

# Indoor Air Problems and Hoarseness in Children

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**Summary: Objectives.** A well-functioning voice is becoming increasingly important because voice-demanding professions are increasing. The largest proportion of voice disorders is caused by factors in the environment. Moisture damage is common and can initiate microbial growth and/or diffusion of chemicals from building materials. Indoor air problems due to moisture damage are associated with a number of health symptoms, for example, rhinitis, cough, and asthma symptoms. The purpose of this study was to investigate if children attending a day care center, preschool, or school with indoor air problems due to moisture damage were hoarse more often than the children in a control group.

**Methods.** Information was collected through electronic and paper questionnaires from the parents of 6- to 9-year-old children ( $n = 1857$ ) attending 57 different day care centers, preschools, or schools with or without indoor air problems due to moisture damage.

**Results.** The results showed a significant correlation between the degree of indoor air problem due to moisture damage and the frequency of hoarseness. Significant predictors for the child being hoarse every week or more often were dry cough, phlegm cough, and nasal congestion.

**Conclusions.** The results indicate that these symptoms and exposure to indoor air problems due to moisture damage should be included in voice anamnesis. Furthermore, efforts should be made to remediate indoor air problems due to moisture damage and to treat health symptoms.

**Key Words:** Hoarseness—Children—Indoor air problems—Moisture damage—Health symptoms—School buildings.

## INTRODUCTION

Voice use is becoming more important for the working population, and the number of persons working in voice-demanding professions is increasing (eg, Vilkman<sup>1</sup>). They are, for example, salespersons, priests, receptionists, actors, and teachers.<sup>2,3</sup> From 1970 to 2000, there was a doubling of the number of persons working in educational occupations in Finland,<sup>4,5</sup> and the number of persons who work in education has continued to grow.<sup>6</sup> Similar trends can probably be seen in other countries as well.

The increasing importance of voice use in different professions indicates that a well-functioning voice is becoming increasingly important for a person's occupational and social functioning.<sup>7</sup> Sick leave and possible restrictions in career choice can become expensive, not only to the person in question but also to the society.<sup>8</sup> If the development toward more voice-demanding jobs continues, a hoarse voice might be a substantial problem for a child when he or she grows up and chooses a profession.

The largest proportion of voice problems is caused by environmental factors,<sup>1,9</sup> and by investigating which these are, it might be possible to prevent voice problems. In children, voice problems are usually more common among boys than girls.<sup>10,11</sup> The prevalence of hoarseness in children has, in previous studies, been reported to be 23.4% (chronic hoarseness),<sup>12</sup> 14% (acute hoarseness),<sup>13</sup> 12% (hoarseness),<sup>14</sup> 3.9% (hoarseness),<sup>15</sup> and 0.12% (husky and hoarse voice).<sup>16</sup> The reported prevalence has varied because of different

choices of methodology, definitions, and age-group of the participants.

Moisture damage is the starting point for indoor air problems and frequent in Finnish buildings.<sup>17–19</sup> When investigating a random sample of homes in Finland, Koskinen et al<sup>17</sup> found moisture problems in 58% of the schoolchildren's homes. In school buildings, the reported prevalence of moisture damage was 24%.<sup>20</sup> Mudarri and Fisk<sup>21</sup> presented a population-weighted average prevalence of moisture damage and mold of 47% on the basis of six previous studies from 1989 to 2003 in the United States. When moisture is present in a building, it promotes microbial growth<sup>22</sup> and diffusion of chemicals from building materials.<sup>23,24</sup> The microbes can be fungi, yeast, and bacteria,<sup>25</sup> and they can each have different effects on the health.<sup>26</sup> Children spend most of their time indoors,<sup>27,28</sup> which means that the amount of exposure time to possible moisture damage in the school building or at home can be substantial.

According to three reviews<sup>29–31</sup> and a meta-analysis,<sup>32</sup> there is sufficient evidence for an association between moisture-related factors and health effects. Moisture damage has been found to have an association with cough,<sup>17,29,33</sup> rhinitis,<sup>17,34</sup> and asthma symptoms.<sup>30,31,35</sup> The results of a study by Smedje et al<sup>36</sup> showed that asthma symptoms in children were enhanced by several factors in the indoor environment of the school although the children spend a minor part of the day in school. These factors were among others relative humidity, formaldehyde, volatile organic compounds, viable bacteria, and viable molds. Other health symptoms associated with moisture damage and mold are dyspnea, wheezing, respiratory infections, bronchitis, allergic rhinitis, eczema, and upper respiratory tract symptoms.<sup>31</sup> Rhinitis can cause postnasal drip of mucus onto the vocal folds resulting in cough and, sometimes, hoarseness.<sup>37</sup> Coughing involves mechanical forces that strain the vocal folds,<sup>38</sup> and exacerbated asthma symptoms may lead to an increased use of asthma medication which may have

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a negative impact on the voice.<sup>39–42</sup> The results of a study on preschool children<sup>17</sup> showed that exposure to moisture damage and mold resulted in a threefold increase of the risk of hoarseness. In two previous studies in schools with moisture and microbe damage, the prevalence of hoarseness was higher for the pupils of the school with moisture and microbial damage than for the control group.<sup>43,44</sup> The prevalence of hoarseness decreased significantly after extensive remediation of the school building.<sup>44</sup>

The aim of the present study was to investigate if children attending a day care center, preschool, or school with indoor air problems due to moisture damage are hoarse more often than the children in the control group. Another purpose was to explore possible predictors for hoarseness.

