each recording: the highest frequency, the lowest frequency, the maximum and minimum intensity. The maximum area, in semitones * dB, and the frequency ranges were automatically calculated by the Phog 2.5 software.

Study III: Audiograms

The mean value of 500, 1000, 2000, 4000 Hz was calculated for each ear. The sound pressure levels for 3000, 4000 and 6000Hz were also analyzed separately.

Statistical methods

For *studies I-IV* the Statistical Package of Social Sciences (SPSS) was used (vers 15.0 *study I*; 16.1 *studies I and II*; vers. 18.1 *studies III and IV*). The calculations of Odds Ratios for paired samples in *study III* were performed by SAS® 9.2 for Windows. Both parametric and non-parametric methods were used. All statistical methods used throughout the four studies are summarized in Table 5. The alpha level for all statistical analyses was set to 0.05.

Table 5. Summary of statistical methods used in studies I-IV.

Statistical method	Study no
ANOVA	I, IV
Chi-square	II, III, IV
Cronbach's alpha	I
Fisher's exact test	II, III
Independent T-test	I
Intra Class Correlations (ICC)	I, III
Mann-Whitney U-test	II
Odds Ratio analysis	III
Paired samples T-test	III, IV
Pearson product-moment correlation coefficient	I
Principal component Analysis (PCA), factor analysis	II
Spearman's rho	III
Wilcoxon	II

Study I

The test-retest reliability for the VHI- Lund total scores, the values of the subjective voice estimation, and the Throat subscale was estimated by calculating the IntraClass Correlation coefficient (ICC). For the construct validity, independent samples t-tests were used to compare the average scores of the VHI-Throat total, subjective voice estimation values, and the Throat subscale between patients and controls. The Pearson product-moment correlation coefficient was used for computing the correlations between the subscales and the VHI-Throat total score, the throat subscale and the original VHI subscales and for estimating the correlation between the subjective estimation of voice and VHI-Throat total score. The internal consistency and reliability of the total VHI-Throat subscale, as well as of the throat subscale, were calculated with inter-item correlation and Cronbach's alpha coefficient. An ANOVA was performed to further analyze the VHI-T subscales.

Study II

A statistical power-analysis, based on a 20% prevalence of voice problems, suggested that completed questionnaires from 398 teachers were required, with a 5% margin of error. Due to the cross-sectional design of the study, no correlations

were computed within the material. Factor analysis, Principal Component Analysis (PCA), was used to uncover underlying factors and establish interactions between the answers. To assess the appropriateness of the material for PCA analysis, the correlations among the items were calculated. The eigenvalue according to the Kaiser's criterion explains the amount of the total variance explained by a factor and needs to exceed 1.0. Factors were obtained with a Varimax rotation and Kaiser Normalization. The chi square test and the Mann-Whitney test were used for further statistical analyses.

Study III

The statistical analyses were computed using SPSS 18.1. For most continuous variables, paired samples t-tests were calculated, for the comparison of the assessment of voice quality the Wilcoxon signed rank test was used due to skewed distributions. For the discrete outcomes variables, 2-sided chi-square tests were used, with exception for the question "Thoughts about change of work", which was analyzed by Fisher's exact test due to the expected frequency in one cell being below the recommended frequency of five. Spearman's rho was used for the calculation of correlations within the material. The OR calculations for paired samples were performed by SAS® 9.2 for Windows with the lowest level as reference. The inter rater reliability was calculated for each parameter separately, with Intra Class Correlation (ICC).

Study IV

The statistical analyses were computed using SPSS 18.1. For most continuous variables, paired samples t-tests were used. Chi-Square tests were used when parameters were categorical. One way ANOVA was used to compare variations between activities.

Ethical considerations

Informed, written consent was obtained from all subjects and all headmasters of the schools included. Study I was approved by the ethical committee at Lund University (No LU 366-01). Studies II-IV were approved by the Institutional Review Board at Lund University (#248/2008).

RESULTS

Study I

The aim of this study was to develop and evaluate an instrument that could simplify the patients' estimation of symptoms from the throat and to consider their relation to voice problems simultaneously. The Voice Handicap Index (VHI) had been in use at our clinic for a long period. A new subscale, named "throat scale" was constructed, using the same format, the same phrasing, and rating scale as in the VHI. The result, the VHI-Throat (VHI-T) was tested for validity, reliability, and test-retest stability. The test-retest reliability of the total VHI-T score was estimated with IntraClass coefficient (ICC), =0,968, proving a good reliability of the questionnaire. A paired samples t-test revealed no significant differences between the first and second occasion for neither the total VHI-T scores, nor the individual subscale in patients and controls¹. The VHI-T total score in all patients assigned to five different diagnose-groups was significantly higher than in the voice-healthy controls, thus indicating that the questionnaire separated persons with and without voice pathology. The difference in VHI-T scores between the patients and the controls was significant also for all subscales as shown in Table 6.

Moreover, there was a good correlation of the test- retest occasions: the reliability testing of the entire questionnaire showed an alpha value of $r = 0,90$ which shows a high degree of reliability, well in line with results reported by others (Helidoni et al., 2010; Ohlsson & Dotevall, 2009; Rosen et al., 2004; Verdonck-de Leeuw et al., 2008). The Throat subscale separately reached an alpha value of $r = 0,87$, which is also considered a high reliability. The VHI-T thus proves to be a valid and reliable instrument for the estimation of self-perceived throat and voice problems. The throat subscale seems to help revealing a category of symptoms that are common in patients but that have not earlier been possible to cover with the questionnaires designed for use in the voice clinic. Table 7 shows the mean scores

¹ VHI-T total: (M=1,6, Sd= 41,6, N= 142), $t(141)=0,464$, $p=0,6$ Throat: (M=0,9, Sd= 10,4, N= 142), $t(141)=1,0$, $p=0,2$, Functional: (M=0,5, Sd= 12,4, N= 142), $t(141)=0,526$, $p=0,6$, Physical: (M=0,3, Sd= 13,1, N= 142), $t(141)=0,351$, $p=0,7$, Emotional: (M=-0,3, Sd= 13,2, N= 142), $t(141)=-0,2$, $p=0,8$).

of the four subscales in the five groups of patients and the voice healthy controls. It also shows the part, in percent, that each subscale contributes to the total score in each patient-group. The results show that symptoms from the throat are not uncommon in most voice diagnoses and that some scoring on the throat scale also occurs in completely voice-healthy individuals.

Table 6. Results of T-test between patients (N=144) and voice healthy controls (N=58) for the VHI-Throat subscales and VHI-T total.

Scale		M score (Sd)	t	df	P<
Throat scale	Patients	14,5 (7,3)	8,1	138	,001
	Controls	6,9 (5,5)			
Functional	Patients	9,5 (9,7)	8,3	197	,001
	Controls	1,8 (3,4)			
Physical	Patients	15,1 (9,8)	8,8	178	,001
	Controls	5,4 (5,6)			
Emotional	Patients	8,7 (9,5)	8,4	194	,001
	Controls	1,3 (3,1)			
VHI-T total	Patients	47,8 (30,2)	10,2	191	,001
	Controls	15,3 (15)			

Table 7. Mean scores (Sd) of the four subscales and the total VHI-T in five groups of patients and one group of controls. The percentage of each subscale of the total VHI-T score is shown in italics.

	Throat %	Functional %	Physical %	Emotional %	Tot VHI-T %
Neurological N=20	14 (8) 20	19 (8) 27	21 (6) 30	16 (8) 24	70 (22) 100
Ben. Lesions N=41	16 (7) 23	16 (9) 22	29 (7) 42	15 (10) 22	70 (27) 100
Phonastenia N=20	15 (6) 30	10 (7) 20	16 (6) 34	9 (6) 18	49 (19) 100
Ben. Goitre N=41	10 (6) 52	2 (5) 12	6 (6) 29	1 (4) 8	20 (18) 100
Throat rel N=22	20 (7) 56	2 (2) 5	10 (7) 28	4 (5) 11	36 (15) 100
Controls N=58	7 (5) 45	2 (3) 12	5 (6) 35	1 (3) 9	15 (15) 100

Study II

The primary objective of this study was to examine how a group of Swedish teachers rate aspects of their working environment that can be presumed to have an impact on vocal behavior and voice problems. The secondary objective was to explore the prevalence of voice problems in Swedish teaching staff. A questionnaire was distributed to the teachers of 22 randomized schools.

All teachers present at collegial meetings answered the questionnaire, which corresponded to 73% of the total number of teaching staff at the included schools. The results showed that 13% of the whole group reported voice problems occurring sometimes, often, or always (Figure 3).

Factor analysis of the responses

The statements of the questionnaire were subjected to a principal component analysis (PCA). Prior to performing the PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of $\geq .3$. The PCA revealed two components of eigenvalues exceeding 1 for the statements about *room acoustics* explaining 29.7% and 10.7% of the variance. There was a moderately strong correlation between the two factors ($r=.542$). For the statements about the *voice*, four components were found explaining 39.2%, 8.1%, 7.4%, and 5.7% of the variance. There was a weak positive correlation between components 1 and 2 ($r=.338$), 1 and 4 ($r=.352$) and 2 and 4 ($r=.113$) and a weak negative correlation between comp 1 and 3 ($r=-.388$), 2 and 3 ($r=-.306$) and 3 and 4 ($r=-.244$). These findings indicate that the items listed under each component are highly loaded specifically onto one of these four independent underlying components.

The loading of the *acoustic and environmental* statements on the two components of the PCA analysis (Table. 8) were interpreted as follows:

- Component one includes the voice function and the interaction of the voice with the class room acoustics.
- Component two can be interpreted as covering external sources influencing the voice use.

The loading of the *voice* statements on the four components of the PCA analysis (Table 9) was interpreted as follows:

- Component 1 includes symptoms traditionally considered as early signs of voice problems and can most likely be interpreted as such also in this

study, in particular due to the inclusion of statement 32 “I have voice problems” within this component.

- Component 2 can be viewed as “consequences of voice problems”
- Component 3 seems to reflect functional/emotional aspects of voice problems
- Component 4 includes symptoms from the throat.

Table 8. Pattern matrix from PCA analysis for Acoustical/Environmental statements 1-13.

Statement	Component 1	Component 2
3. The class-room is difficult to talk in.	0,763	
4. I need to increase the power of my voice to make myself heard even with just a little noise in the class-room	0,757	
13. The class-room acoustics has influence on my way of talking (with the pupils present).	0,739	
8. The noise made by the pupils is very noticeable in the class-room.	0,726	
1 The class-room acoustics help me talk comfortably.	0,619	
2. There is an echo in the class-room.	0,559	
6. My voice gets muffled by the class-room acoustics.	0,532	
5. The class-room air feels dry.	0,431	
10. The noise from audio/visual resources is noticeable.		0,721
7. There is a draught in the class-room even when the door is closed.		0,625
9. The noise from the ventilation is noticeable.		0,599
11. Noise coming from out-side of the class-room is noticeable.		0,586
12. I have problems with my hearing		0,439

Table 9. Pattern matrix from PCA analysis for Voice statements 14-32.

Statement	Comp 1	Comp 2	Comp 3	Comp 4
16 My voice sounds hoarse	,803			
15 I need to clear my throat	,795			
17 My voice can suddenly change when I talk	,764			
18 I need to strain to make my voice work	,587			
32 I have problems with my voice	,378		-,305	
24 I have stayed at home due to problems with my voice		,932		
22 I have wanted to stay at home due to problems with my voice		,859		
23 Others ask what is wrong with my voice		,443	-,410	
28 My voice makes me feel incompetent			-,769	
21 Due to my voice the pupils have trouble hearing me			-,725	
20 I avoid certain tasks due to my voice			-,697	
19 My voice limits my work	,304		-,599	
14 I need voice amplification			-,496	
27 I run out of air when I talk			-,447	
26 My voice upsets me			-,424	
29 My throat is burning				,707
31 I have sensations of gastritis				,668
30 It feels like a lump in my throat				,662
25 I have a sensation of discomfort in my throat	,466			,568

The division into subject groups

Based on the ratings of statement 32 “I have voice problems”, the participants were divided into two groups. The distribution of the ratings for this statement is presented in Figure 3. *Group I*, (N=60) consisted of teachers having rated 2-4, *i.e.*, suffering from voice problems sometimes, often, or always. *Group II* (N=407) included teachers having rated 0-1, *i.e.*, never or only occasionally experiencing voice problems. There were no significant differences between the groups for gender or age computed by a chi-square test². As shown in Table 10, there were no differences for smoking; years of occupation, voice training, possibility to rest, or for subject taught. Thus, we could not find teaching of any subject to be more hazardous to the voice.

