

ORIGINAL ARTICLE

Assessment of indoor air problems at work with a questionnaire

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Occup Environ Med 2004;61:33–38

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Accepted 11 October 2002

Aims: To assess the extent of indoor air problems in office environments in Finland.

Methods: Complaints and symptoms related to the indoor environment experienced by office workers were collected from 122 workplaces in 1996–99 by using the modified Indoor Air Questionnaire established by the Finnish Institute of Occupational Health. Altogether 11 154 employees took part in the survey.

Results: The most common problems were dry air (35% of the respondents), stuffy air (34%), dust or dirt in the indoor environment (25%), and draught (22%). The most common work related symptoms were irritated, stuffy, or runny nose (20%), itching, burning, or irritation of the eyes (17%), and fatigue (16%). Women reported indoor air problems and work related symptoms more often than men. Allergic persons and smokers reported indoor air problems more often, and experienced work related symptoms more often than non-allergic persons and non-smokers.

Conclusions: The complaints and work related symptoms associated with indoor air problems were common in office workers. The present questionnaire is a suitable tool for the occupational health personnel in investigating indoor air problems and the data of the survey can be used as a reference when the results of a survey at work are being analysed.

Problems in the indoor air of workplaces are issues which occupational health care often needs to consider when evaluating the health risks of a work environment. On the other hand, good indoor air quality has a beneficial effect on the health of employees, the social atmosphere at work, and productivity in offices.^{1–3}

Already in the 1980s the reports by the WHO stated that up to 30% of employees in new or renovated buildings expressed an unusually high number of complaints concerning the work environment, enabling classification of the buildings as "sick".⁴ This appeared to be a problem especially in countries with a colder climate.

Working in these problem buildings may cause respiratory symptoms (stuffy and irritated nose, rhinitis, cough, sore throat, and shortness of breath), skin symptoms, as well as general symptoms (fatigue, headache, fever), all of which are typical to the sick building syndrome (SBS).^{5–7} Some researchers consider SBS as more of a reaction to the work environment than as a disease per se.⁶ By studying the quality and prevalence of the symptoms, they can, in some cases, be attributed to the indoor air, especially when the number of people working in the building is large enough, and the manifestation of the symptoms can thus be studied at the group level. According to the current understanding, SBS is a multifactorial problem, behind which can be found, for example, dirt in the air-conditioning channels or emissions from construction or surface materials. The psychosocial atmosphere of the work community partially affects the prevalence of SBS and the solving of the related problems.³

For the time being, there is very little information on the causal relations of indoor air problems and the mechanisms behind them. Occasionally, it is easy to find the cause of an indoor air problem in a targeted building when, for example, the air conditioning is not working properly, or if there is an obvious moisture damage or mould growth in the structures of the building. However, quite often the situation is far more complex. Previous experience has shown that even extensive technical and microbiological studies, or clinical examination

of the employees, have difficulties in confirming the exact problem area in the building. Systematic investigations of the work environment, combined with information gathered from the employees with interviews or questionnaire surveys, form a basis for further investigation and restorative measures.^{5, 8}

If information is gathered from a large number of workers, a questionnaire is a useful aid. The Indoor Air Questionnaire of the Finnish Institute of Occupational Health (FIOH) is based on a method developed by a Swedish research group.⁸ In the questionnaire, the validity of the questions has been tested, for example, by comparing the answers in the questionnaire with the physicians' evaluation of the symptoms of the target group, and with information on the work environment.⁹ In addition, the reliability of the questionnaire has been confirmed in surveys conducted in office and residential buildings.¹⁰

The present study examines the prevalence of complaints concerning indoor air and the symptoms of office workers. Also personal factors such as sex, age, allergies, and smoking, and their effect on the results of the survey, were assessed. At the same time, reference material was collected from office environments for those conducting indoor air surveys.

METHODS

The Uusimaa Regional Institute of the FIOH has been using the present Indoor Air Questionnaire since 1995 as one tool in the investigation of indoor air problems. The questionnaire was developed in Örebro, Sweden (MM-40 questionnaire);⁸ it comprises four parts, the first of which deals with the work environment, the second with work arrangements, the third with the allergy history of the employees, and the fourth with work related symptoms.

