Hoarseness Among Young Children in Day-Care Centers

T.M. Putus, J. Atosuo, and L.K. Vilén,

Summary: Background. Chronic respiratory symptoms among toddlers are assumed to be due to allergies and common respiratory infections. Because symptoms and respiratory disease in this age group often continue on to school age and later life, it is important to know the possible risk factors for prevention of the chronic hoarseness.

Aim. We aimed to determine the current prevalence of hoarseness and other chronic respiratory symptoms among toddlers and young children. Another aim was to examine the risk factors for hoarseness in the building environments of day-care centers (DCC).

Material. An electronic symptom survey was sent to all parents of children in day-care centers of a large city in southern Finland. In all, 3721 individuals completed the questionnaire (38%), 53.4% were the parents of boys and 46.6% girls.

Results. The prevalence of hoarseness was 5.6%. The boy's parents reported hoarseness more often than the girls, but no significant difference was observed. Risk factors for hoarseness in a built environment in this age group were noise, visible dust and dirt, mold and a cellar like odor, a sewer smell, other unpleasant smells, stuffiness of the indoor air, a too high or too low temperatures, a cold floor, insufficient ventilation, the age of the DCC building, and wood as the bearing construction of the building. The lifestyle factors that correlated with the prevalence of hoarseness were the amount of time spent outdoors; however, passive smoking, the number of siblings and pets at home did not correlate with hoarseness. Hoarseness was significantly correlated with other chronic respiratory symptoms such as rhinitis, coughs, eye irritation, tiredness, headaches, and stomach problems and also with the regular or periodic use of medication. Hoarseness was also significantly correlated with asthma and allergic rhinitis and also with repeated infections, such as a common cold, cold with a fever, laryngitis, otitis media and acute bronchitis, but not with tonsillitis or pneumonia.

When potential confounders had been controlled for with a logistic regression model, the following risk factors in the built environment remained statistically significant: noise, high room temperature, insufficient ventilation and the stuffiness of the indoor air, a solvent odor, wood as the bearing construction and the age of the building.

Conclusions. We conclude that in day-care centers, buildings should be maintained, cleaned and ventilated properly. Concrete and brick used in the construction were protective compared with wood. The acoustic environment should be planned to reduce noise indoors and solvent based chemicals should be avoided. Neither having pets at home or the number of siblings were risk factors, but they were also not found to be protective in this material. All measures that reduce the occurrence of respiratory infections probably also reduce chronic voice problems.

Key Words: Vocal disorders—Hoarseness—Air quality−Indoor—Ventilation—Health−Children—Day-care center.

INTRODUCTION

Hoarseness and other voice problems have been studied in many professions where the voice is used in noisy or dusty surroundings. Smells, microbes and poor acoustics are also risk factors and female workers tend to report hoarseness more often than men.[1] The typical professions in which there is a tendency to have a high prevalence of hoarseness are teachers, singers, priests, sport coaches and employees in day care centers (DCC).[1,2] We have previously studied hoarseness among nursing professionals.[3] The reporting of hoarseness among schoolteachers has increased during the past 15 years.[4] Work-related stress is one of the potential risk factors, especially in connection with remediation work (ie, demolition and renovation of the damaged structures) being carried out in the workplace.[4] Usually, one of the main goals in renovating schools and DCCs is an improvement in the acoustic environment in the building.

In Finland, a majority of children attend public daycare centers in towns and cities. Most infants are at home during the first year of life, while toddlers between the age of 1-3 are in smaller day-care groups; children between 4 to 5 years old are in larger groups and 6-year-old children attend the so-called pre-school that in most cases are situated in DCC buildings. Elementary school begins for children at the age of 7. The DCC buildings are mostly owned by the municipality or town and the health and safety regulations are based on legislation[5] which means that the buildings are regularly inspected by the health inspectors.

Children in DCCs and schools have been previously studied using both surveys and in clinical studies.[6,7] In earlier studies, children's voice problems have been found to be associated with allergies, respiratory infections and indoor

Accepted for publication August 23, 2022.

From the University of Turku, Clinical Medicine, Occupational Health and Environmental Medicine.

