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Occupational exposure to hairdressing chemicals and immunoglobulin E synthesis

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Objective This study assessed the effect of exposure to hairdressing chemicals on total and allergen-specific serum immunoglobulin E (IgE) in hairdressers.

Methods The study was based on a questionnaire sent to 100 hairdressers (91% responding) and a reference group of 95 office workers (84% responding). The questionnaire sought information on allergy, respiratory symptoms during the past year, work conditions (exposure), and smoking habits. The hairdressers were divided into two groups, one of high exposure and another of low exposure. Total serum IgE and allergen-specific IgE towards the most prevalent airborne allergens were analyzed.

Results The serum levels of total IgE were significantly higher among the highly exposed hairdressers than among the office workers. The prevalence of asthma-like respiratory symptoms during the past year was significantly higher among the highly exposed hairdressers than among the office workers. The total serum IgE level was significantly higher among the hairdressers than among the office workers (101 versus 51 IU/ml blood), but this difference disappeared after adjustment for age, atopy, and smoking. A total of 5.5% of the hairdressers versus none of the office workers had specific serum IgE antibodies towards latex. There were no differences in general allergy (Phadiatop®) among the hairdressers and office workers.

Conclusions Serum levels of total IgE were significantly higher among highly exposed hairdressers than among office workers. The relationship could not be completely explained by such covariables as age, smoking, or sensitization to latex allergens.

Key terms allergy, latex.

Long-term exposure to gases, vapors, and fumes in the workplace may cause respiratory symptoms and bronchoconstriction through various pathophysiological mechanisms (1, 2), which may be the result of a direct effect of the irritants on receptors in the airways or inflammation of the bronchial mucosa. Hairdressers have more asthma-like symptoms than the general population (3–5).

Employees in hairdressing salons are periodically exposed to aerosols of various chemicals capable of producing respiratory symptoms (5–7). Some chemicals are considered allergens, whereas others may cause acute,

nonspecific respiratory-tract reactions soon after exposure. Persulfate salts and hair dyes have been associated with chronic and remittent asthma in hairdressers and chemical workers.

High levels of immunoglobulin E (IgE) in humans have been associated with wheezing, hay fever, and asthma (8, 9). It is not clear whether occupational exposure to gases can influence serum IgE levels. A few studies on adults have reported that IgE levels are increased by environmental exposure to such agents as tobacco smoke, allergens, and occupational exposure (10–15).

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The aim of this study was therefore to assess the effect of exposure to hairdressing chemicals on total and specific IgE levels. The hypothesis was that hairdressing chemicals do not cause an increase in the serum levels of total and allergen-specific IgE.

Subjects and methods

Subjects

This cross-sectional study was performed in the city of Bergen, on the southwestern coast of Norway.

The study included hairdressers as the exposed group. Office staff from insurance companies served as unexposed referents. Both groups included women only.

To avoid a study population dominated by hairdressers with a brief period of chemical exposure, we included 100 women who had worked as hairdressers for at least 2 years.

The hairdressers worked in 35 different salons randomly selected from the city of Bergen. The office workers came from eight offices. The hairdressers and the office workers were selected from the same geographic area and were all city residents.

The employers received a letter in which we asked them if their employees would be allowed to participate in the survey. After giving permission, the employers gave the names of their employees. The women filled out the questionnaire and were invited to our office for an interview and a blood sample.

Ninety-one percent of the invited hairdressers (N=91) and 85% of the office workers (N=80) participated in the study. As shown in table 1, the office workers were significantly older than the hairdressers and smoked significantly less (32% versus 50%).

The prevalence of atopy did not differ significantly between the two groups (table 1). The main results from the questionnaire have been published elsewhere (3).

Questionnaire

The questionnaire was sent by mail in October 1995 with a cover letter outlining the aims of the study. It sought information on atopy, respiratory symptoms, smoking habits, previous occupations, and the number of workhours per week.

The questions on respiratory symptoms during the past year were (i) have you ever had wheezing in your chest and (ii) have you ever been breathless? The pre-printed answers were no; yes, daily; yes, weekly; yes, each month; and yes, once in a while. The questionnaire also contained one question on previous allergic and atopic diseases. They were asked: "Have you ever had one of the following symptoms or diseases: eczema, urticaria, hay fever, or asthma?" The recipients were asked to pick one of the preprinted answers: yes, no, or do not know.

Previous surveys in Norway have validated the questions on respiratory symptoms (16) and smoking habits (17).

Atopy was considered present if the subject had a positive Phadiatop® test or an atopic disease in her medical history (18).

The subjects were classified as nonsmokers if they had never smoked daily. Ex-smokers were those who had been smoking daily and quit smoking before the study. Smokers were those who smoked daily at the time of the study.

Exposure

Both the hairdressers and the office workers were interviewed by the same person with the aim of obtaining additional information on chemical exposure, the type of ventilation at the workplace, whether there was local exhaust ventilation or not, and the number of customers served each week. Hair treatment was defined as dyeing, bleaching, or giving permanents.

