Respiratory Symptoms and Infections in Children and Employees at a Water-Damaged Kindergarten

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Abstract: *Objectives*: Several studies have shown an increased risk of infections and respiratory symptoms among people exposed to molds. Here, we report the morbidity of children and staff exposed to several toxic molds at a kindergarten.

Methods: Prevalence of symptoms and the incidence of infections were followed up and compared between children and staff exposed in a day-care center affected by mold and those in a reference day-care center. At both day-care centers, parents (mostly mothers) filled out a questionnaire. Staff members with more severe symptoms were examined at the Clinic for Indoor Air Health Problems of the Skin and Allergy Hospital, Helsinki University Hospital.

Results: Children and staff exposed to mold had more frequent symptoms and illnesses such as hoarseness, bronchitis than the nonexposed reference group. Symptoms in the exposed group were reduced following remedial building work and the avoidance of exposure. In addition, the acute care visits of the children to the local health care center were less frequent after remediation. One of the employees of a water-damaged kindergarten was diagnosed with allergic alveolitis and asthma, one had epipharyngitis, and two had mixed cell inflammation of the eye.

Conclusions: Our study supports the results in which moisture and mold problems have been noted to increase disease rates of children and staff in day-care facilities. The study also suggest that detrimental health effects can be diminished by decreasing or stopping the exposure.

Keywords: Molds, kindergarten, health effects.

1. INTRODUCTION

Over 50% of day-care centers in the capital city area of Finland were found in the 1990s affected by water damage with mold, and moldy odor was perceived in 15% of these centers [1]. Because symptoms associated with exposure to fungi are usually nonspecific, problems may go unnoticed for long periods. Increasing evidence from the 1990s to the 2000s provides convincing certainty for the association of dampness and mold with cough, wheezing, and dyspnea, as well as with upper-respiratory symptoms [2-6]. Other factors, such as insufficient ventilation, high temperature, and emission of chemicals from construction materials, are also associated with symptoms, thus confounding the relationship between fungal exposure and health effects [6].

Preschool children are estimated to spend 80% of their time indoors. One-third of Finnish preschoolers receive home care, with two-thirds partaking of family care or group care at day-care centers. Day-care center attendance is associated with increased incidence of respiratory infections [7-10]. However, a study performed in the Helsinki area indicated, variability in morbidity from infectious diseases in children of different day-care centers [8].

The aim of this study was to investigate the occurrence of health symptoms in a water-damaged building; and a success of a building remediation on the children's and employees' health. This was done by a follow-up of a day-care center with a mold problem and a reference day-care center with no known mold damages.

2. MATERIALS AND METHODS

2.1. Exposure History

The study object is a kindergarten, built in 1990, located in a suburb of Helsinki area. It consists of two one storey wooden building with mechanical ventilation. At the end of 1995, employees of it started to complain of mucous membrane irritation, fatigue, and headaches. Soon children also presented with tiredness and different irritant symptoms. As these complaints were similar to those commonly reported in moisture-problem houses, the Municipality Environ-

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mental Center examined the day-care center. Water-damaged areas in the building were detected in the flooring of the building and in the kitchen. Despite repairs, the moisture problem and complaints of indoor air quality persisted. In spring 1997, when severe symptoms were reported, the Municipal Environmental Center performed new investigations, including air sampling and collection of building materials. Because of concerns about mold-related health risks, the day-care center was closed in June 1997. Children and staff returned, following renovations, at the end of summer 1997.

2.2. Measurements

Culture dishes of airborne microbes were sampled by a volumatic Andersen impactor. Material samples were collected into bags and a dilution series was done before growing the cultures. Fungal samples were cultured on malt extract-dextrone-streptomycin agar, and bacterial samples on tryptone-yeast extract-glucosecycloheximide agar. Fungi were isolated and identified to genus level; bacteria were classified mainly as actinomycetes in the mycological laboratory of the Environmental Center.

Anthropodes like mites are found in moisture-damaged buildings [6]. The semiquantitative Acarex test of dust samples was used for mite analyses. In it, guanine content in dust is used as a marker of arthropods' excrement.

The specific emission rate (SER) from the floor cover, measured by the FLEC (Field and Laboratory Emission Cell) -method, was also determined.

