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The Association Between Work-related Stress, Indoor Air Quality and Voice Problems Among Teachers - Is There a Trend?

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Abstract: Introduction. Hoarseness and other voice problems are common in occupations where the person has to speak, sing or shout in a work environment containing dust, noise, gaseous or particulate irritants. In recent years, stress has often been associated with voice problems.

Objective. The aim of this study was to examine trends over a period of time of the prevalence of voice problems and reported stress in Finnish school buildings.

Study Design. School buildings from different parts of the country were studied for ten years using a similar questionnaire (N = 1721). Five schools participated before and after the remediation of an indoor air problem in the school buildings (n = 315).

Results. In the pilot study (2007–2008), the reported work-related stress was on a very low level (3%) and the prevalence of hoarseness was 10%. After the economic crisis in 2008, the stress was observed to have increased. During the follow-up (2008–2017), the reported stress had continued to increase and in the latest surveys it was 21% and the prevalence of hoarseness 34%. Indoor air factors correlated significantly with hoarseness even when controlling for age, gender, owning pets and job satisfaction in a logistic regression model. In the school buildings where the remediation of the building was completed, the prevalence of hoarseness decreased but the level of stress increased. In general, the proportion of respondents reporting stress was lower than the proportion of respondents with hoarseness. Additionally, the reported stress also correlated with factors other than health in the education branch, especially economic resources and major changes in the core curriculum.

Conclusion. Hoarseness and work-related stress have, to a large extent, different risk factors. Over time, the proportion of individuals with stress has been at a lower level than the proportion of respondents with voice problems; hence, we conclude that it is quite unlikely that stress would be a causative risk factor for hoarseness. We recommend that irritant dust and gases should be reduced from the work environment of teachers to enable recovery from hoarseness and other voice problems. Coping with work-related stress should be alleviated with other measures.

Key Words: Hoarseness—Voice problems—Work-related stress—Work environment—Schools.

INTRODUCTION

Hoarseness and other voice problems are common in all occupations in which a person must speak or sing either as part of their job or in association with their hobbies and where the environment contains irritants such as: gases, dusts, fibers, chemicals, fumes or noise.^{1,2} Some recent studies have also shown a high prevalence of voice problems and a possible connection with stress,^{3,4,5} and a high number of pupils in the classroom.⁶ The professionals most at risk are teachers, priests, sports coaches etc. In cross-sectional studies, when a correlation between work-related stress and voice problems is observed, it is not possible to investigate whether stress is the reason for the hoarseness and other voice problems or whether the stress is a consequence of symptoms that may have an impact on a workability and

on the well-being of the person.⁴ The reporting of general stress and especially work-related stress has increased in Finland during recent years⁷. Only a few intervention studies exist concerning efforts to combat stress among teachers.⁸

To discover the general trend over time and also to establish which of these problems appears first, we have gathered data from school buildings, day-care centers and health care facilities. Findings about the risk factors among nurses have recently been published⁹. In this article, we present the results from the school buildings.

In earlier decades when the generally called Örebro-questionnaire was planned, subjective work-related stress was not included in the questionnaire.¹⁰ The original MM40 questionnaire was designed in Sweden and used for four decades to describe symptoms associated with the sick building syndrome.¹⁰ The sick building syndrome refers to a situation where a large number of individuals experience respiratory irritation and general symptoms, and these symptoms are milder, relieved or disappear outside of the building. Sick building syndrome-symptoms originate from different sources, and are often due to unknown irritants or a combination of low-level exposures. The hypothesis that mental factors and especially stress, worries and fears could

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have an impact on a sick building syndrome was introduced several years ago after the original Örebro-questionnaire was planned and validated.