In the questionnaire, environmental problems (draught, dry, or stuffy air, etc) are recalled from the past three months. Environmental problems and symptoms that had occurred every week or occasionally were enquired about and collected in the present study. The questionnaire also deals with

allergic diseases: past or present asthma, hay fever, allergic rhinitis, or atopic dermatitis. In the present survey, the respondents were distinguished as "allergic" if they reported any of the four allergic diseases. Symptoms attributed to indoor air at work are reported from the past three months, and they are further explained by specifying whether the symptoms are weekly, and whether the persons attribute the symptoms to their work environment. This study focused on symptoms that occurred every week and were attributed to the work environment.

In 1996–99, surveys were conducted by the Uusimaa Regional Institute of the FIOH in 122 workplaces, mainly offices. In addition, nine schools, four hospitals or health care centres, and 14 other workplaces were investigated. An indoor air problem had been suspected in all of the targets before the survey was conducted. The employer or its health care unit had contacted the Regional Institute and ordered the indoor air survey as a part of other investigations concerning the suspected indoor air problem. In some cases, the party ordering the survey had been able to point out a control area for the department to be investigated. The exact response rate was known in 72 workplaces, the average response rate being 73% (range 40–100%).

The workers had two weeks to respond to the inquiry. In most of the cases the occupational health care of the office arranged the delivery and collection of the questionnaires at the workplace. The survey covered questionnaires of 11 154 participants, 7819 of whom were women and 3240 were men (in 95 cases no gender was reported). In the 72 workplaces in which the return percentage was known, the number of participants was 6176.

For the statistical analysis of the data, SAS 6.12 and PEPI 3.0 programs were used. In the analysis of the data, the relative differences between the different groups were studied, and the statistical significance of the differences was estimated with the *t* test from the difference of two values. The significance of the prevalences in difference between the age groups was tested with a paired sample *t* test.

RESULTS

Complaints related to environmental factors

The most common environmental problems that had occurred every week were dry air (35% of the respondents), stuffy air (34%), dust or dirt (25%), and draught (22%) (table 1). The most common environmental problems that had occurred occasionally were varying room temperature

(53%), too low temperature (51%), too high temperature (48%), unpleasant odours (46%), and draught (44%).

The greatest differences between the men and women concerned complaints of dry and stuffy air, dust or dirt, and draught (table 1). Women reported environmental problems more often than men; the difference was statistically significant concerning all of the environmental problems. The differences between men and women were accentuated even more among those who had never had problems in the environmental conditions.

When the complaints regarding environmental conditions are compared between age groups, the younger employees complained more often about low temperatures and stuffy air than did the older employees who, in turn, complained more often about environmental noise than did the younger employees (table 2).

Symptoms

The most common indoor air related symptoms reported by the participants were irritated, stuffy, or runny nose (20%), and itching, burning, or irritation of the eyes (17%) (table 3). When looking at the reported symptoms, which included both work related and other symptoms, the most common symptoms were nasal symptoms (29%), fatigue (28%), dryness of the hands (26%), symptoms of the eyes (22%), as well as hoarse or dry throat (20%).

The greatest differences between the genders in reporting work related symptoms concerned hand and eye related symptoms, nasal symptoms, and fatigue. Women reported work related symptoms more often than men, the difference being statistically significant (table 3). The differences between men and women were accentuated among those participants who had never experienced any symptoms arising from the work environment.

The youngest age groups complained more often about work related fatigue, headache, and dryness of the hands than the two oldest age groups.

Allergic individuals (*n* = 5509) reported more often environmental problems than those who were not allergic. The most significant differences between the groups concerned dry and stuffy air, as well as dust or dirt. Allergic employees also reported more work related symptoms than those who were not allergic. The most significant differences concerned nose and eye related symptoms, as well as hoarse and dry throat.

During 1996–99 the percentage of smokers among the workers in the present survey was 21–22%. In 1996, altogether 22% reported that smoking by others was a

Table 1 Indoor air complaints in office environments; the number and percentage of respondents who reported that the problem had existed "every week" in work environment

Environmental complaints	Every week					
	All workers (n = 11154)		Women (n = 7819)		Men (n = 3240)	
	n	%	n	%	n	%
Dry air	3638	35	3097	42***	579	19***
Stuffy air	3701	34	2925	39***	672	21***
Dust or dirt	2703	25	2121	29***	553	18***
Draught	2310	22	1850	25***	442	14***
Noise	1824	17	1393	19***	422	13***
Room temperature too high	1768	17	1347	19***	406	13***
Unpleasant odour	1757	17	1404	19***	337	11***
Varying room temperature	1371	16	1260	18***	359	12***
Dim light or glare/reflections	1465	14	1157	16***	299	10***
Room temperature too low	1307	13	1099	16***	198	7***
Static electricity	793	8	654	9***	137	4***
Environmental tobacco smoke	370	4	271	4**	94	3**

p*<0.05, *p*<0.01, ****p*<0.001.

