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THE MUTUAL RELATIONSHIP BETWEEN SMOKING, OCCUPATION AND DISEASE

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ABSTRACT

In an analysis of occupation and smoking data obtained from 40 000 households by the Health Interview Survey of the US National Centre for Health Statistics the authors came to the following findings:

1) There are substantially higher proportions of blue-collar workers among smokers, and especially among heavy smokers than there are among nonsmokers;
2) There are almost identical proportions of blue-collar workers among former smokers and nonsmokers;
3) There is a substantially higher proportion of blue-collar workers among smokers of regular than of filter cigarettes;
4) There is a substantially higher proportion of blue-collar workers among individuals who start smoking earlier rather than later in life.

While cigarette smoking has been widely accepted as a major cause of lung and other diseases, it is possible that a high proportion of blue-collar workers among smokers may have masked diseases that are due to occupational exposure rather than to smoking. Some other apparent recovery of former smokers to levels of risks of nonsmokers may be due to the similarity in proportion of blue-collar workers in the two groups.

A large number of investigations have now probed into the environmental antecedents of diseases, especially of cancer. Many of these investigations have concentrated on smoking, others on the effects of exposures in the workplace to toxic fumes and dust. Only lately have occupational health studies also collected data on cigarette smoking while investigations into the health effects of cigarette smoking seldom if ever pay attention to the occupation of smokers. In short, the health effects of smoking and of occupation have been investigated independent of each other. Yet information that has accumulated during the last few years would indicate that these two variables cannot be investigated in isolation of each other.

Foremost are the observations that smoking habits simply are not independent of occupation or of social class. Smoking appears to be very prevalent among the lower socio/economic segments of society, among blue-

-collar workers, especially among workers in "dirty" occupations while nonsmoking is more prevalent among upper socio/economic classes, among professionals, managers and others whose occupation for the most part is "clean". Thus a comparison of groups that differ with respect to their smoking habits is also a comparison of groups that differ in the extent to which their members are exposed to toxic and irritating fumes and dusts. As one consequence, diseases that are observed to occur with greater relative frequencies among smokers than nonsmokers may be related to differences in occupations among smokers and nonsmokers and not to differences in their habits and lifestyles. As another consequence, diseases that are observed to occur with greater relative frequencies among some occupations than others may be related to differences in smoking habits among them rather than to differences in occupational exposures. This type of confusion has been termed "confounding" by statisticians. It is the purpose of this paper to first establish that confounding conditions exist and secondly to suggest ways by which the relative health effects of smoking and of occupation may be isolated.

THE CONFOUNDING OF SMOKING AND OCCUPATION

A small number of studies probing into the environmental, social, and cultural factors influencing smoking patterns reported that smoking appeared to be more prevalent either among individuals in lower socio economic groupings or among individuals who worked in blue-collar occupations[3, 5, 7]. More recently it was reported that smoking appeared to be more frequent among individuals also exposed to certain occupational hazards, including fumes, dusts, and excessive noise[4]. However, the full extent of the inter-relationship between occupation and smoking, especially among males, has been difficult to study because large numbers of observations are required to determine smoking prevalence by the many different occupations in a modern society.

An opportunity arose to obtain detailed data of the distribution of smoking habits by occupation, industry, sex and race from the Health Interview Survey (HIS) of 1970. The HIS collects information on a continuing nation-wide sample of households in the United States as part of an on-going activity of the National Centre for Health Statistics (NCHS). In 1970, HIS used a questionnaire which requested, among other information, the nature of employed individual's occupations, the industry in which they worked, as well as a detailed description of their smoking habits. The survey was conducted in 40000 households. The analysis of the HIS data for occupation/industry and smoking patterns was published before[16].