Questions on work-related stress were added to our questionnaires more than 10 years ago. The bank crisis in 2008 had severe consequences in municipalities and towns in Finland. One of the first studies was piloted in 2007 and after 2008 larger surveys on symptoms and stress were conducted in hospitals and school buildings with and without indoor air problems.^{11,12} Due to the economic crisis, it was not always possible to remediate the buildings immediately, and sometimes the repairs were delayed for many years, or, only small modifications were made such as an increase of the ventilation rate, superficial renovations or the use of air purifiers.

The economic depression in 2008 reduced the resources available for basic education. However, the economic growth between 2015–2018 increased resources to some extent and many school buildings were remediated.^{13,14} A new core curriculum for basic education was launched in 2016 in primary schools, and was introduced into secondary schools during 2017–2019. According to our knowledge, these changes have not been subject to research and the possible impact on the well-being, job satisfaction and health of teachers remains obscure.

All three factors in the work environment of teachers, physical, social, and mental may have an impact on their health and job satisfaction. A better understanding is necessary of the connections between stress, hoarseness and other health problems and what kind of actions are needed to promote the health of teachers and pupils in school buildings. These aspects are especially important in the current situation in which the corona-pandemic is having an acute impact on working life and schools.

The aim of this study is to reveal the time trends of symptoms in Finnish schools that may have an impact on job satisfaction and workability, especially hoarseness and other voice problems, reported stress, and their background factors. A further aim is to determine whether the perceived work-related stress among teachers has increased over time and whether this increase correlates with indoor air factors or symptoms. Another aim is to ascertain whether these symptoms and diseases are related to indoor air factors. We also aim to analyze which age and gender groups are at risk of harmful stress and voice symptoms and the possibility of combating these factors with remediation measures.

MATERIAL AND METHODS

The study plan was approved by an Internal Review Board (IRB), ie, the ethical committee of the University of Turku. First, a pilot study was conducted in four schools in middle Finland with the aim of testing the electronic questionnaire delivered by e-mail. One of these pilot schools had a significant indoor air problem, and one (an elementary school) had a milder indoor air problem. Two of the buildings had no obvious indoor air problems according to a walk-

through inspection by trained construction engineers. These two schools served as a comparison group for the school buildings with indoor air problems. Questions about work-related stress were added to the symptom questionnaire because a similar adaption had been made in the questionnaire for health care professionals.

After the pilot study, the symptom questionnaire was sent to all the teachers in another town and later to different parts of Finland. Several municipalities and towns participated in our nation-wide intervention study of schools with a variety of indoor air problems. By 2017, the new questionnaire had been used in 66 schools in 22 municipalities or towns (1721 respondents). The response rate varied between 39% and 90% in different schools. Follow-up data collected before and after the remediation was obtained from 5 towns and municipalities (315 respondents).

The questionnaire consisted of 60 questions about the work environment, indoor air quality, job satisfaction, symptoms, infections, diagnosed diseases, medication and whether or not actions had been taken to reduce indoor air exposures with the help of remediation, air purifiers, moving the school or the respondent to a cleaner work environment etc. Information was requested about the home environment, smoking, having pets and hobbies that included exposure to organic dusts. The questionnaire comprised the s.c. Örebro-questionnaire (MM040) and parts of the Tuohilampi set of questionnaires¹⁵ which are widely used in indoor air research and validated earlier.^{10,16}

Information concerning the school buildings was obtained from the building authorities in each town, in addition to the respondents' own observations of the indoor air quality. In most of the schools, moisture measurements for the construction and a walk-through inspection had been performed by health inspectors and the work safety officer. These inspections are based on national legislation on work safety and environmental safety.¹⁷ In several of the buildings the moisture damage and remediation of the buildings had been started consecutively.

