PREVENTIVE MEASURES AND INTERVENTION ON CARPET REMOVAL AND VENTILATION IMPROVEMENT IN ELEVEN SCHOOLS

H M Mathisen, F Frydenlund

SINTEF Energy Research, Trondheim, Norway

ABSTRACT

An intervention study in eleven schools with approximately 1000 children age twelve to thirteen has been carried out in the period 1997 to 1999. Four schools with poor ventilation standard, three schools with carpets and four reference schools participated. In the schools with carpets, these have been removed and in the schools with poor ventilation systems, these have been upgraded to Norwegian standards for new buildings.

A questionnaire was answered three times during a two-week period, asking how indoor environment-related symptoms were perceived.

McNemars statistical analyses show that for some symptoms and environmental factors the interventions have been successful. A multiple linear regression carried out on the survey data from before intervention show that there are only few factors associated with the SBS building symptoms, and the variation in symptoms can not be completely described from measured, observed or perceived variables.

KEYWORDS: SBS, school, remedial measure, carpet, ventilation

INTRODUCTION

The indoor environment has become more focused because the extent of complaints regarding indoor environment in existing schools is large. The health authorities observe an increase in the frequency of asthma and allergy among children [1]. Today we also see an increased focus on costs related to a poor indoor environment due to absenteeism and bad health and wellbeing.

In the city of Trondheim, Norway, in 1996 the municipality decided to renovate a large part of their older schools. This gave the opportunity to evaluate the effect of measures during case studies.

Main objectives of the study:
An exposure and effect study before and after implementation of two preventive measures was carried out. The result was to reveal which measures that give a significant and documented positive indoor climate and health effect.

METHODS

Two different measures were carried out in the schools: Removing carpets and improving ventilation.

Due to practical circumstances, there were restrictions in how an intervention study could be carried out and these can limit the generality of the study:

- A limited number of schools to choose between.
- Construction companies will carry out the measures after an open tender process and we have limited control of the quality of their work.
- More schools in Trondheim are situated in urban areas than the average of Norwegian schools.

Another problem is that additional factors to the planned measures (removing carpets and increasing ventilation) might vary over time, and be different from school to school.

- Differences between schools:
  - Some are of the traditional classroom type while others are open landscapes.
  - The room air volumes are different between old and new buildings.
  - Some have a complete mechanical ventilation system while others only have infiltration or window venting.
- Time dependent changes:
  - Outdoor air temperature and relative humidity.
  - Indoor air temperature and relative humidity.
  - Amount of pollen changes during the year.
  - Amount of air transported dust from road surface changes with the weather.
  - Changes in the teacher staff may influence psychosocial relations.
  - There might be different social background for pupils from different areas of the city.
- Other factors
  - Measures in the pupils' homes can influence on the results.
  - Other measures than agreed can be done in the schools.
  - The study itself might influence the results since it is not possible to arrange it as a blind test.

Table 1 shows schematic how the study was planned. Removal of carpets was done in three of the schools and upgrading of ventilation in four. Two of the reference schools had carpets and two had poor ventilation. The questionnaire survey was repeated in 1999 to counteract that it could not be done as a blind test.

Table 1. Accomplishment of questionnaire for children. The measurements that took place in March after the questionnaire were carried out.

February 1997	Summer/Easter 1997	February 1998	February 1999
Questionnaire	*Measure*	*Questionnaire*	*Questionnaire*
A. Children born in 1984 B. Children born in 1985	Carpets removed summer 1997 Ventilation upgraded March to December 1997	C. Children born in 1985 D. Children born in 1986	E. Children born in 1986 F. Children born in 1987

In all eleven schools, the following elements are included in this paper:

1. Perceived indoor climate based on questionnaires to children twelve and thirteen years old and teachers.
2. Microbiological activity in room air and supply air ventilation duct (if there is one) in some rooms covered by the questionnaire.
3. The dusts ability to induce TNF-production in some rooms covered by the questionnaire
4. Measurement of air quality in some rooms covered by the questionnaire.
5. Evaluation of the indoor environment by architects. Visual observations of the aesthetics and maintenance level in all rooms covered by the questionnaire.