Address correspondence and reprint requests to TM Putus, University of Turku, Clinical Medicine, Occupational Health and Environmental Medicine. E-mail: tuula.putus@utu.fi

Journal of Voice, Vol. ■■, No. ■■, pp. ■■−■■

0892-1997

https://doi.org/10.1016/j.jvoice.2022.08.026

air problems.[7] Investigation of toddlers is less common than schoolchildren. The occurrence of respiratory infections is high during the early years of life. As regards asthma and allergies, it was previously thought that for example, pets were a risk factor for allergies and a high number of siblings were a protective factor. During recent years, it has been advocated that furry pets and farm microbes promote children's health and prevent allergies and asthma.[8,9] Children in an urban environment tend to have more allergies than children in families on farms.[10,11]

In Finland, approximately 200000 children spend their days in DCCs while their parents are at work. It is important to know if their environment is safe and health promoting in every way. That is why we aimed to investigate the risk factors of hoarseness and other respiratory symptoms in a younger age group than schoolchildren. Better understanding of the health effects associated with a built environment is needed in order to promote health and well-being of both children and employees in DCCs.

The aim of this study was to investigate the current prevalence of hoarseness among small children and to find the risk factors leading to chronic hoarseness, especially in a built environment. The broader aim is to diminish or eliminate apparent risk factors to prevent disease and to promote the health and well-being of children.

MATERIALS AND METHODS

We sent a symptom survey to all parents whose children were attending public day care centers (n = 158) in a large city in southern Finland. In addition to the e-mail survey, paper questionnaires were available in the DCCs, and the personnel encouraged parents to participate in the study. The survey was available in seven different languages (Finnish, Swedish, English, Estonian, Russian, Somalian and Arabic) in order to reach as many families as possible in their own mother tongue. At the same time, a symptom survey was sent to the personnel (also in 7 languages).

Exposure data was obtained from the city's building authorities (experienced construction engineers) comprising of information on the age and location of the building, the ventilation system (passive, mechanical), bearing construction (wood, concrete and/or tiles), the number of floors and the history of renovations. In approximately half of the buildings, some measurements were available, for example, moisture in the construction, VOC-compounds, microbial samples etc. All the buildings were independently classified by two experienced construction engineers ("normal" condition, waiting for renovation, renovated). Additionally, subjective observations by the DCC personnel on indoor air quality, for example, stuffiness, smell, was used in the analysis. Because chemical and microbiological measurements were not available from all the buildings, this information was not used on this occasion.

Symptom data was collected in four categories, daily, every week, more seldom and never. In the analysis, we combined the alternatives "daily" and "every week" and respectively the alternatives "more seldom" and "never" to obtain a dichotomous variable. Questions were asked separately about chronic symptoms lasting more than one month, that is, rhinitis, cough, fatigue etc. as dichotomous variables. In addition, questions were asked about infectious diseases and the number of infections during the previous 12 months. As background variables, there were questions about the number of siblings, pets, and indoor smoking. The respondents (parents) were unaware of the aim that the data was going to be used specifically for voice research. The purpose of the project was broader, including various aspects of indoor environment in DCCs.

The statistical analysis was performed with an SPSS-26 program (IBM Corp. Armonk, NY), which at first cross-tabulating the occurrence of hoarseness with background variables and then controlled for the potential confounders with a logistic regression model. A statistician performed the power calculation originally for the study by Vertanen-Greis et al.[1]

Overall, information on 3721 children was obtained from their parents. The response rate was 38%. Fifty-three percent of the participants were parents of boys and 47% of girls. The same parents could have one or several children in the study and the questionnaire was completed separately of every child.

RESULTS

The overall prevalence of hoarseness was 5.6%. Hoarseness was slightly more prevalent among boys, no significant difference between genders was observed. The prevalence of hoarseness varied between 4.6% and 7.2% in different age groups, the highest prevalence being in the oldest age groups (6-year-old children). Children below 1 year were few in number (only 6 children) and were excluded from the further analysis.

Smoking indoors was rare and reported smoking did not correlate significantly with the reporting of hoarseness. Several siblings in the family seemed to have a protective effect on hoarseness, but the difference was not statistically significant as large families were quite rare in this material (Table 1).