All the symptom questions with four alternative answers were transformed to dichotomous variables (yes/no) by combining the alternatives 'daily' and 'every week' to 'yes', and the alternatives 'more seldom' and 'never' into 'no'. The perceived indoor air quality questions concerning subjective annoyance were combined in a similar way (eg, "How often are you annoyed by draught?" Alternatives 'daily' and 'every week' were recoded 'yes' and alternatives 'more seldom' and 'never' to a 'no'-answer). Job satisfaction was estimated through a series of questions about well-being at work, the workload, control over work tasks and working conditions and the support provided by peers when needed. Additionally, there was one question about work related stress with the alternatives, 'most of the days', 'sometimes', 'only seldom' and 'never'. The stress was defined as follows: Stress means a situation in which a person feels tense, restless, nervous, or anxious or is unable to sleep at night because his/her mind is troubled all the time. Do you experience this kind of work-related stress?

The data was analyzed with SPSS 26 statistics (IBM Corp. Armonk, NY) and the dichotomous variables were tested with a χ^2 -test and continuous variables with the *t* test. The association between stress, symptoms and the indoor air quality were analyzed with multivariate logistic regression models and risk ratios with confidence intervals were calculated. The *P*-value <0.05 was considered statistically significant.

All respondents participated voluntarily, and informed consent was obtained with an attachment to the questionnaire. In the follow-up study after the remediation, all respondents were pseudonymized after the participants' individual responses had been combined with the respective reply from previous survey(s).

RESULTS

Hoarseness is one of the symptoms teachers tend to report associated with their work and work environment. Calculations for the entire material show that the overall prevalence of hoarseness was 17% and the prevalence of work-related stress was 15% (Table 1).

Subjective annoyance due to indoor air factors was quite common and the most typical factors are given in the Table 1. The most common complaint as regards the indoor air was the stuffiness of the air which annoyed one third of the whole study population. Insufficient ventilation was almost as common as an annoying factor. In addition, almost every fifth person had observed visible signs of moisture damage in the respondent's own room and 26% elsewhere in the work place.

Pilot study

The pilot study showed a 7% prevalence of hoarseness among the personnel in the four school buildings (Figure 1).

TABLE 1.
Descriptive Variables of the Study Population (n, %)

	n	%
Hoarseness	626	17
Work-related stress	253	15
Background variables		
– Smokers	87	5
– Ex-smokers	208	12
Doctor-diagnosed diseases		
– Asthma	156	9
– Allergic rhinitis	268	16
– Atopic eczema	101	6
Pets	660	39
Indoor air factors		
– Stuffiness in indoor air	1013	33
– Insufficient ventilation	856	32
– Moisture spots	368	26
– Noise	700	25
– Dust or dirt	489	13

In the pilot study, 10% of the respondents smoked and 35% of all the respondents had pets.

In the pilot study, hoarseness and work-related stress did not correlate. The prevalence of work-related stress was, on average, under 10%, but the amount of stress varied between school buildings. The highest level of stress was reported in an upper secondary school with good indoor air (16%), whereas in the damaged secondary school, only 3% reported stress. The college building and the upper secondary school with no damage had the highest levels of satisfaction with the HVAC-system.

Respondents in the moisture damaged elementary school had the highest proportion of respondents with hoarseness (21%) and the upper secondary school with no indoor air problems had 18% of the respondents with hoarseness.

National data from 2010 to 2017

In the second phase of the study, we continued every year to collect data from study populations in different locations. Annually, 200–300 teachers participated in the study from different parts of the country (Figure 1). In 2011 and 2012, only a few schools participated, and they were all buildings with an indoor air problem. Other annual studies had both damaged and non-damaged schools, and some of these studies were followed-ups before and after the remediation (Table 2).

The analysis of the crude data shows that work related stress increased rapidly from 8% to 27% during the economic recession. A new increase was observed from 2012 to 2013, but after 2014 the increasing trend has been slower (Figure 1). During the new economic growth and after the introduction of the new core curriculum, the work-related stress started to increase again, and is now approximately 20%.