Table 1: Age, Gender, Prevalence of Atopic Manifestations, and Family and Home Characteristics among both Children of the Exposed and the Reference Kindergartens. No Statistically Significant Differences (p>0.05) were found between the Background Knowledge and Illnesses of the Children in Exposed and Reference Day Care Center

	Reference Day-Care Center % (N)			Exposed Day-Care Center % (N)		
	Boys	**Girls**	**All**	**Boys**	**Girls**	**All**
Children N	61 (30)	39 (19)	(49)	50 (19)	50 (19)	(38)
mean age (years) age range (years)	4.7 3-6	4.8 3-6	4.8 3-6	4.9 3-7	5.3 3-7	5.1 3-7
asthma*	10(3)	-	6.1(3)	11(2)	11(2)	11(4)
allergic rhinitis*	6.7(2)	-	4.1(2)	11(2)	16(3)	13(5)
atopic dermatitis	37(11)	37(7)	37(18)	16(3)	37(7)	26(10)
SPT# or RAST¤ tests	17(5)	5.3(1)	12(6)	21(4)	16(3)	18(7)
Family allergy/ mother asthma/ mother	63(19) 6.7(2)	37(7) 5.3(1)	53(26) 6.1(3)	42(8) -	32(6) 5.3(1)	37(14) 2.6(1)
allergy/ father asthma/ father	23(7) -	21(4) -	22(11) -	21(4) 5.3(1)	32(6) 11(2)	26(10) 7.9(3)
pets**	20(6)	5.3(1)	14(7)	37(7)	21(4)	29(11)
fireplace used often at home	24(7)	11(2)	18(9)	21(4)	16(3)	18(7)
passive smoking at home	6.7(1)	5.3(1)	4.1(2)	10.5(2)	-	5.3(2)
water-damage in history at home	20(6)	11(1)	14(7)	21(4)	21(4)	21(8)
mold spots at home	10(3)	-	6.1(3)	11(2)	5.3(1)	7.9(3)

* Diagnosed by a physician.

**Pets also include aquatic animals.

Positive reaction (>2mm) in skin prick test.

¤ IgE-concentration increased.

2.3. Study Population and Data Collection

The study population included the children and employees of a moisture-damaged kindergarten (Table **1**). In spring 1997, 55 children under seven years of age were located in the main building and 16 children in a smaller building. A questionnaire for the children's parents and the employees was distributed at the end of November 1997, about three months after the repaired day-care center was reopened. The questionnaire covered personal characteristics of the study population, occurrence of respiratory symptoms, allergic diseases, the numbers of different infectious diseases, and antibiotics prescribed, and any absences from the day-care center during spring 1997 and autumn 1997. The response rate was 67%.

The control group consisted of the children and employees of another kindergarten (reference day-care center), which had not had earlier or at the study time signs of moisture or other indoor air problems according to the studies of a trained building engineer of Municipal Environmental Center. This day-care center located about 5 km from the exposed day-care center, and it had ever experienced water-damage. Characteristics of the reference day-care center were similar to those of case day-care center. The distribution of known confounders of the children and staff was also similar except for the control day-care center accepting children under three years of age (Table **1**). To standardize the groups, these children were excluded from analysis.

At the time of distributing the questionnaire, the 12 children and 3 staff members, with the most severe symptoms had moved to other day-care centers, and thus did not receive the questionnaire. The symptoms of these children were, however, investigated with a short questionnaire distributed in spring 1999. Data concerning the symptoms and illnesses of these children were also collected from the files of local health-care centers.

In 1996-7, only four of all employees at a water-damaged kindergarten were examined at the Clinic for Indoor Air Health Problems of Helsinki University Hospital because of suspected occupational disease. All of these patients were interviewed and examined by the same doctor (HMR). Clinic assessment included medical history and current symptoms, physical examination, pulmonary function tests, chest and maxillary sinus radiographs, complete blood cell count, skin prick tests to common allergens and molds, sputum tests (concentration of eosinophil cationic protein (ECP), as an indicator of inflammation process in the mucous membranes), and determinations of IgG and IgE antibodies to molds. In some cases, such examinations as high-resolution computer tomography, flexible bronchoscopy and/ or diffusing capacity determination were also performed. All these patients gave their informed consent.

2.4. Statistics

Statistical analyses were done using SPSS/PC+. Dichotomous variables were tested with the chi-square test and related risk was assessed with multivariate logistic regression models. Adjustments were made for confounders. The Friedmann's test was used for trend analysis.

3. RESULTS

3.1. Exposure

Building examinations in 1995 indicated that rainwater wells of the exposed day-care center were completely blocked. This allowed rainwater to seep into and under the building. The building's bottom surface was horizontal and not sloping away from the building, as recommended. Visual signs of mold were present at ground level. Basement samples contained high concentrations of *Acremonium*, *Penicillium,* and *Cladosporium* molds. In 1997, *Fusarium sp.* was found in the samples from the entrance hall and an exceptional quantity of *Actinobacteria* was present in the bathroom in the rest room air. The dust samples from the ventilation system and building material samples from the kitchen contained high concentrations of *Stachybotrys chartarum, Aspergillus niger, Fusarium sp., Chaetomium sp, Cladosporium sp, Penicillium sp,* and *Actinobacteria*. Despite the reparations in 1997, follow-up investigations revealed molds and *Actinobacteria* in sediment dust and building materials.