Table 1. Total serum immunoglobulin E (IgE) and the characteristics of the participants and the blood tests. (CS = current smokers, ES = ex-smokers, NS = never smokers, GM = geometric mean, GSD = geometric standard deviation)

Group	Mean age (years)	Phadiatop positive(%)	Smoking status			Total serum IgE (IU/ml blood)		
			CS (%)	ES(%)	NS (%)	GM	GSD	Elevated ^a (%)
Hairdressers (N=91)	33	26	50	25	25	101	210	23
Office workers (N=80)	44*	23	32*	22	46	51*	89	14

^a >100 IU/ml blood.

* P-value <0.05, hairdressers versus office workers using t-tests for the differences in the means or chi-square tests for the differences in the proportions.

About 30% of the hairdressers had local exhaust ventilation at their workplace. The ordinary worktime in Norway is 37.5 hours a week. The mean number of customers receiving chemical treatment was 15 per week.

Hairdressers who worked more than 20 hours a week, had more than 15 customers receiving chemical treatment each week, and did not have local exhaust ventilation were allocated to the highly exposed group. The others were designated to the group of low exposure.

Blood sampling

All the blood samples were taken between January and March 1996, between the times of 1000 and 2000. They were drawn from the cubital vein with the subject sitting. Eight milliliters of blood was collected in a sterile Vacutainer® without any preservative or anticoagulant. The blood was clotted in the tube at room temperature. The serum (approximately 4 ml) was decanted after centrifugation and kept in a refrigerator at 4°C. All the samples were analyzed within 3 days.

Serum immunoglobulin E, total and allergen-specific levels

The total and allergen-specific IgE levels in serum were measured by the CAP FEIA system (Pharmacia, Uppsala, Sweden). Allergen-specific IgE was tested for the main inhalation allergens using Phadiatop® (*Dermatophagoides farinae*, *D pteronyssinus*, *Parietaria vulgaris*, cat, horse, dog, timothy, birch, olive, *Cladosporium herbarum*, and mugwort) and latex. The Phadiatop® was analyzed in duplicate. The results were given as negative, positive, or borderline depending on the sample-to-reference ratio of fluorescence activity falling below 0.95, above 1.10, or between these intervals, respectively.

Statistical methods

The differences in the characteristics of the hairdressers and office workers were tested using chi-square tests for differences in proportions and the t-test for differences in the means. The covariates considered in the multivariate linear regression analyses of serum IgE included age, smoking, and atopy.

Because the distribution of the serum IgE levels was highly skewed, all the analyses were conducted using natural log transformed data (lnIgE). The natural log transformed data were normally distributed.

The statistical package SPSS (Statistical Package for the Social Sciences) was used in all the analyses.

Ethics

The Regional Committee on Ethics in Medical Research approved the project.

Results

The geometric mean of the total serum IgE was significantly higher among the hairdressers than among the office workers (101 versus 51 IU/ml, $P=0.04$) (table 1). After adjustment for age, smoking, and atopy, the difference was not statistically significant ($P=0.09$) in the linear regression analysis. Hairdressers with high exposure had higher total IgE levels than those with low exposure and the office workers (table 2). The highly exposed hairdressers and office workers differed significantly (t-test, $P<0.05$). The highly exposed hairdressers who were negative to Phadiatop® had a significantly higher IgE level than the office workers with a negative Phadiatop® (linear regression analyses adjusted for age and smoking, $P<0.05$) (table 2).

Table 2. Total serum immunoglobulin E (IgE) of the hairdressers with high exposure and low exposure compared with that of the office workers. (GM=geometric mean, GSD = geometric standard deviation)

Group	Total group			Smoking status						Atopic status					
				Current smokers			Nonsmokers			Phadiatop positive			Phadiatop negative		
	N	Total serum IgE (IU/ml blood)		N	Total serum IgE (IU/ml blood)		N	Total serum IgE (IU/ml blood)		N	Total serum IgE (IU/ml blood)		N	Total serum IgE (IU/ml blood)	
		GM	GSD		GM	GSD		GM	GSD		GM	GSD		GM	GSD
Hairdressers															
High exposure	17	223	379	11	206	327	6	254	501	5	596	560	12	55	63
Low exposure	73	175	133	34	66	83	35	81	171	19	184	204	50	59	36
Office workers	77	51*	89	25	72*	97	53	40*	84	20	116	140	57	29	47

* $P<0.05$, highly exposed hairdressers versus office workers.

Table 3. Airway symptoms and the characteristics of the hairdressers with high exposure, those with low exposure, and the office workers.

Group	Mean age (years)	Mean worktime (years)	Phadiatop (% positive)	Current smoker (%)	Mean cigarettes/day (among smokers)	Wheezing in past year (yes;%)	Breathlessness in past year (yes;%)
Hairdressers							
High exposure (N=17)	33	13	29	65	13	53	53
Low exposure (N=73)	33	14	27	47	11	32**	39**
Office workers (N=77)	44		25	31*	9*	29	35*

* $P < 0.05$, hairdressers with high exposure versus office workers.

** $P < 0.1$, hairdressers with high exposure versus those with low exposure.

Figure 1. Total immunoglobulin E (IgE) for the different age groups of participants.

