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Allergic and Non-allergic Students' Perception of the Same High School Environment

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Abstract The aim of the study was to describe how allergics and non-allergics perceive the same environment. All high school students in a town in southern Sweden were invited to answer a questionnaire concerning allergy, subjective symptoms, annoyance reactions and perception of the environment (response rate: 81%). The results show that only 45% of the students were non-allergic (n=1,715). Since the symptom frequency among non-allergic students was normal, the schools were classified as healthy. However, compared to the non-allergic students, a higher percentage among the allergics suffered from symptoms every week, a lower percentage was satisfied with the air quality and the cleaning, and a higher percentage was bothered every week by temperature, stuffy/stale air, bad odor, passive smoke, bad lighting, noise, dust and dirt (ANOVA, $P<0.05$). The findings could indicate that allergics note discomfort earlier than non-allergics by being more critical in general and especially critical to factors that could effect their health. The findings could also indicate that awareness of ones own sensitivity could lead to attention to different risk factors, which in turn could lead to stress/anxiety, which could make symptoms worse. The conclusion is that it is important to take allergy into consideration when the environment is assessed.

Key words Allergy; Sick Building Syndrome; School environments; Reporting behavior; Indoor air quality; Environmental psychology

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Introduction

Fifty years ago, the aggravation of chronic bronchitis/emphysema was dramatically illustrated by two smog disasters. In October 1948, a thermal inversion occurred in Donora and the usual smog persisted for three days instead of lifting at noon as usual. By the third day of constant smog, 5,910 persons were reported ill. Then a heavy rain fell, the smog disappeared, and the outbreak of disease stopped immediately. Before the episode, the residents of Donora appeared to have the same health status as people in the rest of the US, but during the nine years that followed the smog, the group who had become ill and recovered showed higher mortality and illness compared to the group unaffected by the smog. This is also true for residents who had no history of heart disease prior to the 1948 episode. During the 1952 smog episode in London, there was also an "excess" mortality of 4,000–5,000 persons, and, as in Donora, the deaths occurred almost exclusively among people with previous broncho-pulmonary disease. The veteran patients in the London clinics almost served as the canaries that miners long ago carried to detect noxious gases – they noted discomfort 6–12 h before it was evident to others that a smog episode was at hand. In both the Donora and London disasters, it was not possible to explain the human reactions by unusually high concentrations of single air quality components (For more information see, for example, Dubos, 1965). However, the findings suggest that the same pollution breathed one or two days at a time without effects could become highly injurious when it is breathed for a few days longer, and that contaminated air actually could initiate disease in man.

Despite the dramatic effects of these episodes, there are some similarities with a relatively new indoor air quality phenomenon (Sick Building Syndrome, SBS): Buildings are characterized by adverse health reactions among the occupants concerning repeated complaints on bad indoor air quality, but no single factor is, according to technical criteria, clearly responsible for these reactions.

The construct SBS has been used since the middle of

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the 1970s to describe a collection of symptoms with unknown origin, reported primarily from occupants of public buildings. The following definition is used by the European Community: A sick building is characterized by a heightened frequency of complaints on deteriorated air quality and subtle medical problems. The indications of this syndrome are varied, but five symptom complexes are regularly encountered: Manifestations in the eyes, nose, throat, and skin, and general manifestations (headache and generalized lethargy and tiredness leading to poor concentration). The characteristic periodicity is that they increase in severity over the working shift and resolve rapidly on leaving the building in the evening. With the exception of some cutaneous symptoms, most manifestations therefore improve over weekends and all symptoms usually disappear on extended leave (Molina et al., 1989). It is emphasized, that the syndrome can only be diagnosed after eliminating other causes of building related illness (e.g., asthma, hypersensitivity, allergic rhinitis).

The World Health Organization and the Swedish Allergy Commission reported a decade ago that up to 30% of the newly built or renovated buildings have these indoor air quality problems (Socialdepartementet, 1989; World Health Organization, 1986). SBS is an issue of growing public concern, and researchers from different disciplines have begun the complex job of sorting out possible causes and proposing solutions. Building site, local climate, the building process, building design and technology, building materials, ventilation, single physical, chemical and biological factors are examples of areas that could explain the syndrome (e.g., Baird et al., 1991; Fanger, 1998; Maroni and Lundgren, 1998; Morey, 1996; Mølhave, 1998; Reijula, 1998; Seppänen, 1996). Inherited or acquired constitutional determinants such as age, gender, past and present health status, as well as individual mental states and psychosocial processes might also explain the syndrome (e.g. Bullinger et al., 1996; Fink, 1998; Jaakkola, 1998; Lahtinen et al., 1998; Smedje et al., 1996).

Stress, Health, Sensitivity and Sick Buildings

There are many studies, which show that human health and single SBS symptoms are affected by *physical stress* (e.g., temperature, humidity, ventilation, molds), and there are also indications that *psychosocial stress* is associated with symptoms. Now, there is an urgent need for knowledge on how these factors interact and how constitutional factors (e.g., inherited or acquired sensitivity) affect SBS reports. The results from a contemporary study suggest that sensitivity, evaluation of the indoor air quality, evaluation of the physical environment and evaluation of the study situation co-vary, and that combination stress (bad physical environment and bad study situation reported from the same student) could be a determining factor for symptom frequency. However, the same results could also indicate that sensitive students have a more negative attitude to the school compared to non-sensitive students (Lundin, 1999a).