The cytotoxity of the material sample from the day-care center was tested with feline fetus cells. The method and results are reported in detail elsewhere [11]. The sample, which contained abundant *Stachybotrys chartarum* was slightly toxic to cells, indicating the possible presence of trichothecenes.

The seven-year-old vinyl flooring was found to be of poor quality, belonging to the M3 class (total volatile organic compound (TVOC) emissions of M3 are over 0.4mg/(m^2h). TXIB (2,2,4-trimethyl-1, 3-pentadi-isobutyrate) concentration was high, 40μg/m^2 detected in indoor air of dwelling-houses. The carpets were changed in 1997.

Table 2: Occurrence of Illnesses and Symptoms among Children in 1997 at the Reference (Controls) and Exposed Kindergarten (Cases). The Renovations at the Case Day-Care Center Took Place during the Summer 1997

Illnesses / Symptoms	Spring 1997					Fall 1997			Trend Test	
	Controls N=36%	Cases* N=31%	p value	Cases # N=38%	p value	Controls n=36%	Cases* N=31%	p Value	Cases * p value	Cases # p value
flu	88.9	93.5	n.s.	94.6	n.s.	80.6	67.7	n.s.	n.s.	n.s.
bronchitis	2.8	19.6	**0.043**	18.4	**0.033**	5.6	-	n.s.	n.s.	n.s.
runny nose	88.9	80.6	n.s.	84.2	n.s.	80.6	71.0	n.s.	n.s.	**0.058**
blocked nose	66.7	72.4	n.s.	72.2	n.s.	57.1	44.8	n.s.	**0.018**	**0.009**
hoarseness	19.4	43.3	**0.033**	41.7	n.s.	37.1	20.7	n.s.	**0.007**	**0.005**
dry cough	50.0	69.0	n.s.	72.2	**0.032**	55.6	53.3	n.s	n.s.	**0.033**
eye irritation	22.2	20.0	n.s.	19.4	n.s.	14.3	6.7	n.s.	n.s.	n.s.
increased temperature	52.8	73.3	n.s	71.4	n.s.	55.6	36.7	n.s.	**0.003**	**0.002**
fatigue	50.0	50.0	n.s.	51.4	n.s.	52.8	43.3	n.s.	n.s.	n.s.
difficulties in con-centration	25.0	10.3	n.s.	13.9	n.s.	25.0	6.9	n.s.	n.s.	n.s.
skin symptoms	25.0	19.4	n.s.	23.7	n.s.	27.8	9.6	n.s.	n.s.	n.s.
health change for better: fall vs. spring						20.0	40.7 46.9 #	**0.067**		

* Only includes children participating in the fall 1997 questionnaire.

Includes also those who moved to another day-care center during early spring 1997 and participated in the 1999 questionnaire.

n.s. p = >0.05.

In the semiquantitative Acarex test of dust samples, there were no signs of mites.

3.2. Evaluation of Symptoms in 1997

3.2.1. Children

Data concerning children's symptoms and illnesses were collected by questionnaire and from the files of local healthcare center. The questionnaire was validated by comparing information provided in it with the those of local healthcare center; for example, the number of physician visits. Because they yielded comparable results (not shown), recall bias is unlikely to be significant.

Twelve children had such severe symptoms that their physicians recommended transferring them in early spring 1997 to other day-care centers. At the end of May 1997, remaining children and day-care staff moved to another day-care center with no known indoor air problems. In the wet-damaged day-care center, the children had reported a high frequency of unspecific symptoms (Table **2**). There was an increased risk of acute bronchitis, but not of other infections compared to the controls. In spring 1997, the risk of acute bronchitis, adjusted for age, sex, and history of allergic rhinitis, was increased in the exposed day-care center: 8.43 (95% CI 0.91, 77.59). The children also had a persistent cough, especially at night, and hoarseness, both of which were significantly associated with stay in the moisture-damaged day-care center. According to parental reports, children's health improved significantly when the exposure deceased: particularly stuffiness of the nose, throat symptoms, cough, fever, and skin symptoms diminished (Table **2**).