Spending time outdoors playing, and exercising was significantly correlated with the occurrence of hoarseness, but the association was not linear. Children spending an average of 2 hours a day outdoors had the least hoarseness in our material.

Children in older buildings and in DCC buildings with a concrete or brick structure had less hoarseness than the children in wooden buildings. Buildings constructed with concrete and brick were also older, mostly built in the 60s and 70s. A majority of the newer DCC buildings have wood as the bearing construction. A vast majority of the oldest DCC buildings had already been renovated and at least half of the building stock from the 70s had been renovated, while more than 90% of the newer buildings (1990-2019) had not yet been renovated.

Most of the observed indoor air factors correlated with the hoarseness of the children. Annoyance due to noise,

TABLE 1.
Description of the Study Material (n, %)

	Children With Hoarseness, n (%)	Total N (%)	*P* value
boys	120 (6.0)	1987	0.26
girls	90 (5.2)	1734	
total	210 (5.6	3721	
age group			0.36
- below 1 year	0	6	
- 1 year	14 (6.7)	210	
- 2 years	31 (5.1)	605	
- 3 years	36 (5.2)	697	
- 4 years	34 (4.6)	747	
- 5 years	45 (6.1)	742	
- 6 years or more	52 (7.2)	719	
pets at home	41 (6.9)	598	0.20
no pets	167 (5.5)	3022	
smoking indoors			0.20
- no	177 (5.6)	3173	
- sometimes	30 (7.6)	396	
- daily	1 (2.7)	37	
number of siblings			0.40
- none	62 (6.1)	1016	
- 1 sibling	104 (5.5)	1896	
- 2 siblings	38 (6.8)	562	
- 3 siblings	2 (2.0)	99	
- 4 or more siblings	2 (5.4)	37	
hours outdoor/day			0.01
- less than 1 hour	0	7	
- 1 hour	14 (9.2)	153	
- 2 hours	65 (4.3)	1524	
- 3 hours	99 (6.5)	1515	
- 4 hours	28 (8.0)	352	
- more than 4 hours	2 (3.4)	59	

dust or dirt, a sewer smell and cold floors were associated with a doubling of the occurrence of hoarseness. Microbial odors, that is, mold odor or cellar like odor and also solvent odors occurred more rarely, but these indoor air exposures were strongly correlated with the reporting of hoarseness. The association with hoarseness of unpleasant temperatures, insufficient ventilation, general stuffiness and other unpleasant smells were also strong and statistically significant (Table 2).

Hoarseness occurring every week or daily correlated significantly with other chronic or frequently occurring irritation symptoms of the respiratory tract, skin, and eyes, as well as general symptoms, such as fatigue, headache, and stomach problems. Of the more than 1600 children who had no chronic symptoms, only 1.6% had hoarseness (Table 3).

Toddlers and other children below school age have respiratory infections more often than for example, schoolchildren. Hoarseness was significantly associated with the occurrence of common viral infections. The mean number of infections among children with hoarseness was significantly higher than among children with no hoarseness (Table 4). However, the occurrence of tonsillitis, sinusitis, pneumonia, or influenza did not correlate with hoarseness (data not shown).

Diagnosed asthma, allergic rhinitis and food allergies were significantly associated with hoarseness. A similar trend was observed with hoarseness and atopic eczema ($P = 0.06$). Hoarseness was also associated with regular and periodic medication, most of which was prescribed for asthma and allergies (Table 5). ADHD, diabetes, coeliac disease, delayed development of speech, rheumatoid arthritis, thyroid disease, heart malformations or other developmental disorders did not correlate with hoarseness (data not shown).

In a logistic regression model, when age, gender, passive smoking, pets and asthma were controlled for, several indoor air factors in the DCC environment had a strong and significant association with the occurrence of hoarseness. At first, each indoor air factor was analyzed separately in a logistic regression model. The highest OR-value was observed for solvent smells, which was reported relatively seldom, only in 22 questionnaires. High OR was observed also when the ventilation was insufficient, when general stuffiness and microbial odors were perceived. Draught, noise, unpleasant temperatures, cold floors, and dirty surfaces were statistically significant risk factors for hoarseness when potential confounders were controlled for. Concrete and/or bricks as the bearing construction was a significant protective factor for hoarseness even when the age of the building and renovations were simultaneously taken into account in a logistic regression model (Table 6).