Lahtinen et al. (1998) argue that a process orientation is needed to understand SBS. Psychosocial factors modify the reactions to physical imperfections in the work environment. This means, for example, that unsolved environmental problems can be a stressor *per se* which give rise to various fears, which in turn could increase the symptoms. Furthermore, ineffective communication patterns could lead to difficulties in handling environmental problems which in turn lead to stress and so on. On the other hand, Hedge and co-workers point out that it is unlikely that some typical SBS symptoms (e.g., eye, nose and throat irritation) could be a direct results of job stress or job dissatisfaction (Hedge et al., 1992 as referred to by Lahtinen et al., 1998). Ten years ago, Whorton and co-workers (1987) noted that considerable caution must be exercised when interpreting subjective data such as symptoms: "This is not to say that symptoms are imagined or contrived. However, when a population is made aware of a problem, it is possible that this awareness increases the willingness of employees to report symptoms". Hedge et al. (1987) support this view by describing how poor design and leading questions may have increased the tendency to be attentive to symptoms. It is well known that the mechanisms behind mass psychogenic illness are normally always present in groups of humans, and can coincide with other environmental factors, but it should be emphasized that SBS and mass psychogenic illness are two different phenomena (e.g., Colligan et al., 1982; Finnegan and Pickering, 1986; Lahtinen et al., 1998; Singer, 1982).

However, environmental awareness as a result of sensitivity, attitudes, norms or culture might affect judgments of air quality and indoor environments. When 122 unemployed Swedish subjects and 130 students from Sweden, and a control group of 38 students from the US, reported how they imagined eleven locations with different function, it was found that allergic subjects expected themselves to be less satisfied with the air quality than non-allergic subjects. There were also indications that gender, age, smoking habits, work situation, visiting frequency and culture did not affect the air quality images, but the American students were less negative with reference to general impression of the environment (Lundin, 1999b).

Hence, sensitivity appears to be a factor that should be taken into account when the environment is assessed. In a recent study, relations among health, comfort and different physical stressors were reported as well as relations among SBS symptoms, perceived air quality, asthma and airway infections (Norbäck and Smedje, 1996). The Office Environment model (Jaakkola, 1998) suggests that "the physical environment causes physical and psychological effects via physiological and/or psychological processes. The social environment causes physical and psychological effects via psychological processes. The physical and social environment may have synergistic effects, and constitutional factors, such as gender and atopy are additional determinants of the outcomes, as well as possible modifiers of the relations between environment and health". Jaakkola argues that it is necessary to focus separately on different determinant-outcome relations to understand the health effects of the environment.

One of the constitutional factors, allergy, is classified both as an immunological related and psychosomatic disease (Krantz et al., 1982). In addition to the inherited factor, a combined action of many different interacting environmental factors are involved (e.g., Fischer et al., 1998). Some researchers argue that a combination of allergens – which always surrounded humans – and "modern" pollutants contributes to the considerable increase in allergy and hypersensitivity during recent decades (e.g., Bakke, 1995). There are three distinct main groups of hypersensitivity, each of them consisting of different subgroups and combinations of mechanisms that may give *similar reactions/symptoms:* (1) Allergy is a specific immunological hypersensitivity representing an altered function in the organism's immunological defense mechanisms; (2) specific chemical sensitivity is connected to altered function of the organism's enzymes and/or metabolisms; and (3) unspecific hyperresponsiveness is connected to altered function in cells and organs with too strong reactions to different kinds of stimuli/irritants (Bakke et al., 1993).

Sick Students or Sick Schools?

In summary, the phenomenon SBS appears to have a multifactorial etiology in which chemical, physical, biological, physiological, social, psychological and personal factors interact. Building dysfunction or other technical/practical problems can make some buildings sick (e.g., Lahtinen et al., 1998). In Sweden, there are a total of 21,500 schools and day-care centers. Many of them show deficiencies in maintenance, cleaning and ventilation. The latter fact was pointed out in 1995, when the obligatory control of building ventilation in Sweden was followed up. As many as 931 schools or day-care centers (4%) were still not controlled and with reference to the buildings that were controlled and did not pass in 1993, the steps taken to improve the ventilation were not good enough for 24% two years later (Boverket, 1997).

So far, it has not been possible to point out or measure one single factor that could be responsible for all sick buildings. Despite this fact, the body of knowledge about risk factors is large enough to provide a good basis for united efforts from the technical and health related disciplines to help humans to live and work in healthy environments (e.g., Maroni, 1995). There are three general principles concerning the mismatch between the environment (the school) and the humans using the building: (a) adjust the students to the environment, i.e., medical solutions or treatment of the occupants; (b) adjust the environment to the students, i.e., technical/organizational/psychosocial modifications of the environment; and (c) separate effected students from the environment, that might be an economical/political/ethical question.

