Respiratory Disease Prevalence in Cosmetologists and its Relationship to Aerosol Sprays[1]

ALAN PALMER,[2] ATTILIO D. RENZETTI, JR.,[3] AND DEAN GILLAM

Division of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health, Cincinnati, Ohio; and the Pulmonary Disease Division, University of Utah College of Medicine, Salt Lake City, Utah

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A randomized, cross-sectional epidemiologic study of the prevalence of respiratory disease from exposure to hair spray in cosmetologists was conducted in the state of Utah in all but the sparsely populated western regions of the state. The sample selected for survey consisted of 262 student cosmetologists, 213 graduate practicing beauticians, and 569 females not exposed to hair sprays as part of their occupation (except that of housewife), matched for age, smoking history, and geographic location. Study methods included a modified British Medical Research Council respiratory symptom questionnaire, chest X-ray, forced expiratory spirogram, and measurements of individual and environmental hair spray particulate exposure concentrations. Additionally, for a subgroup in the study population closing volume, slope of phase III and closing capacity of the lung and carbon monoxide diffusing capacity were measured, and sputum cytology was studied. Study findings indicated that, in comparison to the control population, cosmetologists have an increased prevalence of chronic respiratory disease symptoms, small airway obstruction, and atypical sputum cytology and that these increases were significantly related to duration of occupational exposure. The findings with regard to thesaurosis, although suggestive of a positive relationship with hair spray exposure of long duration, were not conclusive.

INTRODUCTION

The existence of a diffuse pulmonary disease related to the inhalation of hair spray is a matter of controversy. The term thesaurosis has been applied to some individuals who, after repeated exposure to hair spray, exhibit clinical and chest X-ray abnormalities that are also consistent with a diagnosis of sarcoidosis. As originally described by Bergmann, Flance, and Blumenthal, thesaurosis is a pulmonary disorder secondary to storage in the reticuloendothelial system of nonbiodegradable macromolecules, primarily polyvinylpyrrolidone (PVP) and its copolymers (1). This conclusion was based on the observation that subcutaneous injection of hair spray residue in guinea pigs produced granulomatous lesions in which there were foam cells containing granules that were stain-positive for periodic acid–Schiff (PAS) (2). Forty-three cases, (1–11), ranging in age from 8 to 69, have been reported to date, 30% of these by the same authors (1,

[2] SRI International, Center for Occupational and Environmental Safety and Health, 333 Ravenswood Avenue, Menlo Park. California 94025.

[3] Requests for reprints should be addressed to Attilio D. Renzetti, Jr., M.D., Head, Pulmonary Disease Division, University of Utah Medical Center, 50 North Medical Drive, Salt Lake City, Utah 84132.

2). The lung and lymph nodes examined after biopsy and autopsy on a small number of patients have shown infiltration by large numbers of histiocytes that contain PAS-positive granules. However, Brunner and his colleagues (12) have shown that the *in vitro* staining characteristics of several hair spray polymers do not correspond to those of the granules found *in vivo* in thesaurosis, and they have also pointed out that such PAS-positive granules were also present in pulmonary disorders in which hair spray exposure was absent or unlikely.

To date 2146 women, 90% of whom were beauticians, have been examined in hair spray-related surveys (7, 8, 13–18). The great majority of the subjects surveyed (87%) received only a brief questionnaire, which did not include an adequate allergy history or a chest X-ray. One study included simple ventilation tests (14), and another included tests of pulmonary diffusing capacity (17). Neither included chest X-ray examinations. None of these studies have yielded conclusive evidence in support of the concept of thesaurosis. However, these surveys neither selected their population by random methods nor did they use an appropriate combination of tests to detect positive cases.

The purpose of this study was to determine if a subgroup of a population (cosmetologists) highly exposed to hair spray experienced an increased prevalence of a lung disorder consistent with thesaurosis or sarcoidosis. Because of recent reports in animals and man of a possible relationship between PVP and malignancy (7, 19, 20) and because of the possibility that long-term hair spray inhalation might play a role in the development of chronic obstructive pulmonary disease, the study was also designed to determine the prevalence of (i) abnormal exfoliative cytology of the sputum, (ii) chronic bronchitis, and (iii) early obstructive airway disease. The results indicate positive findings in these three areas but are not conclusive regarding the occurrence of thesaurosis.

MATERIALS AND METHODS

Experimental design. The study was designed as a randomized cross-sectional epidemiologic survey of cosmetologists. To avoid a self-selection process by which short-term employees in the cosmetology industry might change employment because of respiratory symptoms, the survey gave equal weight to student cosmetologists—a group with hair spray exposure of relatively short duration. Thus, the sample selected came from a population of all practicing and student cosmetologists in the state of Utah. Stratification of the population was based on geographic location and beauty salon size. Salon size is important because observations of a random sample of salons indicated that large salons (arbitrarily set at 10 or more employees) had efficient mechanical ventilation systems, whereas 90% of small (less than 10 employees) salons had limited ventilation and, therefore, presumably higher concentrations of suspended hair spray aerosol particles. Geographic location is important because of differences in an area's population smoking habits and exposure to air pollution. As of 1971, nearly 70% of the Utah population resided in the greater Salt Lake valley (21), which contains Salt Lake City, and Ogden and Provo and their suburbs. These are the major areas of air pollution, in contrast to the rural nature of other areas. These areas also contain the majority of the non-Mormon population of the state and therefore the largest number of those who smoke, a practice proscribed for the members of the Mor-

mon church. Thus, geographic stratification provided areas with high versus low air pollution and areas in which large segments of the population were either smokers or nonsmokers.

