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Changes in the nasal mucosa of furniture workers

A pilot study

by Morten Boysen,¹ Lars A Solberg²

BOYSEN M, SOLBERG LA. Changes in the nasal mucosa of furniture workers: A pilot study. *Scand j work environ health* 8 (1982) 273-282. Nasal carcinoma, particularly adenocarcinoma, is associated with the furniture industry. The present study was carried out in order to evaluate whether precancerous lesions could be detected in the nasal mucosa of furniture workers. Histological examination of nasal biopsies from 113 workers (103 active and 10 retired) and 54 referents was performed. The histological sections were evaluated blindly according to a numerical classification scale, and the results were compared, by means of multiple regression analysis, to age, type and duration of exposure to wood dust, smoking habits, nasal allergy, and rhinoscopic findings. Nasal stenosis and mechanical wood preparation were significantly related to the histological findings by the partial correlation coefficients. Fourteen cases (12 %) of dysplasia were found among the furniture workers, preferentially among those performing mechanical wood preparation, and among the referents there was one (2 %). The evaluation of the importance of exposure to dust of individual types of wood was not possible. Nasal epithelial dysplasia should probably be interpreted as a preneoplastic lesion and may be of significance in the pathogenesis of nasal adenocarcinoma. Standard nasal biopsies appear to be valuable in identifying groups of persons with an increased incidence of nasal carcinoma.

Key terms: dysplasia, metaplasia, multivariate analysis, rhinoscopy.

The high frequency of nasal carcinomas among employees in the furniture industry was first noted by Macbeth in 1965 (24). His findings have been confirmed in studies in Great Britain, Denmark, Belgium, The Netherlands, France, Sweden, Australia, and East Germany (1, 2, 4, 9, 10, 13, 15, 21, 23). In Norway there are several furniture factories located in the western part of the country. Preliminary statistical analysis suggests a somewhat increased incidence of nasal carcinoma, in particular adenocarcinoma, in some of the municipa-

lities where these factories are located (personal communication from the Cancer Registry of Norway). These findings possibly reflect an increased incidence of nasal malignancies among workers in the Norwegian furniture industry.

Nasal epithelial dysplasia, which probably represents a precancerous lesion, has been described in nickel workers, an occupational group with an increased incidence of nasal carcinoma (31, 32), but little is known about the pathogenesis of malignant tumors in workers in the furniture industry. The present study was undertaken to evaluate the occurrence of histopathological changes and the possible presence of precancerous lesions in the nasal mucosa of furniture workers. The histological findings have been correlated with the occupational history, type and duration of exposure to various types of

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wood dust, age, smoking habits, nasal complaints, and rhinoscopic findings. Moreover, we wanted to study the significance of rhinoscopic examination and subjective nasal complaints.

Material and methods

Five long-established furniture factories in the western part of Norway, each employing more than 30 workers, were chosen for this study. These factories employ a stable force of approximately 300 workers.

The raw material used in these factories has changed considerably throughout the years. Before the 1950s the raw materials were mainly solid birch, beech, oak, pine, and mahogany. After the 1950s solid teak and chipboard made from pine and spruce and veneered with teak and mahogany came into use. In the 1960s teak and mahogany were to a great extent replaced by bibo, rhamin, and koto. During the last 10–15 a these latter imported woods, together with hard woods like oak and beech and soft woods such as pine and spruce, have been the main materials.

Industrial furniture production is complex and the processes vary according to the type of product. After being cut, the wood is dried. The material used is either solid wood or a veneered product. The veneering is achieved through the glueing of thin sheets of wood to plywood or chipboard brought in from other factories. The mechanical processing of these materials includes planing, sanding, grinding, milling, and tenoning. These processes are generally associated with a high degree of exposure to wood dust. The pieces are then stained and varnished before assembly.