But how should we assess the environment? ASHRAE (1989) suggests that 80% of the occupants should not be dissatisfied with the air quality in the building. The European concerted action Indoor Air Quality and its Impact on Man recommend that SBS should be diagnosed after eliminating "other causes of building related illness, e.g., allergy (Molina et al., 1989), while the Swedish Institute of Public Health emphasizes that the reactions from sensitive humans' should become the standard for assessing healthy buildings (Säfvenstrand-Rådö, 1995). Bakke (1995) argues, in the same line of thinking, that the attention will be moved away from the real problem – a deteriorated environment – if allergy medicines are used to keep humans in unhealthy environments. The question is: Do sensitive humans react like the veteran patients in the London clinics during the smog episode fifty years ago, i.e., do they notice deterioration of the air quality earlier than others?

Aims

The study is part of a project which aimed to stop the increase in allergy among children and adolescents in a town with 60,000 inhabitants in south-eastern Sweden. It was carried out as a basis for further work. The purpose was to map the allergy prevalence among the high school students and to describe their work environment. This report focus on possible differences between allergic and non-allergic students' perception

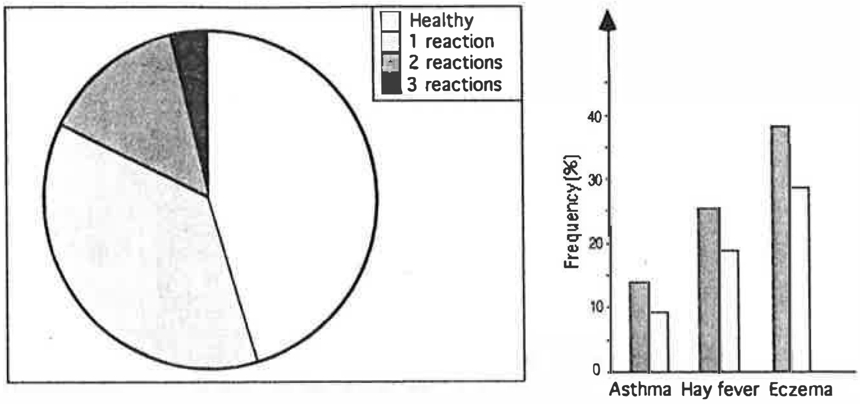


Fig. 1. Frequency (%) of asthma, hay fever and eczema (right diagram), and frequency of students reporting 0–3 allergic reactions (left diagram). Gray bars in the right diagram mark the frequency among the high school students and white bars mark "normal" prevalences in Sweden (Säfvenstrand-Rådö, 1995)

of the same environment. No school was previously classified as sick.

Methods

The whole body of students at the five high schools in the town (n=2,113) were invited to take part in the investigation. The response rate was 81% (n=1,715). Each subject answered a questionnaire which is frequently used in the area of work environment and/or "sick buildings" (Andersson, 1998). The questions concern 13 subjective symptoms and possible annoyance reactions from 12 specific physical factors (response categories: often/weekly, sometimes, never). The subjects were also asked if they ever had asthma, hay fever and eczema (response categories: yes/no). Additions were made inspired by a questionnaire used in a neighboring town (Karlsson, 1996). Only one question is discussed here: General impression of the school environment in terms of (a) indoor air quality, (b) sound level and (c) cleaning (response categories: good, acceptable, bad). The questionnaire was filled in during class in November 1996.

All questions were analyzed with the help of descriptive and comparative standard statistics: Pearson correlation, χ^2-test, one-way ANOVA, Fisher PLSD ($P<0.05$). Data were analyzed in several steps: the answers from the entire group were compared to reference data, the answers from different schools were compared, and the answers from allergic and non-allergic students were compared.

Reference data with respect to frequency of weekly symptoms and frequency of annoyance reactions for schools without indoor climate problems were given in the questionnaire manual (580 pupils) and the frequencies of eczema, hay fever and asthma among Swedish pupils were given by the Swedish Institute of Public Health (Säfvenstrand-Rådö, 1995).

The American Society of Heating, Refrigerating and Air-Conditioning Engineers has developed a standard that for a long time has guided engineers over the whole world (ASHRAE, 1989). The recommendation for good indoor air climate was used here, i.e., ≥20% of the occupants should not make complaints.

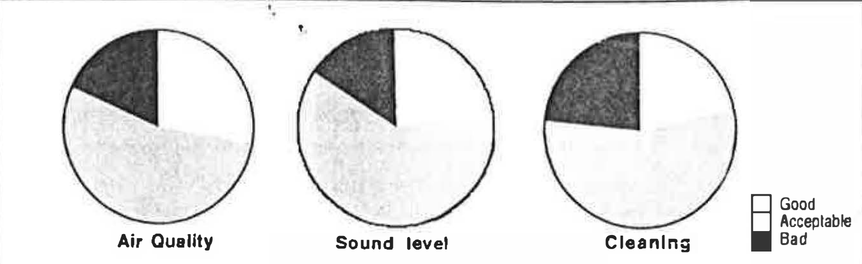
Results

The allergy frequencies are elevated compared to the frequencies reported from the Swedish Institute of Public Health (Fig. 1). Furthermore, only 770 out of the 1,715 students answering the questionnaire (45%) reported that they are healthy: 37% have or had asthma or hay fever or eczema (one reaction), 14% have or had two reactions and 4% have or had asthma, hay fever *and* eczema. There were no differences between the five schools with respect to the number of reactions ($P>0.05$).