Women tend to report work-related stress slightly more often than men. The differences between genders in some schools was close to a statistical significance ($P < 0.05$). The respondents with a lower educational training had significantly less work-related stress (10%), than respondents with an academic degree (19%, $P < 0.001$). A vast majority of the respondents had a good or excellent level of job satisfaction and only 10% of these participants reported work-related stress. Of the 63 participants who reported poor job satisfaction, nearly half (46%, $P < 0.001$) had a very high level of work-related stress.

During the same years (2010–2011), the prevalence of hoarseness increased rapidly and faster than work-related stress. The fastest change occurred in the years from 2008 to 2011. After which a clear reduction in hoarseness was observed from 2012 to 2015. However, in the same periods only a slight variation was seen in work related stress.

During the years from 2015 to 2017, an increase in hoarseness was observed. In the most recent study material, hoarseness was reported by more than 30% of the respondents. During the follow-up period of ten years, the prevalence of hoarseness has increased to three times higher level

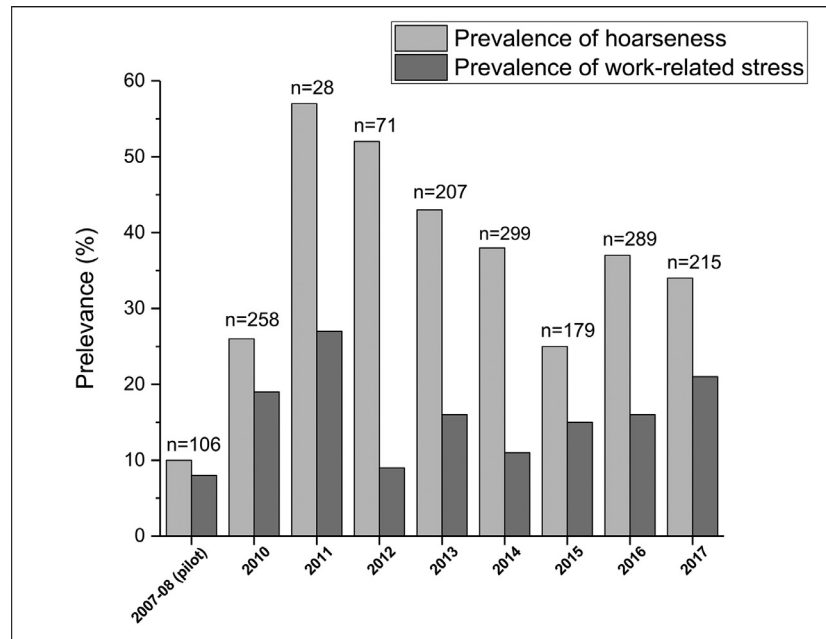


FIGURE 1. The prevalence of hoarseness and work-related stress among teachers according to surveys in 2007–2017.

compared with the year 2008 (Figure 1 and Table 2). Hoarseness occurred significantly more often by women compared with men in the same buildings.

Hoarseness was associated with respondents' previous history of asthma and allergies, such as allergic rhinitis and atopic eczema as well as with hypothyroidism, but not with smoking or having pets at home (Table 3). Respondents with asthma had almost two times more often hoarseness than the non-asthmatic respondents.

Work related stress had different associations with the same background factors. Smokers reported significantly less stress than non-smokers or ex-smokers, but the number of respondents were small (Table 4). Work-related stress was not associated with either having pets or a diagnosed allergic disease, coeliac disease, thyroid disease or inflammatory bowel disease (data not shown).

In a subgroup of the follow-up data ($n = 315$) we observed stress and hoarseness before and after the remediation of the building. Work-related stress before remediation was on the same level in both genders. After the remediation process, the level of work-related stress had increased. After remediation, every fifth respondents reported stress 'much or very much' during the previous 12 months. However, the increase was not statistically significant.