Table 2 Environmental complaints in age groups

Environmental complaints	1	2	3	4	p value
	18–34 y (n = 2238) % (n)	35–44 y (n = 3247) % (n)	45–54 y (n = 3799) % (n)	>55 y (n = 1870) % (n)	
Draught	20 (446)	22 (675)	22 (805)	22 (384)	NS
Room temperature too high	17 (369)	18 (543)	17 (584)	17 (272)	NS
Varying room temperature	18 (382)	16 (490)	16 (522)	15 (236)	NS
Room temperature too low	15 (314)	14 (410)	13 (416)	11 (167)	**1 and 4
Stuffy air	36 (787)	36 (1148)	33 (1179)	30 (524)	*2 and 4 ***2 and 4 **1 and 4 **2 and 3
Dry air	35 (757)	37 (1145)	34 (1209)	35 (590)	NS
Unpleasant odours	16 (351)	17 (523)	17 (592)	17 (291)	NS
Static electricity	8 (168)	8 (257)	8 (267)	6 (101)	*2 and 4
Environmental tobacco smoke	3 (73)	3 (89)	4 (140)	4 (68)	NS
Noise	16 (342)	17 (530)	18 (629)	19 (323)	*1 and 4
Dim light or glare/reflections	12 (262)	15 (450)	15 (530)	13 (223)	**1 and 3
Dust or dirt	24 (519)	26 (807)	26 (948)	25 (429)	*1 and 2 NS

*p<0.05, **p<0.01, ***p<0.001; NS, statistically not significant.

problem at their workplace, and in 1997–99 nearly 20% still had this opinion. Smokers complained of environmental problems more often than non-smokers (table 4). In addition, smokers reported more work related symptoms than non-smokers (table 5).

Those who complained about symptoms in nose, eyes, or hands, or fatigue, also reported environmental problems more often than those who had never experienced any of those symptoms (fig 1). On the other hand, those who reported dry or stuffy air, draught, or dust, reported work related symptoms more often than those who had not experienced any of these symptoms (fig 2).

DISCUSSION

The present study presents the causes of complaints about environmental factors and symptoms related to indoor air, reported by over 11 000 office employees. In the future, the present results can be used as reference material for indoor air surveys conducted at other office workplaces. The investigated workplaces were not randomly chosen; an indoor air problem had been suspected in each one before the survey. The number of complaints is thus assumed to be slightly higher than normal.

Indoor air problems can be caused by several factors. An indoor air problem is rarely caused by a single factor such as,

for example, the formaldehyde emissions from construction materials in the 1970s. Problems in air conditioning, moisture damage, material emissions, or dust and dirt problems may occur simultaneously at one workplace. On the other hand, the complaints and symptoms reported by employees do not provide a reliable overall picture if the number of individuals voicing their opinion is not large enough. Both the physical and the psychosocial environment affect the reporting of health issues and symptoms; however, personal factors also affect the results.^{11 12}

Occupational health care personnel need tools for studying indoor air problems. In larger workplaces, a health inspection including an interview cannot be arranged for all the employees. Information thus needs to be gathered by some other means. In these cases, the occupational health personnel may use questionnaire surveys exploring the relations between the work environment and health.

The Indoor Air Questionnaire of the FIOH is based on a Swedish questionnaire which has been tested earlier in offices, schools, and residential buildings.⁸ The questionnaire has been condensed into one two-sided page which contains, in addition to the sections on work environment and symptoms, sections on the participant's allergy history and on the psychosocial conditions at work. The FIOH has been using this short form of the questionnaire since the

Table 3 Symptoms related to indoor air problems; symptom had occurred "every week during past three months"

Work related symptom	Every week					
	All workers (n = 11154)		Women (n = 7819)		Men (n = 3240)	
	n	%	n	%	n	%
Irritated, stuffy, or runny nose	2190	20	1760	23***	412	13***
Itching, burning, or irritation of the eyes	1857	17	1554	20***	285	9***
Fatigue	1779	16	1464	19***	299	9***
Hands dry, itching, red skin	1721	15	1513	19***	200	6***
Hoarse, dry throat	1561	14	1270	16***	280	9***
Dry or flushed facial skin	1216	11	1042	13***	169	5***
Feeling heavy headed	1026	9	888	11***	127	4***
Headache	726	7	626	8***	91	3***
Scaling/itching scalp or ears	715	6	577	7***	136	4***
Cough	542	5	435	6***	103	3***
Difficulties in concentrating	367	3	280	4*	84	3*
Nausea/dizziness	150	1	128	2***	21	1***

*p<0.05, **p<0.01, ***p<0.001.