Population sampling. Table 1 shows the experimental design for the distribution of the preidentified sample sizes in relation to geographic location. By using a randomized block sampling design, each of the blocks shown in Table 1 was defined as a geographic area. Because of the few cosmetologists in western Utah, no sample was drawn from this area. Each block was divided into two parts on the basis of salon size. By employing a random number table, a random sample of salons was selected, with the number of salons allocated to each block by the worker census of each salon unit. An attempt was made to have an equal number of large and small units for each block, but the predominant number of small salons required additional sampling from the strata of small units to achieve the desired number for each group. All employees of each salon selected were included in the survey.

The sample size of 500, which constituted the experimental group, was divided into two exposure subgroups: (i) 250 licensed cosmetologists currently working, for the most part, in large salons and (ii) 250 students enrolled in registered colleges of cosmetology. It was assumed that practicing cosmetologists were proportionately distributed to salons; hence, Table 1 indicates that the sample selected in this group is in proportion to salon distribution. However, to account for the disproportionately high number of large salons in Block II, this area was slightly over-represented. For student cosmetologists, no assumptions were necessary because enrollments in all colleges were known. Hence, the distribution of students among the blocks was planned to coincide exactly with the distribution of students in the four geographic areas.

The protocol of study required that an all-female control population of 500 subjects be drawn in equal proportions to the number of cosmetologists from each geographic area and that, insofar as possible, they be matched for age and smoking habits. The sources of this control group were retail clerks; Bell Telephone Company employees; and students from medical assistant, dental assistant, and secretarial schools. A public relations program was conducted in each place of business to provide controls identical to those used to recruit experimental subjects. Posters advertised the intent of the survey, as did information handouts and invitations to participate. This procedure was supplemented by survey "motivators" who personally contacted each eligible subject and encouraged their participation.

Environmental sampling. A preliminary survey of a sample of beauty salons provided information that led to the decision to use both area and personal sampling techniques. All units included in the survey had environmental sampling performed, with the exception of those in Block IV where, because of the large number of individually owned shops, only a 31% subsample of units were so tested.

Salon air was sampled with sequential samplers set at a flow rate of 4 liters/min placed in strategic locations. Samples were collected for 1-hr periods before the shop opened, during the morning and afternoon, and 2 hr after closing. Personal air was sampled with a Mine Safety Appliance (MSA) model G portable pump

TABLE 1
GEOGRAPHIC DISTRIBUTION OF BEAUTY SALONS AND COLLEGES OF COSMETOLOGY AS RELATED TO PREIDENTIFIED SAMPLE SIZES

Utah block	Total beauty salons		Salons in sample		Cosmetologists in sample		Total students in Utah colleges		Students in sample		Experimental groups		Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I. Ogden and suburbs	255	19	17	31	50	20	116	14	35	14	85	17	100	20
II. Salt Lake City and suburbs	526	39	16	29	112	45	508	62	155	62	267	53	225	45
III. Provo and suburbs	199	15	9	16	38	15	60	8	20	8	58	12	75	15
IV. North-east and south	348	26	13	24	50	20	128	16	40	16	90	18	100	20
Total	1328	100	55	100	250	100	812	100	250	100	500	100	500	100

calibrated to 2.0 liters/min of air that flowed through a filter. Samplers were worn on the belt, with the sampling orifice fastened to the lapel of the cosmetologist's smock; the sampling period consisted of one complete work shift of 8 hr. For both the area and personal samplers, a 37-mm Gelman Metrocel (nonhydroscopic) filter was used to collect a sample of total particulate on the filter. Filters were weighed twice, and the average reading was taken before and after sampling by using a Cahn Electro-Balance model 4100. The two measurements were subtracted to obtain the weight of the particulate, which was then expressed in milligrams/m^3 of air. Hair spray products used in each salon were listed, and, to further validate the measurement of concentration, cans of hair spray were weighed before and after the workday. The difference in can weights was correlated with the personal sampler particulate weights.

