EVALUATING EFFECTS OF MOISTURE DAMAGE REPAIRS ON STUDENTS' HEALTH USING QUESTIONNAIRES

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ABSTRACT

Symptom questionnaire responses were collected from upper secondary and high school students (n=245) before comprehensive repairs of moisture damage in the school unit. The questionnaire study was repeated one year (n=227) and three years (n=256) after the repairs. The data was analyzed both cross-sectionally including all respondents, and longitudinally including paired observations for those individuals who had responded both before and after the repairs. Compared to the situation before the repairs, the situation after the repairs was significantly improved in most of the 20 symptoms studied among the whole population. However, the improvement was not so clear in the paired analysis and regression analysis among the students who had responded to all three questionnaires. The results indicate that the repairs succeeded in terms of that new cases of symptomatic students were no longer expected. However, the situation of the group of exposed individuals may need to be considered separately.

INDEX TERMS

Follow-up, Health effects, Mold, Renovation, Schools

INTRODUCTION

Only a few studies have been published of the effects of repairs on children's health (Savilahti et al. 2000, Koskinen et al. 1995). These studies have used a study design based on case and control groups of children, where the dependency of repeated observations has not been taken into account, and the follow-up periods have been around one year. In this study, the moisture and microbial status of upper secondary and high school unit (including two school buildings), and the health status of the school occupants were assessed based on the results of comprehensive investigations. Advice was given in order to repair the buildings successfully (Haverinen et al. 1999a). Repair works included improving drainage and structural changes in order to ensure drying of ground floor structures, improving ventilation in crawl spaces and renewing damaged materials. Both technical and microbial follow-up measurements made one year after the repairs (Haverinen et al. 1999b), and partially repeated three years after the repairs (unpublished data) suggested that the repairs succeeded satisfactorily. Also an analysis of the health parameters done in the group level one year after the repairs reflected improvement (Haverinen et al. 1999b). This paper continues analyzing health data collected from the upper secondary and high school students. It includes both group level and individual level analyses, and consists of a perspective of long-term follow-up. An aim of this study is to develop an approach in assessing the effects of repairs on occupant health in this kind of follow-up situation.

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MATERIAL AND METHODS

Symptom questionnaires were sent to the school occupants before the investigation started in May 1996, and the study was repeated in May 1997 after the repairs were completed, and again in May 1999. The questionnaire included 44 questions on respiratory and general health and allergies of the subject, 12 questions of background information and 16 questions about the school (Haverinen et al. 1999a). In the original questionnaire, the occurrence of symptoms was examined separately with respect to fall and spring semesters. For the final analyses, 20 symptom variables were selected based on their assumed association with moisture and mold problems. Only the occurrence of symptoms during the spring semesters was included in the analyses (Table 1).

Table 1. Selected symptom variables and confounding factors.

Selected symptoms		Confounding factors
Sinusitis	Nocturnal cough	Selected*: Smoking Gender Home location (urban / rural areas) Age
Doctor visits	Dyspnea/ wheezing	
Need of antibiotics	Eye symptoms	
Blocked nose	Fever	
Rhinitis	Fatigue	
Sore throat	Headache	
Hoarseness	Difficulties in concentration	Not selected*: Pets Type of home Size of family Moisture damage in home
Nasal bleeding	Muscular pain	
Cough without phlegm	Arthralgia	
Cough with phlegm	Asthma	

* Based on stepwise logistic regression

Response rate was 91% in 1996, 79% in 1997 and 95% in 1999. A portion of the student population ends their school term each spring, and concurrently, new students enter into the curriculum each fall. Because of this, the number of students who attended the school before the repairs (in 1996) until the second questionnaire (first follow-up in 1997) was 157, and the number of those who participated the whole three years study and returned the third questionnaire (second follow-up in 1999) was 49. The study population is presented in Figure 1.

