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Occupational dust or gas exposure and prevalences of respiratory symptoms and asthma in a general population

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ABSTRACT: The relationship of occupational airborne exposure to respiratory symptoms and asthma was examined using a self-administered questionnaire in a cross-sectional survey of a random sample (n=4,992 subjects) of the general population aged 15–70 yrs of Hordaland county, Norway. The response rate was 90%. Twenty nine percent of the population had a history of occupational dust or gas exposure, 5% reported having been exposed to asbestos at work, and 4% reported quartz exposure. A history of occupational dust or gas exposure was associated with morning cough, chronic cough, phlegm when coughing, breathlessness on exercise, occasional wheezing and a physician's diagnosis of asthma after adjusting for sex, age, smoking habits and urban-rural area of residence. The adjusted relative odds ratios for the respiratory disorders in subjects exposed to dust or gas ranged from 1.6–1.9. The population attributable risk of occupational dust or gas exposure for the respiratory disorders ranged from 11–19%. The study indicates that respiratory disorders are independently associated with occupational airborne exposure in a Norwegian general population sample.

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Longitudinal studies of occupational groups have revealed a causal relationship between occupational exposure to both organic and inorganic dust and gas, and the prevalences of obstructive lung disease [1, 2]. Investigations of industrial populations may be biased by the selection of healthy subjects to employment and the remaining of healthy subjects in the industry. Examining the effects of occupational exposure in the general population, where subjects may be studied regardless of their present occupational status, reduces the health selection effect [3]. Few community surveys have focused on the relationship between occupational exposure to airborne pollutants at work and lung disorders.

In a general population study in Arizona of 1,195 men over 18 yrs of age, subjects exposed to silica, smoke and car exhaust fumes had higher age and smoking adjusted rates of respiratory symptoms than unexposed subjects [4]. A more recent population survey of 8,515 individuals aged 25–74 yrs residing in six US cities, showed that occupational exposure to dust, gas and fumes was associated with higher prevalences of respiratory symptoms and chronic obstructive lung disease [5]. In North Italy a community study of 3,289 individuals aged 18 yrs and over observed higher prevalences of respiratory symptoms in subjects exposed to dusts, fumes or chemicals than in unexposed subjects [6]. Limited population based information is available from Scandinavia on the relationship between occupational dust or gas exposure and the occurrence of respiratory symptoms.

The objectives of the present study were to examine the relationship of occupational dust or gas exposure to the prevalences of respiratory symptoms and a physician's diagnosis of asthma in a general population sample. Furthermore, we assessed the proportion of the respiratory symptom load in the community that can be attributed to occupational dust or gas exposure.

Subjects and methods

A 1.8% random sample of 4,992 persons was drawn from the general population aged 15–70 yrs of Hordaland county located on the south west coast of Norway. Bergen is the only urban municipality, with about half the population of the county. From September to December 1985 a self-administered questionnaire was sent to the persons included in the sample. The response rate was 90% of the sample after two reminder letters.

The questionnaire sought information on respiratory symptoms and asthma, smoking habits and occupational exposure to dust or gas including asbestos and quartz. The wording of the questions on respiratory symptoms were: 1) Do you usually cough or clear your throat in the morning?; 2) Do you have cough for three months or more altogether during a year?; 3) Do you have phlegm when coughing?; 4) Are you breathless when you climb two flights of stairs at an ordinary pace?; 5) Do you ever have wheezing in your chest? The preprinted answers were yes and no. Asthmatics were defined as those answering positively to the question: Have you ever been treated by a physician or in hospital for asthma? The wording of the questions on occupational exposures were: 1) Have you ever had a working place with much dust or gas in the air?; 2) Have you ever been exposed to asbestos dust in your work?; 3) How many years altogether have you had a job in which you have worked with asbestos?; 4) To what extent would you say that you have been exposed to asbestos: light, moderate or heavy?; 5) Have you ever been exposed to quartz dust or stone dust with quartz at work? If yes, please state how many years you have been exposed to such dust at work? Only past or present employees and self-employers were asked to answer the occupational exposure questions.

Subjects were classified as nonsmokers if they had never smoked daily [7]. Ex-smokers were those who had been smoking daily and given it up prior to the survey. Smokers were those who smoked daily at the time of the study. The questionnaire information on respiratory symptoms has previously been validated against forced expiratory volume in one second (FEV_1) in a Norwegian population sample [8]. Subjects with respiratory symptoms had a greater extent of airflow limitation than subjects without symptoms, the difference being greatest for breathlessness and wheezing and smallest for morning cough and chronic cough. Previous surveys have also validated the questions on smoking habits [9] and asbestos exposure [10].