Survey facilities and procedures. A medical survey trailer provided with necessary equipment was usually parked within one block of each salon. The following five examination procedures took place in the order stated: (i) interview for respiratory symptoms employing the British Medical Research Council (BMRC) questionnaire, modified to include questions on allergies and aerosol spray use. A history of known asthma or the occurrence of wheezing after exposure to infection, pollens, dusts, and various chemicals was determined by the allergy questions. The same five trained interviewers were used throughout the study. The questionnaires were administered 2 weeks before the medical examinations in an area that afforded some privacy at the study subject's place of business. Although this required that the interviewers know whether the subject was experimental or a control, it was felt that the training of the interviewers minimized any bias that might result from this method. (2) Posterior−anterior (PA) and left-lateral chest X-rays; the chest films were obtained on all examinees except those who were pregnant (3.0% of cosmetologists and 1% of controls). A radiologist[4] (ILO U/C class C reader) interpreted all of the films without knowledge of the group in which the individual belonged. (iii) A forced expiratory spirogram maneuver was performed five times using an electronic spirometer, modified to include a panel of motivational lights, interfaced with a digital computer controller (22). From the best trial (largest vital capacity and smoothest, fastest expiratory flow), the following measurements were stored on tape: forced vital capacity (FVC), forced expiratory volume at one second (FEV$_1$), and forced expiratory flow rates at 50 and 75% of the FVC (FEF$_{25\%}$, etc.) and between 25 and 75% of the FVC (FEF$_{25-75\%}$). Results were calculated as percentage of predicted values according to the regression equations of Discher and Palmer (22). (iv) Measurements of closing volume (CV) and diffusing capacity of the lung (DL) were taken for every 10th person. The single-breath nitrogen method for measuring closing volume of the lung was used with three trials and hand measurement of the data (23). Total lung capacity (TLC) was measured from the PA and lateral chest X-rays by a planimetric method (24). This allowed the calculation of the residual volume which, when added to the CV, permitted calculation of the ratio of closing capacity (CC) to TLC. Predicted values for CV/VC and CC/TLC were those of Buist and Ross (25).

TABLE 2
GEOGRAPHIC DISTRIBUTION OF SAMPLE SIZES (SAMPLE = 1044)

Utah block	Cosmetologists				Students		All cosmetologists		Controls	
	Large salon	Small salon	Total	%	No.	%	No.	%	No.	%
I	35	14	49	23	53	20	102	21	32	6
II	74	21	95	45	141	50	236	50	471	80
III	18	7	25	11	27	10	52	11	0	0
IV	0	44	44	21	41	20	85	18	66	14
Total	127	86	213	100	262	100	475	100	569	100

Also, the slope of Phase III was measured as percentage nitrogen change per liter of expired volume (N_2/L). The DL was measured by the modified single-breath carbon monoxide method of Ogilvie et al. (26). Three measurements were made with a 3-min rest between each, and the average of the three was calculated and expressed as a percentage of a predicted value by employing the regression equations of Cotes (27). A value of <80% of predicted was considered abnormal. (v) Sputum specimens were obtained in all examinees older than 30 and in a systematized subsample of approximately 10% of those younger than 30. Samples were induced by inhalation of the vapor of a water–propylene glycol mixture. Sputum samples were stored in a solution of 50% alcohol in distilled water with a small amount of Carbowax added. All of the samples were interpreted "blind" as either normal or atypical by the same expert pathologist.[5]

RESULTS

Population Surveyed

The population surveyed consisted of 1044 subjects: 213 cosmetologists from 55 salons (4:1% of all salons in the state), 262 student cosmetologists from 9 schools, and 569 controls. They are enumerated according to hair spray exposure group and geographic location in Table 2. Comparison with Table 1 indicates that the distribution of the experimental groups was for the most part close to the preidentified sample. Although the sample of student cosmetologists in the Salt Lake City group (Block II) was somewhat less than projected, the 91% (141/155) response rate indicates the sample representativeness was not impaired. Likewise, the sample of cosmetologists in the Provo group (Block III) was less than its projected size (66% or 25/38). Comparison between respondents and nonrespondents in the experimental group showed no significant difference ($P > 0.05$) in age, years as a beautician, allergy history, or respiratory symptoms but did show a significant difference ($P < 0.05$) in smoking history. The impact of the nonrespondents having a greater smoking prevalence was to artifically diminish differences in respiratory findings that may have been present because of occupational exposures.

Nonresponse data for the control groups could not be calculated with the same

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TABLE 3
Mean Age and Smoking History by Block and Exposure Groups

Group	Mean age (years)	Nonsmokers (%)	Smokers (%)	Ex-smokers (%)
College	22.6	72.2	17.9	9.9
Large salons	31.9	70.1	18.9	11.0
Small salons	32.5	77.9	9.3	12.8
All cosmetologists	26.9	72.7	16.6	10.7
Controls	29.1	75.0	16.2	8.8
Block I control	23.8	59.4	28.1	12.5
Block I cosmetologists	27.1	71.6	14.7	13.7
Block II control	28.4	75.4	16.3	8.3
Block II cosmetologists	27.2	70.3	18.6	11.1
Block III control	—	—	—	—
Block III cosmetologists	25.3	94.3	1.9	3.8
Block IV control	37.1	80.3	9.1	10.6
Block IV cosmetologists	26.6	67.1	22.3	10.6

precision as for the experimental groups because of complexities encountered in obtaining control group participation. Businesses that cooperated in supplying employees for the control group only permitted certain departments or, as it turned out, portions of departments to participate because of pressing business reasons. Approximations were therefore made about the size of the available universe.

A review of Tables 2 and 3 shows that in the Ogden area (Block I) control groups, are underrepresented, average 3 years younger than beautician groups, ($P > 0.05$), and have more ex-smokers. Two groups were used as a source of control: students from a business college and clerks from a retail department store. Of the female students available during the survey, approximately 60% responded, whereas response rates from the retail clerks, who comprised about 40% of the preidentified control group, were low (probably less than 25%). The generally low response rate of retail clerks in all blocks may have resulted because they were required to be on the job at all times.