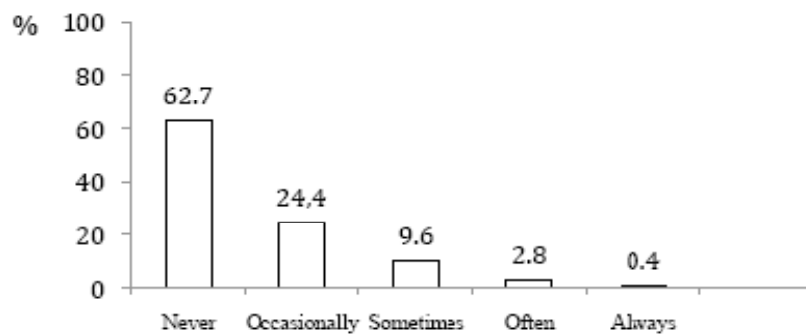


Figure 3. Distribution of the answers in percent for statement 32, “I have voice problems” in 467 teachers.

2

Gender: (*Group I* F80%:M20%; *Group II* F71%:29% M). Result of chi-square test for gender: $\chi^2=3,221$ (1) $p=0.073$

Age: (*Group I* Md=49,5; *Group II* Md=46). Result of chi-square test for age: $\chi^2=53,105$ (44) $p=0,163$.

Table 10. Comparison between teachers with voice problems (Group I) and those without voice problems (Group II) on background items

Question	Group I % (N=60)	Group II % (N=407)	χ^2	P 2-sided
School level				
Junior/intermediate	45	43	(3,N=467)=10,331	NS
Secondary	27	23		
High school	28	34		
Group size				
1-6	22	7	(2,N=467)=13,514	0,001
7-15	7	8		
15-30	71	85		
N of teachers in room				
1	75	78	(3, N=467)=1,889	NS
2	21	16		
3	3	5		
>3	0	1		
Possibility to take a break	20	28	(1, N=460)=1,458	NS
Voice training	40	35	(1, N=467)=0,596	NS
Voice demanding spare-time	22	26	(2, N=466)=,595	NS
Referral for voice-help	38	8	(1,N=463)=47,591	0,000
Sick-leave	35	9	(1,N=466)=33,274	0,000
N occasions of sick-leave			(1, N=56)=1,576	NS
1	10	4		
>2	23	5		
Smoking				
Yes	10	7	(2, N=467)=1,424	NS
No	52	60		
Have quit smoking	38	33		
Asthma	17	8	(1, N=466)=5,314	0,021
Asthma medication	13	6	(1, N=39)=0,031	NS

Strong scents	37	21	(1, N=464)=8,000	0,005
Other hyper reactivity	12	7	(1, N=40)=1,184	NS
Hearing aid	10	2	(1, N=464)=11,859	0,001
Job satisfaction				
Great	52	49	(3, N=466)=,897	NS
Broadly	36	41		
So-so	12	9		
Not at all	0	1		
Voice amplification	3	97	(2, N=464)=4,778	NS

The teachers' estimation of the statements

There was a significant difference between the groups for the index statement “the classroom acoustics help me talking comfortably” as shown by a Mann-Whitney U-test: ($z=-3,319$) $p=0,001$. Within the whole group, 38% (ratings: 0-1) disagreed that the class room acoustics helps the teacher to talk comfortably (Figure 4).

There were significant differences between the two groups for several of the items. The ratings were analyzed with a Mann-Whitney U-test. The teachers with voice problems rated items on room acoustics and work environment higher, thus as being more noticeable, see Table 11. Moreover, the differences between the groups were significant for all statements within the voice section, Table 12. Absence from work because of voice problems was significantly more common in the group with voice problems: 35% versus 9% in the group without problems, concluded by χ^2 ($p<0,05$), Table 10.

In the news media, the noise caused by the pupils is often discussed as a problem for both staff and pupils. In the present results, 92% (rating 1-4) of the teachers agreed on the presence of noticeable noise from the pupils (#8). Also, the perception of disturbance from other noise sources, such as ventilation noise (#9), noise from technical equipment (#10), and noise from outside the classroom (#11) received a moderate to strong agreement by the entire group, but with no statistical differences between the two groups.

In summary, teachers suffering from voice problems react stronger to voice loading factors in the teaching environment, report more frequent symptoms of voice discomfort, and are more often absent from work due to voice problems than their voice-healthy colleagues.

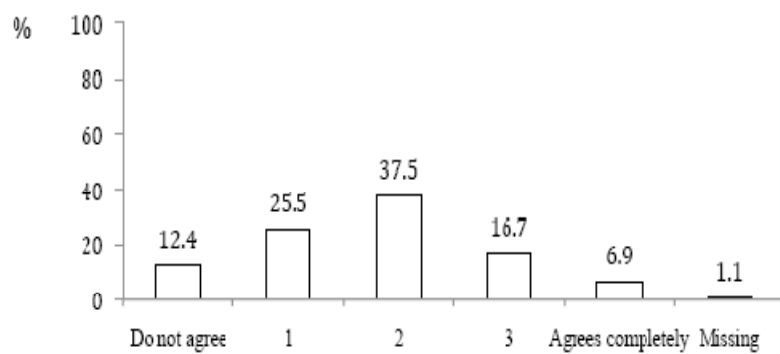


Figure 4. Distribution of the answers in percent for statement 1, “The classroom acoustics help me talking comfortably” in 467 teachers.

Table 11. Distribution of the ratings in percent, of statements on acoustics and environment (Grades: 0=completely disagrees-4=agrees completely).

Acoustical and environmental statements	N	0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	z	p
1 The class-room acoustics help me talk comfortably	60 402	25 11	30 25	33 39	7 18	7 7	- 3,319	0,001
Group I								
Group II								
2. There is an echo in the class-room.	59 403	29 36	29 28	20 23	17 10	5 3	- 1,489	0,137
Group I								
Group II								
3. The class-room is difficult to talk in.	60 407	10 23	19 29	39 29	25 16	7 3	- 3,521	0,000
Group I								
Group II								
4. I need to increase the power of my voice to make myself heard even with just a little noise in the class-room	60 407	5 17	14 28	25 27	37 20	19 8	- 4,595	0,001
Group I								
Group II								
5. The class-room air feels dry.	60 407	7 17	17 18	20 28	26 24	30 12	- 3,377	0,001
Group I								
Group II								
6. My voice gets muffled by the class-room acoustics.	58 404	9 19	14 23	46 35	26 21	5 2	- 2,584	0,010
Group I								
Group II								
7. There is a draught in the class-room even when the door is closed.	60 404	23 40	22 25	15 13	27 13	13 9	- 3,114	0,002
Group I								
Group II								
8. The noise made by the pupils is very noticeable in the class-room.	59 405	5 8	12 14	19 25	34 28	30 25	- 1,602	0,109
Group I								
Group II								
9. The noise from the ventilation is noticeable.	60 404	12 24	29 24	22 20	17 20	20 12	- 1,903	0,057
Group I								
Group II								
10. The noise from audio/visual resources is noticeable.	60 404	35 37	19 27	21 17	15 11	10 8	- 1,004	0,315
Group I								
Group II								
11. The noise coming from out-side of the class-room is noticeable.	60 405	17 19	18 24	30 24	23 22	12 11	-,883	0,377
Group I								
Group II								
12. I have problems with my hearing	59 406	37 37	18 21	17 15	14 13	14 13	-,012	0,990
Group I								
Group II								
13. The class-room acoustics has influence on my way of talking (with the pupils present).	58 406	21 28	8 16	14 26	29 18	28 12	- 3,278	0,001
Group I								
Group II								

Table 12. Distribution of the ratings in percent, of statements on voice for Group I (N=60), teachers with voice problems and Group II (N=407) teachers without voice problems. (Grades: 0=never, 1=occasionally, 2=sometimes, 3=often, 4=always). The z and p values for the Mann-Whitney U test comparing the groups are also provided.

Voice statements	N	0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	z	p
14 I need voice amplification	58	83	3	9	5	0	-	0,016
Group I	404	92	4	2	1	1	2,410	
Group II								
15 I need to clear my throat	59	5	14	32	42	7	-	0,000
Group I	406	21	45	27	7	0	7,824	
Group II								
16 My voice sounds hoarse	60	3	15	42	38	12	-	0,000
Group I	406	29	46	20	4	0	8,771	
Group II								
17 My voice can suddenly change when I talk	59	15	24	35	24	2	-	0,000
Group I	407	40	39	18	2	0	6,263	
Group II								
18 I need to strain to make my voice work	60	10	8	37	37	8	-	0,000
Group I	405	47	37	13	2	0	9,475	
Group II								
19 My voice limits my work	59	15	25	36	20	4	-	0,000
Group I	406	64	28	6	2	0	9,139	
Group II								
20 I avoid certain tasks due to my voice	60	43	25	17	8	7	-	0,000
Group I	407	83	14	1	0	0	7,798	
Group II								
21 Due to my voice the pupils have trouble hearing me	60	35	40	20	5	0	-	0,000
Group I	406	79	18	3	0	0	7,678	
Group II								
22 I have wanted to stay at home due to problems with my voice	60	47	23	27	3	0	-	0,000
Group I	407	83	14	3	0	0	6,850	
Group II								
23 Others ask what is wrong with my voice	60	62	23	12	3	0	-	0,000
Group I	404	94	5	1	0	0	8,151	
Group II								
24 I have stayed at home due to problems with my voice	60	65	22	12	2	0	-	0,000
Group I	407	85	12	2	0	0	3,988	
Group II								

25 I have a sensation of discomfort in my throat	60	10	23	30	34	3	-9,110	0,000
Group I	405	56	30	12	2	0		
Group II								
26 My voice upsets me	60	8	27	43	14	8	-13,437	0,000
Group I	407	83	14	3	0	0		
Group II								
27 I run out of air when I talk	60	47	18	20	12	3	-6,064	0,000
Group I	406	79	16	4	1	0		
Group II								
28 My voice makes me feel incompetent	60	48	15	22	15	0	-8,360	0,000
Group I	401	88	9	2	0	0		
Group II								
29 My throat is burning	59	32	29	20	19	0	-6,847	0,000
Group I	407	71	22	6	1	0		
Group II								
30 It feels like a lump in my throat	60	37	25	23	12	3	-6,280	0,000
Group I	407	72	20	6	2	0		
Group II								
31 I have sensations of gastritis	60	50	20	20	8	2	-3,500	0,000
Group I	407	72	14	9	4	1		
Group II								
32 I have problems with my voice	60	0	0	75	22	3		
Group I	407	72	28	0	0	0		
Group II								

Study III

The aim of this prospective, randomized case-control study was to compare pairs of teachers from *study II*. Teachers with self-reported voice problems, n=31, were compared to age, gender and school-matched colleagues with self-reported voice health. The self-assessed voice function was related to factors known to influence the voice: laryngeal findings, voice quality, personality, hearing, psycho social and coping aspects, searching for objective manifestations of voice problems in teachers.

Differences were found for all statements of all subscales of the VHI-T as shown by paired samples t-test (Table 13), and for time for recovery after voice problems computed by chi-square test: χ^2 , (7 n=60)=17.608, $p=0,014$, Table 14. Within the group of teachers with voice problems, 18% had considered change of work due to voice problems but none in the voice healthy group, as shown by Fisher's exact test ($p=0,029$). For the frequency of occurrence of voice problems, a chi-square test showed significant differences between the two groups: χ^2 , (5 n=60)=20.138, $p=0,01$, Odds Ratio= 3.99, indicating that teachers with voice problems were close to four times as likely to rate a high frequency of voice problems. There were also significant differences between the groups for voice problems occurring without a concurrent upper-airway infection, χ^2 , (2 n=60)=18,670 $p=0.0008$, OR=3.60.