Finally, when all the indoor air factors and information about the building were simultaneously introduced into the logistic regression model, several indoor air factors lost their statistical significance. Hence, the final model shows those factors that seemed to have the highest relevance where the risk of hoarseness is concerned. The bearing construction material of the DCC building and the age of the building were relevant, and a poor acoustic environment, insufficient ventilation and an inconvenient (high) temperature were significantly associated with a higher risk for hoarseness. Furthermore, the stuffiness of the indoor air and a solvent smell were associated with a high risk of hoarseness. Microbial smells were no longer statistically significant as a risk factor when all other indoor factors were present in the same model (Table 7).

DISCUSSION

Hoarseness has been investigated in many professions where the voice is strained because of the work itself or because of unhealthy or noisy working conditions.[1,2,12] The noise and

TABLE 2.
Information Concerning the DCC Building and the Subjective Indoor air Quality

	Respondents With Hoarseness, n (%)	Total N in Each Category	*P* value
bearing construction of the DCC			0.001
- concrete	43 (3.3)	1322	
- wood	169 (6.9)	2438	
the age of the DCC building			0.002
- 1960-69	3 (3.3)	92	
- 1970-79	4 (1.2)	334	
- 1980-89	53 (6.2)	857	
- 1990-99	54 (7.5)	722	
- 2000-09	47 (6.4)	738	
- 2010-19	41 (5.6)	729	
indoor air quality according to the parents			
- noise	100 (11.1)	903	0.001
- draught	36 (17.1)	210	0.001
- high temperature	28 (18.8)	149	0.001
- low temperature	36 (15.6)	231	0.001
- cold floor	70 (10.7)	654	0.001
- dust, dirt	47 (12.8)	368	0.001
- mold odor	16 (26.7)	60	0.001
- cellar like odor	15 (22.1)	68	0.001
- sewer smell	21 (11.0)	191	0.002
- solvent smell	9 (40.9)	22	0.001
- other unpleasant smell	12 (20.3)	59	0.001
- stuffiness	66 (20.2)	327	0.001
- insufficient ventilation	68 (20.5)	331	0.001

acoustic environment of children have also been subject to investigations in school buildings.[6] Toddlers' hoarseness has been associated with respiratory infections, asthma, asthma medication and gastroesophageal reflux,[13] but surprisingly little is known about the significance of built environments, ventilation, and construction materials for the health of small children.

Indoor air research has previously shown moisture damage and mold exposure to be a risk factor for both children and adults.[14-17] Moving to healthier premises has been found to reduce both symptoms and infections among children and teachers.[15-17] Most of previous studies have been relatively small.

Our aim was to investigate hoarseness and the risk factors for voice problems among small children in Finland and to compare the results previously found among school children and teachers.[1,6] The focus was on the lifestyle factors and the built environment, because with deeper analysis of these factors we hoped to find better intervention possibilities to reduce hoarseness and to promote the health of those using the buildings.

We chose a larger city in southern Finland and invited all day care centers to participate in the study. This city had already participated a large survey of teachers and pupils.[1] The participation rate (38%) was somewhat higher than in the teacher study by Vertanen-Greis,[1] but significantly higher than in other large surveys in neighboring cities.[18] Our large cluster sample represents the urban population in southern Finland.

Our symptom questionnaire including the MM40 questionnaire has been used nation-wide for several decades and it has been validated earlier by Savilahti and coworkers.[19]

Our results show a lower prevalence of hoarseness than that found by for example, Kallvik et al. among schoolchildren (2015).[6] Our study shows a growing prevalence of hoarseness as the children grow up, but age and gender were not statistically significant factors. Our finding is in line with Duff and coworkers (2004),[20] but the overall prevalence was somewhat higher than in their observational study. Koskinen and coworkers reported, 25 years ago, a much lower prevalence of hoarseness in Finnish day care centers (2.2%), but her material was very small and maybe not representative of the whole of Finland.[21]

Built environments have previously been observed with special reference to noise and the acoustic environment. McAllister and coworkers have measured noise levels exceeding the level of 82 dB(A).[22] In our study, perceived noise was one of the factors that was significantly associated with hoarseness.

