

Cancer morbidity by occupation

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LYNGE E. Cancer morbidity by occupation. *Scand J Work Environ Health* 1992;18 Suppl 1:50-56. Data on cancer morbidity by occupation are available from surveillance systems, such as linkage studies based on census data and cancer register data. These data serve various purposes. First, they show the social distributions of cancer diseases. Second, they can form the background for generating hypotheses about chemical carcinogens by identifying occupations at high risk of cancer. Third, cancer morbidity data can be used in the interpretation of results from hypothesis-testing studies. Fourth, the data can facilitate the identification of cancer risks associated with new technologies and way of life in the service society. Finally, the data can be considered for inference about future trends in cancer mortality. Data from the Danish occupational cancer study are used for illustration.

Key terms: cancer mortality.

Cancer morbidity data versus cancer mortality data

The main purpose of analyzing cancer occurrence by occupation is to identify human carcinogens. Cancer morbidity is the best indicator for the risk of cancer development. In many countries, however, only cancer mortality data are available. It was estimated recently that 1 186 000 cancer cases are diagnosed every year in the European Community (1). The registered number of cancer deaths within this area is 730 000 (1). Thus, overall, cancer morbidity is underestimated by the use of cancer mortality data. There is, however, a considerable variation across the different types of cancer. The number of lung cancer deaths in the European Community is close to 90% of the lung cancer cases, whereas the number of breast cancer deaths is only equivalent to 40% of the cases.

Occupational cancer epidemiology

Heavy exposures were found in the early phase of industrialization. The health consequences of some of these exposures have been documented epidemiologically. An example is the excess mortality from nasal and lung cancer among workers from the Clydach nickel refinery in Wales. Sixty-two of the workers employed in this nickel refinery before 1920 died of nasal cancer, whereas only 0.2 deaths were expected on the

basis of the mortality rates for England & Wales (2). The high cancer risk in the nickel refinery was recognized by the factory inspector before a formal study was carried out (3).

Clusters of occupational cancers have also been observed in more recent times, for example, in the polyvinyl chloride industry, where it was noticed in 1974 that four workers had developed angiosarcoma of the liver (4). The post-World War II labor market has, however, been characterized in general by lower exposure levels and higher labor market turnover.

Identifying occupational cancer risks today therefore requires a thorough investigation. Consequently, emphasis has been placed on the epidemiologic concepts of chance, bias, and confounding, and several methodological innovations have been made in the fields of statistics, exposure assessment, and data ascertainment. Computers have facilitated the use of large data sets, and it is now possible to create various surveillance systems and multicenter studies. This paper focuses on the surveillance systems.

Surveillance systems

Many surveillance systems use data already collected for other purposes. A common form is register-linkage studies based on census data and death certificate or cancer register data. The linkage studies are limited by the fact that data on specific exposures and confounding factors are not available, and the occupation may be known only for one point in time. The advantage of census-based linkage studies is the access to carefully collected employment data for entire national populations. Tabulation of the cancer mortality or morbidity across occupational groups in such data sets makes it possible to identify groups at high risk of cancer, and these studies serve the purpose of hypothesis generation.

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Cancer morbidity by occupation in Denmark

Data from the Danish occupational cancer study can illustrate the potentials and limitations of register-linkage studies (5). The Danish study was a follow-up of cancer morbidity over a 10-year period for persons aged 20–64 years in 1970. The study included 115 000 cancer cases diagnosed among 2.8 million persons.

The overall health differentials are small for the Danish population. During the 50 years of life covered by the study (from 22.5 years to 72.5 years) men with a university education lived 45.7 years, whereas semi-skilled and unskilled workers lived 44.2 years. This difference in expected years of life of 1.5 years is actually less than the difference of 2.1 years between men and women (6). Differences in cancer morbidity across occupations were nevertheless found in this population.

The linkage data showed the classic associations between occupation and cancer known from in-depth studies. Examples are excess risks of lip cancer among farmers and fishermen, primary liver cancer among waiters, pleural mesotheliomas among plumbers, and nasal cancer among furniture workers. These observations indicated the validity of the linkage data. A mapping of the social pattern of cancer morbidity was made through a tabulation of the data for 42 different cancer diseases by 20 socioeconomic groups. The difference between the highest and lowest rates are shown for each cancer site in table 1. There was an almost twofold difference in the overall cancer morbidity. When the cancer morbidity rates for all economically active men were used as standard rates, farmers had a standardized incidence ratio (SIR) of 0.7, and seamen had an SIR of 1.3. When an equivalent tabulation was made for women, farmers and agricultural workers had an SIR of 0.7 and well-educated, self-employed women had an SIR of 1.2.