Prevalences of respiratory symptoms were calculated for subjects with and without occupational airborne exposures after adjusting for sex, age and smoking habits using the direct method [11]. Each respiratory symptom was used as a dependent variable in a backwards stepwise logistic regression analysis [12]. Sex, age, smoking habits, urban-rural area of residence and a history of occupational dust or gas exposure were used as independent variables. Occupational dust or gas exposure was used as a dichotomous variable as well as a variable for categorization divided into asbestos exposure, quartz exposure and exposure to other dusts or gases. Additional logistic regression analyses were applied to examine the association of duration and degree of asbestos and quartz exposure to the prevalence of respiratory symptoms and to examine the interaction between sex and dust or gas exposure. Each analysis started with all the independent variables within the model. To preserve an overall low risk for for type 1 error, the enter and exit levels were set at p=0.01. Only significant variables were kept in the final models.

The population attributable risk was estimated by summing the attributable cases, as derived from the strata in the final logistic regression model, divided by the total number of cases in the population sample [13].

Results

The overall lifetime prevalence of occupational exposure to dust or gas in the population was 29% (table 1). In men 46% and in women 12% had a history of past or present occupational exposure to dust or gas. The mean age of the sample was 41 yrs and did not differ between the exposed and unexposed individuals. Higher percentages of smokers and ex-smokers reported occupational airborne exposures than did nonsmokers. Exposure to quartz and dust or gas other than asbestos or quartz were more often noted in rural than in urban areas, while asbestos exposure did not vary with area of residence. Of those exposed to asbestos, 5% had been exposed more than 25 yrs and 30% had been exposed 5–24 yrs. Quartz exposure more than 25 yrs was noted in 10% of those exposed and 40% had been exposed for 5–24 yrs.

Prevalences of the respiratory symptoms adjusted by sex, age and smoking habits were higher in subjects with a history of occupational dust or gas exposure (table 2, column 4) than in those with no exposure (table 2, column 5), with a 46–66% excess among the exposed. The adjusted rates of asthma were twice as common in the dust or gas exposed subjects compared to the unexposed. The adjusted prevalences of respiratory symptoms and asthma did not vary significantly among the occupational exposure groups. Neither did the symptom rates differ significantly between those reporting no occupational exposure and those not answering the question, except for chronic cough and wheezing that was more often ($p<0.05$) reported by the latter (table 2).

All symptoms except breathlessness were more frequent in men than in women. Breathlessness was more common in women than in men. After controlling for age, smoking habits, urban-rural area of residence and occupational dust or gas exposure, only breathlessness still showed sex-difference in prevalence. The adjusted odds ratio for breathlessness in women was 2.0 (95% confidence interval 1.5–2.4) compared to men. In the logistic regression analyses age was related to morning cough and breathlessness, the adjusted odds ratios of both symptoms increased with ageing. In the logistic regression analyses smoking habits were significantly related to all the symptoms studied, but not to asthma. The adjusted relative odds ratios for respiratory symptoms increased with increasing cigarette consumption. The odds ratios for symptoms in smokers of 10–19 cigarettes per day ranged from 2.8–6.0 being lowest for phlegm when coughing and highest for wheezing. Area of residence had an influence on chronic cough in the logistic regression analysis. The adjusted odds ratio for chronic cough in urban residents was 1.4 (95% confidence interval 1.2–1.8) compared to rural residents.

Table 1. – Lifetime prevalences of airborne occupational exposure in the population aged 15–70 yrs of the county of Hordaland, Norway 1985 (n=4,469)

Variable	Number of subjects	Asbestos*	Quartz*	Gas or dust exposure other than asbestos or quartz	No exposure	No answer
		%	%	%	%	%
Sex						
Men	2220	10.0	8.4	29.3	46.1	8.2
Women	2249	0.4	0.4	11.1	67.3	20.8
Age						
15–29 yrs	1496	3.7	2.3	21.9	51.7	19.7
30–49 yrs	1647	4.6	3.9	21.4	63.0	6.0
50–70 yrs	1326	4.1	3.9	16.7	54.8	19.5
Smoking habits**						
Nonsmokers	1819	3.9	2.5	14.6	59.5	20.1
Ex-smokers	882	5.3	5.3	26.3	54.3	10.2
Smokers	1724	6.4	5.8	23.4	55.4	10.0
Area of residence						
Urban	2343	5.0	3.4	19.6	59.2	13.6
Rural	2126	5.4	5.5	20.7	54.0	15.6
Total	4469	5.2	4.4	20.2	56.7	14.5

*: 46 subjects reported exposure to both asbestos and quartz and are included in both columns; **: 44 subjects with unknown smoking habits are excluded.