Wooden buildings are commonly thought to be healthier for children than buildings constructed of bricks or concrete. We have earlier found higher levels of microbes in the

TABLE 3.
The Association of Hoarseness With Other Chronic Symptoms

	Respondents With Hoarseness, n (%)	Total N in Each Category	*P* value
chronic rhinitis	129 (12.0)	1077	0.001
chronic cough	130 (13.4)	970	0.001
chronic eye symptoms	18 (17.5)	103	0.001
chronic skin symptoms / rash	61 (11.1)	548	0.001
chronic fatigue	47 (24.1)	195	0.001
repeated headache	28 (19.4)	144	0.001
chronic stomach ache	31 (11.3)	274	0.001
no chronic symptoms	26 (1.6)	1649	0.001

TABLE 4.
The Association of Hoarseness With the Mean Number of Common Respiratory Infections During the Previous 12 Months

	Mean no. of Infections Among Children With Hoarseness	Mean no. of Infections Among Children With no Hoarseness	*P* value, *t* test
common cold	3.1	1.9	0.001
cold with fever	1.9	1.2	0.001
ear infection	0.6	0.3	0.001
acute bronchitis	0.2	0.1	0.001
laryngitis	0.1	0.02	0.001
gastroenteritis	0.6	0.4	0.001

TABLE 5.
The Association of Hoarseness With Diagnosed Diseases and Medication (n, %)

	Respondents with Hoarseness, n (%)	Total N in Each Category	*P* value
asthma	20 (12.7)	157	0.001
allergic rhinitis	15 (10.4)	144	0.01
atopic eczema	49 (7.2)	682	0.06
allergic conjunctivitis	4 (6.7)	60	0.47
food allergy	23 (8.9)	259	0.03
no diagnosed diseases	89 (4.8)	1851	0.004
no medication	108 (4.4)	2444	0.001
regular prescribed medication	17 (13.0)	131	0.001
periodical medication	16 (14.4)	111	0.001

indoor air of wooden buildings, but more severe health effects in school buildings made of concrete or bricks.[23] We could not find any previous data on a comparison between wood and concrete/brick buildings and children's health. To our knowledge, this is the first scientific article showing that wooden day-care center buildings have a higher risk for adverse health effect. The information concerning the buildings was obtained from the construction experts, not the respondents. The preliminary finding of possible adverse effect of wooden construction needs a more thorough investigation, for example, measurement on terpenes and other VOC-compounds in the indoor air.

This material is to our knowledge the largest study on the prevalence of hoarseness and related risk factors among infants and very young children in Finland. We found no previous publications about the specific effects of draughts, dust, humidity, temperature, ventilation, sewer or solvent smells on the prevalence of hoarseness among very young children in daycare centers. More evidence is available on the indoor air quality of school children, office workers, employees in hospitals and adults in residential buildings.[24-27] Our findings concerning poor indoor air quality and irritation symptoms among young children are in line with previous results among adults, and also among older school children.[17,23]

TABLE 6.
The Adjusted Odds Ratio for Hoarseness and Factors in the Built Environment in DCCs When Age, Gender, Pets, Passive Smoking, and Asthma were Controlled for in a Logistic Regression Model

	OR for Hoarseness	95% Confidence Interval	*P* Value
noise	2.81	2.06–3.82	<0.001
draught	4.03	2.63–6.18	<0.001
high temperature	3.93	2.44–6.31	<0.001
low temperature	3.77	2.47–5.73	<0.001
cold floors	2.85	2.05–3.96	<0.001
dust, dirt	2.91	2.00–4.25	<0.001
mold odor	6.57	3.31–13.06	<0.001
no mold odor	1		
cellar-like odor	4.32	2.18–8.57	<0.001
no cellar-like odor	1		
solvent smell	13.04	5.37–31.63	<0.001
no solvent smell			
sewer smell	1.95	1.15–3.32	0.01
no sewer smell	1		
other unpleasant odor	4.03	1.97–8.26	<0.001
no odor			
stuffiness	5.87	4.14–8.30	<0.001
insufficient ventilation	6.06	4.31–8.54	<0.001
concrete building	0.49	0.33–0.71	<0.001
wooden building	1		
age of the building	0.90	0.80–1.01	0.07