The distribution of allergics studying in different schools is shown in Table 1. There were *no* differences concerning asthma and eczema ($P>0.05$), but School no. 3 and School no. 5 differed significantly with respect to hay fever (19.8 and 30%, respectively). The frequency of hay fever in School no. 3 was comparable

Table 1 Frequency of eczema, asthma and hay fever

	Eczema			Asthma			Hay fever		
School	n	Yes	%	n	Yes	%	n	Yes	%
1	268	89	33	266	43	15	265	67	25
2	403	159	40	404	47	12	403	110	27
3	262	98	37	263	36	14	263	52	20
4	356	139	39	360	59	16	357	79	22
5	379	162	41	393	46	12	393	118	30
Σ	1668	647	38	1686	231	14	1681	426	25



School Code.	Air Quality All	Air Quality Bad	Air Quality Bad (%)	Sound level All	Sound level Bad	Sound level Bad (%)	Cleaning All	Cleaning Bad	Cleaning Bad (%)	Mean Bad (%)
1	263	75	28.5	262	61	23.3	262	100	38.2	30.0
2	391	42	10.7	394	65	16.5	394	88	22.3	16.5
3	262	25	9.5	262	23	8.8	260	29	11.2	9.8
4	353	62	17.6	356	36	10.1	353	63	17.8	15.1
5	398	100	25.1	399	78	19.5	396	105	26.5	23.7
Σ	1667	304	18.2	1673	263	15.7	1665	385	23.1	18.7

Fig. 2. General impression of the school environment (charts), and general impression of single schools (table)

with the frequency reported from the Swedish Institute of Public Health.

Life style, family and living circumstances among allergic and non-allergic students

Similarities and differences among allergic and non-allergic students were studied with the help of ANOVA ($P<0.05$). The results show that a significantly higher percentage allergics were female (56% compared to 40%) and a higher percentage had allergic parents (father: 27 vs. 15%; mother: 29 vs. 16%). The two groups did not differ in age (13–18, mean 15) or with respect to smoking and snuffing habits (10 rep. 5%). A higher percentage allergics lived in single-family houses (88% compared to 80%, $P<0.05$), but there were no other differences with respect to the other building related factors studied: 64% lived in homes heated by electricity, 45% in homes renovated during the last decade, 27% in homes built before 1960, 33% in homes with wall-to-wall-carpets and 6% lived in homes infected by molds or with water damage. There were no differences between the two groups in terms of furred animals or passive smoking at home: 71% had pets and 43% of the students live in homes where somebody else smokes.

Perception of the School Environment

One purpose was to describe how the students perceive their work environment, and to study possible differences in how allergics and non allergic students perceive the same environments (i.e., schools). The response rates from the five schools varied but were reasonably high (no. 2=91%, no. 4=85%, no. 5=80%, no. 1=76%, no. 3=71%).

The majority of the students reported that they mostly feel happy/comfortable at school (often=58%, sometimes=39%, never=3%). The highest percentage of comfort was reported from School no. 3 ($P<0.05$), but there were no differences between the schools in terms of that part of students who never feel comfortable at school.

General impression of the school environment

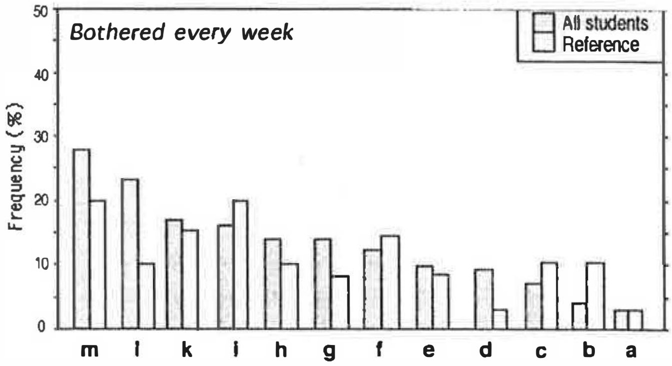
More than 75% of all students reported that the air quality, the sound level and the cleaning of the school was good or acceptable. The sound level was perceived to be the best, followed by air quality and cleaning, but there were significant differences between the five school concerning percentage of students marking bad environment. Hence, the students from School no. 1 and School no. 5 were significantly more dissatisfied compared to the students from School no. 3 (Fig. 2: $P<0.05$ for each single variable).

Inconvenience from specific physical factors

A higher percentage of the students were bothered every week by stuffy/stale air and dirt/dust compared to the reference group (Fig. 3). A moderately high percentage (10–20%) were also bothered every week by low or varying room temperature, dry air, passive smoke, noise and odor, but there were significant differences among the schools.