Furniture workers

All workers who had been employed for more than 16 a in the furniture industry were requested to participate in the study. One hundred and three active and ten retired workers, about 60 % of those with sufficient length of employment, volunteered for the examination. Accordingly, this material was not randomized. The mean age of the examined group was 56 (range 32–81) a with an average length of employment of 35 (range 16–57) a (table 1).

Referents

The reference group comprised 54 age-matched volunteers. Twenty-four were selected from the office staff of two chemical industries, 12 from outpatients seeking medical advice at the Ear, Nose and Throat Department, Rikshospitalet, Oslo, because of hardness of hearing, and 18 from the laboratory personnel at The Norwegian Radium Hospital, Oslo. None of the referents had overt nasal disease or occupations with any known relation to nasal carcinoma.

Collection of samples

After the application of local anesthesia (tetracaine 2 %/adrenaline 0.1 %) to the mucosal surface for approximately 10 min, biopsies were taken from the anterior curvature of the middle turbinate from the nasal cavity judged to have the best air flow. The specimens were fixed in 6 % buffered formaldehyde (pH 7.4), dehydrated, embedded in paraffin, sectioned, and stained with hematoxylin and eosin by routine methods.

Table 1. Mean age and number of years from first occupational exposure to wood dust.

	Number	Age (a)		Years employed (a)	
		Mean	Range	Mean	Range
All furniture workers	113	56	32–81	35	16–57
Active furniture workers	103	48	32–69	34	16–57
Retired furniture workers	10	72	68–81	44	28–57
Referents	54	51	35–79	—	—

Collection of relevant information

All the exposed workers and the referents gave detailed information on a questionnaire concerning their occupational history. Smoking habits and previous nasal complaints such as recurrent nasal bleeding, nasal obstruction, recurrent sinusitis, and nasal allergy were recorded. Persons who had stopped smoking less than 1 a prior to the investigation were recorded as smokers. The diagnosis of nasal allergy was based on a history of periodic nasal obstruction, sneezing, thin nasal discharge, and itching. The furniture workers were asked to list the principal types of woods to which they had been exposed, the duration of employment, and the type of work they had performed. In addition to this information about individuals, inquiries were also made in order to trace nasal cancer among former employees of the furniture factories studied.

Rhinoscopic examination

A rhinoscopic examination was made by means of a head lamp and nasal speculum before the personal and occupational data were collected. Each person was given a score according to the following characteristics (30): no abnormalities: 0; hyperplastic rhinitis and diffuse swelling of the turbinates, particularly the middle one, still present after the application of local anesthesia: 1; polypoid surface with or without single or multiple polyps: 2.

The rhinoscopic examination, the evaluation of the rhinoscopic findings, and the selection of the appropriate anatomic region for the sampling of specimens were based on the examiner's (MB) previous training and experience.

Histological examination

Both authors examined the histological sections independently and without consulting clinical or occupational information. The histological grading and scoring were based on the concept of gradual epithelial transformation of pseudostratified epithelium to metaplastic squamous epithelium and dysplasia (31, 32).

The different types of epithelia are presented in fig 1–5 (on the next page), and the scores given to each type of epithelium

can be found in table 2. Disagreements in the grading were discussed, and a final consensus obtained. Specimens presenting more than one type of epithelium were graded according to the highest score.

Statistical methods

In an attempt to explain the histological scores (Y) from 0 to 5 by means of independent variables (X_1 – X_{10}), we used an ordinary linear multiple regression analysis. This particular statistical procedure was chosen because the method has been used in similar investigations (31, 32) and because a computer program was available. The following model equation was applied:

$$Y = a + B_1X_1 + B_2X_2 \dots + B_{10}X_{10}$$

where a is a constant; B_1 – B_{10} are regression coefficients; X_1 is individual age; X_2 is the number of years from first employment; X_3 is mechanical processing (1 if yes, otherwise 0); X_4 is other processes (1 if yes, otherwise 0); X_5 is tobacco smoking (1 if yes, otherwise 0); X_6 is nasal stenosis (1 if yes, otherwise 0); X_7 is nasal allergy (1 if yes, otherwise 0); X_8 is rhinoscopic findings (0 = normal, 1 = hyperplastic rhinitis, 2 = polyps); X_9 is exposure to soft woods (pine, spruce) (1 if yes, otherwise 0); and X_{10} is exposure to hard woods (beech, oak, teak, mahogany, birch) (1 if yes, otherwise 0).