TABLE 3.
The Association of Background Factors, Health Problems and Diseases With the Prevalence of Hoarseness

	N	n (%) with hoarseness	P
Men	320	30 (9)	<0.001
Women	1296	237 (18)	
Total	1616	267 (17)	
Pets At Home	641	106 (17)	0.88
No Pets	992	168 (17)	
Smoker	81	11 (14)	0.52
Ex-smoker	202	32 (16)	
Non-smoker	1262	221 (18)	
Asthma	149	90 (60)	0.001
No asthma	1484	543 (37)	
Allergic rhinitis	262	135 (52)	0.001
No rhinitis	1371	498 (36)	
Atopic eczema	99	48 (48)	0.01
No atopy	1534	585 (38)	
Hypothyroidism	75	23 (31)	0.001
No thyroid disease	1558	251 (16)	

The number and percentage of respondents reporting hoarseness according to different exposure groups.

TABLE 2.
The Prevalence of Hoarseness in Finnish Schools; Symptom Prevalence Every Week or More Often During the School Year

	2007-08 (pilot)	2010	2011	2012	2013	2014	2015	2016	2017
Number of buildings	4	29	1	3	6	10	5	7	4
Participants (N)	106	258	28	71	207	299	179	289	215
Participation rate	65%–78%	57%–68%	62%	54%–79%	62%–76%	47%–90%	50%–86%	49%–73%	65%–73%
Prevalence of hoarseness	10%	26%	57%	52%	43%	38%	25%	37%	34%
Work-related stress	8%	19%	27%	9%	16%	11%	15%	16%	21%

Crude Numbers (%) And Time Trends From 2008 To 2017.

TABLE 4.
The Association of Background Factors and Diagnosed Diseases With Work Related Stress

	N	n (%) with stress	P
Men	333	49 (15)	0.85
Women	1348	204 (15)	
Total	1681	253 (15)	
Pets at home	659	122 (19)	0.10
No pets	81040	135 (13)	
Smoker	86	7 (8)	0.03
Ex-smoker	211	36 (17)	
Nonsmoker	1301	208 (16)	
Asthma	157	25 (16)	0.77
No asthma	1542	232 (15)	
Allergic rhinitis	272	48 (18)	0.71
No rhinitis	1427	209 (15)	
Atopic eczema	102	13 (13)	0.89
No atopy	1597	244 (15)	
Hypothyreosis	76	11 (15)	0.87
No thyroid dis.	1623	246 (15)	

The number and percentage of respondents reporting work related stress according to different exposure groups.

Before remediation, the overall prevalence of hoarseness was at a high level, 41%. Women reported hoarseness significantly more often than men. After the remediation process, the reported hoarseness was somewhat lower among women, but remained on the same level among men. After the remediation, the difference between genders was no longer statistically significant (Table 5).

Those respondents who had an air purifier at work in his/her own class room had more hoarseness than those respondents who did not have an air purifier. In both groups, the women experienced hoarseness more often than the men, and in the group with no air purifier the difference between genders was statistically significant.

Respondents who had air purifiers at work ($n = 140$) reported almost as much stress (12%) compared with those who did not have an air purifier (14%, $n = 742$, $P = 0.26$). Of those who had air purifiers, 22% had hoarseness. The effect of air purifiers is difficult to evaluate, because they were in most cases situated in rooms with no visible moisture damage.

When possible, confounders were taken into account in the logistic regression model, however, age, having pets and smoking did not have a significant association with the prevalence of hoarseness. Instead, we found a significant association with reported mold odor in the indoor air and hoarseness. Poor job satisfaction was also associated with hoarseness. Visible moisture damage had a weaker, but statistically significant association when age, gender, smoking and having pets were controlled for in the model (Table 6). When the effect of remediation was added to the model ($n = 315$), the remediation seemed to reduce the risk of hoarseness, but the association did not reach a significance level ($P = 0.07$, OR 0.62, CI 0.37–1.04).