The full extent of the concentration of smoking among blue-collar workers and the relative low number of smokers among individuals who work in clean occupations is summarized in Table 1. The table and figure compare 40 occupations with the highest prevalence of smoking with the 40 occupations with the lowest prevalence of smoking. Among the 40 occupations with the highest prevalence of smoking only one is of technical, professional and managerial work (Store Buyers and Department Heads – Occupation Code 250).

TABLE 1

Comparison of 40 occupation categories with the highest and lowest smoking prevalence among white males. Based on 40 000 household interviews. From Sterling[16], by permission of the Journal of Occupational Medicine.

Type of worker	Prevalence		%	
	Highest 40	Lowest 40	Highest 40	Lowest 40
Blue-collar	29	4	72.5	10.0
Service	9	7	22.5	17.5
White-collar	1	2	2.5	5.0
Technical/professional managerial	1	27	2.5	67.5
Total No. of occupations	40	40	100.0	100.0

On the other hand, among the 40 occupations with the lowest smoking prevalence, only four are of blue-collar work [Airconditioning Mechanics (470), Airplane Mechanics (471), Compositors and Typesetters (414), Stationary Engineers (520)] and 27 of technical, professional, and managerial work (that may be considered "clean") and the rest of white-collar and service workers. Thus, smoking appears to be a habit strongly tied to those social classes that make up the blue-collar labouring forces. This then brings us next to the question of the extent of confounding incurred when individuals are compared who differ with respect to smoking habits.

To begin with, we list a number of major observations that have been consistently found when the health of different types of male smokers and male nonsmokers were compared. These observations have been variously discussed and repeated and are summarized best in the report of the Advisory Committee to the Surgeon General on Smoking and Health[18] and in yearly follow-up reports:

1. The higher the prevalence of smoking in a series of individuals the higher the rate of respiratory diseases (and of almost every other disease).
2. Former smokers experience a sharp decrease in mortality risk so that eventually the mortality of "former smokers" and of "never smokers" become very similar.
3. Smokers of regular cigarettes have a higher mortality risk than smokers of filter cigarettes.
4. Individuals who start to smoke early in life have a higher mortality risk than individuals who start to smoke late in life.

We have used the HIS data to compare the occupations of different series of smokers, nonsmokers, former smokers, smokers of regular and filter cigarettes, and smokers who started early or late in life. To begin with, we divided occupations into groups. One group usually associated with a high probability of exposure to toxic fumes and dusts and with low socio/economic status and all that this implies we call "Blue-Collar". Another group usually associated with low probability of exposure to toxic fumes and dusts and high socio/economic status we call "Professional, Managers and Proprietors" (or PMP for short).

Next we compare the proportion of Blue-Collar and of PMP workers in series identified by a particular smoking habit. Figure 1 summarizes our findings. The proportions along each horizontal line represent the proportion of individuals who either are blue-collar or PMP. Other occupations are not shown. But it should be kept in mind that the total represented by each line adds up to 100 percent. Let us take the first line as an example. There were 8951 white males who smoked 20 or more cigarettes. Of this number, 44.1 percent were Blue-Collar, 6.2 percent were PMP, and the rest (not shown here) had other occupations. In the next group there were 2589 individuals who smoked between 10 to 19 cigarettes a day. Of this number, 42.7 percent were Blue-Collar and 5.8 percent PMP, with the rest (not shown) adding up to 100 percent. Or if we compare two groups that differ by type of cigarettes smoked, we find that in the sample of 3538 white males who smoked regular cigarettes, 46.9 percent were Blue-Collar and 3.9 percent PMP, while in the sample that smoked filter cigarettes, 41.8 percent were Blue-Collar and 7.2 percent were PMP's.