Table 2. – Sex, age and smoking adjusted prevalences of respiratory symptoms by various airborne occupational exposures in the general population of Hordaland county, Norway 1985 (n=4,469)

	Asbestos	Quartz	Dust or gas other than asbestos or quartz	Dust or gas	No exposure	No answer
n	(232*)	(196*)	(901)	(1,283)	(2,536)	(650)
	%	%	%	%	%	%
Morning cough	19.1	17.1	26.4	26.0	17.7	17.2
Chronic cough	14.2	11.8	13.1	11.7	7.1	12.2
Phlegm when coughing	21.1	25.2	27.4	26.6	17.3	16.7
Breathlessness grade 2	8.5	7.7	14.7	14.5	8.9	10.3
Occasional wheezing	22.5	29.7	28.7	27.4	16.0	19.7
Asthma	7.6	6.1	5.8	5.4	2.4	4.0

*: 46 subjects reported exposure to both asbestos and quartz.

A history of dust or gas exposure was a significant predictor of all the respiratory symptoms as well as asthma after adjusting for sex, age, smoking habits and area of residence through logistic regression analysis (table 3, column 4). The adjusted odds ratios in exposed subjects ranged from 1.6–1.9 compared to unexposed subjects. No interaction effect (*i.e.* no departure from a multiplicative model) on respiratory symptoms was evident between smoking habits and occupational dust or gas exposure. For all symptoms except morning cough and wheezing the odds ratios related to occupational dust or gas exposure were greater than those associated with smoking of 1–9 cigarettes per day. To be sure that the association between occupational dust or gas exposure and respiratory symptoms was not driven by subjects with asthma, the analyses were repeated excluding the asthmatics. The adjusted odds ratios for respiratory symptoms by occupational dust or gas exposure were now slightly reduced, varying between 1.4–1.7, but remained significant.

Table 3. – Adjusted* odds ratios with 95% confidence intervals for respiratory symptoms in subjects with airborne occupational exposures compared to those unexposed in the general population of Hordaland county, Norway 1985 (n=4,469)

Respiratory symptom	Asbestos	Quartz	Dust or gas other than asbestos or quartz	Dust or gas
Morning cough	1.7 (1.2–2.4)	1.7 (1.3–2.9)	1.5 (1.2–1.8)	1.6 (1.3–1.8)
Chronic cough	2.1 (1.4–3.3)	2.3 (1.4–3.7)	1.5 (1.1–1.9)	1.8 (1.4–2.2)
Phlegm when coughing	2.1 (1.5–2.9)	2.3 (1.6–3.3)	1.6 (1.3–2.0)	1.9 (1.6–2.2)
Breathlessness grade 2	1.5 (0.9–2.6)	2.0 (1.2–3.2)	1.7 (1.3–2.2)	1.7 (1.4–2.2)
Occasional wheezing	2.2 (1.5–3.2)	3.3 (2.3–4.9)	1.8 (1.6–2.3)	1.9 (1.6–2.3)
Asthma	1.8 (0.9–3.6)	2.4 (1.1–5.3)	1.7 (1.2–2.6)	1.8 (1.3–2.6)

*: adjusted for sex, age, smoking habits and area of residence.

Table 4. – Adjusted* odds ratio (OR) with 95% confidence interval (95% CI) for respiratory symptoms by occupational dust or gas exposure in men and women of the general population of Hordaland county, Norway 1985

Respiratory symptom	Men		Women	
	OR	(95% CI)	OR	(95% CI)
Morning cough	1.4	(1.2–1.9)	1.5	(1.1–2.9)
Chronic cough	1.6	(1.4–2.1)	1.7	(1.3–2.4)
Phlegm when coughing	1.5	(1.1–2.0)	2.1	(1.4–3.2)
Breathlessness grade 2	1.6	(1.2–2.2)	1.9	(1.3–2.7)
Occasional wheezing	2.0	(1.7–2.6)	2.2	(1.6–2.9)
Asthma	1.7	(1.2–2.5)	1.9	(1.3–2.7)

*: adjusted for age, smoking habits and area of residence.