In order to briefly describe each school, an environmental index was calculated in the following way: (a) all schools were rank ordered with reference to each single physical factor; (b) the number of good judgments (left column in Fig. 3) and the number of bad judgments (right column in Fig. 3) were summarized for each school; (c) the number of good judgments minus the number of bad judgments was calculated for

Fig. 3. Percentage of students bothered every week by different physical factors (bar charts) and summary of the responses on the questionnaire (table). Gray bars mark responses from the studied population and white bars mark responses among the reference group (Andersson, 1998)



Perception of the school environment

	Mean %	Most positive < School	%	School	%	School	%	School	%	> Least positive School	%
Often comfortable	58	No. 3	76	No. 4	60	No. 1	58	No. 2	54	No. 5	50
General impression											
Bad sound level	16	No. 3	9	No. 4	10	No. 2	17	No. 5	20	No. 1	23
Bad air quality	18	No. 3	10	No. 2	11	No. 4	18	No. 5	25	No. 1	29
Bad cleaning	23	No. 3	11	No. 4	18	No. 2	22	No. 5	27	No. 1	38
Bothered every week by:											
a Static electricity	3	No. 1	1	No. 3	3	No. 5	3	No. 2	4	No. 4	5
b Draft	4	No. 5	2	No. 4	3	No. 1	4	No. 2	6	No. 3	6
c Bad lightning	7	No. 1	6	No. 3	7	No. 4	7	No. 2	8	No. 5	8
d High temperature	9	No. 2	5	No. 3	6	No. 4	11	No. 5	12	No. 1	13
e Bad odor	10	No. 2	5	No. 1	8	No. 3	11	No. 5	13	No. 4	14
f Noise	12	No. 3	8	No. 4	9	No. 2	12	No. 1	16	No. 5	17
g Smoke from others	14	No. 4	11	No. 1	12	No. 3	14	No. 2	15	No. 5	17
h Dry air	14	No. 2	7	No. 3	8	No. 1	16	No. 1	16	No. 5	21
i Varying temperature	16	No. 5	13	No. 3	14	No. 1	16	No. 3	18	No. 2	20
k Low temperature	17	No. 1	11	No. 4	12	No. 5	12	No. 3	23	No. 2	27
l Dirt and dust	23	N0. 2	15	No. 3	16	No. 5	23	No. 1	31	No. 5	32
m Stuffy/stale air	28	No. 2	12	No. 3	15	No. 4	33	No. 5	38	No. 1	42

each school. This results showed that two schools (no. 3 and no. 2) are described by a positive environmental index (+4 and +3, respectively), while the others are described by negative environmental index (no. 4=−1, no. 1=−2 and no. 5=−4). This means that the physical environment in School no. 3 appears to be better than the physical environment in School no. 5 (for details, see Lundin, 1997).

Bothered by symptoms during school time

The European Community suggests that the classification of sick or healthy buildings should be based on the symptom frequency among non-allergic occupants. Analyses of symptom reports from the non-allergic students showed no significant differences between the schools for any of the single symptoms (response alternative often: $P>0.05$). The symptom frequencies among non-allergics were not elevated compared to the reference group (Fig. 4).

With reference to symptoms, reported from all students, there were small, but significant, differences between the schools concerning two single symptoms ($P<0.05$). The frequency of eye irritation was lower in School no. 3 compared to no. 1 and 2, and the lowest frequency of cough was also reported from this school (highest in School no. 5).

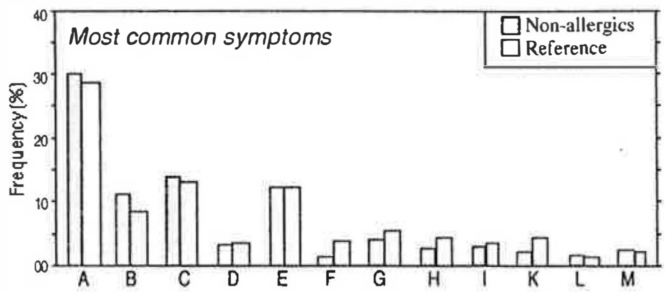


Fig. 4. Part of the non-allergic students (%) bothered by symptoms (often during school time): A=Fatigue, B=Heavy head, C=Headache, D=Dizzy, E=Concentration problems, F=Eye irritation, G=Nose irritation, H=Throat irritation, I=Dry skin in face, K=Irritated scalp/ears, L=Dry skin on hands, M=Other symptoms. Gray bars mark responses from the studied population and white bars mark symptom frequencies among the reference group (Andersson et al., 1988)

Sensitive and Non-sensitive Students' Perception of Specific School Environments

So far, the findings indicate that the schools are healthy, that School no. 3 has a better physical environment than School no. 5. Since these schools also differed significantly in frequency of hay fever (and cough) they were selected for further analyses (ANOVA: $P<0.05$). The results showed that significantly more students felt comfortable in School no. 3 (76% vs. 50%, $P=0.001$), and that these schools also differed with respect to general impression of the school environment, i.e. percentage of students reporting that the air quality, the sound level and the cleaning was bad (Fig. 5: $P<0.05$ for each single variable). There were no differences in terms of the percentage of students believing that the environment affects their intellectual performance.

