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SYMPTOMS OF BRONCHITIS IN ASPHALT WORKERS ENGAGED IN PAVING AND ROOFING

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ABSTRACT

Two hundred and thirty-one asphalt workers (road workers and roof layers) were examined with reference to spirometric values and subjective symptoms of bronchitis. The workers exposed to asphalt were compared with a control group, matched by age and smoking habits, from other categories in the building trade who were not exposed to any great extent to dust, smoke, or gases in their work environment.

The spirometric values of the asphalt group do not differ significantly from those of the controls. On the other hand, the frequency of subjective symptoms of bronchitis among asphalt workers increases with the increasing period of exposure. The increase appears to be dose dependent.

The work involving the handling of asphalt has elicited interest in the field of occupational medicine for a long time. The primary concern have been the effects on the respiratory organs and the possibility of a higher risk of bronchitis and/or cancer by analogy with that associated with smoking[6]. Skin cancer and other skin diseases are also conditions for which it has been suspected that work with asphalt may have aetiological significance. Baylor and Weaver[2] made a general survey of the health of asphalt workers without finding anything they considered out of the ordinary. Hammond and co-workers found an increased incidence of lung cancer and cancer of other sites among roofers[4].

The material used to pave roads and streets consists mainly of stone (about 90–95 per cent), which is bound by asphalt (5–10 per cent). The latter is prepared from crude oil by vacuum distillation. To produce roofing asphalt air is blown through the mixture in order to bring about oxidation.

There are three main components in asphalt, viz. asphaltenes, resins and oils. Asphaltenes are aromatic hydrocarbons with a molecular weight of 5 000–100 000. They also contain sulphur and nitrogen. Resins have a lower molecular weight of 1 000–5 000 and are also characterized by an aromatic structure, but they contain smaller quantities of sulphur and nitrogen than

asphaltenes. Finally, oil has an even lower molecular weight (200–1 000) and contains both aromatic and aliphatic hydrocarbons.

Asphaltenes and resins form a colloidal suspension in oil, constituting "micelles" in the continuous oil phase.

Until a few years ago so-called tar-boiled asphalt was frequently used for paving roads. The mineral substances were mixed with coal tar before asphalt was added. Thus coal tar and asphalt are two entirely different products.

In connection with the asphalting of streets and roads a number of other substances is also used for wich occupational medical risks cannot be ruled out, e.g. fatty amines which are used to improve adhesion between the mineral substance and asphalt.

Asphalt is generally handled at temperatures around 150 °C both in paving and roofing. It is then in liquid form and easy to spread. At these temperatures the most volatile components evaporate and form smoke on coming into contact with the ambient air. In addition to smoke, gaseous substances can also be released. This is especially so if the heating is excessive and the large molecules begin to break down: so-called cracking. This may be the case in roofing work in particular when asphalt is heated in a pot by means of an LP gas burner. Among other substances, hydrogen sulphide may be formed in such a cracking process. Investigations in the USA[9] showed that the values measured were under the threshold limit values (TLV) established at the time (1975) for carbon monoxide, nitrogen dioxide, sulphur dioxide, phenol and ozone, among other substances. The values measured for asphalt (petroleum) fumes were around the TLV. The maximum values for polycyclic aromatic substances have been questioned, however, some authors claiming that they have been much too high.

As regards such known carcinogens as benzopyrene and benzanthracenes, the investigators measured low concentrations which did not differ appreciably from the amounts measured in the town air. It should be noted here that the measurements apply to smoke from pure asphalt without an admixture of coal tar. Coal tar may contain about a 100 times more benzopyrene than pure petroleum asphalt. Swedish measurements for road-paving operations using tar-boiled asphalt have shown that the values for benzopyrene and benzanthracene in the smoke are considerably higher: between 100 and 1 000 times according to The Construction Industry's Organization for Working Environment, Safety and Health[1].

In several studies made in recent years predominantly subjective symptoms of the bronchitic type have been demonstrated in certain occupational groups such as miners[5] and welders[1]. In the light of the fact that asphalt workers engaged in paving as well as roofing are exposed to polluted air in their working environment, we have considered it to be of interest to study the prevalence of respiratory symptoms in such a group.