Smoking habits	Total number for all occupations	Percent blue-collar	Percent professional
Current amount smoked			
Smoke 20 +	8 951	44.1	6.2
Smoke 10 – 19	2 589	42.7	5.8
Smoke 1 – 9	1 572	38.6	7.6
None	18 203	30.7	10.9
Smoking status			
Never smoked	9 694	30.5	10.8
Former smokers	8 509	30.9	11.0
Type of cigarette			
Smoke regular	3 538	46.9	3.9
Smoke filter	9 778	41.8	7.2
Age started			
Younger than 20	9 825	43.7	5.5
Older than 20	1 744	33.3	9.9

FIG. 1 – Comparison of proportions of blue-collar and professional workers in series of white male individuals and within households headed by white males; differentiated by smoking habits. From the U.S. 1970 household interview survey.

The HIS data do not have information on mortality of the sample. However the mortality experiences of individuals in the different series of smokers, which we compare in Figure 1, are well known and were reviewed before. The question now is what, in view of the confounding with occupation, can we really say about the observation of differences in disease in the series of smokers compared in Figure 1.

Disease as a function of number of cigarettes smoked

Comparing groups of individuals who smoke more with groups of individuals who smoke less is the same as comparing groups of individuals with a higher proportion of blue-collar workers (the smokers or heavy smokers) with groups with a lower proportion of blue-collar workers (the nonsmokers or light smokers) or groups with a lower proportion of PMP's with groups containing a higher proportion of PMP's. Thus elevated disease rates seen in groups that smoke more may be in part or in total a reflection of the larger proportion of blue-collar workers among them.

The decrease in risk among former smokers

Individuals who stopped smoking appear to come from occupations similar to individuals who never smoke. Thus a decline in risk among individuals who stopped smoking, a decrease that approaches that of individuals who never smoked (especially a risk from respiratory disease) may be due in part or in total to the similarity in the proportion of blue-collar workers among those who never smoke and those who ceased smoking.

Differences in risk between smokers of regular and filter cigarettes

Groups of individuals who smoke regular cigarettes may have a higher incidence of (respiratory) disease than groups of individuals who smoke filter cigarettes simply because there are more blue-collar workers among them. (Rather than the difference being due to a lesser exposure to tar and nicotine among filter cigarette smokers.)

The higher risk in relation to starting to smoke young

Groups of individuals who start smoking at an earlier age rather than when they are older may have a higher rate of (respiratory) disease because they contain a higher proportion of blue-collar and a lower proportion of PMP workers than groups that start smoking later in life.

We then conclude that the observed relationship between smoking and disease could very well hide a relationship between type of employment and disease. (Especially in the four categories of comparisons which we have just reviewed.) Smoking, in a statistical sense may be a major index for individuals exposed to occupational hazards.

DISENTANGLING THE CONFOUNDING BETWEEN SMOKING AND OCCUPATION

It is clear that in order to assess the effects of occupation independent of smoking or of smoking independent of occupation, information of both smoking and occupation must be had about individuals who are either prospectively followed or retrospectively compared. Because that information is absent in most prospective smoking and health studies, these studies cannot provide an answer. (We might note that a study like Doll's of British Physicians is limited to a single

occupational grouping and thus, at best, can be used to determine the possible effects of smoking independent of occupation. But even in Doll's study crucial information is missing such as exposures of physicians to chloroform or other anesthetics or to radiation – all of them occupational cancer risks.)

Some useful information has been lately accumulated that may help clarify the extent of confounding in the case of lung cancer. Public alarm generated by an epidemic of lung cancer in some industries led to investigations in which comparisons were made between the incidence of this disease among smoking and nonsmoking workers. Theoretically at least it should be possible from the study of such epidemics to determine the "weight" of the occupation by using the incidence of lung cancer among nonsmoking workers as the base and then determining the added effect of smoking by that portion of the incidence of lung cancer among smoking workers that is in excess of that expected from knowing the incidence of lung cancer among nonsmoking workers. With one exception however the numbers of lung cancers observed in a single industry, while large in relations to the incidence of that disease outside that industry, have not been sufficiently numerous to permit the kind of calculation which we suggest here. Nevertheless, while the studies are few, the results are interesting. With one exception (a very important exception that we shall discuss below) the data indicate that contrary to common belief, occupation and not smoking seems to be the major determinant of that disease in industrial workers.