Annoyance reactions

Inconvenience or annoyance was also studied, i.e. frequency of students bothered every week by specific physical factors. To summarize, the results indicated that the ventilation systems and/or maintenance of the systems differ: significantly more students in School no. 3 were annoyed every week by low temperature and draft (Fig. 5: $P=0.000$ and 0.007 respectively) while more students in School no. 5 were annoyed by dry air, stuffy/stale air and high temperature (Fig. 5: $P=0.000$, $P=0.000$, $P=0.013$). In addition, a higher percentage of the students in School no. 5 were annoyed by noise ($P=0.001$) and dust/dirt ($P=0.000$). With respect to the highest acceptable dissatisfaction level recommended by ASHRAE, there were three air quality factors above the 20%-level in School no. 5 and only one in School no. 3.

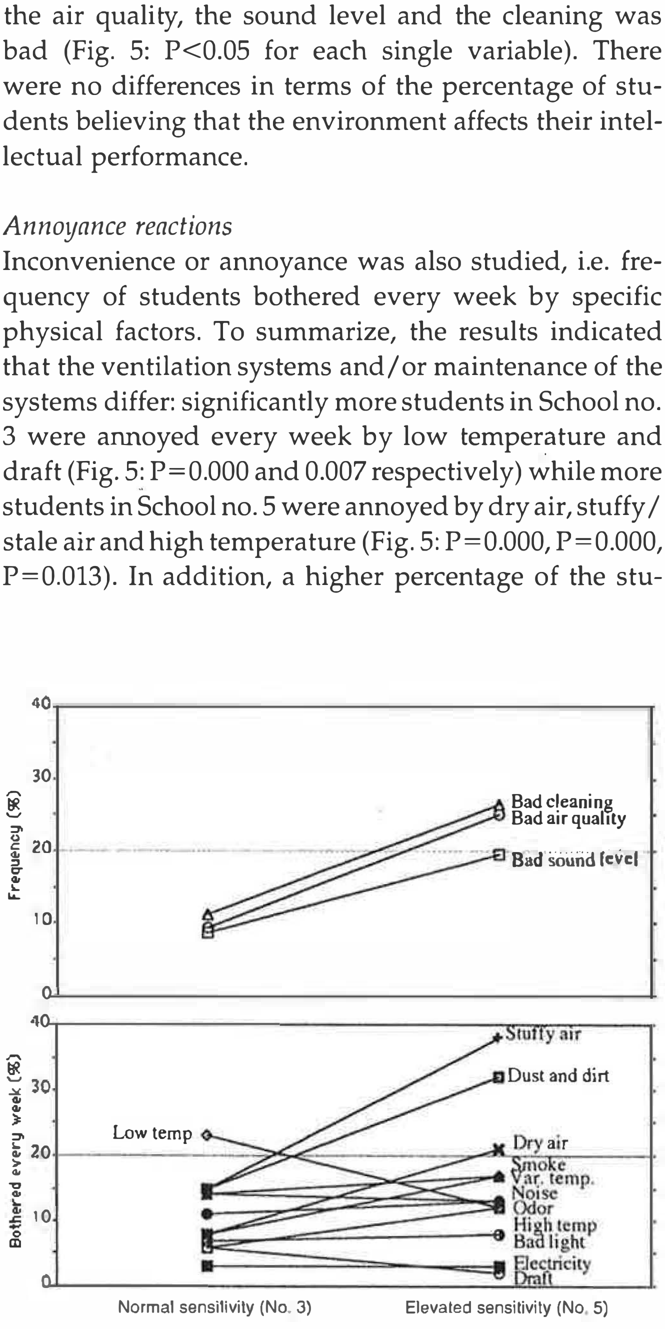


Fig. 5. General impression of the environment (upper panels) and annoyance (lower panels) in one school with "normal" frequencies of hay fever (left) and in one school with elevated frequencies (right)

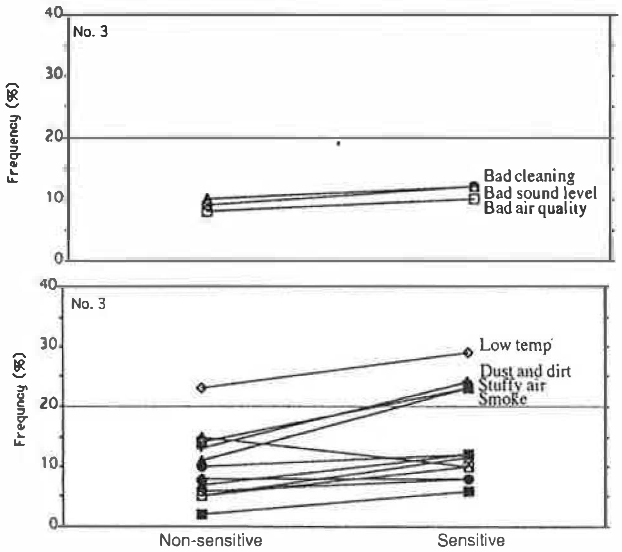


Fig. 6. Allergic and non-allergic students' perception of a relatively good environment with "normal" frequencies of hay fever

Comparisons between how subjects with and without hay fever perceived the same environments show that they do *not* reach ASHRAE's upper dissatisfaction level, and they did not differ when they judged the general impression of a school that appeared to have a good environment (no. 3). Concerning a bad environment (School no. 5) there was a different trend: the 20% dissatisfaction level was exceeded for cleaning and air quality (both groups). Allergic students also exceeded the dissatisfaction level for general impression of noise, but this was not true for the non-allergics (Fig. 6 and 7).