Table 13. Mean and *t* and *p* values for paired samples *t*-test along with Odds Ratios for VHI-T in two groups of teachers: Teachers with voice problems (Group I, N=31) and teachers without voice problems (Group II, N=31).

Subscale	Group I M(Sd)	Group II M(Sd)	<i>t</i> (<i>df</i>)	<i>p</i>	OR
Throat	15,3 (5,9)	8,7 (5,0)	5,451 (29)	0,0001	1,43
Physical	13,8 (8,6)	6,7 (6,6)	4,394 (29)	0,0001	1,27
Functional	8,5 (7,0)	2,5 (3,6)	4,199 (29)	0,0001	1,26
Emotional	9,0 (9,5)	1,7 (3,2)	4,248 (29)	0,0002	2,03
VHI-T Total	46,7 (22,2)	19,3 (15,0)	6,406 (29)	0,0005	1,93

Table 14. Time for recovery from voice problems in two groups of teachers, teachers with voice problems (Group I) and teachers without voice problems (Group II), in percent.

	Zero	One hr or less	A couple of hrs	Over night	Weekend	Holiday	Never	%
Group I (N=31)	0	13	10	27	23	17	10	100
Group II (N=29)	34	17	7	24	7	10	0	100

Minor morphological abnormalities of the vocal folds were found in 13 subjects (5/31 in Group I (teachers with voice problems), 8/31 in Group II (voice healthy teachers)); some remarks on voice quality and hearing were made, as well as some negative reports of psychosocial well being however, but with no differences between the groups. The instrumental analyses of voice range (Voice Range Profile) and F0 in running speech did not show any differences between the groups. Further, there were no differences between the groups shown by the analysis of the Long Time Average Spectras. The ratios of the 0-1 kHz and 1-5 kHz frequency bands and the energy in the frequency band 5-8 kHz show that the voices should be considered to be modal to hyperfunctional.

Study IV

The study aimed at closer investigating the vocal behavior and voice use in teachers with self-estimated voice problems and their age-, gender and school matched colleagues without voice problems, using matched pairs as in *study III*. The teachers' fundamental frequency, Sound Pressure Level, and phonation-time were recorded with an Ambulatory Phonation Monitor (APM) during one workday and they also reported their activities in a structured diary. The main hypothesis was that teachers with and without voice problems act differently with respect to

classroom acoustics and air-quality, and that the vocal doses obtained with a voice accumulator would separate the groups.

Subjective ratings

The analysis of the diaries confirms the results of *studies II-III*. The group with voice problems rated their voice problems during the day significantly worse than their voice healthy colleagues, on the Visual Analogue Scale, according to a paired t-test³ ($p=0.003$). This group also rated their degree of vocal fatigue ($p=0,007$) and loss of air during speech ($p=0,007$) significantly higher than their voice-healthy matched peers, as shown by a chi-square test, see Table 15.

³ The groups' ratings on the Visual Analogue Scale. Paired t-test: Group I ($M=32,3$ $SD=20,8$) and Group II ($M=11,2$ $SD=11,8$) $t(19)=3.441$, $p=0.003$.

Table 15. The result of Chi-square test for independence of the diary-questions in two groups of teachers: Group I: teachers with voice problems (n=14), Group II: teachers without voice problems (n=14).. Distribution are presented in % . Chi-square values, degrees of freedom and p-values are also provided. Number of answers: Group I: n=42, Group II: n=43.

a)

Question	No (%)	Partly (%)	Moder (%)	Much (%)	χ^2 (Df)	p
Do you perceive voice fatigue?					12,245	0,007
Group I	29	48	19	5	(3)	
Group II	58	40	2	0		
Does your voice break or tire?					5,757	0,12
Group I	64	29	5	2	(3)	
Group II	86	12	2	0		
Do you have difficulties in making yourself heard?					0,770	0,68
Group I	67	29	5	0	(2)	
Group II	74	23	2	0		
Do you have a need to clear your throat?					9,647	0,02
Group I	31	36	17	17	(3)	
Group II	44	46	9	0		
Do you have a need to cough?					5,684	0,128
Group I	57	26	12	5	(3)	
Group II	79	14	7	0		
Does your throat ache?					9,088	0,03
Group I	52	33	9	5	(3)	
Group II	81	16	2	0		
Is your throat tense?					10,951	0,01
Group I	38	43	17	2	(3)	
Group II	70	28	2	0		
Do you have a hoarse voice?					6,443	0,04
Group I	67	14	19	0	(2)	
Group II	77	21	2	0		

Table 15. b)

Question	(%)	(%)	(%)	(%)	χ^2 (Df)	p
Do you have enough air when you talk?	Always	Nearly always	Almost never	Never	9,907(2)	0,007
Group I	52	45	2	0		
Group II	84	16	0	0		
Stress-level	Low	Rel. low	Rel. high	High	8,522	0,04
Group I	45	31	19	5	(3)	
Group II	35	58	7	0		

Voice measurements

Vocal doses

Teachers with voice problems behaved vocally different from their voice healthy peers, in particular during teaching sessions. The *time dose* (percent of voicing) was significantly higher in the group with voice problems as shown by a paired t-test for the entire work-day and specifically for teaching⁴. The phonation time for teachers in this material can thus be established to vary between 17-24%. Further, the *cycle dose* (number of cycles) during work-time differed significantly between the groups as shown by a paired t-test⁵. The cycle dose varied between activities for both groups as shown by a one-way ANOVA and post-hoc comparisons with Tukey HSD test indicated that the mean score for "teaching" differed significantly from "preparation/break" for both groups with the higher cycle dose for teaching⁶.

F0 and SPL

Also the F0 pattern, related to both voice-SPL and the room acoustics differed between the groups. The group with voice problems did not raise their F0 with increasing SPL of the voice, whereas the voice healthy group raised the F0 with the SPL increase. The voice-problem group either kept the F0 stable or decreased it as shown by Figure 5. This is shown by the difference between the groups in the

⁴ Difference in time-dose, entire day: Group I (M=20.9 SD=8.1) and Group II (M=15.5 SD=8.0) $t(87)=4.870$, $p=.0006$

Teaching: Group I (M=23.6 SD=7.1) and Group II (M=17.3 SD=9.0) $t(50)=3.929$, $p=.0003$

⁵ Difference in cycle dose: Group I: M=169 921 SD=162 931 and Group II; M=118 946 SD= 101 247 $t(93)=2.875$, $p=.005$.

⁶ One-way ANOVA between activities of the groups: Group I $F(5, 98)=9.623$, $p=.0001$; Group II: $F(6,113)=10.131$ $p=.0006$. Post-hoc comparisons: Tukey HSD test indicated that the mean score for "teaching" differed significantly from "preparation/break" for both groups:

Group I "teaching" (M=202 823, SD=117 202) "preparation/break" (M=65 252, SD=46 842).

Group II: "teaching" (M=169 829, SD= 93 543) "preparation/break" (M=47 228, SD=52 955).

direction of the correlation coefficients, when correlating F0 to SPL during teaching. Group I: $r = -0.379$ whereas Group II: $r = 0.295$.

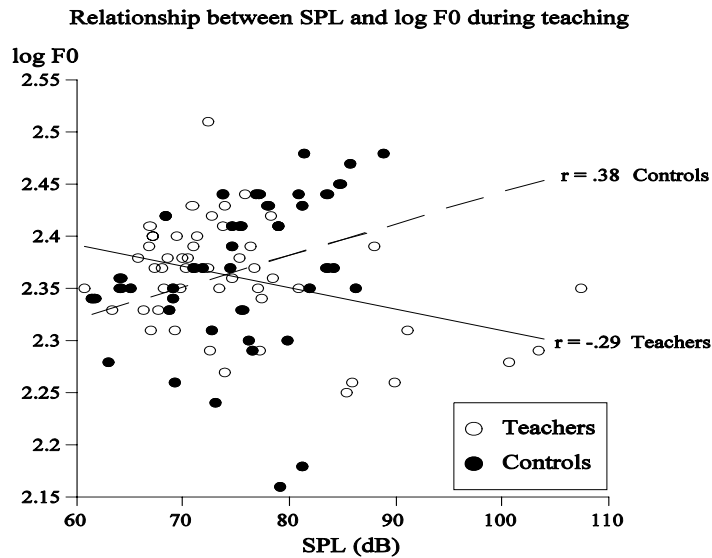


Figure 5. Plot of sound pressure level and fundamental frequency during teaching.

Measuring of the rooms

Air quality measurements

There were no differences in temperature between the classrooms of the groups, with temperature ranging from 17,3°-25,1°C. The present measurements were made during the winter, which means that the temperature comes from indoor heating. The mean CO₂ levels were below the Swedish regulation for indoor work, 1000 ppm (AFS, 2009:02), but, in a few rooms the CO₂ level exceeded the stipulated maximum value. The mean humidity estimate was low, 26%, which is normal during the winter in Sweden (AFS, 2009:02).

Room acoustics

In order to explore the room acoustics, every classroom was measured for the physical dimensions (floor area S_A and volume V), the background noise level (BNL), the reverberation time (RT), the sound strength (G), the speech transmission index (STI), the room gain (G_{RG}), and the Acoustic Voice Support (ST_V). The classrooms were unoccupied (with the presence of 2-3 persons) and

furnished. Only the BNL, RT, STI, and ST_v will be presented in the following and are shown in Table 16. For details of the measurements of the rooms see Pelegrín-García, Lyberg Åhlander, Brunskog, & Löfqvist, (2011)

Grouping of rooms

Many of the room acoustic parameters have a strong dependence on the room volume. The rooms were grouped according the following:

- *Small classrooms* ($V < 100 \text{ m}^3$): classrooms for special education or small groups.
- *Medium sized classrooms* ($100 \text{ m}^3 < V < 500 \text{ m}^3$): regular classrooms, including also classrooms for science and manual work.
- *Sports halls* ($V > 3500 \text{ m}^3$): these facilities are educational spaces which have different acoustic requirements than regular classrooms in the building regulations, due to the physical differences with smaller spaces.

The overall mean/maximum A-weighted level of background noise in the empty rooms ranged between 32,3 dB/38,5dB (*small classrooms*); 32,7dB/43,5dB (*medium sized classrooms*) and 37,6dB/43,5dB (*sports halls*). Thus, the maximum values in both small and medium sized classrooms exceeded the regulated maximum for classrooms of 35 dB (Afs, 2009). The background noise levels were similar in all rooms, although the overall level in the large rooms was slightly higher than in smaller rooms. In all cases, low frequency noise was markedly dominating. This is an indication that the noise sources could be ventilation or external noise.

The values of Acoustical Voice Support in the one-octave frequency bands between 125 Hz and 4 kHz are shown in Figure. 6. The shape of the curves is similar for small and medium classrooms, with a predominant increase at high frequencies. The only difference between the two classroom groups was that the small classrooms had a slightly higher overall value. The large classrooms (sports halls) not only had an overall lower value, but the frequency characteristics were qualitatively different, because the low frequencies were predominating. This indicates that the room does not reflect efficiently the high frequencies.

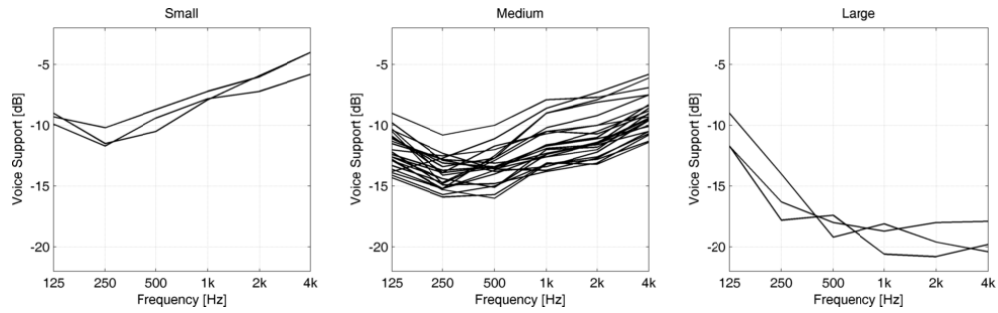


Figure 6. 1/1 octave band spectra of the voice support measured in the classrooms. Left: small classrooms. Center: medium-sized classrooms. Right: large (gymnastic) halls.