It should be pointed out that this investigation is of a cross-sectional nature, so it is not possible to rule out uncontrollable selection mechanisms that would cause the individuals most affected by exposure to asphalt to abandon the trade

and therefore not to be included in the study. If such mechanisms are in force, the investigated risks of asphalt work are underrated. The material was collected during the asphalt paving and roofing season in the summer and autumn of 1975.

SUBJECTS AND METHODS

The group studied consisted of 231 asphalt workers (194 road workers and 37 roof layers). A control group was selected from the following occupational groups: office workers, electricians, carpenters, glassworkers, work supervisors, linesmen, crane operators and bricklayers, i.e. individuals who are not normally exposed to dust, smoke or gases in their occupations. The asphalt workers were then compared with their controls, with whom they were matched by age and smoking habits. Thus the control was of the same age as the subject ± 2 years and belonged to the same category of smokers.

Smoking habits were categorized in the following manner: non-smokers, moderate smokers, heavy smokers. The smoking habits of the preceding year were decisive. Persons who only smoked a pipe were characterized as moderate smokers. Snuffing was not taken into consideration. Besides pipe-smokers, cigarette-smokers who averaged 1–15 cigarettes a day were also classified as moderate smokers. Individuals smoking 16 or more cigarettes a day were characterized as heavy smokers.

The concept of "asphalt years" was used as a measure of exposure. It was the total length of time that the subject in question had been engaged in asphalt work. Both roofing and paving work are weather dependent and, therefore, partly seasonal. According to the number of asphalt years, each worker was classified in terms of a low (≤ 3 years), moderate (3–8 years) and high-level exposure (>8 years).

The same simple questionnaire concerning respiratory symptoms of a bronchitic nature was completed by the asphalt workers and their controls. It would have been desirable to use standardized questions about bronchitis in accordance with the British Research Council Bronchitis Questionnaire[8], but pratical difficulties prevented our using it.

The following questions were asked to grade the symptoms:

1. Have you coughed for more than three months during the past year?
2. Do you usually have a mucus-producing cough the year round – even during your holiday and days off?

Subjects who answered question 1 in the affirmative but question 2 in the negative were characterized as having "slight symptoms" and those who responded affirmatively to question 2 were classified as having "marked symptoms".

In addition to answering the questions about bronchitis, the subjects and their controls were tested with a portable spirometer (Vitalograph). Three expiratory tests were performed. The values for the best test were used in the calculations. FVC (forced vital capacity) and FEV_1 (forced expiratory volume in 1.0 second) were calculated.

RESULTS

Subjective symptoms

The subjective symptoms of the bronchitic type were characterized as slight or marked in accordance with the definition above.

TABLE 1
Slight bronchitic symptoms.

	Short exposure	Medium exposure	Long exposure	All categories
Non-smokers	0/0 N = 27	1/0 N = 40	1/1 N = 32	2/1 RR = 2.0
Moderate smokers	0/0 N = 26	1/2 N = 36	3/0 N = 28	4/2 RR = 2.0
Heavy smokers	2/3 N = 19	1/0 N = 11	3/0 N = 12	6/3 RR = 2.0
All categories	2/3 RR = 0.67	3/2 RR = 1.5	7/1 RR = 7.0 p = 0.035*	12/6 RR = 2.0 p = 0.119*

*One-tailed
RR = Relative risk

Table 1 for slight symptoms shows that the symptoms tend to increase with longer periods of exposure. This is expressed by the relative risk (RR), which is defined as the quotient of the number of cases of sick exposed individuals over the number of sick non-exposed individuals[7].

TABLE 2
Marked bronchitic symptoms.

	Short exposure	Medium exposure	Long exposure	All categories
Non-smokers	0/0 N = 20	1/1 N = 40	1/0 N = 32	2/1 RR = 2.0
Moderate smokers	0/1 N = 26	2/1 N = 36	2/0 N = 28	4/2 RR = 2.0
Heavy smokers	1/2 N = 19	0/0 N = 11	2/0 N = 12	3/2 RR = 1.5
All categories	1/3 RR = 0.33	3/2 RR = 1.5	5/0 RR = 5 p = 0.031*	9/5 RR = 1.8 p = 0.21*

*One-tailed
RR = Relative risk

If the substance under investigation to which the subjects are exposed (in this case, asphalt smoke) has no aetiological significance for the development of bronchitic symptoms, one should find, under stochastic conditions, as many cases of bronchitis among the asphalt workers as among the controls. The relative risk would then be 1.0. If the symptoms in question are underrepresented in the group under investigation in relation to the control group, the value obtained will of course be less than 1.0, and, conversely, if the investigated group is overrepresented, the relative risk will be greater than 1.0. The greater the overrepresentation, the greater the relative risk.