Looking at specific physical factors, both groups in the good environment (no. 3) exceeded the upper dissatisfaction level for low temperature, and allergics also exceeded the 20% level for three factors related to air quality (dust/dirt, stuffy/stale air and passive smoke). In the bad environment (no. 5), both groups exceeded the 20%-level for stuffy/stale air, dust/dirt and dry air.

Even if the trend that students with hay fever appeared to be more critical in general and/or especially critical to some air quality variables was obvious, most differences were not statistically significant ($P>0.05$).

Similarities and Differences between Reports from All Allergic and Non-allergic Students

In order to control for possible differences in attitudes and/or reporting behavior, further analyses were done

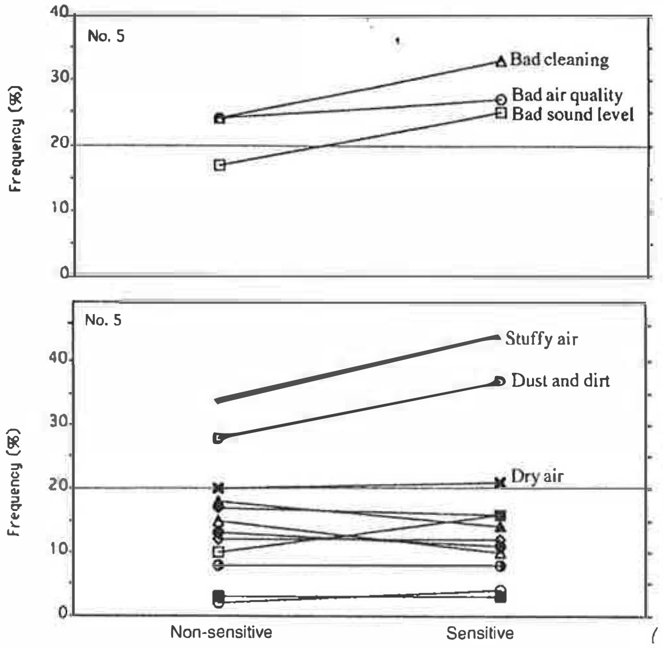


Fig. 7. Allergic and non-allergic students' perception of a relatively bad environment with elevated frequencies of hay fever

on the basis of all allergic and all non-allergic students (i.e. all schools). Allergics were here defined as students reporting asthma or eczema or hay fever or combinations. The results showed that allergics and non-allergics differ in terms of percentage feeling comfortable at school. Concerning possible beliefs that the indoor environment affects their performance there were no differences ($P>0.05$). Earlier indications that allergic students have a different attitude to the environment was confirmed (Fig. 8).

Allergics are more critical to specific factors that could affect their health: general impression of environment in terms of bad cleaning and bad air quality differ ($P<0.05$), but there were no differences between allergics and non-allergics in terms of tolerance for noise, i.e. bad sound level. A higher percentage of the allergics were bothered every week by single physical factors, and a higher percentage reported that they suffered from symptoms every week.

Allergics and non-allergics displayed the same annoyance pattern and the same symptom pattern, but the frequencies were higher among the allergic students (Fig. 9: $R^2=0.94$ and $R^2=0.98$, $P<0.05$). This means that earlier indications that allergics are more critical in general was confirmed. It was also shown that more subjects from the allergic group report symptoms, i.e. they are more sensitive to the environment. Hence, allergic and non-allergic students differed significantly with respect to all single symptoms except for "bothered every week by dry skin on hands" and almost all single physical factors (ANOVA: $P<0.05$): stuffy/stale air (31 vs. 23%), dust/dirt (27 vs. 18%), varying room temperature (18 vs. 14%), passive smoke (17 vs. 11%), noise (14 vs. 10%), high room temperature (11 vs. 7%), bad odor (12 vs. 7%), and lighting (9 vs. 5%).

Looking at the upper level for dissatisfaction recommended by ASHRAE (1989), the percentages reported from both groups concerning general impression of the air quality as well as stuffy/stale air were too high. Only the allergic group exceeded the upper dissatisfaction level (20%) with reference to general impression of the cleaning of the schools and the single factor "dust and dirt".

Discussion

One main result of the study is that the allergic students appears to react like the veteran patients in the London clinics during the smog episode five decades ago: They report deteriorated air quality and symptoms more often than others.