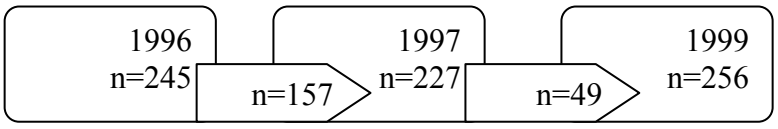

Figure 1. The study population. The numbers in blocks represents the whole population, while the numbers in arrows represents respondents who were present in the first questionnaire in 1996.

Statistical analyses were done with SPSS – program (SPSS Inc. 1988). A cross-sectional analysis including all respondents was done using χ^2-test for the selected symptom variables. A longitudinal analysis including paired observations for those individuals who had responded both before and after the repairs was done using McNemar-test for the same variables. A stepwise logistic regression model was developed in order to take possible confounding factors into account in assessing the effects of the repairs. The regression analyses were made both among the whole population and the

group of the 49 students who had responded all three questionnaires. In these analyses, the dependency across the subjects in the repeated observations in each questionnaire was not taken into account. The criteria in evaluating the effects of repairs between the study periods and different populations were based on risk decrease, statistical significance, and the trend of changes between different time points.

RESULTS

Compared to the situation before repairs, statistically significantly smaller prevalence values were seen in 11 symptoms in the first follow-up, and in 14 symptoms in the second follow-up, among the whole study group using unpaired observations (Table 2). Paired analyses suggested significant decrease in 8 symptoms in the first follow-up but no statistically significant change was seen in the second follow-up, which may be partly due to smaller number of respondents. However, the crude prevalence was lower in 11 symptoms and higher in 8 symptoms in this group.

Table 2. Prevalence of symptoms among the unpaired and paired groups in different time points.

Health symptom/	Unpaired observations[a]			Paired observations[b]				
spring	**-96**	-97	-99	**-96**	-97	**-96**	-97	-99
N of observations	**245**	**227**	**256**	**157**	**157**	**49**	**49**	**49**
Prevalence	**%**	%	%	**%**	%	**%**	%	%
Sinusitis	**21**	11	14	**17**	12	**17**	13	11
Doctor visits	**27**	21	14***	**25**	18	**24**	20	17
Need of antibiotics	**22**	16	10***	**20**	14	**22**	15	11
Blocked nose	**76**	55***	58***	**73**	58***	**78**	62	65
Rhinitis	**74**	55***	60***	**72**	58***	**74**	59	63
Sore throat	**51**	31***	39**	**48**	36*	**46**	37	47
Hoarseness	**42**	28***	30**	**41**	32*	**46**	28	36
Nasal bleeding	**14**	11	8*	**9**	12	**7**	16	4
Cough without phlegm	**37**	27*	24**	**32**	33	**30**	30	29
Cough with phlegm	**40**	30*	29*	**39**	33	**33**	35	30
Dyspnea/ wheezing	**19**	11	13	**14**	13	**11**	16	22
Nocturnal cough	**27**	20	19*	**20**	20	**16**	9	18
Eye symptoms	**36**	23**	21***	**31**	26	**28**	18	22
Fever	**32**	30	30	**27**	31	**24**	31	28
Fatigue	**81**	63***	71*	**80**	68**	**83**	64	96
Headache	**68**	55**	58*	**64**	57*	**65**	51	65
Difficulties in concentration	**54**	26***	32***	**48**	33***	**50**	36	51
Muscular pain	**40**	26**	38	**42**	29**	**46**	40	48
Arthralgia	**18**	12	18	**15**	13	**9**	14	22
Asthma	**11**	18	7	**11**	9	**20**	20	16

[a] Tested using χ^2-test; [b] Tested using McNemar-test; * $p< 0.05$ ** $p < 0.01$ *** $p < 0.001$

Adjusted odds ratios suggested significant decrease in 13 symptoms in the first follow-up, in 16 symptoms in the second follow-up, and the trend was decreasing in 9 symptoms among the whole

population. Similarly, significant decrease was observed in three symptoms and increase in one symptom in the second follow-up among the 49 students who had responded to all three questionnaires. For these students, the trend was decreasing in five symptoms and increasing in four symptoms. These results are shown in Table 3.

