MOISTURE DAMAGES IN SCHOOLS - SYMPTOMS AND INDOOR AIR MICROBES

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ABSTRACT

The association of moisture damages of school buildings with microbial indoor air quality and health status of school children was studied. To determine the association the school buildings (N=32) were divided into the moisture damaged (index) and non-damaged (reference) schools according to technical inspection data. Children's health surveys were made by questionnaires. Microbes were determined from indoor air of school buildings using a six-stage impactor. Children in the index schools reported more respiratory symptoms compared to children in the reference schools. No significant differences in total concentrations of airborne viable fungi between the damaged and non-damaged schools could be shown. However, some differences in microbial flora were found.

KEYWORDS: moisture, schools, mould, bacteria, symptoms, fungi

INTRODUCTION

Moisture damages and indoor air quality are a concern of schools [1,2]. Moisture damages are a risk factor for health implications [3, 4], and the health status of school children requires special surveying. However, the exposing agents are still unclear. Indoor air counts of microbes and fungal flora of school buildings have been reported in a few studies, but their association to moisture damages or occupants' symptoms has not been shown.

The purpose of this study was to determine whether the health status of children and microbial quality of indoor air in schools with visible moisture and mold problems differ from those in non-damaged schools. The school buildings were classified as moisture damaged (index) schools or non-damaged (reference) schools according to technical inspection data from the buildings.

MATERIALS AND METHODS

Technical investigations and microbial sampling were performed in 32 school buildings during years 1994-1999. Health data were collected in 30 schools. The schools are located in central Finland representing typical school buildings of various sizes, construction styles and building materials. The schools were either primary or secondary schools. Area of the schools varied from 380 m^2 to 10 900 m^2 and the number of pupils from 12 to 700. Total number of pupils was 4365.

Building inspection

All the buildings were thoroughly inspected for visible signs of moisture by a trained building engineer. Surveying was made according to a checklist for various types of moisture signs. Surface moisture recorders were used. Types and obvious reasons for the damage were recorded, when possible. The inspection procedure and the basis for decision of the damage degree have been developed earlier [5]. Based on moisture observations, the buildings were classified into moisture damaged schools that are called index schools (n= 24) and non-damaged schools or reference schools (n= 8). Areas and the severity of the damages and the size of the building were taken into account, when estimating the classification of the buildings. This classification was used in the analysis of microbial and health data.

Health surveys

Children's health data were collected by questionnaires. The questionnaire used was modified from those used in other Finnish studies concerning respiratory symptoms and diseases [6,7]. The questionnaire comprised 32 questions of personal characteristics, indoor air characteristics, the occurrence of respiratory symptoms and infections, doctor visits, sick leaves, hospitalization and use of medication for respiratory diseases.

Air sampling

Airborne microbes were determined by using a six-stage impactor (Andersen 10-800) [8] in different rooms, i.e. classrooms, corridors and gyms. Media used were 2% malt extract agar (MEA) and dichloran glycerol agar (DG18) for fungi and tryptone glucose yeast agar (TGY) for bacteria and the samples were incubated and analyzed as described before [2,9]. Samples (N=224) were taken during winter months when the ground was covered by snow and during school days when the buildings were occupied. Sampling times were from 7 to 15 minutes and detection limit varied from <2 to <5 cfu/m^3 depending on the sampling time.

Statistical analysis

The association between the symptoms and moisture damages in the index or reference schools was tested with logistic regression. The concentrations of airborne microbes were not normally distributed and normal distribution could not be obtained by transformations. Non-parametric tests were used for data analysis. The difference in total concentrations and concentrations of most common fungi between the index and reference schools were compared with Mann-Whitney U test. χ^2 – test was used to test the differences in frequencies of different concentration categories and for the occurrence of certain fungal genera. SAS statistical package [10] was used in analyzing the data.

RESULTS

Health findings

The response rate for health surveys was 82%. Out of 4365 children 3687 came from the index schools and 678 from the reference schools. No differences in the prevalence of self reported allergies were found. Children occupying index schools reported more nocturnal cough and common cold, cough without phlegm and with phlegm and muscular pain during spring session (p=0.0001 for all symptoms) than children in the reference schools.

Fungal concentrations

The ranges and geometric means of total concentrations of airborne microbes are presented in Table 1. Differences between the index and reference schools were not statistically significant. When comparing corresponding frequencies of total concentrations in four categories (classified according to percentiles of 50, 75, 90 and >90) no statistical differences between the schools were found.

Table 1. The ranges (R) and geometric means (GM) of total concentrations of airborne fungi and bacteria and the ranges and geometric means of concentrations of actinomycetes in the index and reference schools and the percentiles of fungal concentrations

	Index schools	Reference schools
fungi		
R (cfu/m^3)	0 – 950	0 – 550
GM (cfu/m^3)	26	18
percentiles		
median	30	26
75%	61	62
90%	138	145
95%	230	507
99%	450	545
bacteria		
R (cfu/m^3)	0 – 11 000	0 – 5 900
GM (cfu/m^3)	604	431
actinomycetes		
R (cfu/m^3)	0 – 2 700	0 – 99
GM (cfu/m^3)	2.3	1.2

Fungal flora

The most common fungal genera in the school buildings were *Penicillium*, yeasts, *Cladosporium* and *Aspergillus*. *Penicillium*, *Aspergillus* and yeasts were found more often in the index schools, but the differences were not statistically significant. Neither were the concentrations of those genera significantly higher in the index schools than those in the reference schools. *Cladosporium* was found significantly more frequently in the index schools

than from the reference schools (p=0.0080 for MEA and p=0.0230 for DG18). The concentrations of *Cladosporium* were also significantly higher in the index schools than in the reference schools (p=0.0056 for MEA and p=0.0103 for DG18). When taken into account both growth media, the range of concentration of *Cladosporium* was from 0 to 170 cfu/m^3 in the index schools and from 0 to 39 cfu/m^3 in the reference schools.

Aspergillus versicolor, whose presence indicates moisture damage in materials [11,12], was found more frequently in the index schools. The difference was significant (p=0.0380) for *A. versicolor* detected on DG18-agar. *Stachybotrys* was found in five samples, all of which were from the index schools (from three different buildings and five different rooms).

Bacteria

The ranges and geometric means of total concentrations of airborne bacteria and those of actinomycetes are presented in Table 1. The differences of total concentrations of bacteria and concentrations of actinomycetes between the index and reference schools were not significant.

DISCUSSION

To determine whether the moisture damages have an association with microbial indoor air quality in school buildings and health status of school children, the schools studied were divided into the damaged and non-damaged schools. A difference in the prevalence of respiratory symptoms and infections between the school children occupying damaged and non-damaged schools was shown. Similar relationship between symptoms and moisture damages has earlier been reported for school-aged children in our studies concerning home environment [13].

Fungal concentrations detected in indoor air of schools were low compared to those previously found in homes [9,14]. A similar finding has been made by Dotterud et al. [15]. In other studies, made in warmer climate, concentrations found in schools have been higher, but the impact of outdoor air has been evident in those cases [16,17,18]. Although some differences in microbial flora between the damaged and non-damaged schools were found, no significant differences in total concentrations of airborne viable fungi were observed. In conclusion, there are some exposing factors that cause symptoms in moisture damaged schools, but this exposure cannot be expressed as total number of viable fungi. The presence of microbes indicating moisture damage is some kind of surrogate for exposure, however, semiquantitative.

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