TABLE 5.
The Effect of Remediation on the Prevalence of Work-Related Stress (%) and Hoarseness (%)

	men	women	total	P
Stress in schools before remediation	40 (14)	168 (14)	208 (14)	0.14
Stress in schools after remediation	9 (21)	36 (21)	45 (21)	0.45
Hoarseness before remediation	85 (31)	485 (43)	570 (41)	<0.001
Hoarseness after remediation	14 (33)	65 (38)	79 (37)	0.53

After the adjustment of several confounding factors, we found that age, gender and smoking had no significant association with work-related stress. Having pets had a protective effect on stress and the recent remediation of the school building seemed to increase the risk of work-related stress. Poor job satisfaction had the highest association with stress. Good job satisfaction was significantly protective as regards work-related stress when other factors were taken into account with a logistic regression model (Table 7).

DISCUSSION

In occupations where the voice is either often or continuously strained, hoarseness and other voice problems are common. Our material indicates that nowadays almost 30%

TABLE 6.
The Association Between Hoarseness and Potential Risk Factors in the Logistic Regression Model When Adjusted For Age, Gender and Smoking

	P	OR	95 % confidence interval
Age	0.48	0.99	0.98–1.01
Gender, male	0.003	1	
Female		2.27	1.33–3.88
Pets	0.79	0.96	0.68–1.34
No pets		1	
Smokers	0.59	0.96	0.81–1.13
Non-smokers		1	
Good job satisfaction	0.001	1	
Poor job satisfaction		1.54	1.19–1.98
Visible moisture spots	0.04	1.24	1.01–1.51
No moisture damage		1	
Mold odor in indoor air	0.001	1.86	1.58–2.18
No mold odor		1	

TABLE 7.
The Association Between Hoarseness and Stress Among Teachers in a Logistic Regression Model When Adjusted for Age, Gender, Smoking, Having Pets and Job Satisfaction

	<i>P</i>	OR	95 % Confidence Interval
Age	0.91	1.00	9.98–1.02
Gender, male	0.56	0.90	0.62–1.30
Female		1	
Pets	0.003	0.64	0.48–0.86
No pets		1	
Smokers	0.37	1.07	0.93–1.23
Non-smokers		1	
Good job satisfaction	0.001	0.35	0.28–0.44
Poor job satisfaction		1	
Remediation of the school	0.10	1.64	0.91–2.96
No remediation		1	

of the teachers in schools have voice symptoms. This finding is in line with many other publications in other countries.^{1,6} Our study also shows significant gender differences; hoarseness was reported significantly more often by women than men in similar work and in the same buildings. This is also in line with other articles reported recently.^{1,4,5}

The trends over time have been documented less often. In a ten-year follow-up of symptomatic workers in continuous exposure, Karvala et al found a significant increase in the incidence of asthma¹⁸ but prevalence of hoarseness was not documented in detail in this study. Our study shows an increasing trend in reporting voice problems during the last 10 years and an association with asthma. This trend was seen in both men and women in the teaching occupation. Our study material only included 315 respondents who described their health data pre and post remediation. Their risk of hoarseness diminished, but their reported stress increased.

Work related stress is associated with hoarseness and voice problems. To date, it has been unclear whether voice problem cause stress or vice versa. Our study shows an increase in work related stress over time, but this increase is slower and not linear in comparison with the prevalence and an increase in hoarseness. Follow-up studies in this field are rare and the follow-up periods have been short.¹⁹ To our knowledge, this is the first long-term follow-up study on the prevalence of stress and voice problems among teachers in the Nordic countries.

We found a difference between genders when reporting work related stress. This is also in line with many other studies.^{1,20} Work related stress occurred equally often in the material from 2014 among men as women. Although the numbers are relatively small, it does not seem likely that work related stress could cause hoarseness, because in many schools, hoarseness is more prevalent than stress and there

is considerable delay in the increase of work-related stress in schoolteachers compared with the increase of the hoarseness. In addition, the results show a slight decrease of hoarseness after the remediation of school building, although the remediations seemed to have increased the level of work-related stress among teachers. This may be due to practical changes in schoolwork, ie, moving to cleaner premises, the need for rearranging and cleaning of books, furniture, the transport of pupils etc. This is more or less speculation based on practical experience and our questionnaire did not include questions concerning the reasons for the work-related stress. Only the small pilot study questionnaire included several questions about the reasons for stress, but because only 3% reported stress, no further analysis of the reasons for stress was carried out.