Table 3. Adjusted [c] odds ratios for the effects of the repairs on the symptoms.

Health symptom/ spring	Whole population			49 students		
	-96 OR	-97 OR	-99 OR	-96 OR	-97 OR	-99 OR
Sinusitis	1.0	0.58	0.49*	1.0	0.44	0.35
Doctor visits	1.0	0.65	0.42***	1.0	0.53	0.34
Need of antibiotics	1.0	0.64	0.37***	1.0	0.30	0.90*
Blocked nose	1.0	0.38***	0.44***	1.0	0.43	0.55
Rhinitis	1.0	0.40***	0.51***	1.0	0.66	1.55
Sore throat	1.0	0.38***	0.56***	1.0	0.57	0.65
Hoarseness	1.0	0.43***	0.51***	1.0	0.52	1.24
Nasal bleeding	1.0	0.69	0.47*	1.0	3.05	1.44
Cough without phlegm	1.0	0.61*	0.52**	1.0	1.00	1,28
Cough with phlegm	1.0	0.61*	0.53**	1.0	0.67	0.19
Dyspnea/ wheezing	1.0	0.50*	0.56*	1.0	1.62	4.27
Nocturnal cough	1.0	0.60*	0.49**	1.0	0.25	0.08*
Eye symptoms	1.0	0.49***	0.46***	1.0	0.70	1.74
Fever	1.0	0.90	0.90	1.0	1.97	3.90
Fatigue	1.0	0.36***	0.57*	1.0	0.47	11.6**
Headache	1.0	0.47***	0.58**	1.0	0.58	1.56
Difficulties in concentration	1.0	0.28***	0.35***	1.0	0.58	1.21
Muscular pain	1.0	0.52***	0.93	1.0	1.10	2.11
Arthralgia	1.0	0.62	0.94	1.0	0.05	5.26
Asthma	1.0	0.76	0.60	1.0	0.46	0.07*

[c] Adjusted for smoking, gender, home location, age; * $p< 0.05$ ** $p < 0.01$ *** $p < 0.001$

DISCUSSION

This study was made in order to develop an approach in assessing the effects of moisture and mold repairs on students' health. Earlier studies have used a study design based on case and control groups of children, where the dependency of the repeated observations has not been taken into account, and the follow-up periods have been around one year. Such a study design is weaker in assessing whether the possible change observed actually is a result of the repairs or some other changes related to the study population. Following the same group of students throughout the study may bring additional information on that type of assessment. However,

especially in a long-term situation the student population may change remarkably: part of the students finishes school each spring and new students start each fall. Therefore, following one consistent group of students throughout the study is difficult. A simple analysis is made by looking at symptoms' prevalence in the school level, but on the other hand, an assumption of the groups of respondents being independent from each other between each time series under consideration may not be theoretically or practically justified. Further on, whether the health effects related to exposure in moisture damaged school are reversible by their nature should be assessed by taking the dependency into account, by following the exposed individuals after the exposure is ceased.

This study used two different approaches: by assessing the occurrence of symptoms among total population it was possible to compare the situation before the repairs with the situations after the repairs in the school level. The number of students in the school remained closely similar through the three years study period, including a decreasing amount of students being those who had been exposed before the repairs. On the other hand, those individuals who responded to the questionnaires both before and after the repairs were followed, and the situations before and after repairs were compared using paired analyses. The effect of the repairs on the health risk was further analyzed by adjusting for confounding factors in a logistic regression model. From the 20 symptoms selected for the analyses, statistically significant change was observed in altogether 18 symptoms using one of these approaches. One year after the repairs, the situation was significantly improved in 11 symptoms among the whole population, and improved in eight symptoms in the paired analysis. Three years after the repairs, the situation was significantly improved in 14 symptoms among the whole population, but no significant change was seen in the paired analysis compared to the situation before the repairs. After adjusting for the confounding factors, the risks remained decreased in 12 symptoms over the whole follow-up period, and a decreasing trend was seen in 9 symptoms among the whole population. Among the 49 students who responded all three questionnaires, the risks were significantly decreased in three symptoms and increased in one symptom, and the trends were decreasing in five symptoms and increasing in four symptoms. In general, the improvement appeared to be strongest in sinusitis and upper respiratory symptoms (e.g. rhinitis), but not so strong in lower respiratory symptoms (e.g. cough and wheezing) in the first follow-up, and general symptoms (e.g. fatigue) in the second follow-up. The decreasing trend was usually seen in sinusitis and cough symptoms.