In the Salt Lake City area, the controls came from employees of the Mountain Bell Telephone Company in Salt Lake City with a response rate of 60%, and from the students and staff of a medical–dental assistant school with a response rate greater than 90%.

Because of the restricted time for this study, the control group from the Provo area was not included. Although this was unfortunate, certain considerations indicate that this in fact strengthened rather than detracted from some survey conclusions. For statistical analysis the control group for Block II has also been used for Block III. An examination of possible confounding variables that might result from this procedure revealed that the only possible bias that might distort the findings was associated with smoking history. Specifically, Table 3 shows that the experimental group in Block III smoked significantly less ($P < 0.05$) than that in Block II. This suggests that if the controls for Block III had also been drawn from that geographic area, a better smoking match would have been obtained.

Thus, this smoking difference reduces the sensitivity of the survey findings because smoking alone is known to increase symptom prevalence. The overall effect would be to decrease the differences in observed prevalence rates of respiratory symptomatology between experimental and control groups. This smoking difference between the Provo and Salt Lake City groups, however, did not obscure the findings because of the overwhelming increase of nonspecific respiratory disease in the Provo cosmetologists (79.0% vs 37.6% in Salt Lake City controls). Finally, Table 3 indicates a nonsignificant 3-year age difference between the beauticians in Provo and the controls in Salt Lake City.

The rural areas of Northeast and Southern Utah—Vernal, St. George, and Cedar City (Block IV)—provided one-third of the controls from each area; the controls were composed of retail clerks, telephone employees, and female workers from a tent and camping equipment manufacturing company. Again, except for retail clerks (about 20% of the projected control sample), participation rates approximated 60−70%. The older age of these controls ($P < 0.05$) suggests the presence of a volunteer bias whereby older, more health-conscious subjects reported for the examination and younger workers did not. Because chronic respiratory disease symptomatology and dysfunction are more frequently found in older people, this bias could increase control prevalence rates in this block and reduce the sensitivity of the survey findings.

Overall, the differences in age and smoking history between experimental and control groups would tend to bias the medical findings by artificially increasing the prevalence rate of symptomatology and functional abnormality in the control data, thereby obscuring small experimental increases in prevalence rates. Because the data (see below) unequivocally show increased symptomatology, sputum atypia, and trends in abnormal pulmonary function data, the bias tends to strengthen the findings. With a better control match, the differences might have been greater.

Prevalence of Thesaurosis or Sarcoidosis

Thesaurosis or sarcoidosis was considered to be possibly present on the basis of one or more of the following: a radiologic interpretation consistent with such a diagnosis, a reduced FVC, or a reduced DL. Table 4 indicates that, although there

TABLE 4

Abnormalities in Chest X-Ray and Pulmonary Function Consistent with a Diagnosis of Thesaurosis or Sarcoidosis

Abnormalities	Cosmetologists		Students		All cosmetologists		Controls		P
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	
1. X-ray	12	5.6	0	0	12	2.5	9	1.6	>0.05
2. Reduced FVC	1	0.5	3	1.1	4	0.9	7	1.2	>0.05
Total	13	6.1	3	1.1	16	3.4	16	2.8	
Sample size	213		262		475		569		
DL	6	16.2	4	10.5	10	13.3	5	11.4	
Sample size	37		38		75		44		

TABLE 5

PREVALENCE OF RESPIRATORY SYMPTOMS BY QUESTIONNAIRE, AGE AND SMOKING–BLOCK ADJUSTED (%)

Symptoms category	Age adjusted			Smoking–block adjusted		
	Cosmetologists	Control	$P*$	Cosmetologists	Control	$P*$
Borderline (B)	34.73	26.79		36.3	23.6	
Abnormal (A)	12.25	9.29		12.04	7.6	
Prescreened (PS)	9.66	12.42		7.96	12.3	
B + A	46.98	36.09	<.01	48.36	31.2	<0.001
B + A + PS	56.64	48.52	<.01	56.32	43.5	<0.001

* Mantel–Haenszel χ^2.

was a slight numerical increase in X-ray abnormalities and DL findings in cosmetologists, no significant differences ($P > 0.05$) were found. Neither was a relation noted between these findings and an allergic history, although allergic cosmetologists demonstrated slightly higher prevalence rates of the thesaurosis syndrome than their nonallergic peers (7.7:4.3%).

Prevalence of Respiratory Symptomatology by Questionnaire

A prior physician's diagnosis of heart disease, asthma, bronchitis, emphysema, or other "chronic lung conditions" (prescreen category) was not a cause for excluding a subject from further study, nor was a diagnosis of tuberculosis or fungal infection of the lung. Results were classified as "abnormal" for any one or more of the following four positive responses: (i) cough and sputum production at least 3 months/year for more than 2 years; (ii) more than 50 attacks of shortness of breath/year; (iii) dyspnea equal to or greater than that occurring when walking on level ground in comparison to persons of the same age; and (iv) wheezing on most days for as many as 3 months/year. The designation of "borderline" was given to those who responded positively in one or more of the following three areas: (i) chronic cough and sputum production of less than 3 months/year and less than 2-years' duration; (ii) a chest illness of 3 weeks or more duration or of 1-week disability with excessive sputum production in the previous 2 years; or (iii) breathlessness or wheezing of lesser degree than that required for designation as abnormal.