The explanatory values of each of the independent variables were tested by a stepwise multiple-regression analysis, estimating the regression coefficients (B_1 – B_{10}) and the simple and partial correlation

Table 2. Types of nasal epithelia and histological score. (See also fig 1–5.)

Types of nasal epithelia	Histological score
Pseudostratified columnar epithelium	0
Stratified cuboidal epithelium	1
Mixed stratified cuboidal/stratified squamous epithelium	2
Stratified squamous epithelium, nonkeratinizing	3
Stratified squamous epithelium, keratinizing	4
Dysplasia	5

Fig 1. Pseudostratified epithelium with ciliated and goblet cells.

Fig 2. Stratified cuboidal epithelium composed of cuboidal cells and lacking ciliated cells.

Fig 3. Mixed stratified cuboidal/stratified squamous epithelium with a thin layer of squamous cells covering stratified cuboidal cells.

Fig 4. Partly stratified squamous epithelium with several layers of squamous cells overlying cells with distinct cell borders.

Fig. 5. Dysplasia of the nasal mucosa with cellular and nuclear pleomorphism and partial loss of polarity.

Table 3. Distribution of the histological score of the furniture workers and the referents.

	Number	Histological score						Mean
		0	1	2	3	4	5	
All furniture workers	113	13	20	21	37	8	14	2.4
Active furniture workers	103	13	19	17	35	7	12	2.4
Retired furniture workers	10	0	1	4	2	1	2	2.9
Referents	54	11	15	18	9	0	1	1.5

coefficients between the histological score (Y) and each of the independent variables ($X_1 - X_{10}$). The significances of the correlation coefficients and the differences between the histological scores of the furniture workers and the referents were tested by Student's t-test. The differences in the rhinoscopic findings and the subjective complaints were tested by the chi-square test.

Results

During the last 15 a three cases of nasal adenocarcinoma have been encountered among workers in the five factories from which this material was collected. Based on these occurrences, a rough estimation gives an annual incidence of 0.6 cases of nasal carcinoma per 1,000 furniture workers.

Table 3 presents the results of the histological grading and the mean histological score. Forty-five of the furniture workers (40 %) showed metaplastic squamous epithelium compared to only nine of the referents (17 %). Dysplasia was found exclusively in squamous epithelium and observed in 14 of the furniture workers (12 %) and in one of the referents (2 %), a 45-year-old clerk. The mean histological score of the furniture workers was 2.4 in comparison to the 1.5 of the referents ($p < 0.05$). No case of carcinoma was detected among the workers studied.

Histology and age

Table 4 presents the histological score of three major age groups. For both the furniture workers and the referents the mean histological score was somewhat higher for persons over 50 than those under 50 a of age ($p > 0.05$).

Table 4. Distribution of average histological score of the furniture workers and referents according to age group.

	Age group (a)		
	≤50	51-60	≥61
All furniture workers	2.1	2.5	2.5
Active furniture workers	2.1	2.5	2.4
Retired furniture workers	—	—	2.9
Referents	1.5	1.3	2.0

Table 5. Average histological score of the furniture workers in relation to duration of employment.

	Employment (a)		
	≤25	26-35	≥36
All furniture workers	2.2	2.1	2.6
Active furniture workers	2.2	2.1	2.6
Retired furniture workers	—	2.7	3.0

Histological changes and duration of employment

The mean histological score was the highest for biopsies from furniture workers with the longest duration of employment ($p > 0.05$) (table 5).