Table 5. – Population attributable risk (AR_{pop}) of current smoking and airborne occupational exposure for respiratory symptoms in the general population of Hordaland county, Norway 1985

Respiratory symptoms	Current smoking AR_{pop} %	Dust or gas exposure AR_{pop} %
Morning cough	49.9	10.6
Chronic cough	48.1	16.7
Phlegm when coughing	39.0	15.2
Breathlessness grade 2	27.9	14.5
Occasional wheezing	54.1	16.0
Asthma	-	18.9

The analyses were repeated using dust or gas exposure as a variable for categorization (table 3, columns 1–3). All the airborne occupational exposure groups were related to morning cough, chronic cough, phlegm when coughing and occasional wheezing. Asthma and breathlessness were significantly associated with quartz exposure and exposure to dust or gas other than asbestos or quartz. The adjusted odds ratios for respiratory symptoms in subjects with asbestos or quartz exposure tended to be higher than the adjusted odds ratios in subjects exposed to dust or gas other than quartz or asbestos. Additional logistic regression analyses were performed using duration and degree of asbestos exposure and duration of quartz exposure instead of asbestos and quartz exposures as dichotomous variables. The rates of respiratory symptoms did not significantly vary with duration or degree of asbestos exposure or with duration of quartz exposure.

In logistic regression analysis, sex did not modify the association between occupational dust or gas exposure and respiratory symptoms. However, there was a tendency that the adjusted odds ratios were higher in women than in men (table 4). In both sexes the greatest odds ratio associated to dust or gas exposure was observed for wheezing.

The population attributable risk of occupational dust or gas exposure for respiratory symptoms ranged from 11–19%, being lowest for cough in the morning and highest for asthma (table 5).

There was no evidence that airborne pollutants contributed more to rates of mucus hypersecretion symptoms (chronic cough, phlegm when coughing) than to rates of obstructive respiratory symptoms (breathlessness, wheezing). The data indicated that occupational airborne exposure gives a contribution to the respiratory symptom load of the general population ranging from one fifth to one half of the contribution given by current cigarette smoking.

Discussion

The survey demonstrated a uniform positive association between occupational exposure to dust or gas and the occurrence of all the respiratory symptoms studied as well as asthma. The relationship of occupational dust or gas exposure to respiratory symptoms is in agreement with findings of the six city US study [5]. Recently, results from a French general population survey including 16,464 subjects aged 25–59 yrs have been reported [14]. As in our study, significant differences were observed in prevalences of respiratory symptoms and asthma by occupational airborne exposure. The magnitude of the adjusted odds ratios was similar in both the present and the French surveys as well as in the six city US study.

The tendency of a stronger association between exposure and respiratory symptoms in women than in men was also observed in the French study [14]. The finding may be due to the possibility that exposed women have a higher degree of exposure than exposed men. More valid exposure characterization in women than in men may be another explanation.

We also observed that occupational exposure to asbestos and quartz was associated with the respiratory symptoms studied. However, no dose-response relationship was found. This may be due to the cross-sectional design of the study, requiring stronger effects of exposure on symptom rates to be detected compared to longitudinal studies [15]. We are comparing lifetime prevalences of exposure with prevalences of symptoms. Thus, the exposure may have ceased a long time prior to our study, obscuring the effects of degree and duration of exposure on symptom rates. Selection by death from pulmonary disorders in highly exposed subjects may be another explanation. The Tucson study also failed to show a uniform dose-response relationship between asbestos and quartz exposure on the one hand and respiratory symptoms on the other [4].

The presence of respiratory symptoms indicating obstructive lung disease in subjects exposed to mineral dusts may be confounded by other occupational contaminants. Other agents may be more hazardous to the airways, although the workers may be less aware of them. Thus, information on asbestos and quartz exposure obtained by a self-administered questionnaire may only be a crude indicator of an unhealthy working environment.

Several recent studies on various occupational groups have shown a relationship between airflow limitation and exposure to inorganic dusts such as asbestos [16], quartz [17] and coal [18]. The morphological basis of the relationship between inorganic dust exposure and airway obstruction is however unclear [19]. CHURG *et al.* [20] have described a histological entity of fibrosis and pigmentation throughout the small airways in subjects exposed to dust, a lesion morphologically distinguishable from the small airways disease produced by tobacco smoke. Similar morphological changes have recently been described in rats exposed to quartz dust, but not in a control group of rats exposed to iron oxide [21].