Table 5 shows that after both age and smoking/block adjustments,[6] the cosmetologists have an excess over controls in both borderline and abnormal categories of symptoms, and when these categories are combined, the differences are significant ($P < 0.01$). Note that there is a higher prevalence of controls than cosmetologists with prediagnosed respiratory disease, probably resulting from the well-known phenomenon of volunteers often participating in such studies because of some symptom concern. Nevertheless, despite this reverse bias, the differences between cosmetologists and controls remain significant when the prescreened are

[6] Due to the relocation of data files from the NIOSH Salt Lake City office to Cincinnati headquarters, distributions of data which would have permitted data to be age, smoking, and block adjusted as one function were lost. Remaining data only permitted such adjustments to be made separately.

TABLE 6
PREVALENCE OF RESPIRATORY SYMPTOMS BY QUESTIONNAIRE

Group	Mean age (years)	Nonsmokers (%)	Abnormal (%)[a]
Control	29.1	75.0	36.9
Large salons	31.9	70.1	46.4
Small salons	32.5	77.9	51.0
Colleges	22.6	72.2	45.1
P			<0.05

[a] Combination of borderline and abnormal symptom categories (see text). $P < 0.05$ for difference between salons and control. College vs control and large- vs small-salon differences not significant.

included with the borderline and abnormal categories. Not shown are the data indicating that most of the contributions to the respiratory symptom differences come from the nonsmoking subjects of Blocks II and III. Table 6 demonstrates that there are major differences between groups in prevalence rates for symptoms. The χ^2 is statistically significant between the groups ($P < 0.05$), indicating that the reporting of symptoms is dependent on group. The major contributions come from all three of the cosmetology groups. In other words, each cosmetology group demonstrates more respiratory symptomatology than the control group. Not shown in tabular form are the data indicating that the major differences in symptomatology prevalence rates between cosmetologists and control groups were attributable to those below the age of 39, whereas no significant differences were present for those 40 years or older. Also not shown was the expected finding of significantly more symptomatology in the smokers as compared to ex-smokers and nonsmokers ($P < 0.001$). Finally, both allergic cosmetologists and control subjects demonstrated a significant increase in symptom prevalence in comparison to their nonallergic counterparts.

Prevalence of Pulmonary Function Abnormalities

The results of spirometric measurements are shown in Table 7 as mean values for each exposure group. Because these data are expressed as percentage predicted, they incorporate age and height adjustment, the basis for the prediction

TABLE 7
MEAN FORCED EXPIRATORY VOLUME AND FLOW RATES BY EXPOSURE GROUPS (% PREDICTED)

Measurement[a]	Large salon	Small salon	Students	All cosmetologists	Control	P[b]
FVC	105.2[b]	110.9[b]	104.8	105.7	105.6	<0.05
FEV$_1$	102.9	106.8	103.2	103.6	103.6	
FEF$_{50\%}$	94.8[b]	90.6[b]	92.9	93.0	88.9	<0.05
FEF$_{25-75\%}$	94.7	92.7	94.8	94.5	93.0	
FEF$_{75\%}$	81.0[b]	73.3[b]	81.4[b]	80.3	77.6	<0.05

[a] FVC = forced vital capacity; FEV$_1$ = forced expiratory volume in 1 sec; FEF$_{50,75,25-75\%}$ = forced expiratory flow rate at 50, 75, and between 25 and 75% of FVC.
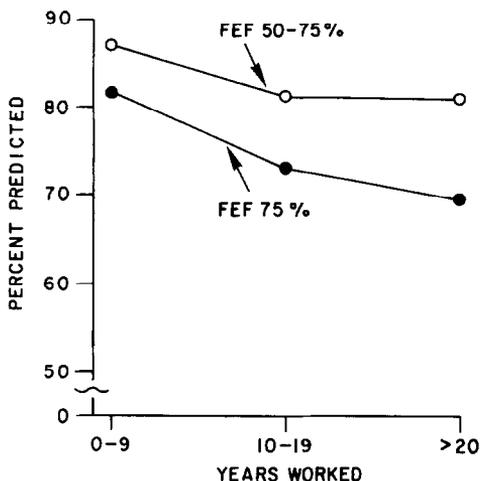[b] See text.