3.3. Evaluation of Symptoms before 1997

In 1996, children's health in the control day-care center had also been inquired about by local health center physicians. They had drafted a questionnaire of their own, which 61 children (31 boys and 30 girls) filled in. According to this questionnaire, children had numerous symptoms in the wet-damaged day-care center all year round 1996 (Tables **3** and **4**), and were often absent from the day-care. Parents reported that the average visit rate of children in the exposed day-care center to local healthcare centers was 4.2 in 1993, 5.3 in 1994, 8.5 in 1995, 7.6 in 1996, 3.1 in 1997, and 3.5 in 1998.

Table 3: Prevalence of Children's Illnesses and Use of Antibiotics in the Exposed Day-Care Center According to the Questionnaire of Physicians of the Local Healthcare Center. No Statistically Significant Differences (p>0.05) were found in Illnesses between Boys and Girls

	January-June 1996%		July-December 1996%	
Illnesses	**Boys N=31**	**Girls N=30**	**Boys N=31**	**Girls N=30**
Upper airway respiratory infections	86	86	75	64
Pharyngitis or tonsillitis	17	11	-	-
Otitis	46	36	20	14
Sinusitis	7	11	13	7
Bronchitis/ Pneumonia	14	26	13	3
Use of antibiotics	62	70	36	27

Table 4: Prevalence of Symptoms of the Children in the Exposed Day-Care Center According to the Questionnaire of the Physicians of the Local Healthcare Center. No Statistically Significant Differences (p>0.05) were found in Symptoms between Boys and Girls

Symptoms	January-June 1996 often or Frequently%		July-December 1996 often or Frequently%	
	Boys	**Girls**	**Boys**	**Girls**
Blocked nose	52	62	59	70
Runny nose	55	73	59	70
Hoarseness	35	23	38	23
Nose bleeding	12	19	14	13
Dry cough	38	46	47	43
Mucous cough	31	35	31	37
Dyspnea or wheezing	16	15	11	-
Eye irritation	35	23	41	20
Temperature over 37.5°C	36	48	41	24
Joint pain	12	4	14	3
Fatigue	31	24	41	41
Headache	11	15	25	27
Myalgia	8	8	7	3

3.4. Employees

In spring 1997, employees of the exposed day-care center reported higher frequencies of voice problems, cough, dyspnea, eye irritation, and fatigue than employees of the reference day-care center. In fall 1997, after the remediation all but one of the employees of the exposed kindergarten reported improvement in health condition (Table **5** and **6**).

Table 5: Age, Gender, Prevalence of Atopic Manifestations, and Family, Home, and Workplace Characteristics of Employees in both the Exposed and Reference Day-Care Centers

	Exposed Day-Care Center	**Reference Day-Care Center**
N	4*	13
Mean age (years)	46	37
Range (years)	41-49	21-56
Women (%)	100	85
Asthma	1	0
Allergic rhinitis	1	4
Home		
Pets	1 (25%)	4 (31%)
Passive smoking	2	0
Water-damage or mold spots in history	0	4 (31%)
Workplace #		
High indoor (%) temperature	0	15
Low indoor temperature (%)	0	15
Dry air (%)	50	15
Unpleasant odor (%)	25	31
Dust (%)	25	39
Noise (%)	50	77

Perceived weekly in spring 1997.

* Includes the data of only one of the four employees with most severe symptoms and examined for occupational disease.

In 1996, four of the employees of the exposed day-care center went for examination to the Clinic for Indoor Air Health Problems. Indication for hospital examinations was suspicion of an occupational disease. These employees suffered especially from nose and eye irritation, cough, shortness of breath, and increased temperature, resulting in numerous absences from work. All had increased concentrations of IgG antibodies against *Stachybotrys atra*, rating ++ or +++ on the semiquantitative scale (Kuopio Regional Institute of Occupational Health). One of the employees had IgE antibodies against the *Aspergillus fumigatus* mold. Two, who were not atopic, had increased

Table 6: Illnesses and Symptoms Appearing Weekly (%) in Employees of Exposed (N = 4*) and Reference (N = 13) Day-Care Centers. The Renovations at the Case Day-Care Center Took Place During the Summer 1997

Illness/ Symptom	Exposed # Day-Care Center Spring 1997	Reference Day-Care Center Spring 1997	Exposed # Day-Care Center Fall 1997	Reference Day-Care Center Fall 1997
Flu	75	54	75	62
Sinusitis	25	15	25	15
Blocked nose	75	31	50	23
Hoarseness	50	7.7	25	0
Cough	25	7.7	25	23
Shortness of breath	25	0	0	0
Eye symptoms	50	7.7	50	0
Skin symptoms	25	7.7	0	23
Increased temperature	25	0	0	0
Sore throat	25	0	25	0
Health condition improved in fall vs. spring ##			75%*	31%

Only one of the four employees with most severe symptoms and examined for occupational disease participated in the questionnaire.