Table 4 Indoor air complaints and workers' smoking habits

Environmental complaint every week	Smokers		Non-smokers		p value
	n	%	n	%	
Draught	513	26	1554	21	***
Room temperature too high	347	18	1281	18	NS
Varying room temperature	357	19	1083	16	**
Room temperature too low	261	14	866	13	NS
Stuffy air	724	36	2598	35	NS
Dry air	797	40	2429	34	***
Unpleasant odours	377	19	1242	17	**
Static electricity	221	11	484	7	***
ETS	10	1	315	4	***
Noise	392	20	1262	17	**
Dim light or glare/reflections	299	15	990	14	NS
Dust and dirt	599	30	1735	24	***

*p<0.05, **p<0.01, ***p<0.001; NS, not significant.

beginning of the 1990s, first to test the form, and later more systematically as a part of field studies on indoor air problems.

Complaints about environmental factors

The most common complaints about environmental factors at work were dryness and stuffiness of the air, dust or dirt, draught, and noise. In a previous Danish study, the most common complaints about environmental factors reported at the Copenhagen City Hall were also dry and stuffy air, as well as varying temperature, and draught.¹³ In a Dutch study covering over 7000 office employees and 61 buildings, the most common complaints concerned indoor air temperature, quality, dry air, lighting (too bright or dim), and noise.¹⁴ The Dutch study did not include buildings in which indoor air problems had been previously encountered.

In the present study, men and women differed clearly in their complaints about environmental factors. Women had more complaints concerning environmental factors than men. Similar observations have been made in other studies as well.^{8, 13} The significance of age could not be proven with certainty, based on the results of this study. The complaints concerning environmental factors differed between the age groups. This might at least partially be due to different job descriptions: the complaints might be different in the jobs to which employees of various ages are assigned. On the other hand, the differences might also be explained by the physical changes that occur in the ageing process.

Symptoms

The most common work related symptoms were irritation, a stuffy or runny nose, and itching, burning, and irritation of the eyes. Jaakkola and colleagues¹⁵ encountered the effect of

mechanical ventilation on SBS symptoms in an office building with 1719 employees. The survey focused on symptoms during the past seven days, both at work and at home. About a half of the participants complained of dryness of the skin, nose, and throat, as well as stuffiness of the nose. In their study, one third reported itchiness of the skin, headache, and fatigue, while one fifth complained about irritated, itchy, or dry eyes. More symptoms prevailed if the room temperature was above 22°C. Stuffy nose, dry skin and throat, fatigue, and headache were more common in the previous than in the present study.

Finnegan and colleagues⁶ found fatigue, headache, and mucous membrane and nasal symptoms to be the most common symptoms related to the work environment in mechanically ventilated buildings in England. In the study of Burge and colleagues,¹⁶ covering over 4300 employees, the most common symptoms related to the indoor climate were fatigue, stuffy nose, dry throat, and headache. In their study they avoided buildings that were already known as problem buildings. When work related and other symptoms are taken together, the most common symptoms are irritation of the nose, fatigue, and dryness of the hands. Skov and Valbjorn¹³ noted that the most common symptoms reported by the workers at the Copenhagen City Hall were fatigue, headache, and irritation of the nose and throat. Furthermore, general symptoms (fatigue, headache, etc) were accentuated compared with other studies. However, the authors noted that the prevalence of the irritation and general symptoms varied significantly between the different buildings.¹³ In the present study, symptoms of the upper respiratory tract and eye irritation are the most prevalent.

We found a clear difference between men and women in the reporting of work related symptoms. Women reported

Table 5 Work related symptoms and smoking habits

Work related symptom	Smoker		Non-smoker		p value
	n	%	n	%	
Fatigue	403	19	1216	16	**
Feeling heavy headed	242	12	691	9	***
Headache	154	7	490	6	NS
Nausea/dizziness	32	2	103	1	**
Difficulties in concentrating	70	3	244	3	NS
Itching, burning, or irritation of eyes	399	19	1247	16	**
Irritated, stuffy, or runny nose	450	21	1471	19	*
Hoarse, dry throat	323	15	1053	14	NS
Cough	117	6	369	5	NS
Dry or flushed facial skin	263	13	788	10	***
Scaling/itching scalp or ears	147	7	481	6	NS
Hands dry, itching, red skin	382	18	1159	15	**

*p<0.05, **p<0.01, ***p<0.001; NS, not significant.