Doll ruled out cigarette smoking altogether as a selective factor in lung cancer among coke oven workers after comparing smoking habits of persons employed in several areas of the gas industry[2]. Newman and colleagues[12] found a significantly elevated incidence of bronchogenic carcinoma among copper smelter workers and copper miners when compared to other men in the same Montana counties. Yet they report also that "smoking habits did not differ significantly between the three male groups" Weiss and Boucot[22] report an "inverse relationship" among men exposed to chloromethyl methyl ether. The lung cancer rates actually were smaller for smokers than for nonsmokers. Weiss and Boucot[22] and Wagoner[19] reported that in their study of women employed between 1940 and 1962 in the manufacture of asbestos textiles, seven lung cancers were observed when only 0.5 cases were expected. But more than half of these lung cancer cases had no history of smoking[20]. Wagoner's findings support those of Newhouse and co-workers[11] who report as high an incidence of lung cancer among women who had worked with asbestos textiles as among male asbestos workers – despite differences in smoking characteristics.

A number of studies have also looked at the "excess" incidence of lung cancer among some industrial populations in relation to expectations based on the observation of groups of "heavy" smokers. Lloyd[9] concludes that carcinogenic agents responsible for the excess lung cancer seen in coke workers have an effect considerably beyond that predicted for heavy cigarette smoking. Decoufle[1] finds the same for retired asbestos workers. Wagoner and co-workers[19] reported a significant excess of lung cancer risk among a cohort of workers in a manufacturing complex utilizing predominantly chrysotile asbestos in a textile,

friction, and packaging products. The workers were Dutch Amish, a population known for its abstention from alcohol and cigarettes. The famous study on uranium miners concludes that an excess of lung cancer among uranium workers is way beyond what could be explained by their smoking[10].

Three retrospective studies, one of laryngeal carcinomas rather than of lung cancer may be of exceeding importance. In a study, 4802 patients with lung disease were divided into eleven occupational groups. Smoking histories were known so that individuals could be matched for smoking habits. Chronic obstructive lung disease and especially lung cancer, were found "to occur predominantly in jobs involving hard physical work and heavy inhalative and climatic influences"[13]. A recent study based on the Third National Cancer Survey Interview series finds elevated lung cancer rates in a number of occupations but notes that "controlling for cigarette smoking did not change these associations"[23]. Stell and McGill[15] retrospectively examined occupational exposures of a large series of patients with laryngeal carcinoma. They found that 27.7 percent of patients had had occupational exposure to asbestos as compared to only 2.5 percent in a controlled series. They also failed to find any difference in the smoking habits of patients who were asbestos workers compared to those patients who had had no association with asbestos. But many such retrospective studies need to be done, especially studies that review occupational backgrounds of patients for a number of cancers, but especially for cancer of lung, bladder, and pancreas.

There is yet one more study that seems to have considered both smoking and occupation among a group of workers with a high incidence of lung cancers and has supported claims that lung cancer is only found among smoking and not among nonsmoking workers. This study has been quoted most often and is used most aggressively, (very often by spokesmen for the asbestos companies – see in Re Johns Manville[24]) that it is smoking and not exposure to asbestos that is responsible for lung cancer cases. This is the well known study by Hammond and Selikoff[6] which claims that the lung cancer rate is dramatically increased, but only among those asbestos workers who smoke. There are serious flaws in the way Hammond and Selikoff present and analyse their data, flaws that may very well invalidate their conclusions. Because the claims based on Hammond and Selikoff are so aggressively advocated, the flaws of the study need to be publicly discussed or at least ought to be clarified by the authors. Here are the major problems with their data:

First the observed number of lung cancers among nonsmoking asbestos workers is 27 percent (about a fourth) that expected. A source of bias is suggested by those figures, unless one is willing to assume that exposure to asbestos dust protects nonsmoking workers from lung cancer. That source of bias is better understood if one looks at the second paradox in their data.