Personal judgement.

*p<0.05.

concentration of ECP as a marker of inflammation in the airways. Three of the four employees were bronchofiberscoped: one employee had lymphocytosis in bronchoalveolar lavage and two had edema in bronchial PAD samples. One of the employees was diagnosed with alveolitis and asthma, one had epipharyngitis, and two had mixed cell inflammation of the eye. According to follow-up interviews after 5 years, eye symptoms were chronical moderate or severe in three of the persons in spite of intensive medical treatment and avoidance of moldy places. No other reasons for their eye symptoms were found.

4. DISCUSSION

Several studies have shown the form of daycare to have an effect on the infection rate of children [7-10]. Moisture damages are common in day-care centers and schools. Moisture damages and mold have been demonstrated to cause severe health hazards such asthma, dyspnea, wheeze, cough, respiratory infections, rhinitis and upper respiratory tract symptoms [3, 11-19]. For example, it was reported by data on over 58,000 children (aged 6-12 years), exposed to mold, that confounder-adjusted combined ORs ranged from 1.30 (95% CI 1.11 to 1.39) for 'nocturnal' cough to 1.50 (1.31 to 1.73) for 'morning' cough [13].

To alleviate the problem in Finland, the municipalities have been given guidelines to prevent and repair moisture damages in buildings by the Ministry of Social Affairs and Health and the Ministry of the Environment.

Although the sample size and response rate was relatively low, our case study shows that exposure at the wet-damaged kindergarten is associated with morbidity, and frequent prevalence of illnesses and symptoms among children and employees.

Clinical studies of the employees at the hospital showed detectable findings for example allergic alveolitis in the bronchofiberscopy which can be associated to mold exposure. There is, however, no adequate epidemiological evidence on dampness associated microbiological agents and allergic alveolitis [20].

The parents of the children and the employees reported that symptoms decreased or disappeared when the exposure ceased. The children and adults of the wet-damaged day-care center had various kinds of irritant symptoms, some of which were severe. Certain staff members showed signs of persistent symptoms despite moving to another day-care center or profession. These may have been immunogenic or long-lasting toxic effects.

Fusarium and *Stachybotrys* fungi are regarded as indicator organisms for high-water activity (aw 0.90-0.95) in moisture-damaged building materials [21]. Because of the threat posed by mycotoxins, these

fungi have received increasing attention in connection with some human diseases of originating from the immediate environment. Toxins produced by *Stachybotrys* may cause severe irritation of the eyes, skin, and mucous membranes as well as nosebleeds, necrosis, organ hemorrhages, and immune system dysfunction [20-25]. Satratoxin is one of the most potent known fungal toxins [22].

Several types of fungi were identified at the exposed day-care center, including among others, the above-mentioned *Stachybotrys* and *Fusarium* species. Qualitative cell studies showed that the *Stachybotrys* strain was mildly toxic. In bronchoscopy, the employees were found to have blood-shot mucous membranes of the bronchus.

In epidemiological studies, emissions from PVC surface materials have been associated with bronchial obstruction [26]. Here, the physician-diagnosed asthma prevalence in the exposed kindergarten was not excessively high (girls 10.5%) (Table **1**). Correlations between TXIB emission and eye and nose irritations have also been reported [27], suggesting that emissions from poor-quality vinyl flooring which was changed in 1997, may have caused symptoms, too.

The success of the building remediation processes has not always proved to be good [28-29]. Sauni *et al*. [30] studied the effectiveness of remediating buildings damaged by dampness and mold to reduce or prevent respiratory tract symptoms, infections and symptoms of asthma by the literature review. They found moderate to very-low –quality evidence that repairing mold-damaged houses and offices decreased asthma-related symptoms and respiratory infections compared to no intervention in adults. For children, they reported very low-quality evidence that although repairing schools did not significantly change respiratory symptoms in staff or children, pupils' visits to physicians due to a common cold were less frequent after remediation.

CONCLUSION

Our study supports the investigations in which moisture and mold problems have been noted to increase disease rates of children and staff in day-care facilities. Many pollutants such as the emissions of volatile organic compounds from molds and vinyl flooring, mold spores, and mycotoxins may cause various symptoms and illnesses. In some cases, chronical health symptoms (eq., eye symptoms) may be generated. This study also suggests that detrimental health effects can be prevented by decreasing or stopping the exposure. This can be done avoiding the exposure but also by building renovation, emphasizing the importance of timely and proper renovation procedures.

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