The minimum acceptable *speech transmission index* value according to the Swedish regulation is $STI=0,6$ (SS25268:2007). All the classrooms fulfilled this requirement, and more than one third of the rooms (11 out of 30) had an STI rating of “excellent”. Nevertheless, these values were measured in the empty classrooms and are expected to have lower values when they are occupied, due to the activity noise. This noise affects the largest spaces with a greater incidence. The small classrooms had the highest STI, which falls in the category of excellent. The medium classrooms had an average STI rating which is in between “good” and excellent, and the sports halls had an STI rating of good which will decrease in the presence of activity noise.

The *reverberation time* is highly correlated to the volume of the rooms; those with smallest volumes have the lowest reverberation times. As shown in Table 16, the mean RT did not exceed the regulation for reverberation time in classrooms (0,6 s). The variability of RT among rooms was highest at lower frequencies (125 Hz and 250 Hz) and at these frequencies the RT limit was exceeded in some rooms.

Table 16. Comparison of mean values of overall Acoustic Voice Support, Speech Transmission Index and Reverberation time in three categories of class rooms.

	OverallST _V	STI	RT _{500-2k} [s]
<i>Small classrooms</i>			
Mean	-5.6	0.80	0.34
Std. Dev.	0.78	0.02	0.05
<i>Medium classrooms</i>			
Mean	-10.2	0.75	0.46
Std. Dev.	1.58	0.03	0.08
<i>Sports halls</i>			
Mean	-18.8	0.63	1.50
Std. Dev.	1.01	0.02	0.23

Voice parameters in relation to room acoustics

The results showed that both teachers with voice problems and their voice healthy colleagues were equally affected by noise and behaved in accordance with the Lombard effect (Lane & Tranel, 1971), increasing their voice intensity with increasing background noise Figure 7. However in relation to the *Acoustic Voice Support*, the vocal behavior of the two groups showed opposite trends, Figure 8. The teachers with voice problems decreased the SPL of the voice with increasing *Voice Support* in the classrooms, whereas the voice healthy teachers increased or stabilized the SPL. The results thus show that different individuals make different use of the room acoustics.

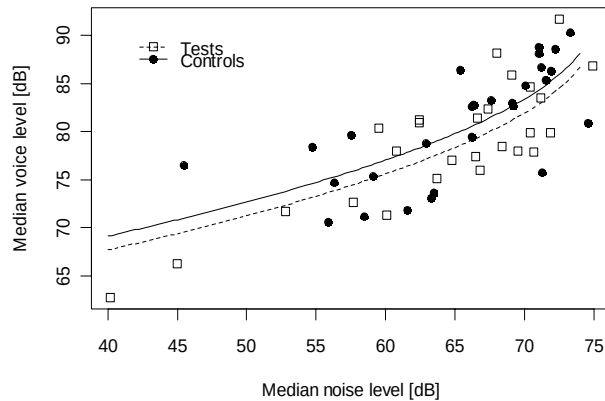
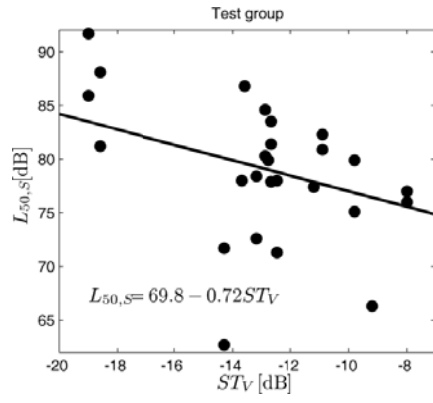
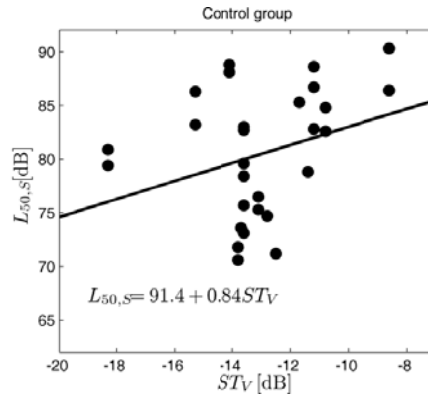


Figure. 7 Median SPL of the voice in relation to back-ground noise in a group of teachers with voice problems and their voice healthy colleagues.



a)



b)

Figures 8a + b. Median SPL in relation to room-support in the group with voice problems (a) and their voice healthy colleagues (b).

GENERAL DISCUSSION

The aim of the studies was to investigate teachers' voice use and voice health in teaching environments. Additional aims were to explore the prevalence of voice problems in teaching staff, and to develop a questionnaire to cover problems related to both throat and voice.

Teachers' voice use in teaching environments

Teachers have other demands on their voice than other speakers in voice demanding occupations. They have as great need for vocal flexibility as actors and constantly need to make sure that they are not only heard but also understood. Contrary to actors, they don't have a calm and silent audience and the room conditions are not always suitable for long-time talking. Teachers want to be able to make use of the voice as an educational tool but have rarely any education on voice use or voice hygiene (*study II*).

The results from the questionnaires from *studies II-III* show that one group of teachers (13%) suffer from voice problems sometimes, often, or always. However, most teachers have symptoms of voice problems from time to time. The teachers who do not consider this to be a problem are more prone to feel vocal discomfort in combination with upper airway infections.

In spite of occasional voice problems, precautions are rarely made either by individuals or by the management. Voice amplification is used to a very small extent, if at all. There are no amplification systems in the classrooms by default. When reporting actions to prevent voice problems (*study III*), the comments were seldom about the physical environment but mostly about trying to get the students to talk in more hushed voices, or to resist straining the own voice by using written instructions, handclapping to draw attention, or simply to talk less (and to keep quiet after school). However, a number of teachers, mostly within the group with voice problems, reports having changed to small-group teaching to decrease the vocal load. This might explain the somewhat surprising result of a significantly greater part of the teachers in the group with voice problems who worked with smaller groups. There have been studies showing a dominance of voice problems in teachers teaching specific subjects, with chemistry teachers at the top of the list (Thibeault, Merrill, Roy, Gray, & Smith, 2004; Roy et al., 2004) and sports as well as music teachers have traditionally been considered to be at higher risk for voice disorders. However, no such findings were made in the current set of studies (*studies II-IV*).

Females are commonly more represented at voice clinics (Fritzell, 1996). Females are reported to be at higher risk for developing voice disorders, e. g. by Roy et al., (2004). Roy et al., (2004) reported female gender to be one of the factors positively correlated with having experienced a voice problem. In this light, the equality of the gender distribution of the compared groups of *study II* is surprising, with no differences in proportion of females between the group with voice problems (80%) and the voice healthy group (70,5%). The female proportion of the whole group was 72%. The different gender distribution in the present studies compared to other reports might be explained by differences in methods, selection bias, or by cultural factors.

In addition to gender, age has also been discussed as a contributor to voice problems, however the findings are contradictory. Studies by Roy et al., (2004) and Russell et al., (1998) concluded that females in the range of 40-59 years and >50 years were prone to report current or previous voice problems. These findings are contradicted by the findings of *study I,I* where no differences were found between the age groups, a finding in line with the those of Bermudez de Alvear et al. (2010) and Kooijman et al. (2007); none of them found age to be a significant risk factor for voice disorders.

Teachers need to talk a lot. In instructing, reading, cheering, they use their voices. As shown in *study IV*, the phonation time was 17-24%, which is well in line with the findings by others. Ohlsson et al. d (1989) showed that nurses had a phonation time of 5,4% and Masuda et al. (1993) 7% for office workers, both of which are considerably lower than the measured phonation times in both teachers with and teachers without voice problems. The conclusion is thus that the phonation time in teachers, both in those with and without voice problems is high.

Pausing has been shown to be of importance for vocal recovery (Titze et al., 2007; Titze et al., 2003). The phonation time and the vocal doses presented in *study IV*, indicate that the possibilities for vocal rest – long and short – are few for all teachers. *Study II* showed that the teachers do not consider it possible to rest when needed during the day. One more piece of evidence dor too few possibilities of vocal rest was the measured peaks for both SPL and F0 during lunch time, probably due to a number of teachers having lunch with the children in so called “pedagogic lunches” (*study IV*).

Absence from work and help-seeking due to voice problems

Study II showed that 35% of the teachers with, and 9% of those without voice problems, stay at home from work due to their voice recurrently. These numbers can be compared to a group without the vocal demands of teachers. (Smith et al.

1998) reported that 4% of a group without vocal demands refrained from working due to voice problems. Thus the 9% in the voice healthy group is remarkably high. However, many changes in work load and other work related circumstances have taken place during the twelve years elapsed since the Smith study. Hence, new comparisons between teachers and other occupational groups are called for. The number of teachers in the two groups who had contacted professional help was of the same size as for sick-leave (38% and 8%). Information of what kind of help that was contacted was provided only by some teachers. Of those reporting, a surprisingly small number reported voice therapy treatment. The same pattern has been reported by others (e.g., Morton & Watson, 1998; Smith et al., 1998; Yiu, 2002).

Is it a problem?

Despite recurring or persisting voice problems, the teachers do not seem to seek help. This is a common finding in studies of voice problems in teachers (e.g., Sapir et al., 1993; Smith et al., 1998; Yiu, 2002). Interestingly, Morton & Watson, (1998) found teachers to be more persevering with their voice problems and less active in seeking help compared to a control group of non-teachers. Smith et al. (1998) discusses possible reasons for the discrepancy between need of help and actual help-seeking: “[The reasons] may be due to the difficulty of taking off work for a medical appointment, fear that school staff will learn of their problem leading to potential adverse work-related evaluations, or fear that the physician may strongly prescribe that the teacher either cut back verbal activities at work, stop teaching altogether, change occupations, or risk permanent vocal impairment” (Smith et al. 1998 p 488). It is thus possible that voice problems are viewed as personal matters by both staff and management. Vocal discomfort is commonly considered to be a problem of short duration, and hence may not be considered a problem before it starts to reoccur more frequently. Many may even consider it shameful or embarrassing to seek help. Furthermore, the awareness of the connection between voice problems and vocal load is commonly low, as well as the knowledge of where to refer oneself to find help for voice problems. In addition, the adverse effect of a troublesome voice on the students’ learning (Morton & Watson, 2001; Rogerson & Dodd, 2005) is most likely unknown by teachers. If the students’ perspective should be included when discussing voice problems in teachers, then the problem is no longer only a personal problem. In my opinion, voice-related problems in teachers should be viewed as a work related issue. Moreover, the possibility of supporting the teachers’ voice should be taken into consideration when discussing work environment in schools and designing spaces that are to be used for teaching purposes.

Voice training

Studies by Leppänen, Ilomäki, & Laukkanen (2010) and Leppänen, Laukkanen, Ilomäki, & Vilkman (2009) of voice training in groups of day-care center staff, by Ilomäki, Laukkanen, Leppänen, & Vilkman, (2008) in teachers, and by Simberg, Sala, Tuomainen, Sellman, & Ronnema (2006) of preventive group voice-therapy in teacher students are conclusive, and show that voice therapy is an effective tool. In both groups of teachers in *study II*, 17 % reported having had voice training during the teacher education. Oral reports by individual teachers describe a large variety of both the extent, contents, and quality of the voice teaching. This is mirroring the situation at Swedish teacher educations. Considering that voice therapy programs are of relatively low cost compared to the recurring sick listing of both active and future teachers as well as being a long-term effective tool, it should indeed be of interest for school managements and authorities to start discussing the implementation of such programs.