Fig. 1. Maximum expiratory flow rates (age and height adjusted) vs time of exposure at work in the cosmetology industry of 474 beauticians. $FEF_{50-75\%}$ = forced expiratory flow rate between 50 and 75% of the forced vital capacity. $FEF_{75\%}$ = forced expiratory flow rate at 75% of the forced vital capacity. Differences between all points for $FEF_{75\%}$ and between 0–9 and >20 years for $FEF_{50-75\%}$ were significant ($P < 0.05$).

regressions. The normal values for FVC and FEV_1 for all experimental groups indicate a lack of evidence for either restrictive or large-airway obstructive diseases. However, the significant reductions in $FEF_{50\%}$ and $FEF_{75\%}$, as revealed by use of multiple comparison tests, for the small-salon employees as compared to those in large salons and students, suggest some obstructive effect in the small airways. It should be noted that the small-salon employees had a significantly larger FVC than all other groups; this suggests that they represent a different population from the standpoint of lung size. Thus, it may be that were they comparable to the other groups, their reductions in forced expiratory flow rates may have differed more significantly than observed. Another finding of importance with respect to small-airway disease is illustrated in Fig. 1 in which the $FEF_{50-75\%}$ and $FEF_{75\%}$ data are expressed as percentage predicted and graphed for the salon employees according to years worked in the cosmetology industry. The only control data that exist for such observations are studies of normal populations at different ages, rather than the more desirable prospective study of a suitable control population. Nevertheless, the evidence of increasing degrees of obstruction with increasing time of exposure, as demonstrated by multiple regression analysis, is consistent with the possibility of a cumulative damaging effect on small airways.

As another measure for the presence of small-airway disease, the CV test, was given to a subsample of 114 study subjects of which 56 were from salons, 30 from colleges, and 28 from controls. Table 8 indicates that a trend toward a higher prevalence of abnormality among beauticians is evident in the measures calculated from this test. However, none of the differences are statistically significant by either the Student t test or a one-way analysis of variance.

TABLE 8

DISTRIBUTION OF ABNORMAL VALUES FOR CLOSING VOLUME, CLOSING CAPACITY, SLOPE OF
PHASE III, AND DIFFUSING CAPACITY AMONG EXPOSURE GROUPS IN A SUBSAMPLE OF CONTROLS
AND COSMETOLOGISTS (%)

Function test[a]	Salons	(N)	Colleges	(N)	All cosmetologists	(N)	Controls	(N)
CV/VC (1)	8.9	(56)	20.0	(30)	12.8	(86)	10.7	(28)
CC/TLC (2)	26.8	(56)	26.7	(30)	26.7	(86)	21.7	(28)
$\Delta N_2/L$ (3)	3.6	(55)	3.3	(31)	3.5	(86)	0.0	(27)
(1) + (2) + (3)[b]	39.3	(56)	50.0	(31)	43.0	(87)	28.6	(28)
DL	16.2	(37)	10.5	(38)	13.3	(75)	11.4	(44)

[a] CV/VC = Closing volume as a percentage of vital capacity; CC/TLC = closing capacity as a percentage of total lung capacity, $\Delta N_2/L$ = slope of Phase III as a percentage nitrogen per liter of expired volume. DL = diffusing capacity of lung.
[b] Abnormal for 1, 2, and 3 = 1.645 SEE, for D_L <80% of predicted.

Sputum Cytology

Although an approximately 50% subsample (526 subjects) of the study population was scheduled for sputum examination, Table 9 shows that technical problems and a 5.6% nonresponse rate among the controls resulted in 40% satisfactory specimens. For analysis, the results were divided into normal or atypical. The latter were defined as Class II and higher (i.e., mild and moderate atypical squamous metaplasia). No readings greater than Class II, Stage 2 (moderate atypia) were seen. The percentage of cosmetologists with atypia was significantly greater ($P <$ 0.05) than that for the controls. Table 9 also compares each cosmetology group with the control group; the χ^2 is statistically significant ($P < 0.05$), the major contribution coming from the small salon workers. This difference remained after block adjustment, although Blocks II and III had significantly higher prevalence of atypia than Blocks I and IV. Not shown is the fact that although a χ^2 test showed smoking history and sputum class to be independent in this population, neverthe-

TABLE 9

SPUTUM CLASSIFICATION ACCORDING TO EXPOSURE GROUPS[a]

Sputum class	Number of subjects				Control	Total
	Large salon	Small salon	Students	All cosmetologists		
Normal	23	19	49	91	194	285
Atypical	18	18	30	66	56	122
Unreadable	11	10	18	39	31	70
Destroyed	8	—	21	29	2	31
Nonresponse	—	—	1	1	17	18
Total	60	47	119	226	300	526
Atypical (%)	43.9[b]	48.6[b]	40.0[b]	42.0[b]	22.4	
Block adjusted (%)	—	—	—	41.8	21.7	
Mean age (years)	31.9	32.5	22.6	26.9	29.1	

[a] Calculated from satisfactory specimens only (i.e., normal and atypical).
[b] Differences between control group and each cosmetologist group significant ($P < 0.05$).

less the highest prevalence of abnormality was found to be in smokers (38.8%), followed by nonsmokers (29%) and by ex-smokers (22.5%). Also not shown is the fact that there was a significant ($P < 0.05$) association between the percentage of atypical cells and increasing prevalence of respiratory symptomatology. This effect was not evident in beauticians with a positive history for allergic disorders.

Aerosol Exposure and Medical Findings

Table 10 indicates that environmental concentrations of particulates, as measured by personal samplers, were significantly ($P < 0.05$) higher in the small salons than in the colleges. With the exception of Block IV, which was made up entirely of small salons, no differences in concentration were found among the other blocks. Also shown in Table 10 are the correlations between area and personal sample concentrations of particulates and medical findings. The only finding of significance was the correlation between respiratory symptomatology and personal sampler concentrations.