Histological changes and smoking habits

The mean histological score was somewhat higher for smokers than for non-smokers among both the furniture workers and the referents ($p > 0.05$) (table 6). Dysplasia was found in two of the 43 furniture workers who were smokers (5 %) and in five of the 38 workers who had never smoked (13 %). Seven cases of dysplasia were observed among 32 workers who had stopped smoking more than 1 a prior to the investigation. None of the workers or referents took snuff.

Table 6. Average histological score of the furniture workers and the referents in relation to smoking habits.

	Never smoked		Former smokers		Smokers	
	Number of workers	Mean score	Number of workers	Mean score	Number of workers	Mean score
All furniture workers	38	2.1	32	2.2	43	2.7
Active furniture workers	33	2.3	30	2.3	40	2.6
Retired furniture workers	5	3.4	2	1.5	3	2.7
Referents	34	2.1	13	2.4	17	2.6

Table 7. Rhinoscopic findings in the furniture workers and the referents.

	Rhinoscopic findings					
	Normal		Hyperplastic rhinitis		Polypoid mucosa polyps	
	N	%	N	%	N	%
All furniture workers	73	65	37*	33	3	3
Active furniture workers	71	69	30	29	2	2
Retired furniture workers	2	20	7	70	1	10
Referents	48	88	5	9	1	2

* $p < 0.05$

Table 8. Frequency of nasal complaints among the workers occupationally exposed to wood dust and among the referents.

	Subjective complaints									
	Persons with complaints		Recurrent epistaxis		Obstruction		Allergy		Recurrent sinusitis	
	N	%	N	%	N	%	N	%	N	%
All furniture workers (N = 113)	35	31	3	3	9*	8	23	20	3	3
Active furniture workers (N = 103)	31	30	3	3	8	8	20	19	3	3
Retired furniture workers (N = 10)	4	40	0	—	1	10	3	30	0	—
Referents (N = 54)	6	11	0	—	1	2	5	10	0	—

* $p < 0.05$.

Table 9. Simple and partial correlation coefficients between the histological score (Y) and tested variables (X_1 – X_{10}).

	Simple	Partial
Age in years (X_1)	0.20335*	0.09927
Years from first employment (X_2)	0.31190**	0.02382
Mechanical processes (X_3)	0.30880**	0.16687*
Other processes (X_4)	0.09960	0.07398
Tobacco smoking (X_5)	0.12431	0.03675
Nasal stenosis (X_6)	-0.21651*	-0.27931**
Nasal allergy (X_7)	0.01050	0.04443
Rhinoscopic findings (X_8)	0.09280	0.08976
Soft woods (X_9)	0.26399**	0.06501
Hard woods (X_{10})	0.23826*	0.07689

* $p < 0.05$, ** $p < 0.01$

Relation between histological changes, type of work and exposure to different types of wood

With few exceptions the workers had participated in many steps in the production process. All except 15 had performed mechanical wood preparation for long periods. These 15 workers were upholsterers, lacquerers, and assemblers. Dysplasia was only seen in machinists, with one exception, a lacquerer. Epithelial dysplasia

was present in 4 of 15 furniture workers who had been working mainly with birch and soft woods like spruce and pine. Among the 84 workers mainly exposed to dust from hard woods, like oak, teak and mahogany, nine cases of dysplasia were found.

Histological changes and rhinoscopic findings

Thirty-seven (33 %) of the furniture workers and five (9 %) of the referents showed hyperplastic rhinitis, mainly located in the middle turbinate ($p < 0.05$). Three (13 %) of the furniture workers and one (2 %) of the referents had a polypoid nasal mucosa (table 7). Of the 14 cases with epithelial dysplasia, six showed swelling of the nasal mucosa, and the remaining eight had a normal rhinoscopic appearance.