The questionnaires with 48 questions were repeated three times within two weeks in 1997, 1998 and 1999. It was done as a point prevalence study where the person is asked how he/she perceives the situation at the moment, with alternatives yes or no at most of the questions. To get the average it was repeated three times. It was done at the same time in all schools. From the three repetitions the average for each person is calculated, so it could be interpreted as: Yes always, sometimes or never.

The measurements were done after the questionnaire was finished during a three weeks period.

Twelve of the questions were on indoor related problems; Tired, Heavy-headed, Headache, Nausea/Dizziness, Difficulties concentrating, Itching or irritation of the eyes, Hoarse or dry throat, Irritated, Stuffy or runny nose, Cough, Cold, Itching face or hands, Sick or unwell. These questions correspond roughly to the Örebro questionnaire [2], but are adjusted to be suitable for children. Other questions were on perceived thermal, atmospheric, actinic and acoustic environment. There were also some questions related to the home situation like contact with animals and passive smoking.

RESULTS

Due to absenteeism all the children and teachers did not participate in all three repetitions. The data could be treated in two different ways. The first way is to delete the children that only participated one time. The other way is to keep all the children in the analysis. A comparative analysis between the two ways of treating the data was performed and shows that there are only insignificant differences between the two methods. In the further analysis, children and teachers that answered only one time to the questionnaire are also included.

From the twelve questions of SBS related symptoms a factor BSI (Building symptom index) [3] is calculated by counting the number of symptoms for each person. Only answers "yes, always" are counted. "Yes, always" are calculated from the three times the questionnaire was used during the two-week period. Table 2 shows the average number of symptoms for each person in the different schools.

Regression analysis was performed to investigate whether the BSI could be explained form environmental factors. In Table 3 a regression model for the dependent variable BSI based on strictly informative questions from questionnaire, observations and measurements done in all rooms are shown. One unexpected result is that the older the building the fewer are the complaints. From R^2 it can be seen that the model can explain only a small amount of the variation in BSI.

Table 2. Average number of symptoms (BSI) for each person in the different schools for the three years. n = number of children participating at each school.

	Reference schools				**"Carpet" schools**			**"Ventilation" schools**			
	7	3	6	2	1	5	11	4	8	9	10
1997	1.39	1.76	1.38	1.30	1.97	2.45	1.68	2.27	1.97	1.23	1.83
n	93	107	64	138	96	51	114	30	158	125	121
1998	1.20	1.73	1.69	1.28	1.45	1.71	1.35	2.00	2.02	1.48	1.31
n	87	115	65	61	92	49	71	25	173	90	143
1999	1.34	1.28	1.37	1.81	1.01	1.46	1.49	1.52	1.11	.95	1.36
n	82	95	71	105	80	41	68	25	176	92	130

Table 3. Linear regression on strictly informative questions form questionnaire, observed or measured variables, R^2=0.1

	Unstandardized Coefficients	95% Confidence Interval	
Constant	5.58	3.81	7.35
Volume per person (m^3/person)	-0.12	-0.19	-0.04
Building age (Years)	-0.08	-0.11	-0.06
Open window during night in sleeping room at home (1= yes, 2=no) [a]	0.85	0.34	1.37
Spacious or narrow classroom (1=spacious to 5=narrow) [b]	0.34	0.16	0.51
Ventilation (1=no ventilation to 5= good vent)	-0.79	-1.23	-0.36
Outdoor in break before answering? (1= yes, 2=no)	0.58	0.15	1.02
Sitting at window's row? (1= yes, 2=no) [a]	-0.39	-0.75	-0.03

[a] from children's questionnaire, [b] from architect's evaluation of the school

Variables not associated with BSI are: In the classroom all day? [a] Sitting in the back of the room? [a] Have you eaten today? [a] Share sleeping room? [a] Carpet in sleeping room? [a] Passive smoking at home? [a] Animals at home? [a] Time of day? Number of pupils? Absent pupils? Venting before lesson? Number of minutes since break? Bright or gloomy? [b] Room in good shape or worn? [b] Cultured or casual? [b] Friendly or unattractive? [b] Type of flooring? Landscape or classroom? CO_2 concentration, microbiological activity and TNF.