Factors affecting voice load in teaching environments

Background noise and room acoustics

Background noise increases the voice load which is also shown by the results from *studies II and IV*. Nearly all teachers in the questionnaire survey, *study II*, 86% reported that they were affected by the noise from the students, sometimes, often or always. This is high compared to the findings by Simberg et al. (2005) who reported that 54% of the investigated teachers in 2001 and 40% of the same group in 1988 that the background noise, often attributed to the behavior of the pupils, was disturbing.

As shown by Pelegrín García, Lyberg Åhlander, Rydell, Brunskog & Löfqvist (2010), all teachers in *study IV* raised the sound pressure level as a consequence of the Lombard effect, as the activity-noise from the students increased. The teachers were also affected by other noise sources such as outside noise, noise from ventilation, and from technical equipment. The teachers with voice problems were also significantly more affected by the back-ground noise as compared to their voice healthy peers. In analogy with the findings of Brunskog et al. (2009) and by Pelegrín-Garcia et al. (2011) the teachers reported being perceptive of the room-acoustics: 57% that they could perceive the influence of the room during teaching, 48,5% that the room was hard to talk in. and as much as 73% (ratings 0-2) disagreed that the room-acoustics helped the talker; for these questions there were significant differences between the groups. Most studies of room-acoustics in teaching environments have concluded that the classrooms are too reverberant (Kob et al., 2008; Pekkarinen & Viljanen, 1991; Sala & Viljanen, 1995). However,

the teachers' ratings of the classrooms in *study II* showed an impression of rather damped rooms: 60% considered the classroom acoustics to muffle the voice, and 58% reported a need to increase the voice level even with quiet students. Only 33% reported some kind of "echo". The reporting of "echo" in the room was not significantly different between the groups. The measurements of the class-rooms' acoustics may give some confirmation: the Speech Transmission Index was rated as "excellent" in most measured rooms and the mean reverberation times were below the regulations for Swedish classrooms.

Indoor-climate

Patients with voice problems often mention aspects of the indoor climate in class rooms or offices to be troubling. The most commonly mentioned aspects are "dry air", "poor air", and dustiness. One further aspect sometimes commented is "bad smell" due to dirty filters in the airshafts. In *study III*, the teachers were asked about bad smell, but no one remarked about it. In *study IV* the air quality in the class rooms were measured, along with the room temperature, the levels of Carbon dioxide (CO₂), and the humidity. The room temperature ranged between 17,3°-25,1°C. The Swedish regulation for indoor work recommends an upper range value of 22°C for teaching environments (Hellberg, 1996). There is evidence that mild heat might make the children sleepy and un-focused (Hygge, 1991). Depending on their age, the students may react with more noise due to their need to stay alert, or they may need to be activated, forcing the teacher to be the active part. Both alternatives increase the teacher's voice load. The mean CO₂ levels were below the Swedish regulation for indoor work, 1000 ppm (AFS 2009:02), but in a few rooms the CO₂ level exceeded the stipulated maximum value. According to the Swedish occupational safety and health administration (AFS 2009:02), the reaction to the CO₂ levels also depends on the air humidity and the temperature. Higher temperatures increase the perception of poor air, even though the PPM values do not exceed the recommendation. The mean humidity estimate was low, 26%, which is normal during winter in Sweden (AFS 2009:02). Air humidity measures are more complicated than the other measures. The level of air humidity is an effect of both indoor heating, number of individuals in the room, and the weather. As a consequence, here is no limit value or recommendation for air-humidity in working environments (AFS 2009:02). In *Study II*, 66% of the teachers found that the classroom air was dry, with a significantly higher percentage in the group reporting voice problems. In conclusion, the individual's perception of the indoor-climate depends on a number of factors including voice load caused by other sources.

How do teachers with self-assessed voice problems differ from their voice healthy peers?

As concluded above, most teachers reports symptoms of voice problems. *Studies II-IV* show that there were significant differences in the perceived frequency of the symptoms and that the teachers who assessed themselves as having a voice problem suffered from this also in the absence of upper-airway infections. However, as shown in *study III*, these differences between the groups were not manifested in corresponding differences in laryngeal morphology or voice quality.

Interestingly, there was a difference in how the two groups' assessed aspects of the work-environment (*studies II and III*). The teachers with voice problems differ significantly from their voice healthy peers in their ratings of the effect of the classroom acoustics on their voice use. They also say that they need to increase the level of the voice. They also judge the classroom as being hard to talk in, think that the voice gets muffled by the classroom acoustics, and disagree that the classroom acoustics helps the speaker to talk comfortably. The interpretation is thus that the teachers who suffer from voice problems are more easily affected by any environmental factor that increases the background noise. This, of course, does not tell us anything of the origin of the voice problems.

As mentioned above, complaints of dry indoor air are common in patients with voice disorders. Consequently, the ratings of the room climate also differed between the groups for this statement and the group with voice problems reported perceiving the classroom air as dry. At the time of the measurements, the air in the classrooms was indeed dry; however, the humidity varies with season and weather and the ratings in *study II* were performed during winter and spring, in a period of varying weather. The perception of dryness might thus be caused by something else. For example, the ratings of dry air can be a sign of a generally dryer lower airway mucosa, or a predisposition for this. Furthermore, the ratings of "dry air" in the group with voice problems might be due to the fact that there were significantly more teachers with allergies and hypersensitivity to strong scents in the group with voice problems in *study II*. Thus, the dryness might be induced by a more or less constantly stuffed nose, maybe originating from allergies or by an easily affected upper airway mucosa, preventing the individual to breathe through the nose, which is essential for moisturizing and warming the inhaled air. Oral breathing might thus, enhance the perception of dryness of the inhaled air. This line of reasoning is supported by Sivasankar & Fisher (2003) and Sivasankar, Erickson, & Schneider (2008) who conclude that oral breathing increased the phonation threshold which, in turn, results in an increased vocal effort. In the diary in *study IV*, the teachers were asked about their intake of water during teaching.

None of the teachers drank water during teaching, which is both remarkable and surprising.

Consequences of voice problems

As mentioned above, significantly more teachers in the group with voice problems had stayed at home or been on sick leave due to voice problems (*study II*). Moreover, the questionnaire in *study III* showed that significantly more teachers in the group with voice problems had considered change of occupation due to their voice problems. Similar findings are reported by others. Sapir et al. (1993), Smith et al. (1997), Yiu (2002) all report that teachers consider their vocal problems negatively influence the communicative situation.

Roy et al. (2005) reported that 4,3% of the general population found the voice to be a limitation of their work. Less than 0,5% reported that they had changed their work due to voice problems, however, and 13 % reported that they were likely to change work soon. Given these results, the 18% of the teachers in this study who say they want to change their work due to their voice problems is a remarkably high number. There are today no reports of the number of teachers in Sweden who have already done this change of occupation, so the number remains unknown.

Differences in voice use in classrooms, cues to functional voice disorders?

F0 and SPL pattern

The teachers' voice use in the classrooms differed between the groups for a number of aspects (*study IV*). In line with the findings by Rantala & Vilkmann (1999), the group with voice problems did not raise the level of the fundamental as the SPL of the voice increased. Rising of the fundamental have been thought to be a sign of healthy vocal behavior (Jonsdottir et al., 2002; Laukkanen et al., 2008). So, this lack of an F0 increase seems to show an incapacity, possibly due to a lack of the functional or physical prerequisites. It is essential to point out that these different strategies or possibilities of raising the F0 simultaneous with an SPL rise, were not detected by the full voice-range profiles (VRP) in *study III*. They did not show any significant differences between the two groups. Nor were there any differences between the groups for the analyses of F0 in running speech. However, the averaged F0 estimations from the APM recordings were higher on all occasions than the average F0 from the studio recordings. These differences between the studies may, possibly, be due to methodological differences. First, the

F0 values measured for the VRP:s and studio recordings are registered by a head mounted microphone whereas the F0 measurements in *study IV* by the Ambulatory Phonation Monitor (APM) are calculations based on skin vibrations. Second, the circumstances for the two kinds of measurements differ widely. The VRP:s are made with the individual standing still in one room for about ten minutes with a supporting person, pepping the subject to systematically work the voice F0 and SPL all the way out to the extremes of the voice range. The APM recordings in *study IV* are made during one day and mirror the individual's "normal" vocal behavior. The fact that there are no differences between the groups for the VRP:s might show that both groups have both functional and physical prerequisites to increase F0 along with increasing SPL:s while in laboratory conditions and without occupational voice load. However, this vocal flexibility in daily work only seems possible for the individuals with voice problems under conditions of low or no vocal load. One explanation might be micro-changes to the vocal fold structures. According to Titze (1994), the largest mechanical stresses in vocal fold vibration are the tensile stresses required for pitch increase. Another cue to this variation of capacities might be differences in voice production. There were no differences between the groups for the LTAS analyses in *study III*. However, we did not explore possible spectral differences during the measured day, which might have given other results. Rantala et al. (1998) and Löfqvist & Mandersson (1987) found that there was a tendency towards a more hyperfunctional phonatory pattern in voice healthy individuals, measured during a day. Rantala et al. (1998) found a tendency for subjects with more vocal complaints not to be able to maintain this increase of the energy of the higher spectral components. Thus we may speculate of a more hypofunctional phonatory pattern in the group with voice problems.

Breathing and lung volumes

Hypofunctional voice quality is clinically connected to a low subglottal air pressure and might give indications of the individual's breathing pattern. The lung-volumes and phonatory breathing patterns of the subjects included in these studies are, however, unknown. There are findings that indicate a deviant phonatory breathing pattern in subjects with voice problems in comparison to healthy controls (Iwarsson, 2001; Sapienza, Stathopoulos, & Brown, 1997). The most relevant study in this context is the study by Lowell, Barkmeier-Kraemer, Hoit, & Story (2008) which reported teachers with voice problems to start and end their phonation at significantly lower lung volumes than their controls. Knowledge of the phonatory breathing and subglottal air pressure in the subjects in these studies could have added interesting information about the differences in pitch regulation between the groups. Voice therapy is commonly based on work that will develop an abdomino-diaphragmatic breathing pattern, increasing the

subglottal pressure without a costly effort. The clinical experience of this approach is positive. In the light of these findings, breathing exercises are important in voice therapy/preventive voice training.

Voice use in relation to room-acoustics and working time

Interestingly, and as also described by Pelegrín García, Lyberg Åhlander, Löfqvist & Brunskog (2011), the groups were equally affected by the background noise (Fig. 7), but they differed in how they made use of the room-acoustics, *i.e.* the Acoustic Voice Support (ST_V). The voice affected teachers decreased the SPL of the voice with increasing SL_V in the classrooms, whereas the voice healthy teachers increased it (Fig 8). These results thus show that different individuals make different use of the room acoustics and that the teachers with voice problems actually use the “help” provided by the room. However, the back-ground noise does influence the actual use of the ST_V . Bottalico, Pelegrin-Garcia, Asstolfi, & Brunskog (2010) reported that the Acoustic Voice Support seemed to have a more significant effect on the Vocal Loading Index (Rantala & Vilkman, 1999) in rooms with lower background noise levels. Thus, at a high level of background noise, the Lombard effect determines the vocal reactions whereas at lower background noise levels, it is the Acoustic Voice Support that dominates.

There may be a contradiction in the earlier literature of the contribution of the room acoustics to the speaker's vocal effort in classrooms. Pekkarinen & Viljanen (1991) concluded that many Finnish classrooms were too reverberant resulting in reduced intelligibility, which may cause the speaker to use more effort when speaking. On the other hand, Black (1951) concluded that speakers talk louder in highly absorptive rooms than in more acoustically live rooms. The effect on the vocal effort is in both cases the same: an increased effort in making oneself heard. However, the underlying causes of this increased effort are different. In the case of the too reverberant classrooms, the reverberation causes more noise from the students forcing the teachers to increase the level of their voices, in analogy with the Lombard effect. In the more damped rooms the feedback to the speaker, that is the ST_V is low, since high levels of ST_V in general are related to high RT:s which are lacking in a highly absorptive room. This underlines the usefulness of a measure that includes the speaker's perception of the voice and not only the measurement of the room and the perspective of the listener, as is traditionally done.