Since the group under investigation and the control group are matched in respect to smoking habits, an increase in the relative risk following an increase in tobacco consumption would indicate that asphalt and smoking not only have an additive effect as causes of respiratory symptoms but also that they potentiate one another.

In the tables showing bronchitic symptoms of different degrees (Tables 1 and 2) the number of cases of bronchitis in the subgroups within the asphalt group is given in the numerator and the number of cases of bronchitis in the

TABLE 3
Differences between asphalt workers and controls expressed as percentages of normal values.

Parameter	Category		Short exposure	Medium exposure	Long exposure
FVC	Non-smokers	$\bar{X}$	0.7	1.50	− 3.81
		N	27	40	32
		S.D.	14.89	15.02	15.95
	Moderate smokers	$\bar{X}$	0.88	1.81	1.18
		N	26	36	28
		S.D.	14.79	17.22	17.89
	Heavy smokers	$\bar{X}$	− 0.84	6.36	− 0.75
		N	19	11	12
		S.D.	20.68	16.48	10.23
	All smoker categories	$\bar{X}$	0.36	2.24	− 1.36
		N	72	87	72
FEV	Non-smokers	$\bar{X}$	− 6.26	1.53	− 4.97
		N	27	40	32
		S.D.	19.25	20.20	18.72
	Moderate smokers	$\bar{X}$	− 1.50	− 1.06	0.68
		N	26	36	28
		S.D.	17.05	20.92	21.93
	Heavy smokers	$\bar{X}$	− 3.68	2.09	− 0.83
		N	19	11	12
		S.D.	27.75	19.63	12.25
	All categories	$\bar{X}$	− 3.86	0.53	− 2.08
		N	72	87	72

control group is indicated in the denominator. The number of studied pairs in different subgroups is indicated by N.

A tendency to an increase in the relative risk with increasing exposure to asphalt is distinct, but statistical significance at the 5 per cent level is attained only when different groups of smokers in the exposure category "long exposure" are combined.

The figures in Table 2 showing "marked bronchitic symptoms" do not contradict the tendency demonstrated for slight bronchitic symptoms.

Respiratory function investigation

The spirometric values have been compared with normal values corrected for age, sex and height[3] and expressed as a percentage of the expected normal value. Table 3 shows the mean differences ($\bar{X}$) between the values noted for the asphalt workers and for the controls as well as the number of pairs in the subgroup (N) and the standard deviation within the subgroup (S.D.).

No trends are readily discernible, and there are no significant differences indicating that the spirometric values are altered by exposure to asphalt smoke.

There were no notable differences between the group under investigation and the control group or between the different categories of smokers with respect to blood pressure, haemoglobin concentration or height. The weights of the asphalt workers were slightly higher on the average. The smokers, both the investigated subjects and the controls, showed a tendency to higher ESR values than the non-smokers ($P = 0.09$). The asphalt workers also showed the same tendency in relation to the controls, but this was considerably less pronounced.

DISCUSSION

The present study of 231 asphalt workers shows that in the subjects exposed to asphalt smoke the frequency of symptoms of the bronchitic type is higher than in their controls. There are no definite findings in the study which indicate that the smoking of tobacco and exposure to asphalt smoke are mutually potentiating factors. On the other hand, nearly all of the cases of bronchitis which occurred in the group with a long exposure to asphalt involved smokers and this may suggest that a correlation exists, after all.

In a study of this type it cannot be definitely ruled out that the subjects exaggerate their symptoms. On the other hand, this is contradicted by the dose--response relationship between increasing periods of exposure and higher frequencies of bronchitic symptoms.

With the spirometric apparatus which we used it was not possible to demonstrate any tendencies to impaired respiratory function in the asphalt workers. Although the method of investigation is rather crude, especially with regard to changes in the peripheral areas of the lungs ("small airway disease"), it seems plausible to rule out the possibility that asphalt smoke causes any significant impairment of respiratory function.

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