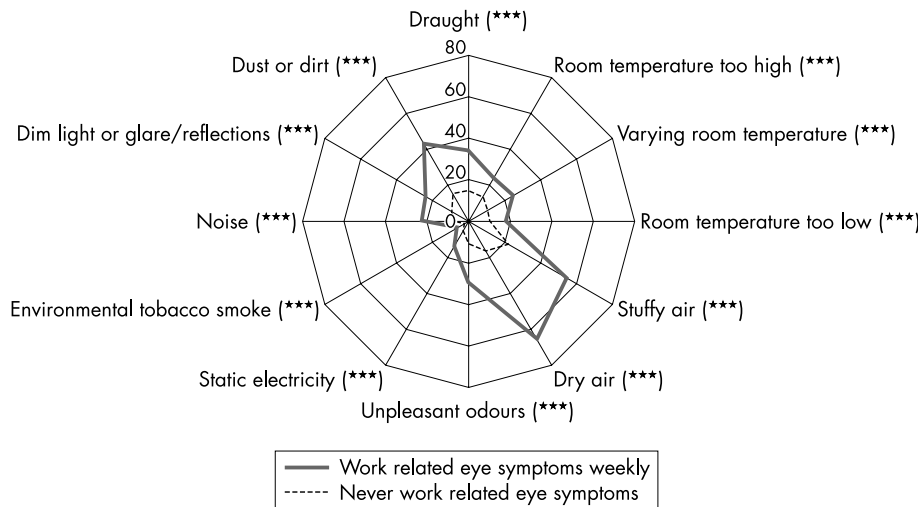


Figure 1 Indoor air related symptoms in eyes by environmental complaints. ***p<0.001.

more work related symptoms than men. A similar observation has also been previously reported by others.^{8 13 16} Gender based differences may arise from differences in the work tasks and work arrangements of men and women, or differences in the psychosocial work community, as well as in other spheres of life, such as home and family relations.¹⁷ In a previous study, it was estimated that women describe changes in their health more easily than men; it was suggested that the overall life situation, both at home and at work, should be considered when assessing the reports of the symptoms.¹⁸

In indoor air surveys, factors that affect the reporting of symptoms include the physical and social work environment, as well as physiological and psychological characteristics of the employee.¹⁹ In studies on indoor air, it is important to consider the symptoms and sensations of the participants, even though the mechanisms affecting them are not known. The observed differences between the genders are real, and they are partly explained by work related factors, factors outside the work, and physiological factors.¹⁶ When looking at the results of the survey, the gender based differences should be considered especially when a workplace is clearly dominated by either sex.

Stenberg and Wall¹⁷ have stated that the only environmental complaint which influenced women’s work related symptoms was dry air. Experiencing the air as dry, on the

other hand, could be linked to symptoms of the eyes and facial skin, but not necessarily to the level of moisture in the air. Neither did their study find a connection between the women’s marital status or number of children and the symptoms. The authors noted that certain organ related factors could increase symptoms in women. For example, women more often have diseases which cause dryness of the eyes and mouth; hormonal factors could also have an effect on eye symptoms. According to Stenberg and Wall,¹⁷ the most important factor behind SBS symptoms that is not associated with the building itself is gender. Other factors are atopy, psychosocial working conditions, computer related work, and “paperwork”.

The differences in reporting symptoms between the different age groups in the present report may depend on the participant’s stage in work life or other life situation. Burge and co-workers¹⁶ noted that employees aged 21–40 years reported symptoms more commonly than older or younger age groups. In the study by Zweers and colleagues,¹⁴ no clear connection between age and the frequency of complaints was found.