Of the 49 brands of hair spray encountered in the survey, 79% were dispensed from pressurized cans and the remaining 21% from a centralized bulk sprayer with an aerosol gun located at each work station. Particulate concentrations were significantly lower ($P < 0.05$) in salons that used bulk sprayers. Nineteen (38.8%) of the brands of aerosol were used by individuals who demonstrated abnormal respiratory findings. One brand in particular was used most frequently (29.9%) and this one, together with 16 others, was significantly ($P < 0.05$) associated with respiratory symptomatology. No associations were found between brands and sputum atypia or allergies.

By using a computed score (frequency of use combined with length of each

TABLE 10

MEAN ENVIRONMENTAL CONCENTRATIONS OF PARTICULATES BY EXPOSURE GROUP AND THEIR CORRELATION WITH RESPIRATORY PATHOLOGY

Respiratory pathology	Exposure group		Particulate concentrations (mg/m^3)	
			Personal sampler (SD)	Area sampler
	Small salons	(N = 39)	0.48 (0.23)*	—
	Large salons	(N = 52)	0.58 (0.29)*	—
	Colleges	(N = 69)	0.30 (0.15)*	—
Normal sputum cytology			0.37	0.16
Abnormal sputum cytology			0.40	0.16
CRD symptoms				
Normal			0.36**	0.15
Borderline			0.51**	0.15
Abnormal			0.48**	0.15
Prescreened			0.34	0.13

  * $P < 0.001$ colleges vs small salons and large salons.
 ** $P < 0.001$ normal vs borderline, normal vs abnormal.

exposure) it was found that cosmetologists used significantly more aerosol preparations at home (apart from hair spray) than did the control population. To determine if any associations existed between a particular group of aerosols and respiratory symptoms, a Pearson's r correlation coefficient analysis was performed. The significant correlations demonstrated are in Table 11. Most of the described symptoms and their association with aerosol sprays were prevalent among cosmetologists who either smoked or had previously smoked. When contrasted with the smoking controls, where associations were much smaller, the data suggest that those cosmetologists who are current or past smokers are more susceptible to reaction with aerosol sprays.

Chest X-Ray Findings

Suggested abnormal readings were delimited to 11 categories of gross cardiac, pulmonary, or pleural diseases. For the category of suspected pneumoconiosis, the ILO/UC classification was required (28). Overall categorization of abnormal versus normal was not significantly different between all cosmetologists and all control groups, nor were they among blocks, cosmetologist subgroups, and smoking categories.

DISCUSSION

Although one of the major aims of this study was to determine whether a group of subjects at high risk experienced an increased risk of a restrictive lung disease caused by hair spray exposure, the results do not provide an unequivocal answer. Employing the following three criteria, either singly or in combination—an abnormal chest X-ray pattern consistent with a diagnosis of thesaurosis or sarcoidosis, a reduced FVC, and a reduced DL—the survey showed no significant differences between the beautician and control groups. On the other hand, the salon employees with longer exposure and higher environmental concentration of

TABLE 11
CORRELATIONS AMONG SELECTED AEROSOLS, SMOKING HISTORY, AND RESPIRATORY SYMPTOMS

		All cosmetologists			Controls		
Aerosol type	Symptoms	Smoking history[a]	r	P	Smoking history	r	P
Hair spray	Phlegm	Sm	+0.80	<0.01	Sm	+0.30	<0.02
	Cough	Sm	+0.64	<0.01	Sm	+0.24	<0.055
Breath freshener	Phlegm	ExS	+0.64	<0.001	NS	+0.17	<0.001
Other beauty aerosols	Phlegm	ExS	+0.60	<0.01	NS	+0.13	0.004
	Chest illnesses	ExS	+0.60	<0.01	—	—	—
Deodorant	Cough	ExS	+0.60	<0.01	—	—	—
	Wheeze	—	—	—	NS	+0.01	0.039

[a] Sm = current smoker; ExS = ex-smoker; NS = nonsmoker.

hair spray particulates had a numerically higher prevalence of chest X-ray indicators than students and controls. Although none of the three criteria provide specificity for diagnosis, the chest X-ray probably comes closest to this goal. However, almost all (7/8) of the positive X-rays were classified in the 1/0 or 1/1 category (ILO/UC classification) of small density profusion, a category in which great interobserver variation has been demonstrated in standard film reading (29). This interpretation of the findings with regard to thesaurosis, although suggestive of a positive relationship with hair spray exposure of long duration, is not conclusive. These results indicate the need for a comprehensive medical examination of the suspect positive subjects.

The survey findings with respect to the prevalence of obstructive, in contrast to restrictive, lung disease are unequivocal. The clearest evidence for increased prevalence of respiratory abnormality was in the results of the respiratory questionnaire. Cosmetologists as a group showed a prevalence rate of abnormal and borderline respiratory symptoms 10% greater than that of the control group. The differences were not related to smoking because this variable was well controlled and not significantly different between experimental and control groups. The significance of the relationship between respiratory symptoms and hair spray exposure is strengthened by the trend that much of the increased prevalence was derived from the employees of small salons who demonstrated the lowest smoking rates and the highest environmental concentrations of hair spray particulates.