Analyses stratified by smoking showed similar trends and a significant difference (linear regression analyses adjusted for age and atopy, $P < 0.05$) (table 2). The highly exposed hairdressers reported significantly more airway symptoms than did the office workers (table 3).

The hairdressers with high and low exposure did not differ significantly in their response to Phadiatop®, age, years working as a hairdresser, current smoking, and cigarettes smoked per day (table 3).

A higher percentage (23%) of the hairdressers than the office workers (14%) had an elevated serum IgE concentration (> 100 IU/ml blood), but this difference was not statistically significant.

The mean serum IgE increased with age among the hairdressers (figure 1), whereas the mean levels decreased with age in the reference group. However, in the multivariate analyses, there was no significant interaction between age group and work group.

For 3% (N=5) of the women, serum IgE with specificity towards latex (class 1 or higher) was found; all the women were hairdressers. The mean total serum IgE level of the latex-positive group was 635 IU/ml (N=5). After the latex-positive hairdressers were excluded, the hairdressers with high and low exposure still tended to differ in total serum IgE (t-test $P = 0.08$; linear regression analyses adjusted for age, smoking, and atopy $P = 0.1$).

Twenty-six percent of the hairdressers and 23% of the office workers were Phadiatop® positive (table 1).

The difference was not significant. No association was found between a positive Phadiatop® test and age.

Phadiatop® was analyzed twice; there was no difference between the results.

Discussion

This study showed that the total serum IgE levels were significantly higher among the highly exposed hairdressers than among the office workers. The highly exposed hairdressers without atopy (negative Phadiatop®) had a significantly higher IgE level than the nonatopic office workers. Age, smoking, and latex allergy could not totally explain the differences. The hairdressers and office workers did not differ with respect to airway symptoms in the past year or the Phadiatop® test results.

About 25% of the women in the population sample were positive in the Phadiatop® test. Leino et al (19) found the same result among hairdressers in Finland in 1998, as did Wüthrich et al (20) in a normal adult population in Switzerland. Similarly, Omenaas et al (14) did not find any relationship between antibodies to common airborne allergens and occupational dust or gas exposure.

Hairdressers are at high risk of developing sensitization to latex allergens. The frequent use of powdered latex gloves to reduce the risk of hand eczema represents considerable exposure. Leino et al (19) found that 3 of 103 hairdressers were IgE-positive to natural rubber.

With unadjusted data, the total IgE concentration was higher among the hairdressers than among the office workers (101 versus 51 IU/ml blood). This difference seems high compared with the levels found in a normal adult population in Switzerland (30 KU/l) (20) and among women in The Netherlands (below 50 IU/ml) (21). IgE is a marker of allergic diseases: elevated serum levels are present in patients with hay fever, allergic rhinitis, and extrinsic asthma (8, 9). However, elevations of serum IgE are more pronounced in

atopic dermatitis, parasitic infestation, and certain immunopathological diseases. In addition, gender, age, tobacco smoke, and occupational exposure may influence IgE serum levels to some degree (14, 22–24).

The total IgE levels declined with age among the office workers, whereas the mean IgE level of the hairdressers increased with age. However, the age trend was not statistically significant. Several studies (8, 14, 25–28) have found declining IgE levels with increasing age. We have previously shown (3) that hairdressers older than 40 years of age report a significantly higher prevalence of airway symptoms, and this trend can have parallel explanations to the IgE change related to age. Hairdressers older than 40 years of age have been exposed to hairdressing chemicals for many years. Today, the exposure to some of the most hazardous chemicals has been substantially reduced and new products that are less irritative and dusty have been introduced.

Hairdressers are exposed to many different chemicals, but at low levels when compared with the Norwegian threshold limit values (6, 28). The exposure time is usually short, only a few minutes for each customer. The total personal exposure can still be considerable, because worktasks with high exposure are repeated many times a day. Local exhaust ventilation reduces effectively the level of chemicals in hairdressing salons (6, 7). Our highly exposed hairdressers reported more airway symptoms such as wheezing and breathlessness during the last year than the hairdressers with less exposure. The results indicate that an unknown factor that stimulates the production of IgE and gives rise to increased airway symptoms exists in hairdressing salons. A dose-response relationship between chemical exposure and total serum IgE may exist, but it was not significantly documented. An alternative explanation is that life-styles and other characteristics associated with the hairdressing profession may contribute to the associations observed. Total serum IgE reflects the individual genetic disposition to respond with IgE production to allergenic and other stimuli. Our results are compatible with the hypothesis that working in a hairdressing salon stimulates the production of IgE.

The healthy worker effect may be a problem in small cross-sectional studies. It is known that hairdressers often have to leave the profession prematurely because of allergy (29). Therefore, it is even more interesting that the IgE level is still high among hairdressers who continue. This situation would contribute to the degree of significance found in this study.

Another limitation of cross-sectional studies on the effect of age is that changes in risk between generations may cause differences between age groups. Both the relationships of specific IgE and total IgE with age may be influenced by this “cohort effect”. A prospective study is needed to investigate further the lifetime course

of total serum IgE sensitization to airborne allergens and chemicals among hairdressers.

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