## METHOD

The data were collected in the years 2007–2014 from the nationwide Satakunta-project where the aim was to activate at least 100 Finnish municipalities to investigate and remediate day care centers or school buildings. The Satakunta-project was launched in the year 2007 simultaneously with the moisture and mold project called Hometalkoot in the Ministry of Environment. The aim of Hometalkoot was to increase awareness of indoor air problems and give information about best practices to tackle the problem. By the year 2009, 20 municipalities were participating in the Satakunta-project,<sup>45</sup> and by the year 2014, more than 100 day care centers, preschools, and schools had been participating in the project. The collection of data was initiated by municipal authorities that wanted to investigate symptoms related to moisture damage in day care centers, preschools, and schools with a questionnaire. The primary purpose was to evaluate the health status of the children attending these day care centers, preschools, and schools before remediation of the buildings. The word preschool refers, in Finland, to the preparatory year before the primary school starts. The data were collected through electronic or paper questionnaires filled in by the parents. Data for the control group were collected from parents of children in schools with no known indoor air problem due to moisture damage. Permission for using the data material for research purposes was obtained from the parents and the municipalities where the day care centers, preschools, and schools were situated. The parents agreed that the data can be used for research by filling in the questionnaire. This information was specified on the information sheet that they received with the questionnaire or with the link to the electronic questionnaire.

The questionnaire was based on the so called Tuohilampi questionnaire,<sup>46</sup> and similar questionnaires have previously been used by Meklin et al.<sup>44,47</sup> The questions have been validated.<sup>48</sup> The questionnaire included questions regarding the present and previous day care, school and home environment, changes in the general health, infections, doctor-diagnosed illnesses, medication and surgery, symptoms in airway, skin, voice, and joints, nausea, fatigue, learning difficulties, and sleeping habits and disorders. The questions chosen for the statistical analysis in this study were questions regarding

respiratory and laryngeal symptoms, nasal symptoms, and general information such as age, gender, number of siblings, and which day care center, preschool, or school they attended. All other questions were excluded. For respiratory, laryngeal, and rhinitis symptoms, an ordinal four-point scale was used with the alternatives “never, almost never,” “once or a few times per month,” “every week,” and “daily or almost daily.” For the statistical analysis, the answer alternatives for the question on hoarseness were merged into two groups. The alternatives “never, almost never” and “once or a few times per month” were combined to “seldom/never” and “every week” and “daily or almost daily” to “every week or more often” to facilitate the data analysis. A similar kind of grouping has been done previously in other studies.<sup>49,50</sup> The question on the frequency of laryngitis was answered on an eight-point ordinal scale from “once” (1) to “eight times or more often” (8). Because very few participants had had laryngitis more than once, the laryngitis variable was recoded as “yes or no” for the data analysis. The other questions in the questionnaire were answered “yes or no.”

Participants who were included in this study were 6- to 9-year-old children whose parents had filled in information on age, which day care center, preschool, or school their child attended, and how often the child had been hoarse during the fall. These inclusion criteria were met by 1857 of the original sample of 2925 children from 57 day care centers, preschools, and schools in the east, south, and west of Finland. Of the original sample, 88 parents (3%) chose to fill in the paper questionnaire and 2837 (97%) filled in the electronic version. In the sample used in this study, data from 30 (1.6%) paper questionnaires and 1827 (98.4%) electronic questionnaires were used. The age-group 6–9 years was chosen to reduce the risk of the voice being affected by puberty which starts at around the age of 10 years for girls and at around the age of 11 years for boys.<sup>51</sup> The parents had been asked to answer the symptom questions for both spring and fall term, during either the same academic year or the same calendar year. The data for the fall were chosen for the analysis to reduce the risk of seasonal allergies affecting the results.

In Finland, evaluation and risk assessment of educational facilities is made in collaboration with construction engineers, experts in environmental health (health inspectors), and personnel in health care services (school health care and occupational health care) and should be followed up every year.<sup>52</sup> On the basis of the degree of indoor air problems due to moisture damage in the day care center, preschool, or school that the children had attended, they were coded into three groups. One group consisted of children who had attended day care centers, preschools, or schools with indoor air problems due to minor moisture damage, one group of children who had attended day care centers, preschools, or schools with indoor air problems due to severe moisture damage, and one control group of children who had attended day care centers, preschools, or schools with no known indoor air problems due to moisture damage. No damage meant no need for repair or only cosmetic repair, minor damage meant visible moisture damage and need for repair between 0.1 m<sup>2</sup> and <1 m<sup>2</sup> in one or more classrooms,

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