Secondly, the proportion of deaths from all causes of cancer is identical among smoking and nonsmoking asbestos workers. We have summarized the proportion of smoking and nonsmoking asbestos workers who died from lung cancer, from mesotheliomas, from cancer from all other sites, and from all

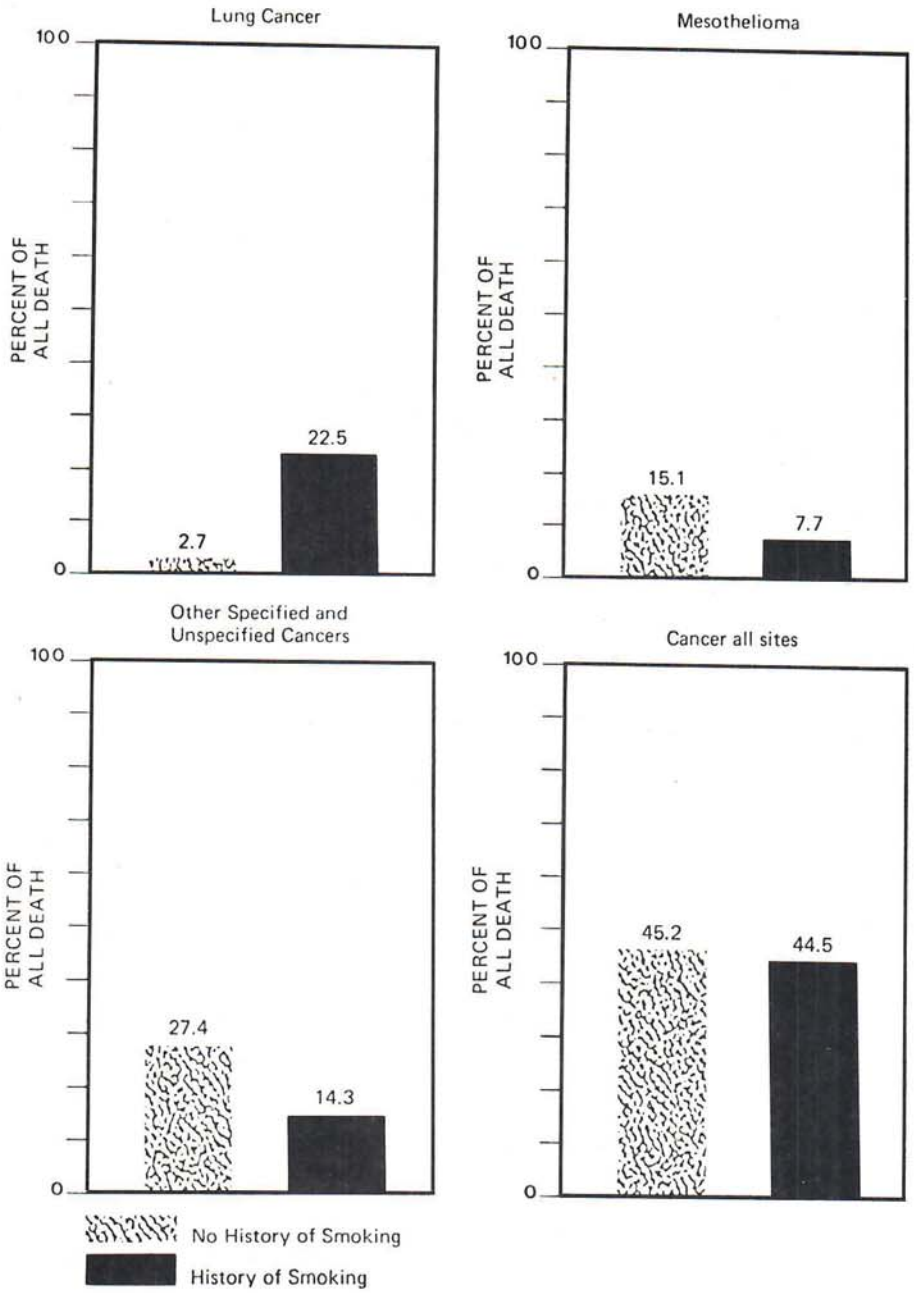

FIG. 2 – Distribution of reported causes of deaths for some cancer sites among 17800 asbestos insulation workers (Extracted from Hammond[6]).