In the present survey, the prevalence of allergy and atopy was higher than in the general Finnish population. Clinically confirmed IgE mediated allergy is usually less frequent than the prevalence of allergy based on inquiry surveys. People tend to overestimate the presence of allergic diseases which

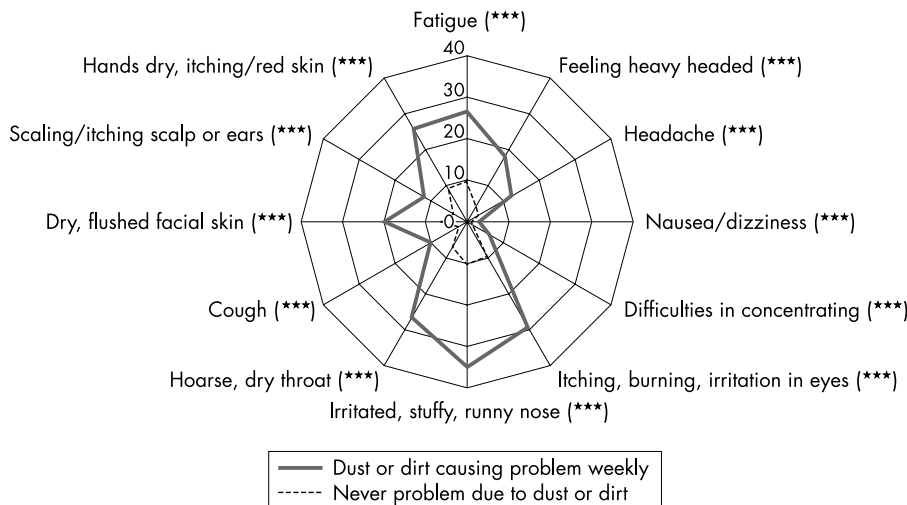


Figure 2 Indoor environment complaints due to dust and dirt by work related symptoms. ***p<0.001.

may also explain the high prevalence in the present survey.

We found that allergic individuals reported environmental problems related to the work environment and work related symptoms more often than non-allergy persons. Similar results have been found earlier in a Dutch study.¹⁴ Furthermore, based on over 100 indoor air symptom surveys, Andersson stated that atopic persons had more symptoms of the mucous membranes and skin symptoms than non-atopic persons.⁸ Allergic individuals may react to environmental factors earlier than others, and their awareness of their sensitisation helps them to pay attention to different hazards known to cause symptoms.¹⁹

Based on these results, smokers reported more environmental problems and work related symptoms than non-smokers. However, Zweers and colleagues¹⁴ did not find a connection between the participants' smoking and the complaints. A clear connection between exposure to ambient tobacco smoke and complaints about environmental factors and symptoms has nevertheless been found.¹⁴ The material of the present study has been collected after 1995, when the renewed Tobacco Act was launched to reduce exposure to tobacco smoke at work in Finland.²⁰ When questioned about environmental problems in 1997–99, nearly 20% of the employees who participated in this survey reported smoking by others to be a problem. This shows that, at least then, the Tobacco Act was not enforced sufficiently in workplaces, and the tobacco smoke spread throughout the premises.

The prevalence of the complaints about environmental factors and problems related to indoor climate presented in this study can be used as reference material when conducting indoor air surveys at other workplaces. It should be noted that symptoms related to work and working conditions are reported also in "healthy" buildings.⁸ However, if the level of complaints rises exceptionally high, it can point to problems in the building and in the air conditioning system. When using the Indoor Air Questionnaires of the Institute of Occupational Health, the basic rules are: for work related complaints about environmental factors (the hazard is experienced every week), a rate of over 30% is considered higher than normally found at workplaces; for the prevalence of symptoms (that is, the symptom is work related and is experienced every week), a rate of over 20% is considered higher than normal. Such results warrant further investigations. It should be noted, however, that a lower prevalence of complaints can be significant, and therefore each problem site should be examined as an entity, taking into account other information gathered from the workplace. In addition, the employees' individual characteristics affect the complaints about environmental factors and the prevalence of the symptoms, thus complicating interpretation of the questionnaire results.

The individual characteristics of the employees and of the work environment should be considered as their own entity, especially when the solution to the problem is delayed, despite proper repair measures. The psychosocial atmosphere of the work community, work arrangements, and problem

solving processes play a significant role in the solving of indoor air problems at work.³

Solving an indoor air problem requires systematic work, in which the indoor air questionnaire serves as an aid for the occupational health personnel; it is part of a more comprehensive process to clarify and evaluate risks. When solving an indoor air problem, one should pay attention to distribution of tasks, responsibility, information, goal directed activities that activate the participants, as well as a follow up of the effects.³ The indoor air survey provides a possibility for each employee to personally take part in the process to solve an indoor climate problem.

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