The logistic regression analyses that were made did not take into account the dependency across the subjects in the repeated observations, although it was partly controlled by confounding factors such as gender, which is constant for an individual. The confidence intervals estimated for the odds ratios may therefore be biased. For more detailed modeling of the longitudinal data in order to establish associations between the health symptoms and the repair situation, Generalized Estimating Equations (GEEs) could be useful (Zeger and Liang, 1986). The fact that a part of the data is systemically missing, due to that only part of the students are present each year, may complicate the use of GEE-models. Whether the pattern of missing data is random, or depends on the previous outcomes at a given time, should be carefully considered.

In practical level among building owners and other groups of interest, there seems to be an increasing need for tools in evaluating repairs and their effects (Haverinen et al. 2000). The use of questionnaires is a relatively cost-effective method in collecting information of occupants' health and

perceived indoor air quality, especially if the study population of interest is large. Therefore, the usability of the method in evaluating repairs needs to be assessed, and the method and the corresponding analytical methods should be further developed. The underlying hypothesis in this study was that repairing the moisture damaged school erases the previous exposure, which should have favorable effects on occupant health. This study brought up a need to establish more detailed hypotheses related to the reversibility of the symptoms in the level of exposed individuals, and the time period during which the effects of the repairs should be seen. For example, if the decrease of the symptoms is seen in the group level only, it may be explained by new, healthy students entering the school after the exposure is ceased. The result is in favor of usefulness of the repair in terms of that new cases of symptomatic students are no longer expected. However, the group of exposed students may need to be considered separately. The question of time period needed for the clearance is also important: how long of a time period is needed to reach the "normal" level in the symptom prevalence; and when does the effect of the repair vanish due to other environmental and individual factors changing over time in the school and among the population.

CONCLUSION AND IMPLICATIONS

Although the overall health status of the students in the school level improved after the repairs, the prevalence of symptoms may have remained same and even increased among those who had been exposed. This indicates that more detailed analyses are needed before the reversibility of the symptoms and the effect of the repairs in the level of exposed individuals can be established.

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REFERENCES

Haverinen U, Husman T, Toivola M, *et al.*1999a. An approach to management of critical indoor air problems in school buildings. *Environmental Health Perspectives*, 107 (3), 509-514.

Haverinen U, Husman T, Wahlman J, *et al.*1999b. A Follow-up of the repairs and health effects in a moisture damaged school center. *Proceedings of the 8th International Conference on Indoor Air Quality and Climate, Edinburgh, Scotland 3-13 August 1999, -Indoor Air '99*, Vol 4, pp 191-197.

Haverinen U, Hyvärinen A, Husman T, *et al.*2000. Preliminary experiences on developing tools for evaluating repairs and their effects in practical situations. *Proceedings of the Healthy Buildings 2000*, August 6-10, Espoo, Finland, Vol 3, pp 427-432 (2000).

Koskinen O, Husman T, Hyvärinen A, *et al.*1995. Respiratory Symptoms and Infections among Children in a Day-Care Center with Mold Problems. Indoor Air 5, 3-9.

Savilahti R, Uitti J, Laippala P, *et al.*2000. Respiratory morbidity among children following renovation of a water-damaged school. *Archives of Environmental Health*, 55(6), 405-410.

Zeger SL, Liang K-Y. 1986. Longitudinal data analysis for discrete and continuous outcomes. *Biometrics* 42, 121-130.