TABLE 7.
The Adjusted Odds Ratio for Hoarseness and Indoor air Factors Together With the DCC Buildings Characteristics When Age, Gender, Pets, Passive Smoking, and Asthma were Simultaneously Controlled for in a Logistic Regression Model

	OR for Hoarseness	95% Confidence Interval	*P* Value
noise	1.87	1.33–2.63	<0.001
high temperature	1.83	1.07–3.13	0.03
solvent smell	2.67	1.03–6.93	0.04
no solvent smell			
stuffiness	1.89	1.33–2.63	0.05
insufficient ventilation	2.54	1.33–4.86	<0.01
concrete building	0.57	0.38–0.86	<0.01
wooden building	1		
age of the building	0.85	0.75–0.96	0.01

The association between hoarseness and asthma medication is a well-established finding. It has also been estimated that more than 50% of asthmatic children have gastroesophageal reflux.[13] It is difficult to evaluate if the hoarseness is due to the asthma, the asthma medication or the stomach problems or perhaps all of them. Our findings suggest that all of these factors may increase the risk of hoarseness. More research is needed, because indoor air irritants and allergens are associated with respiratory symptoms, infections and asthma in a very complex way. Follow-up studies could reveal the risk factors and pathophysiology of asthma and allergies among children and the role of lifestyle factors; it could provide information on protective and health promoting factors that could be used in built environments.

It has been postulated, that small particles in urban air are an important risk factor for human health.[28] At the same time, it has been postulated that soil and forest microbes may prevent allergies and asthma in children. Our study suggests that while very little time spent outdoors increases the risk for hoarseness, more than 4 hours per day spend outdoors is associated with a higher risk. Our study results show the lowest risk is associated with approximately two hours outside in an urban environment.

We found no association between pets at home or smoking indoors and children's hoarseness. Adult smoking has decreased in Finland during recent decades and many parents smoke outdoors or on the balcony. It is also possible that smoking is under-reported in health surveys. Pets bring allergens into homes, but, on the other hand, they also bring in soil microbes, which is postulated to be healthy. In our study, pets present neither a risk, nor a health promotion as regards hoarseness among very young children.

One strength of our study was the size of the material and the relatively satisfactory response rate. Another strength was the possibility to obtain reliable information about the buildings and ventilation system from the building authorities. There was also some information available on the renovation and selection of materials used in the renovation processes and this may allow us to follow the study population and combine the exposure data and health data in more detail in the future.

One of the factors that made the study setting more robust was that a survey was sent to the teachers and other employees at the same time as the child survey was sent to the parents. These surveys were sent simultaneously, however, they were unaware of each other's study results. This enabled a kind of quality control and evaluation of the exposure data and a comparison of these results with the official construction data and measurements.

Another detail making the results more reliable was the use of a standard and validated questionnaire which has been used for many years in several languages. This enables a comparison of results over time and between different

geographical areas in Finland. We have already published similar material from DCCs and elementary schools for another age group in different parts of the country.[7]

In the future, our aim is to fill the gaps in our knowledge about indoor air factors and clinical disease with more detailed and comprehensive measurements of exposure and clinical allergological and immunological studies among children.

RECOMMENDATIONS

To promote health and wellbeing among toddlers (and employees) in daycare centers, we recommend sufficient ventilation, a better acoustic environment, proper cleaning and adjustment of the inside temperatures. Renovation work and the use of solvent-based paints and glues should be performed outside of the working hours of the DCC. After renovation, proper cleaning and a washout period with high volume ventilation is recommended before the children return to the building.

ACKNOWLEDGMENTS

We cordially thank all participants who took part in this study. The financial support from the Parliament of Finland is greatly appreciated.

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