Why the use of the room acoustics differ between the groups remains pure speculations. It might be an indication that subjects with voice problems are more sensitive to anything in the background – helping or hindering. It may also be an adapted behavior, reducing the voice load. According to Pelegrín García

(unpublished manuscript) the mechanisms behind the speakers' reduction of the voice level in relation to the voice support is equal to when using voice amplification. Thus, the auditory cues seem important. Moreover, recent findings by (Hafke, (2008) indicate that both the fundamental and the SPL are unconsciously controlled and corrected by the auditory motor-control system.

Vocal doses

A further finding of difference in voice use between the groups was the significant differences for both time and cycle doses between the groups, as calculated by the APM (*study IV*) and showing higher doses for the group of teachers with voice problems. The time dose indicates that the teachers with voice problems speak for longer times in relation to the measured time and the vocal dose indicates that their vocal folds collide more frequently. Following Vilkman (2004), a might speculate that the teachers with many voice complaints perhaps do not necessarily only talk for longer periods of times, but that the magnitude of the time dose is a result of the inability to produce soft voice, with hard vocal attacks and vocal fry at the ends of phrases, resulting in a higher number of vocal cycles. Titze et al. (2007) discuss possible changes on a micro-level as a consequence of too many prolonged collisions of the vocal folds. The teachers in the present studies did not estimate their own speaking time, which would have provided valuable information of how the individuals estimate their speaking in relation to voice problems and voice health. However, self estimations of speaking time in a group of teachers were investigated by Thibeault et al. (2004) who reported talking "often" as opposed to "occasionally" were significantly correlated to reports of voice disorders. Nevertheless, both the time and cycle doses may show that the teachers with voice problems do not pause as often as might be needed to prevent the effects of a harmful load.

One methodological issue about the field recordings of the teachers is that they were performed during one single day, a day that was chosen by the teachers as being a representative "typical school-day", to avoid days with mainly meetings. Recordings of a couple of "typical schooldays" would perhaps have provided information for comparison and might have shown a clearer pattern of possible differences between types of sessions.

Vocal recovery

One more piece in the puzzle of voice problems in teachers is the differences of the estimated times for vocal recovery in *study III*. The teachers with voice problems were significantly more prone to estimate longer times for vocal recovery than did their voice healthy peers. Similar findings have been reported by

Sala et al. (2001). Hunter & Titze (2009) investigated the time course of vocal recovery in healthy subjects and found that full vocal recovery required up to 2 days after a loading test. About 80% of the recovery occurred within the first 5-8 hours, thus confirming the theoretical model by McCabe & Titze (2002) (see Introduction chapter). Hunter & Titze, (2009) concludes that almost all teachers in their study “demonstrate a pattern in occupational voice users who continues to use their voice before recovery is complete” (Hunter & Titze, 2009 p455). This is most probably a very plausible statement that is also true for the teachers in the present studies. The lunch-break may be considered to be a time for pause and recovery but this should be questioned in every context measured. The present teachers who were teaching younger children had their lunch with the children as a part of teaching. This is certainly not a voice rest. As for the duration of and activity during a break, the findings of Lindström, et al. (2010) and Vintturi et al. (2001a) provide some indications but are still inconclusive. Lindström et al. (2010) observed a decrease in F0 during lunch time, measured with a voice accumulator, whereas Vintturi et al. (2001a) concluded that 45 min of lunch break with small talk with colleagues is probably not a sufficient rest to restore the vocal function. Thus, the F0 drops but this is not enough to relieve the voice load. Probably, many shorter brakes during phonation than one longer rest after loading give better results in the long run. However, similar studies of voice recovery in individuals with voice problems are lacking. Based on the findings by Hunter & Titze (2009), and Titze et al. (2007) there is reason to believe that their time course for vocal recovery differs from that in voice-healthy individuals.

Stress

Stress has often been considered to add to the vocal load. There was a significant difference in the ratings of stress level between the groups in *study IV*, the higher ratings in the group with voice problems. However, when aspects of coping, burnout, job-control, and personality were examined in *study III*, no differences were found between the groups. Roy, et al. (2000a, b) found patients diagnosed with functional dysphonia to experience life as more stressful, compared to groups of patients with other diagnoses. However, it is relevant to stress that the subjects included in *studies II-IV* have not actively searched for help, which might make an important difference. Thus, the stress reaction in this population has to be considered in an overall perspective, and related to the combined effects of the voice loading in the classroom. Above all, the stress reaction is obviously something that is possible to observe only when the teacher is “in action”.

In conclusion, there are some clear differences between the groups that also may give indications of the mechanisms behind functional voice disorders. Teachers with voice problems seem to be more perceptive of most vocally loading factors,

indicated by their rating of these factors as causing problems. They also behave vocally different from their voice healthy peers when under vocal load and in relation to the room acoustics. Teachers with voice problems also recover from episodes of vocal load significantly later than their voice healthy colleagues and they rate higher degrees of perceived stress during the day. Some of these aspects only emerged “in action”, during the work-day, and were not discernable in the results of *study III*. This underlines the importance of field-studies to explore the vocal actions and reactions in teachers. These results also put the recent findings by Simberg, Santtila, & Soveri (2009) into the context. They explored the possible genetic effect on voice disorders in 1728 Finnish twins and concluded that although both genetic and environmental factors affect the etiology of voice problems, the environmental factors seem to play the key role, especially in persons with voice demanding occupations.

Prevalence of voice problems in teachers, considerations

The prevalence of voice problems in the group of teachers in *study II* was 13%. This is in agreement with findings of the point prevalence in other studies (Roy et al. 2004; Russell et al. 1998; Smith et al., 1998), and thus shows that the experiences of teachers in Swedish schools are similar to those of teachers elsewhere. However, it is complicated to compare studies due to differences in methods; the participating groups, and the definition of the core concepts. Studies have covered public-school teachers together with pre-school staff or one of the categories specifically. In the present study, the group does not include staff at day care centers and preschools due to the differences in acoustical environment. The activities of Swedish day care centers are often performed outdoor.

Moreover, the definition of voice problems varies and may or may not include the teacher’s own judgment of the severity. A number of studies estimate the severity of the problems based on the number of symptoms that the subjects report, which of course may be in accordance with the perceived severity of the voice problem. In the studies by Roy et al. (2004), Roy et al. (2005), and Thibeault et al. (2004), the definition reads: “a voice disorder occurred at any time the voice did not work, perform, or sound as it usually does for that person such that it interfered with communication.” (Thibeault et al. 2004, p 787), forming a very broad definition.

The variation in the findings of prevalence of teachers’ voice problems may thus in part depend on the definition of the concept “voice problem”. Our definition was the teacher’s own rating of the statement “I have voice problems”. That is, a teacher was considered to suffer from voice problems if the rating was two or more on the frequency based scale, indicating that the problems occurred “sometimes”, “often” or “always”, see Figure 3. Hence, the composition of the

groups in *study II* and the matched pairs in *studies III-IV* is based on the interpretation of the teachers' answers to the statement above. Other authors have defined voice problems/voice disorders more objectively, i.e. the definitions have been based on the occurrence of deviations from normal laryngeal morphology (e.g., Urrutikoetxea et al. 1995) or the number of experienced symptoms, (e.g., Simberg, Laine, Sala, & Ronnemaa, 2000). The subject-grouping in *study II* was confirmed through the groups' differences in their rating of the extracted statements from the Voice Handicap Index-Throat (VHI-T, *study I*) and, further, in *study III* through differences in the ratings of the complete VHI-T-questionnaire. The VHI is commonly considered as the title reads: an index of the voice handicap and thus serves as a confirmation of an individual's perception of the severity of the voice problem. The difference between the teachers with voice problems and the voice healthy teachers was significant for all VHI-T subscales and for VHI-T total.

Since the recruiting of the teachers for *studies III* and *IV* was made during *study II*, some aspects are important to keep in mind. We used a frequency based rating scale for the subjects' rating of the voice items in *study II*. A frequency based scale shows the absence, presence, and frequency of occurrence of a problem, but it does not tell anything about the duration of the problem. However, and according to Simberg et al. (2005), the memory factor may influence the results when a time based rating is used. The reason is that the subject may better remember recent voice episodes and this approach may thus result in a higher prevalence if the episodes have occurred close to answering the questionnaire. The frequency based scale used here may reduce the influence of the temporal aspect and rather mirror the current, overall impression, of the voice problems in the individual teacher.

When comparing self-report based studies, the response rate is important to consider. A low response rate increases the risk for bias since the responses may be given by individuals with special voice interest. As discussed by Simberg et al. (2005), the method for distributing the questionnaire may have a significant effect on the number of responses. In earlier studies, the response rate has varied between 29%-98%, with higher rates in studies where interviews were made over the phone or with a questionnaire distributed "face to face". The present study used a face-to-face manner of distribution by attending pre-scheduled, compulsory, collegial meetings at the schools. The questionnaire was completed by all the teachers attending the meetings, equal to 100%. The teachers not participating were summed to a total of 27% of the included schools. They were absent from the meetings due to sickness or vacation. It was not possible to get information on the individual causes of the absence, and it is of course completely possible that some teachers were absent due to voice problems, which may have positively distorted the prevalence result. The present data are most likely

reasonably unbiased by individual teachers' special interest in the voice or voice disorders. As to the participating schools, the individual headmasters' motives of acceptance/rejection of the schools' participation in the study are not known. However the rejections to participate have often been accompanied by explanations of heavy work load, tight schedules, and also that many investigations are currently being performed in Swedish schools.

Investigating voice use and voice problems

The use of questionnaires is by far, the most common way to investigate teachers' voices and voice problems, e.g. (Roy et al. 2005; Russell et al. 1998; Simberg et al. 2005; Smith et al. 1998; Thibeault et al. 2004). The advantages of questionnaires are obvious, giving possibility to reach many individuals during the same time-span and with no involuntary restrictions on the geographical distribution. However, one of the drawbacks is that there is no possibility to ask follow-up questions. In a way, this was compensated for by asking follow-up questions to the group that was investigated in *study III*.

As in *study III*, studies of larynx and voice function have been performed in other studies (Sala et al. 2001; Urrutikoetxea et al. 1995). The technique of high-speed digital imaging was used in *study III*, not commonly used in comparable studies. The choice was based on the hypothesis that more, and definitely smaller deviations of morphology would be possible to detect. Further, it was hypothesized that asymmetrical vibrations would occur more frequently in the group with voice problems. This was not the case, which is in line with the findings of Lindestad, Hertegård, & Björck (2004) who found asymmetries to prevail in 70% of 109 vocally healthy subjects. The findings of morphological changes are of a surprisingly low number in *study III* compared to the findings of e.g. Urrutikoetxea et al. (1995), who found structural deviations in 20,8% of the teachers investigated. It is hard to compare other studies due to the large variety of methods that have been used for laryngeal investigations and recordings for analyze.

Self-assessment of voice problems, the VHI-T

There is a profound clinical assumption that voice problems are manifested in most cases by deviations of either voice quality, laryngeal morphology, or both. However, this assumption is worth some debate. Many authors have found no correlation between vocal or laryngeal findings and self-assessments of voice symptoms and voice handicap. The results from *study III* also indicate that there is no correlation between the perceived voice problems and laryngeal or vocal deviations. This brings the importance of self-assessment to the foreground. Self-

assessment of voice problems has come more into focus during the last decade. In *study I*, the stability of a Swedish translation and adaptation of the Voice Handicap Index (VHI) was assessed. A set of ten new statements, forming a subscale on throat-related problems, was developed for the patients' possibility to make a self-assessment of throat related problems in relation to voice. The resulting questionnaire, VHI-T, was used in full in *study III* and parts of it in *studies II and IV*. Traditionally, symptoms of globus, throat clearing, and dry cough have been considered early signs of a functional voice disorder. The results from *study I* indicate that also voice healthy subjects commonly report discomfort from the throat. In addition, symptoms from the throat coexisted with most diagnoses, most common in phonastenia/functional dysphonia or in patients with throat disorders. In patients with functional dysphonia, there was a concurrent increase in the rating of the physical subscale. This was important in designing and assessing the results of the subjective judgments in *studies II-IV*. The most common complaints in all investigated teachers (*study II*) were throat clearing and hoarseness. The results from *study I* show that these "symptoms" prevail also in voice healthy individuals, but are often reported to occur with a low frequency (*i.e.* 1-2 on the rating-scale of the VHI-T). Thus, there is reason to be cautious in the interpretation of these symptoms as core symptoms of voice disorders without investigating the individual's own perception of the severity of the problem.