The validity of the exposure-disorder associations may have been affected by several factors. Firstly, selection bias, the degree of this bias depends on the overall response rate and on response rates in the four cells of the two by two exposure-disorder table [22]. In the present study, the exposure-disorder relationships did not differ significantly between respondents to the initial questionnaire and respondents to the reminder letters [23]. This suggests that the selection fractions of the cells in the fourfold table might not vary significantly with regard to specific exposure-disorder combinations. But, even if that were the case, the high overall response rate of 90% would tend to minimize the bias.

Secondly, the relationship between exposure and disorder variables may have been biased towards a falsely high value by diseased subjects tending to recall any exposure better than healthy subjects, or if subjects with a history of dust or gas exposure tended to report more symptoms than unexposed subjects. However, the relationship of occupational exposure to respiratory symptoms remained significant after excluding those reporting asthma.

Thirdly, the validity of both the exposure and effector variables will have influence on the association between them. If both variables had been subject to nondifferential measurement error, the bias would tend to falsely lower the observed risk [24]. The sensitivity and specificity of the question on asbestos exposure in men above 40 yrs of age is 46–97%, respectively [10]. If this consistency is taken into account for both sexes and all age groups, the odds ratios for respiratory symptoms in asbestos exposed relative to unexposed subjects increase by 30–70%.

Finally, as a potential confounder smoking habits were controlled for when examining the exposure-disorder relationships. However, a confounding effect may still remain because of imprecise characterization of the smoking habits of an individual (nonsmoker, ex-smoker, smoker of 1–9, 10–19 and 20+ cigarettes per day). A further bias may occur if underreporting of tobacco consumption is greater in subjects occupationally exposed to dust or gas than in unexposed subjects. To avoid the confounding effect of smoking habits, the relationship of occupational exposures to respiratory disorders were reanalysed in nonsmokers only. For all the respiratory disorders an association to occupational exposure was observed. This further indicates an independent relationship between occupational exposure and respiratory disorders.

From a preventive point of view it is important to know the strength of the association between a risk factor and an effector variable as well as the occurrence of the risk factor in the community. The population attributable risk is interpreted as the proportion of the symptom load that would theoretically be eliminated if the exposure to the risk factor was prevented. The present study suggests that 11–19% of the respiratory symptom load of the general population can be attributed to airborne occupational pollutants.

Our results must be interpreted with caution. The term population attributable risk presupposes a causal

relationship between the risk factor and the respiratory symptoms and not merely an association. Furthermore, in our study each estimate of the population attributable risk assumes that the risk factor in question is the first to be removed [25]. As some of the subjects are exposed to both smoking and occupational airborne exposure, the reduction in symptom prevalence gained by eliminating both risk factors are less than the sum of their attributable risk estimates. For instance, removing current smoking alone, or dust or gas exposure alone, would theoretically eliminate 48 and 17%, respectively, of chronic cough in the population (table 5). However, removing both risk factors would only eliminate 59% of the symptom load, not the sum of 48 and 17%.

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Poussière ou exposition au gaz d'origine professionnelle et prévalences des symptômes respiratoires et de l'asthme dans la population générale. P. Bakke, G.E. Eide, R. Hanoa, A. Gulsvik.
RÉSUMÉ: La relation entre l'exposition professionnelle à des agents aériques et les symptômes respiratoires et l'asthme, a été examinée par questionnaires auto-administrés au cours d'une enquête transversale d'un échantillon choisi au hasard de 4992 sujets dans la population générale de 15 à 70 ans, dans le comté de Hordaland, en Norvège. Le taux de réponse a été de 90%. 29% de la population avait des antécédents d'exposition à des possières ou à des gaz dans le milieu professionnel, 5% signalait une exposition à l'asbeste sur le lieu du travail et 4%, une exposition au quartz. Une anamnèse d'exposition à la poussière ou aux gaz professionnels s'avère en association avec la toux matinale, la toux chronique, l'expectoration par toux, la dyspnée d'effort, les sifflements épisodiques et le diagnostic d'asthme posé par le médecin, le tout après ajustement pour le sexe, l'âge, les habitudes tabagiques et la zone urbaine ou rurale de résidence. Le risque relatif ajusté pour les maladies respiratoires chez les sujets exposés à la poussière ou aux gaz se situe entre 1.6 et 1.9. Le risque d'exposition à la poussière ou aux gaz professionnels attribuable à la population pour les maladies respiratoires va de 11 à 19%. Cette étude indique que les troubles respiratoires sont associés de manière indépendante à l'exposition professionnelle par voie aérique dans un échantillon de la population générale norvégienne.
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