Table 4 shows a model for BSI based on the children's perceived indoor climate. An interesting observation is that the question "Do you feel happy at school?" is associated with BSI.

Table 4. Alternative linear regression model with "subjective" variables where the children describe the indoor climate in the questionnaire, R^2=0.35

	Unstandardized coefficients	95% Confidence Interval	
Constant	10.50	8.99	12.01
Stuffy air? (1= yes, 2=no)	-1.27	-1.65	-0.89
Draft? (1= yes, 2=no)	-1.32	-1.70	-0.93
Feel happy at school? (1= yes, 2= occasionally 3=no)	0.54	0.31	0.78
Difficult to read from blackboard? (1= yes, 2=no)	-0.83	-1.32	-0.34
Dry air? (1= yes, 2=no)	-0.77	-1.15	-0.39
Noise from pupils? (1= yes, 2=no)	-0.50	-0.83	-0.18
Varying room temperature? (1= yes, 2=no)	-0.45	-0.85	-0.05
Noise from other rooms? (1= yes, 2=no)	-0.39	-0.70	-0.07
Good lighting? (1= yes, 2=no)	0.49	0.08	0.90

Variables not associated with BSI are: Room temperature to high, Heat from oven, Heat from sun, Room temp to low, Bad air, Difficult to hair, Noise from outdoor, Noise from building, Reflection in the blackboard, Unpleasant light from sun, Shocks from static electricity, Clean enough.

Every child's answer in 1997 and 1998 are compared to investigate whether the children-experienced symptoms changed as a result of the intervention. To do this a McNemars test is used. Children marked B. and C. in Table 1 could then be used. "Yes, always" and "Yes, often" have been coded as "Yes" while other answers are coded as "No".

Table 5 shows that carpet removal gave a significant reduction and tendency to reduction for some symptoms. There was also a tendency to more children with a cold in 1998.

The same test was used to study the change from 1998 to 1999. Only the children marked D. and E. in Table 1 were used. No measures were carried out at the schools in this period. Table 5 shows that there were significantly fewer symptoms and tendencies to improvements at schools were the ventilation had been increased.

Table 5. Effect of measures. Paired comparison of children by McNemar test. Signs used in the table: + means significant reduction in number of symptoms (5% level, double sided), - means significant increase, (+) and (-) means a clear tendency (25% level).

		1997 compared to 1998			1998 compared to 1999	
		Ref.	Carpet	Vent	Carpet	Vent
9	Are you tired?					
10	Do you feel heavy-headed?	(-)				
11	Do you have headache?			(-)		
12	Do you feel dizzy?			(+)		
13	Do you have problems concentrating?		+			(+)
14	Do you feel itching or irritation of the eyes?		(+)			(+)
15	Do you have hoarse or dry throat?				(-)	+
16	Do you have stuffy or runny nose?					
17	Do you cough?					+
18	Do you have a cold?	(-)	(+)		(-)	
19	Do you have itching face or hands?					
20	Do you feel sick or unwell?		+			+
	n	160	100	101	62	158

DISCUSSION

The number of persons with symptoms in the different schools seems to be in accordance with for instance what is found for offices [3].

The regression model showed only a weak correlation between environmental variables and the Building Symptoms Index. This indicates that there is an unknown factor that is different between the schools which influences the BSI. Some of these might be connected to prosperity and psychosocial relations.

The McNemar test showed that some symptoms were significantly reduced in size comparing before and after the intervention. Opposed to the regression model, the McNemar model studies the effect of the changes that have been carried out within each school (or strictly each child). Unknown differences between schools then have no influence.

The reason why the McNemar test gives results for the ventilation intervention from 1998 to 1999 is probably that the construction work was delayed. At the time the questionnaire was carried out in 1998, the work had just been finished and all technical adjustments were not completed. Disturbance from the construction work might have had a negative impact on the way the questionnaire has been answered (or it might have had a negative impact on the children's health).

It is also an important part of the results that the effect of the carpet intervention remains during the consecutive year.

The conclusion must be that increasing the ventilation and removing carpets reduced the number of health related symptoms, but unknown factors have a significant influence on the number of symptoms in each school.

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