The interpretation of the trends over time requires that other changes in the society have to be simultaneously taken into account. The economic depression in 2008 was reflected in the limited resources in education during the following years. This also meant a delay in the remediation of school buildings (the so called ‘repair debt’ was growing, as stated in national reports²¹). The shortage of economic resources increased the number of pupils per classroom and the simultaneous introduction of the inclusion of handicapped or disabled children with other pupils changed the work environment.^{22,23} During the follow-up years, only five municipalities remediated their schools enabling a follow-up of the health effects after the repairs.

In 2016, a new national core curriculum plan for basic education was launched in all Finnish elementary schools and then during 2017–2019 in all secondary schools.²⁴ This meant an enormous change in the basic education and may have interfered with/affected the increase of reported stress between 2016 and 2018. We assume that the considerable changes in the core curriculum have been a stress factor for both genders. However, to our knowledge, the impact of the core curriculum change on Finnish teachers has not been investigated as yet, although there is at least one ongoing study on this subject (Research & development^{25net} 2021). So far, job satisfaction and intentions to leave teaching have been studied among physical education teachers.^{20,26}

The reporting of work-related stress was almost at the same level in both genders. In certain schools, men reported somewhat higher amounts of stress than women. Work related stress was not associated with age, but surprisingly, the remediation of the buildings seemed to increase the stress level. Work related stress correlated strongly with poor general job satisfaction. Overall job satisfaction among teachers in Finland has been found to be on a good or excellent level. Poor health and impaired job satisfaction increase the risk of work absenteeism and pre-term retirement among physicians, but less information is available about teachers.²⁷ In our material, we were not able to determine whether poor job satisfaction was experienced initially or was a consequence of work-related stress.

The association of hoarseness with other health complaints has not been studied thoroughly in previous studies. In this

material, hoarseness was significantly associated with asthma and other allergic diseases. Hoarseness may also be associated with stomach problems, and it is sometimes treated with acid neutralizing medication, but unfortunately, we did not have questions about gastrointestinal symptoms. We had questions about diseases diagnosed by physicians, including coeliac disease and inflammatory bowel disease. Bowel disease did not correlate with hoarseness, but we found a correlation with thyroid disease. Asthma medications tend to be a risk factor for hoarseness.²⁸

The association between subjective annoyance due to poor indoor air quality and symptoms is a complex question. In previous studies, hoarseness was associated with intolerable conditions due to outdoor air pollution in a large city.²⁹ Our study shows an association between indoor air contaminants and hoarseness, such as the visible signs of moisture damage, visible mold growth or an odor of mold. The finding is in line with previous studies among teachers^{4,30} and pupils.³¹ Subjective annoyance as regards smells, chemical odors, dust, noise and insufficient ventilation may also increase stress at work, because the harmful effects are observable, and the health risk is common knowledge. Nevertheless, the lower levels of stress compared with the prevalence of hoarseness indicated that stress is secondary to impaired health and not vice versa. In a Danish study, building related symptoms and stress were found to correlate and interestingly, a higher level of free testosterone levels were found among women with building related symptoms.³² When stress can be considered work related and when it can be called physiological or even positive stress, remains unclear. In the future, how strongly hoarseness and other symptoms are associated with indoor air factors, stress, remediation processes, leadership and help from peers, can be determined with longer and larger follow-up studies, where the health of the same individuals is followed-up for a longer period of time.