Nasal complaints and histological score

The predominant complaints were nasal stenosis and allergy. Nine furniture workers (8 %) complained of nasal stenosis, but only one (1.9 %) of the referents ($p < 0.05$). Five of the furniture workers had pronounced hyperplastic rhinitis. In the rest the nasal stenosis was related to deviation of the nasal septum. The mean histological score for the workers with nasal stenosis was 1.0 in comparison to 2.5 for those without.

Twenty-three (20 %) of the workers and five (9 %) of the referents presented a history consistent with nasal allergy ($p > 0.05$) (table 8). Mahogany and teak appeared to be the most frequent allergens, but all types of wood were mentioned.

Multiple regression analysis

Table 9 presents the simple and partial correlation coefficients between the histological score and each of the independent variables. Whereas the simple correlation between the histological score and age, years from first exposure, and exposure to soft woods and hard woods was statistically significant, the partial correlation was not. This result was probably due to a strong interrelation between the remaining variables. Mechanical processing and nasal stenosis was significantly re-

lated to the histological score by both the simple and partial correlation. For other processes, tobacco smoking, nasal allergy, and rhinoscopic findings no statistically significant relation was found. In the stepwise multiple regression analysis the number of years from first employment and nasal stenosis contributed significantly to the variability in the histological findings. After the rejection of the remaining variables, the following final equation was calculated:

$$Y = 1.60 + 0.026X_2 - 1.51X_6$$

The multiple correlation coefficient between the histological score and the variables included in the final equation (X_2 and X_6) was 0.40 ($p < 0.001$), which means that these variables can explain 16 % of the variation in the histological score. The partial correlation coefficients between Y and X_2 and Y and X_6 in the final equation were 0.34 and -0.26, respectively (both < 0.01).

We are aware of the fact that a question may be raised of whether Y is normally distributed, whether a linear function of the variables exists, and whether several variables may be interrelated. Therefore the statistical analysis should be interpreted only as a possible explanation of the histological findings, and statements concerning significances should be considered with reservation.

Discussion

Workers in the furniture industry have a markedly increased risk of nasal adenocarcinoma (1, 4, 15, 23) and a smaller, but still significant, risk of squamous cell carcinoma (20). The time from first employment to clinical diagnosis (the latency period) has been reported to range from 27 to more than 50 a, with a mean of 41 a (4). The average annual incidence rate of nasal carcinoma in furniture workers in Great Britain and Denmark is estimated to be 0.5 and 0.7 per 1,000, respectively (1, 4). The exact incidence of nasal cancer in Norwegian furniture workers is not known, but a rough estimate based on inquiries made as part of this study suggest that the incidence may be of a corresponding magnitude. Andersen et al (4) have calculated

that carcinoma of the nasal cavity will develop in 2.5 % of the employees within 50 a of commencement of work in the furniture industry. The risk is obviously relatively small compared to that of nickel workers (3, 26), but as a health problem nasal carcinoma among furniture workers is more marked owing to the greater number of workers.

Most authors consider the ethmoid region to be the preferential site of origin of nasal carcinoma in furniture workers (1, 16, 18). However, Hadfield (17) has presented evidence favoring the anterior part of the middle nasal turbinate as the preferential site of origin. Corresponding observations have also been made from nickel workers (31, 34). Because the ethmoid region may be involved early in the course of the disease, it is at present difficult to decide which of the two sites predominates.

Searching for a method for early detection of ethmoid carcinoma, Drettner & Stenkvist (11) sampled material for cytological examination from the middle nasal meatus. Their study on more than 700 wood workers revealed no case of carcinoma nor precancerous lesions. Only 2 % of the specimens showed cells consistent with epithelial metaplasia. These results contrast with our finding of 40 % metaplastic squamous epithelium and 12 % dysplasia. Biopsies from the anterior part of the middle nasal turbinate thus seem more suitable for the detection of epithelial alterations in furniture workers than cytological smears from the middle nasal meatus. Theoretically, this area, which is the region most heavily exposed to inhaled dust (17), is the most appropriate for studying occupationally induced mucosal changes.