The allergy prevalence was higher than expected: only 45% reported that they are healthy. This means that the majority of the high school students (55%) in this town have or had some form of allergy: 37% asthma or

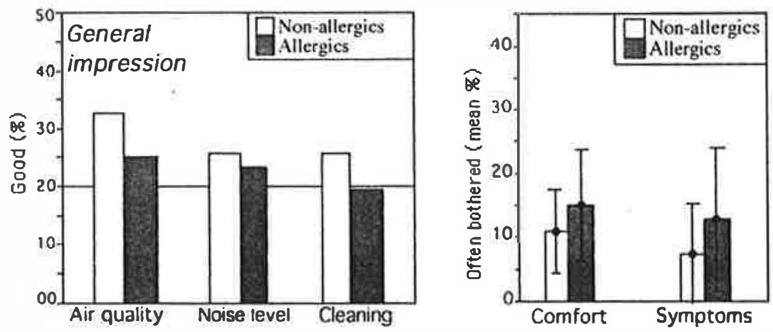


Fig. 8. Allergic and non-allergic students' attitude to the environment in general (left diagram) and reported mean inconvenience (right diagram)

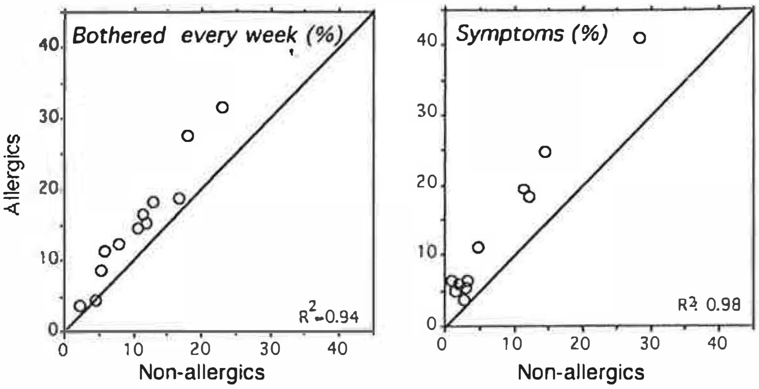


Fig. 9. Relations among annoyance patterns and symptom patterns reported from all allergic and non-allergic students

hay fever or eczema (one reaction), 14% suffer from two reactions and 4% report asthma and hay fever and eczema. The elevated frequency could not be explained by the life-style or family-related or living-related factors studied, and there are no indications that the schools should be classified as "Sick Buildings".

Two schools which differed significantly in frequency of hay fever were selected for further comparisons. There were indications that one of them had a better physical environment compared to the other. The question was: do subjects with and without hay fever judge the same environment in a similar way? Comparisons with the upper dissatisfaction level recommended by ASHRAE show that *all students in the "bad environment"* were dissatisfied with the air quality and the cleaning, and often bothered by dry air, stuffy/stale air and dust/dirt, while *all students in the "good environment"* (where fewer reported hay fever) were satisfied with the air quality and cleaning, but often bothered by low temperature. The results also show that *allergic students in the good environment* were often bothered by three specific factors which all are related to air quality: dust/dirt, stuffy/stale air and passive smoke. Two of these are the same factors as those pointed out in the bad environment. The findings could indicate that allergic occupants note discomfort earlier than others by being more critical to the environment in general and/or more critical to specific factors that could effect their health. The findings could also indicate that a consciousness about own sensitivity could lead to higher attention to different risk factors, which in turn could lead to stress/anxiety, which in turn could lead to higher sensitivity and/or more symptoms (e.g., Lahtinen, et al., 1998).

The office environment model (Jaakkola, 1998) suggests that the physical and social environment may have synergistic effects, and that constitutional factors, such as gender and atopy, are additional determinants of the outcomes, as well as possible modifiers of the relations between environment and health. Jaakkola argues that it is necessary to focus separately on different determinant-outcome relations to understand the health effects of the environment. Looking at the constitutional factors in the present study, the results show that a higher percentage among the allergics are female and a higher percentage have allergic parents, compared to the non-allergics. Looking at the social environment, few students (4%) report that they never feel comfortable at school and 58% report that they often do, but the results also show that a lower percentage among the allergic students feel comfortable at school compared to the non-allergic students. Looking at the physical environment, most students report that the general impression of the air quality, the sound level and the cleaning are acceptable, but the allergic students are, as a group, more critical to the cleaning and the air quality. In addition, a higher percentage among the allergics are bothered every week by specific physical factors, and a higher percentage report that they suffer from symptoms every week. These findings indicate that genetic factors and/or gender and present health status are additional determinants and/or modifiers of SBS.

Sick and healthy buildings are assessed by complaints and health reactions (symptoms) reported from the occupants, and the results from the study indicate that judgments of the environment could be biased by high or low prevalences of allergy. The questions for a building manager could be the following: Which group should be the standard when assessing the environment – allergics or non-allergics? Should we treat the environment or should we treat the allergic occupants? Bakke (1995) argues that the attention will be moved away from the real problem – a deteriorated environment – if we use allergy medicines to keep humans in unhealthy environments. The European community emphasize that non-allergic groups should be the standard for assessing SBS, but the Swedish Institute of Public Health notes that if we change our buildings in a direction which allow allergic persons to stay there, other occupants will also become healthier (Säfvenstrand-Rådö, 1995). The conclusion is that it is important to take allergy into consideration when the indoor environment is assessed, and the implication of this conclusion could be stated as a question: *Could and should allergics serve as the canaries that miners carried long ago to detect noxious gases?*

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