The conclusion might be that if symptoms from the throat are reported in a questionnaire survey, and taken as signs of vocal attrition, they should normally either coexist with symptoms rated on the physical subscale, or be reported in combination with more symptoms from the throat or be of frequent occurrence. A, somewhat unorthodox comparison of the VHI-T ratings of the teachers in *study III* and the patients in *study I*, shows that the group with voice problems rates their voice symptoms as severely as the patients, on all subscales see Table 17.

Table 17. Comparison of results of VHI-T, subscales and total score, between patients and controls from study I and two groups of teachers from study II.

Subscale	Teachers with voice problems M(Sd)	Voice healthy teachers M(Sd)	Pat I	Contr I
Throat	15,3 (5,9)	8,7 (5,0)	14,5	6,9
Physical	13,8 (8,6)	6,7 (6,6)	15,1	5,4
Functional	8,5 (7,0)	2,5 (3,6)	9,5	1,8
Emotional	9,0 (9,5)	1,7 (3,2)	8,7	1,3
VHI-T Total	46,7 (22,2)	19,3 (15,0)	47,8	15,3

The VHI is often referred to as an instrument measuring quality of life. Considering the results of the VHI-T, we expected to find differences between the groups also for some of the scales rating coping (UCL), personality (SSP), burnout (SMBQ), and psychosocial aspects or work (JCQ). Surprisingly, no differences were found. The increasing number of studies linking psychological factors to functional dysphonia indicates the plausibility of psychological aspects influencing the voice problems in teachers. There are, however, only a small number of studies that have investigated the specific contribution of psychological factors to the voice problems in teachers. The group of teachers answering to a questionnaire survey by McAleavy et al. (2008) assessed “trait anxiety” to be present, assessed by the State Trait Anxiety Inventory (STAI). Pekkarinen et al. (1992) did not find any significant correlation between the personality profile (defined as introversion-extroversion) and vocal symptoms in their groups of teachers and nurses, which is similar to the findings of Kooijman et al. (2006) from a questionnaire study in 1878 teachers. The conclusion might thus be that stress and anxiety plays a more important role in the development of voice disorders in teachers than the personality.

Our results may, however, be due to a selection bias. In *study II*, we asked the respondents who wanted to take further part in the project to mark this on the questionnaire. This may have caused the more active teachers with feelings of control of their social life and work situation to step forward. The non-difference within the pairs may also depend on the normality of the data. There were no big differences in any scale as compared to a normal population. The difference between the present study and others might also be due to the use of different instruments. We used a battery of tests that have been developed for a Swedish population (SSP) or had been tried and on a Swedish population (JCG, SMBQ). Apart from The Utrechtse Coping Lijst, that was used in a study by Meulenbroek et al., (2010), none of the scales have formerly been used in teachers with voice problems or in patients with voice disorders. There is to date no consensus about

which questionnaire/questionnaires to use for investigating psychological factors in dysphonic patients or in research groups and further studies are thus warranted in this area. However, for the investigation of work-related issues, we found the Job Content-model very useful, and thus recommend it for further investigations of work-related dimensions in connection to voice problems.

Concluding remarks

For all of the above mentioned findings, it is important to remember that similarly to other studies of voice problems in teachers, the investigated teachers are in most cases not patients at voice clinics, which also explain the small differences compared to voice healthy subjects. The differences between the groups were most clearly shown during the field measurements in *study IV*. Sala et al. (2002) argues that there is no standardized method to measure voice loading. Field measurements, exploring the vocal behavior along with identification of environmental and individual factors influencing the voice use is a useful although time consuming clinical approach.

The self-estimation of voice problems emerges as one of the most important aspects to assess when estimating both problems of voice in teachers as well as in clients referred to voice clinics. According to Deary et al. (2003a p 374): "People's ratings of their symptoms are an important guide in gauging the severity of medical disorders, and are specially useful in assessing the response to treatment".

CONCLUSIONS

- Voice problems in teachers arise from the interplay of the individual and the environment. Teachers with voice problems are more affected by factors in the work environment than their voice healthy colleagues. The differences between a group of teachers with self-assessed voice problems and their voice healthy colleagues were most clearly shown during field-measurements of the voice during a typical school day, while the findings from the clinical examinations of larynx and voice did not differ between the groups. (*studies II-IV*)
- The results show that 13% of the teachers suffer from voice problems sometimes, often, or always. Vocal symptoms were reported in the entire group, but significantly more in the group with voice problems. Teachers with voice problems thus differ from their voice healthy colleagues in their estimation of the voice symptoms, in their ratings of the time for vocal recovery, and by suffering from voice problems also without a concurring cold. Voice-related absence from work was common in both teachers with and without voice problems (*study II-III*).
- Teachers with voice problems are more affected by the room acoustics and by factors adding to the back-ground noise than their voice healthy colleagues. The differences within the group of teachers in *study II* indicate that any voice load is rated as more troubling for the individual who suffers from voice problems. The teachers participating in *study II* agreed on several aspects of working environment being noticeable in their work-situation.
- The teachers with self-estimated voice problems differed from their voice healthy peers in several aspects of voice use, in particular during teaching sessions, measured in *study IV*. The time- and cycle doses were both significantly higher in the group with voice problems. This suggests a higher vocal load with fewer opportunities for vocal recovery during teaching.
- A reduced vocal flexibility in the group with voice problems was indicated in *study IV*. The pattern of F0 changes in relation to both room acoustics and the SPL of the voice differed between the groups. However, all teachers reacted to the background noise in accordance with the Lombard effect.
- Symptoms from the throat are common in most voice patients and also to some extent in voice healthy individuals. Reports of symptoms from throat are common also in investigations of teachers' voices. The VHI-Throat developed and tried in *study I*, proves to be a valid and reliable instrument for the estimation of self-perceived voice and throat problems. The use of the throat

subscale helps to reveal a category of symptoms that are only marginally covered in other available instruments. Similar to other translations of the VHI, it can be used for both clinical purposes and for research.

- The combination of the number of symptoms and of how often the symptoms occur, along with the time it takes to recover, seems to underlie the individual's perception of the voice problem. The main significant differences of the clinical investigations of larynx and voice in *study III* were differences in the ratings of VHI-T and for recovery time after voice problems.
- When investigating or diagnosing voice dysfunction, the individual's self assessment of the problems needs to be included. No correlation was found between subjective assessment of voice problems and deviations of laryngeal morphology or voice quality (*Study III*).

In summary: teachers with voice problems are more dependent on good working conditions and need to learn how to optimize their use of the voice and of the room acoustics. The differences between the groups were most clearly evident while measured with the teacher in action. Thus, field measurements of the voice should be included when exploring occupational voice problems. The findings suggest that discussions about the use of the acoustic properties of the class room should be covered during voice therapy with teachers. The etiology of voice problems in teachers is not possible to define based on the results in these studies, that is, if the voice problems have their origin in the interplay with the work environment or if they existed already before the teacher started in the occupation. However, it is clear that it is in the interplay between the individual and the work environment that the voice problems emerge.

SVENSK SAMMANFATTNING

Undervisning ställer stora krav på lärares röster. Rösten behövs som ett pedagogiskt verktyg, i kommunikation med eleverna, i allt ifrån högläsning till instruktioner i idrottshallen. I en studie från 1996 beskrev Fritzell (1996) att lärare är överrepresenterade i väntrummen på röstmottagningarna. Flera studier om förekomsten av röstproblem hos lärare har genomförts i olika länder (se Tabell 1) men hittills ingen i Sverige.

Röstproblem kan ha olika grund. Sedan ett tjugotal år har forskningen kring orsaker till röstproblem hos lärare koncentrerats på den belastning som lärarrösten utsätts för i klassrummet. Röstbelastande faktorer finns i arbetsmiljön, till exempel om man måste tala mycket och länge, om man får otillräckliga pauser, om det finns bakgrundsbuller och om rummet har dålig akustik. Röstbelastande faktorer kan också vara relaterade till individen. Kön, ålder, psykiskt och fysiskt hälsotillstånd och stress kan vara faktorer som har betydelse för uppkomst av röstproblem.

Idag är mycket känt om lärares röster och röstanvändning, från enkätstudier och laboratoriestudier. Däremot är ännu mycket okänt om hur lärare uppfattar sin arbetsmiljö ur röstsynpunkt. Det finns få studier om hur lärare använder sina röster i det dagliga arbetet. Jämförande studier om den dagliga röstanvändningen hos lärare med röstproblem och deras röstfriska kollegor saknas nästan helt. Klassrummets akustik har undersökts i en mängd studier men då med fokus på eleven/lyssnaren. Trots att klassrumsakustiken ofta nämns som bidragande orsak till röstbelastning och röstproblem har den sällan undersökts i relation till lärarens röst.

Syftet med denna avhandling var att:

undersöka hur lärare bedömer faktorer i arbetsmiljön som anses påverka rösten och särskilt sätta fokus på rumsakustiken (*studie II-IV*).

- undersöka förekomst av röstproblem hos svenska lärare (*studie II*).
- utveckla ett bedömningsinstrument för lärares och patienters självbedömning av röst och halssymtom (*studie I*).
- studera lärares röstfunktion (*studie III*) och den vardagliga röstanvändningen i undervisningen (*studie IV*) och göra jämförelser mellan lärare med röstproblem och deras röstfriska kollegor.

Resultaten från *studie I-IV* visar i sammanfattning att:

Samspelet mellan individ och miljö är avgörande för lärares röstproblem. Lärare med röstproblem påverkas mer av belastande faktorer i arbetsmiljön än de

röstfriska kollegorna. Röstproblemen framträdde tydligast i arbetet och endast få mätbara skillnader fanns mellan lärare med röstproblem och deras röstfriska kollegor vid traditionella, kliniska undersökningar. Resultaten visar att 13 % av lärarna lider av röstproblem. Alla lärare upplever någon gång påverkad röstfunktion men lärare som anger att de har röstproblem skiljer sig från röstfriska lärare i självskattningen av röstsymtomen, i skattningen av återhämtningstiden efter röstbelastning och i att de i högre grad har problem med rösten utan att vara förkylda.

- Lärare med röstproblem påverkas mer av klassrummets akustik och bedömer den i högre grad som hindrande för rösten. Lärare med röstproblem belastas mer av bakgrundsbuller och skattar luften som torrare i högre grad än de friska kollegorna. Hela gruppen av lärare i *studie II* bedömde bakgrundsbullret från eleverna, fläktar och ljud som kommer utifrån klassrummet som störande (*studie II*).
- Röst användningen hos lärare med röstproblem skiljer sig från röst användningen hos de friska kollegorna under skoldagen, i synnerhet under lektionstid. Resultaten från *studie IV* visar att den ackumulerade röst användningen över tid är högre och de har ett högre antal stämbandsvibrationer per tidsenhet. Därtill har de en sämre flexibilitet i röstfunktionen och klarar inte av att förändra röstläget (F0) i relation till ökning av röststyrkan (SPL) på samma sätt som de röstfriska kollegorna (*Studie IV*).
- Hosta, harklingar och andra symtom från halsen är vanligt förekommande hos röstpatienter i allmänhet och rapporterades också av lärare, både med och utan självskattade röstproblem. Hos en yrkesblandad grupp friska kontroller förekom också symtom från halsen. Tidigare har det inte funnits något instrument för bedömning av halssymtom utom för specifika diagnoser och inte i relation till röst. Det instrument för självskattning av symtom från både hals och röst som utvecklades och prövades i *studie I*, Voice Handicap Index-Throat, bedömdes som stabilt. VHI-T fyller en viktig funktion för att kunna sätta symtom från halsen i relation till röstfunktionen. Symtom från halsen bedöms traditionellt som tidiga tecken på röstproblem (*Studie I*).
- Vid studier av t ex. lärares röstproblem och – funktion är det viktigt att ta hänsyn till individens egen skattning av problemen. Detta är även en kliniskt viktig implikation. I likhet med andras resultat fanns det ingen korrelation mellan de självskattade röst- (och hals-) problemen och bedömningen av avvikelser i röstkvalitet eller larynx. (*Studie III*)
- Resultaten visar att diskussioner om arbetsmiljö och belastande faktorer i miljön måste ingå i behandlingen av röstpatienter med röstkrav i yrket och att området röstergonomi bör beredas plats.