In our study, the mean histological score was significantly higher for the furniture workers than for the referents and of the same magnitude as for active nickel workers (7, 8). This higher score is explained mainly by more pronounced metaplastic alterations in the furniture workers, although dysplasia is also of some significance. The metaplastic alterations are generally considered as nonspecific, possibly induced by age (6) and extrinsic factors such as temperature, humidity, dust, and infections (25, 32), but also by carcinogens. On the other hand, the dysplastic epithelial alterations probably result only from the in-

fluence of carcinogenic substances (32).

The finding of 12 % dysplasia is probably an underestimation because of the relatively small size of the biopsies and the multifocal appearance of epithelial dysplasia (6). The results of follow-up studies on nickel workers suggest that the real prevalence of dysplasia is at least twice the frequency detected in single studies (7).

In nickel workers, dysplasia was exclusively found within metaplastic squamous alterations (6, 31). In this context the observation of mucus granules in metaplastic nasal epithelium is of interest (5, 6). This finding implies that the basal or reserve cells have the potential to differentiate into both secretory and squamous cells. From corresponding findings in tracheobronchial epithelium (33) and nasal epithelium of the rat (22) it has been hypothesized that the basal or reserve cells of atypical epithelia may give rise to both adeno and squamous cell carcinoma. In the same way, squamous cell dysplasia of the nasal mucosa may be of significance not only in the pathogenesis of squamous cell carcinoma in nickel workers, but also in adenocarcinoma in employees of the furniture industry.

Several other observations suggest that dysplasia represents preneoplastic epithelial alterations. Dysplasia has almost exclusively been found in occupational groups with an increased risk of nasal carcinomas (7, 8, 31, 32). We have observed the development of nasal carcinoma in a retired nickel worker who previously had dysplasia of the same nasal cavity (Boysen et al, unpublished results). There is also a close resemblance between the surface features of dysplasia and carcinoma (6). These observations, and the biological behavior of similar changes in other organs, for example the cervix uteri, favor the concept of nasal dysplasia being a precancerous lesion.

With one exception, dysplasia was seen in workers performing the mechanical processing of wood. This process is connected with heavy exposure to wood dust, apparently the main factor in the pathogenesis of nasal malignancies in furniture workers (20). However, a great number of chemicals are used in the furniture industry, and formaldehyde, for example, an ingredient in the manufacture of chip-

board, has been shown to be carcinogenic in experimental animals (29).

Hard woods like beech, oak, and mahogany are reported to be the main types of wood associated with nasal carcinoma (20). Only one study exists suggesting an association with the handling of soft woods like spruce and pine (14). All the furniture workers in our study had been exposed to dust from several types of wood, and we are therefore unable to elucidate the importance of specific types. As no systematic measurements of wood dust concentrations have been made at the places of work, we are unable to give exact estimates of the present and previous levels of wood dust exposure.

A surprising finding was that the workers with nasal stenosis had a lower mean histological score than those with open nasal cavities. A possible explanation is that the influence of inhaled substances is reduced when nasal respiration is impaired. This finding is in accordance with experimental surgical closure of one nostril in animals (19).

Upper respiratory tract infections (27), asthma (28), and nasal allergy (12) are common complaints among furniture workers. In the present study 20% of the workers reported complaints consistent with nasal allergy related to exposure to dust from various types of wood, mainly from exotic types. This frequency may well be underestimated, since workers with more serious complaints have probably changed occupations.

Several studies have shown that active and retired nickel workers have a high frequency of epithelial dysplasia (7, 8, 31, 32). The present finding of dysplasia in another occupational group with an increased incidence of nasal cancer suggests that dysplasia determination may be used more universally in the study of groups with known or suspected occupational risk of nasal malignancies.

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