cancers in Figure 2. From the first panel (upper left) it would seem that the proportion of lung cancer deaths among smoking asbestos workers is about ten times the proportion of lung cancer deaths among nonsmoking asbestos workers. However, it is puzzling that the total proportion of deaths from all cancers is approximately the same among smoking and nonsmoking asbestos workers and, in fact, it is slightly higher among nonsmoking asbestos workers (lower right of Figure 2). As the proportion of all cancer deaths among smoking and nonsmoking asbestos workers is identical, and as smoking asbestos workers have a much higher proportion of deaths from lung cancer than nonsmoking asbestos workers, it follows that the proportion of death from other cancer among nonsmoking asbestos workers is higher than that proportion is among smoking asbestos workers. Indeed we can see this in the upper right and lower left parts of Figure 2. The proportion of death from mesothelioma and from cancer from all "other sites" is much higher among nonsmoking than among smoking asbestos workers.

We suggest, (as an obvious interpretation for the low lung cancer incidence among nonsmoking asbestos workers and the curious shift in proportion of cancer deaths from different causes), that the diagnosing physicians, knowing of the smoking habits of an asbestos worker, diagnose them as dying from primary lung cancer if it was known that the worker smoked, but made a more thorough going examination as to the source of cancer when the asbestos worker did not smoke. Also, because the conviction is so strong that smoking is the cause of lung cancer, almost it's sole cause, nonsmoking asbestos workers may have been diagnosed as having primary cancer from some site other than the lung. (The only other interpretation possible may be that exposure to asbestos prevents lung cancer, a patently non-sensical conclusion.) A re-analysis of the well known Veterans Administration study provides further evidence that such a diagnostic bias exists[8, 21]. When my associate and I compared the proportion with which lung cancer was used as a contributing rather than a primary cause of death in those data, it turned out that there were proportionately twice as many nonsmoking as smoking veterans who had a cancer of the lung when they died, although that cancer was not classified as the primary cause of death. Again, our observations do not mean that lung cancer is a more frequent contributor to the death of nonsmokers (and so by implication may be caused by nonsmoking) but that physicians appear to be more inclined to diagnose lung cancer as primary among smokers than among nonsmokers.

The third peculiarity about the Hammond/Selikoff data is that for the third of asbestos workers for whom smoking histories were not determined, lung cancer rates are the same as those of smoking asbestos workers. Yet there is an unknown proportion of nonsmokers among them. The procedure by which smoking histories were determined are in fact unclear from reading any number of the reports produced by these two authors.*

*Our analysis and questions were submitted to Dr. Selikoff some time ago and no satisfactory answers have been forthcoming. The only effect of an inquiry may have been that in his later papers, Dr. Selikoff seems to retract claims made in his report with Hammond. He now claims that three quarters of lung cancer deaths among asbestos workers are attributable to their work with asbestos[11].

Existing evidence simply is inadequate to answer the question to what extent working kills smokers rather than smoking kills workers[17]. A serious effort is needed to clarify the extent with which smoking and occupation together or singly imperil the health of workers. As a minimum, a number of retrospective studies are needed, modelled after those of Stell and McGill[15]. Additional attempts should be made to include information on occupation with other information deposited in so called Cancer Registries. It is curious but nevertheless tells a great deal about the attitude of the medical community that none of existing cancer registries seems to include information on occupation.

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