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APPENDIX

a) Voice Handicap Index- Throat



Avd. för Röst och Talvård
Universitetssjukhuset i Lund, USIL
RoS gruppen 2003

Frågeformulär angående röst (VHI-T)

Tack för att Du tar Dig tid och fyller i detta formulär! Uppgifterna är konfidentiella och behandlas som journalhandling.

Namn _____

Personnummer _____

Dagens datum _____

Yrke (även pensionär) _____

Jag använder min röst

i mitt yrke ☐

i fritidsaktiviteter ☐ vilka? _____

i normalt vardagssamtal ☐

Jag bedömer min röst under de två senaste veckorna som: (ringa in ett alternativ)

Mycket dålig	Dålig	Mellan bra och dålig	Bra	Mycket
bra	Rösten varierar			

Ange hur du upplever din röst nu genom att placera ett lodrätt streck tvärsöver passande ställe på nedanstående linje

Inga	Maximala
Röstbesvär	röstbesvär
I _____ I	

INSTRUKTION:

I påståenden nedan skall Du ringa in den siffra som bäst stämmer överens med dina besvär där: Aldrig=0/ Någon enstaka gång=1/ Ibland=2/ Ofta=3/ Alltid=4

Exempel:

Min röst fungerar bättre på morgonen än på kvällen

0 1 2 **3** 4

Del 1

- | | |
|--|-----------|
| 1. Jag är torr i halsen. | 0 1 2 3 4 |
| 2. Jag måste harkla mig. | 0 1 2 3 4 |
| 3. Jag har mycket slem i halsen. | 0 1 2 3 4 |
| 4. Jag känner att det sitter något i halsen. | 0 1 2 3 4 |
| 5. Det svider i halsen. | 0 1 2 3 4 |
| 6. Jag känner ett tryck utanpå halsen. | 0 1 2 3 4 |
| 7. Det känns som om jag har en klump i halsen. | 0 1 2 3 4 |
| 8. Jag är irriterad i halsen. | 0 1 2 3 4 |
| 9. Jag har ont i halsen. | 0 1 2 3 4 |
| 10. Jag har rethosta. | 0 1 2 3 4 |

Del 2

- | | |
|---|-----------|
| 1. Luften tar slut när jag talar. | 0 1 2 3 4 |
| 2. Kvaliteten på rösten varierar under dagen. | 0 1 2 3 4 |
| 3. Andra frågar om jag är förkyld. | 0 1 2 3 4 |
| 4. Min röst kan plötsligt förändras under ett kortare samtal. | 0 1 2 3 4 |
| 5. Rösten försvinner mitt i en mening. | 0 1 2 3 4 |
| 6. Jag försöker förändra min röst för att låta bra. | 0 1 2 3 4 |
| 7. Det är ansträngande att tala. | 0 1 2 3 4 |
| 8. Min röst är sämst på morgonen | 0 1 2 3 4 |
| 9. Min röst är sämst på kvällen. | 0 1 2 3 4 |
| 10. Min röst låter hes. | 0 1 2 3 4 |

Del 3

- | | |
|--|-----------|
| 1. På grund av min röst spänner jag mig när jag talar med andra. | 0 1 2 3 4 |
| 2. Andra verkar bli irriterade på min röst. | 0 1 2 3 4 |
| 3. Andra verkar sakna förståelse för mina röstproblem. | 0 1 2 3 4 |
| 4. Mina röstproblem gör mig orolig. | 0 1 2 3 4 |
| 5. Jag är mindre utåtriktad på grund av mina röstproblem. | 0 1 2 3 4 |
| 6. Jag känner mig handikappad på grund av min röst. | 0 1 2 3 4 |
| 7. Jag blir irriterad när andra ber mig upprepa vad jag sagt. | 0 1 2 3 4 |
| 8. Jag känner mig besvärad när andra ber mig upprepa vad jag sagt. | 0 1 2 3 4 |
| 9. Min röst gör att jag känner mig osäker. | 0 1 2 3 4 |
| 10. Jag skäms för mina röstproblem. | 0 1 2 3 4 |

Del 4

- | | |
|---|-----------|
| 1. Andra har, på grund av min röst, svårt att uppfatta vad jag säger. | 0 1 2 3 4 |
| 2. Jag har svårt att göra mig hörd i bullrig miljö, som t ex på ett kalas. | 0 1 2 3 4 |
| 3. Jag har svårt att öka röststyrkan för att ropa. | 0 1 2 3 4 |
| 4. Jag undviker att tala i telefon på grund av min röst. | 0 1 2 3 4 |
| 5. Människor ber mig upprepa vad jag har sagt. | 0 1 2 3 4 |
| 6. Jag undviker att tala i grupp på grund av min röst. | 0 1 2 3 4 |
| 7. Jag talar mer sällan än jag skulle vilja med vänner och familj på grund av min röst. | 0 1 2 3 4 |
| 8. Min röst begränsar mig i mina fritidsaktiviteter. | 0 1 2 3 4 |
| 9. Jag blir utelämnad ur samtal på grund av min röst. | 0 1 2 3 4 |
| 10. Min röst begränsar mig i mitt arbetsliv. | 0 1 2 3 4 |

b) Questionnaire for study II

Datum: _____

1 Skola: _____

2 Ålder: _____ **3 Kön:** ☐ Kvinna ☐ Man

4 Årskurs/-er (ev flera): _____ **5 Antal år i undervisning** _____

6 Din postgymnasiala examen? vilken _____ **år:** _____

7 Om huvudämne: vilket? _____

8 Jag undervisar i (kryssa för samtliga aktuella alternativ):

☐ Helklass: _____ Hur många elever?: ca _____ stycken

☐ Halvklass: _____ Hur många elever?: ca _____ stycken

☐ Mindre grupper: _____ Hur många elever?: ca _____ stycken

☐ Enskilt

9 Hur många pedagoger brukar arbeta i klassen samtidigt? _____

10 Kan du påverka Din arbetsdag så att Du kan vila om Du får röstbesvär? ☐ Ja ☐ Nej

11 Använder Du röstförstärkning under lektionerna (mikrofon + högtalare)? ☐ Ja ☐ Nej

12 Har du tränat rösten? ☐ Ja ☐ Nej

Om ja: ☐ Under lärarutbildningen

☐ Jag har tagit sånglektioner: _____ ☐ Regelbundet ☐ Enstaka tillfällen

☐ Annat sammanhang, beskriv: _____

13 Använder Du rösten i fritidsaktiviteter, utöver vanliga samtal? ☐ Ja ☐ Nej

Om ja: vilka? _____

14 Har Du sökt professionell hjälp för röstproblem? (Öron-Näsa-

Halsläkare/foniater/logoped) ☐ Ja ☐ Nej ☐ annan hjälp, vilken? _____

15. Har Du varit sjukskriven p g a problem med rösten? ☐ Ja ☐ Nej

Om ja: ☐ vid ett tillfälle? ☐ Vid mer än ett tillfälle?

16 Röker Du?

☐ Nej, jag har aldrig rökt

☐ Jag har rökt men slutade för år _____ sedan

☐ Jag röker 1-5, 6-10, 11-15, 16-20, >20 cigaretter per dag (ringa in)

17 Har Du astmabesvär? ☐ Ja ☐ Nej
Om ja: medicinerar du för astmabesvären? ☐ Ja ☐ Nej
Om ja: vilken medicin? _____

18 Är Du känslig för starka dofter? ☐ Ja ☐ Nej
☐ Överkänslig för ngt annat? Beskriv: _____

19 Använder Du hörselhjälpmedel? ☐ Ja ☐ Nej

20 Trivs Du med Ditt arbete? mycket i stort sett både/och inte alls
(ringa in det alternativ Du tycker stämmer bäst)

INSTRUKTION

Ringa in det alternativ som du uppfattar stämmer bäst!

Exempel: Luften känns torr i klassrummet 0 1 2 3 4

OBS att samtliga frågor utgår ifrån att dörren till rummet är stängd!

OBS att svarsalternativen till fråga 1 är omvända!

	Instämmer helt			Instämmer ej	
	0	1	2	3	4
1. Klassrumsakustiken hjälper mig att tala bekvämt					
	Instämmer ej			Instämmer helt	
	0	1	2	3	4
2. Det ekar i klassrummet	0	1	2	3	4
3. Klassrummet är svårt att tala i	0	1	2	3	4
4. Jag måste öka röststyrkan för att göra mig hörd i klassrummet även om det endast är lite ljud i rummet.	0	1	2	3	4
5. Luften känns torr i klassrummet	0	1	2	3	4
6. Det känns som om rösten blir dämpad av akustiken i klassrummet (med eleverna närvarande)	0	1	2	3	4
7. Det är dragigt i klassrummet när dörren är stängd	0	1	2	3	4
8. Ljudet från eleverna är påtagligt i klassrummet	0	1	2	3	4
9. Ljudet från ventilationen är påtagligt i klassrummet	0	1	2	3	4
10. Ljudet från AV-utrustning är påtagligt i klassrummet	0	1	2	3	4
11. Ljudet utifrån är påtagligt i klassrummet	0	1	2	3	4
12. Jag har problem med min hörsel	0	1	2	3	4
13. Klassrumsakustiken påverkar mitt sätt att tala (med eleverna närvarande)	0	1	2	3	4

Om Du markerat 1-4 i fråga 13, beskriv på vilket sätt akustiken påverkar Dig:

Positivt:

Negativt:

INSTRUKTION

I påståenden nedan skall Du ringa in den siffra som bäst stämmer överens med din uppfattning där:

0=Aldrig 1= Någon enstaka gång 2= Ibland 3=Ofta 4=Alltid

Exempel: Min röst fungerar bättre på morgonen än på kvällen 0 1 2 3 4

	Aldrig	Någon enstaka gång	Ibland	Ofta	Alltid
14. Jag behöver röstförstärkning under lektionerna (mikrofon + högtalare)	0	1	2	3	4
15. Jag behöver harkla mig	0	1	2	3	4
16. Min röst låter hes	0	1	2	3	4
17. Min röst kan plötsligt förändras under tiden jag pratar.	0	1	2	3	4
18. Jag måste anstränga mig för att få rösten att fungera.	0	1	2	3	4
19. Min röst begränsar mig i mitt arbete	0	1	2	3	4
20. Jag undviker vissa arbetsuppgifter på grund av min röst	0	1	2	3	4
21. På grund av min röst har eleverna svårt att uppfatta vad jag säger	0	1	2	3	4
22. Jag har velat stanna hemma för att jag haft problem med rösten	0	1	2	3	4
23. Andra frågar vad som är fel med min röst.	0	1	2	3	4
24. Jag har stannat hemma för att jag haft problem med rösten	0	1	2	3	4
25. Jag upplever en känsla av obehag i halsen.	0	1	2	3	4
26. Min röst oroar mig.	0	1	2	3	4
27. Jag har svårt att få luften att räcka till när jag pratar	0	1	2	3	4
28. Min röst gör att jag känner mig osäker	0	1	2	3	4
29. Det svider i halsen	0	1	2	3	4
30. Det känns som om jag har en klump i halsen	0	1	2	3	4
31. Jag har känningar av magkatarr	0	1	2	3	4
32. Jag har problem med min röst	0	1	2	3	4