Patovirta and coworkers (2004 and 2005) reported a decreasing trend in the reporting of symptoms among teachers after the remediation of the school buildings.^{33,34} Several studies among pupils confirm the beneficial effect of remediation of school buildings.^{35,36,37} Some studies show reduction in symptoms after the users of the building were moved to healthier premises. This has been confirmed among workers¹⁸ and children.³⁸ Unfortunately, these publications do not discuss the possible association with work-related stress.

A large Swedish study demonstrated the beneficial effect of the remediation of residential buildings on the health of the inhabitants. Unfortunately, this study does not reveal the stress level of the inhabitants.³⁹

Our recent study shows that previous remediation of the school building was not associated with lower levels of voice problems and better workability.⁵ In that cross-sectional study, we had no access to the information on the remediation process in detail, but Meklin *et al* (2005) earlier showed that superficial or partial refurbishing had less beneficial effect on children's health than a thorough remediation of

the whole building.³⁶ This is supported eg, by Lignell *et al* (2007).³⁷

Strengths and weaknesses

The strength of our study is the use of a similar symptom questionnaire from 2008 onwards. We have used a previously validated questionnaire which also includes the MM040 questionnaire, which makes a comparison with many other surveys possible and reliable.^{10,16} The first materials were collected in smaller towns and during the following 10 years, a comprehensive survey was completed in more than 20 municipalities and towns. One of the strengths of our study is the relatively high response rate in many of the subsamples especially in small towns. The fact that exposure data was obtained from local building authorities and not only from the respondents themselves increases the reliability of our findings. Moreover, certain measurements, such as relative humidity, VOC-concentrations, moisture indicator microbes and man-made mineral fibers in the settled dust were available for some of the buildings; however, these measurements were collected for local risk assessment and were not comprehensive. Nevertheless, these measurements confirmed the opinions of the local building authorities concerning the state of the buildings.

Another strength of the study is that the reporting of hoarseness among pupils was similar to the findings among teachers. Several of the school buildings were the same as in the study by Kallvik *et al* (2016).³¹ School buildings with no questions about work-related stress were excluded from this study because we wanted to ascertain the relationship between hoarseness and stress. The parents completed the pupils' questionnaires, so the teachers had no possibility to interfere with the pupils' answers. The use of the same questionnaire throughout the years of the study has enabled an evaluation of the trends over time and will also allow a comparison with other professionals such as kindergarten workers and office workers in the future.

One of the limitations of the study is that there were only two questions about voice problems. When a questionnaire is very long and many background factors are requested, the response rate tends to become low. Subsequently, we had to concentrate on the most important issues. A similar limitation is the lack of a question about stress on our previous surveys prior to 2008, which have made the analysis of work-related stress, other type of stress and reported health problems impossible before that point of time.

The memory bias may be a problem, especially when health and indoor air factors are concerned. To avoid seasonal variations of symptoms, for example, those due to the pollen season, we have used a recall period of 12 months. To minimize the effect of recall bias, we wanted to confirm the indoor air quality from objective sources, ie, health inspectors and construction engineers, who make a walk-through inspection in every school and day-care center every three years. The weakness in all large population

surveys is the lack of objective clinical measurements from the participants, eg, a phoniatic examination, lung function tests, blood samples etc. However, this material and our findings provide some indications concerning the time trends as regards the health and well-being of teachers. In our previous studies, lung function measurements and microbe specific antibodies were also analyzed.³⁰ These clinical measurements have also been carried out in certain studies among pupils.^{16,35}

CONCLUSIONS

During the remediation of school buildings, the acoustic environment and the indoor air quality should be taken into account, because voice problems seem to be increasing among teaching professionals. All questionnaires used in indoor air research should include at least one question about work-related stress because of the obvious connection between physical symptoms and mental well-being. Work-related stress needs attention from occupational health care services and actions should be focused on reducing work-related stress among teachers irrespective of their origin, for example economic or pedagogical factors caused by changes in society.

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CONFLICT OF INTEREST

None.

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