Further indications of a deleterious effect of exposure to hair spray on the airways of the lung can be found in the results of pulmonary function testing. Except for the expected effect of smoking in reducing function, tests of larger-airway function such as FEV_1 were not significantly different between cosmetologists and controls. However, tests that reflect predominantly small-airway function such as the $FEF_{75\%}$ significantly differentiated study groups. Like respiratory symptoms, the $FEF_{75\%}$ abnormalities were most prevalent in small-salon employees. This finding extends the observations of Zuskin and Bouhuys, who demonstrated from partial expiratory flow-volume curves that acute exposure to hair spray preparations resulted in flow-rate reductions as measured by $FEF_{25\%}$ and $FEF_{50\%}$ (30). These reductions were short lived (10−60 min) but may represent a parallel to the effect of cigarette smoke, which has a similar acute effect.

One noticeable difference between the two study findings was the anatomic site of the flow-rate reductions. This survey showed most flow depressions occurring at low lung volumes, i.e., at 75% of the vital capacity, whereas Zuskin and Bouhuys reported reduced airflows at 25 and 50% of the vital capacity (30). These differences would indicate that the site of increased airway resistance in cosmetologists was in the smaller airways (terminal), as opposed to the medial- and larger-airway changes seen in Zuskin's group. Presumably, changes of a similar magnitude would have been observed by Zuskin and Bouhuys if terminal airflow had been measured.

Repeated long-term exposure to hair spray as to cigarette smoke can apparently also result in chronic effects on small airways. Furthermore, as demonstrated in Fig. 1, when $FEF_{75\%}$ and $FEF_{50-75\%}$ are plotted against the number of years worked as a cosmetologist, they show continued reduction. An even stronger relationship between hair spray exposure and obstructive airway disease might

have been demonstrated if the graduate cosmetologists remained in the industry for longer periods. Because occupational histories demonstrated an average of only 4 to 6 years spent in the industry, there is the possibility of a beauticians' self-selection process by changing the nature of their employment, perhaps because of related symptoms. This observation is further supported by analyses of the questionnaire data that showed significantly more disease in those cosmetologists under the age of 40 years, compared to controls of the same age range.

One finding in this survey is of particular interest in regard to the relationship between air pollution and respiratory symptoms. Block III (Provo and suburbs) was found to have a significantly higher prevalence of symptoms, yet the population surveyed in this area was almost exclusively a nonsmoking one (94.3% nonsmokers and 3.8% ex-smokers). Moreover, in this block, the percentage of employees in small salons, with the highest environmental particulate concentrations, was only 28% as compared to 29, 22, and 100% for the other geographic areas. Thus, the finding cannot be attributed to greater hair spray exposure. Unfortunately, logistic considerations resulted in elimination of any contributions to the control population from this block and, therefore, firm conclusions cannot be drawn. However, an effect of air pollution is strongly suspected because this area has a large steel production plant close to the center of population and because prevailing winds expose the population to plant effluent for most of the year. Note that the high prevalence of respiratory symptoms in Block III cannot be responsible for the increased rates of symptoms and sputum abnormalities in all cosmetologists, because exclusion of this block from the analysis does not change the direction of the major cosmetology findings. Obviously, further epidemiologic studies are needed in this geographic area.

The increased prevalence of atypical cells in the sputum of cosmetologists, although not defining any known pathology, is nevertheless a finding of potentially great significance. It is particularly important to note that the grading scheme used to classify sputum cells encompasses a continuum from normality to abnormality. On an epidemiological basis, therefore, any finding of a shift toward abnormal should be considered an important early finding. The increased prevalence of sputum atypia in cosmetologists is related to respiratory symptomatology, to environmental particulate concentration (highest in small salons), and to time of exposure in the cosmetology industry. The trend toward an increase of sputum atypia in smokers is not unexpected and is consistent with findings reported by Frost *et al.* (31). Furthermore, this variable was well controlled for and was equivalent for the experimental and control groups. Because PVP, one of the components of hair spray, has been demonstrated to produce malignant tumors in animals (7) and because there is a suggestion of possible increased incidence of lung malignancy in cosmetologists (7, 20), the sputum findings in this survey indicate the need for further study of the potential of hair sprays to increase the risk of development of lung cancer in humans.

A history of allergic disorders was obtained in this survey to determine whether atopic subjects might be at greater risk of developing one or more of the adverse effects of hair spray exposure. Although the term "allergy" as used by the non-medically educated population undoubtedly has little specificity with regard to atopy, the use of trained interviewers for the administration of the BMRC ques-

tionnaire tends to minimize errors in this regard. Prevalence of findings related to thesaurosis or atypical sputum cytology did not show a significant relationship to a positive history of allergy in this study. However, both allergic cosmetologists and control subjects demonstrated an increase in respiratory symptom prevalence in comparison to their nonallergic counterparts. This would suggest that the atopic individual is not at a particularly increased risk from hair spray exposure.

ACKNOWLEDGMENTS

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