If the entire Danish population had the same cancer risk as farmers, the number of cancer cases among the men aged 25–65 years would be reduced by one-third, and the number of cancer cases among the women would be reduced by one-fourth. This finding is intriguing because the way of farm life which is the background for these low cancer figures is now disappearing.

Table 1 also shows, however, that the widest ranges in the social distribution were found for certain rare cancers with a relatively well defined etiology. The cancer sites with a fivefold or larger range together constitute only 7% of the cumulative cancer morbidity. Within this group are cancers of the lip, pleura, and nose and cancer of the mouth, larynx, pharynx, liver, and esophagus. Within the group of cancers with less than a twofold difference between the socioeconomic groups are the more common cancers for which little is known about the etiology, for example, cancers of the prostate, rectum, and brain and also leukemia.

The social gradients are, however, not uniform across cancer sites. The gradient changes, for exam-

ple, along the digestive tract, as illustrated for cancers of the esophagus, stomach, and colon in figure 1. These three types of cancer show three different social distributions. The age-standardized rates for men in Denmark in 1943–1987 are shown for these cancer sites in figure 2.

The alcohol consumption in Denmark was high at the turn of the century. The consumption was low from 1930–1960, but more than doubled during the period 1960–1985. This change is reflected now in increasing mortality rates for esophageal cancer in recently born cohorts (7). Farmers have reported low alcohol consumption. The considerable excess risk in esophageal cancer among building workers compared with academics is, however, not explicable alone by the difference in self-reported alcohol consumption (8).

Stomach cancer morbidity has been declining in Denmark over the last 45 years, and colon cancer morbidity has been increasing over the last 35 years (9). The social distributions for these two cancers indicate that the higher socioeconomic groups have been ahead

Table 1. Cancer morbidity for men by socioeconomic group in Denmark in 1970–1980.

Cancer site ^a	Ratio between highest and lowest morbidity ^b	Cumulative morbidity <75 years ^c
Lip (140)	12.2	0.34
Pleura (162.2)	8.4	0.18
Liver (155.0)	6.7	0.41
Mouth (143–144)	6.6	0.24
Nasal cavity (160)	6.2	0.10
Larynx (161)	5.9	0.68
Pharynx (145–148)	5.8	0.30
Mycosis fungoides (205)	5.2	0.02
Esophagus (150)	5.0	0.48
Lung, not primary (163)	4.6	0.01
Lung (162.0, 162.1)	3.9	7.72
Melanoma (190)	3.4	0.75
Pancreas (157)	3.4	1.16
Hodgkin (201)	3.2	0.23
Other, nonspecified (199)	3.1	0.47
Bone (196)	3.1	0.06
Small intestine (152)	3.1	0.10
Breast (170)	3.0	0.05
Metastases (198)	3.0	0.53
Tongue (141)	2.9	0.13
Salivary glands (142)	2.8	0.07
Multiple myeloma (203)	2.8	0.34
Mediastinum (164)	2.7	0.04
Bladder (181)	2.5	2.90
Peritoneum (158–159)	2.4	0.12
Kidney (180)	2.3	1.20
Colon (153)	2.3	2.44
Connective tissue (197)	2.3	0.09
Other genital (179)	2.3	0.11
Other skin (191)	2.3	4.95
Endocrine glands (195)	2.3	0.06
Liver, not primary (156)	2.0	0.20
Stomach (151)	2.0	1.45
Gallbladder (155.1)	1.9	0.23
Eye (192)	1.9	0.10
Thyroid (194)	1.9	0.10
Prostate (177)	1.9	3.14
Testis (178)	1.9	0.65
Brain (193)	1.9	1.02
Rectum (154)	1.8	1.82
Non-Hodgkin's lymphoma (200, 202)	1.7	0.70
Leukemia (204)	1.5	0.99
All cancer	1.9	36.68

^a Code of the International Classification of Diseases, seventh revision, in parentheses.

^b Between 20 socioeconomic groups.

^c Per 100 persons.

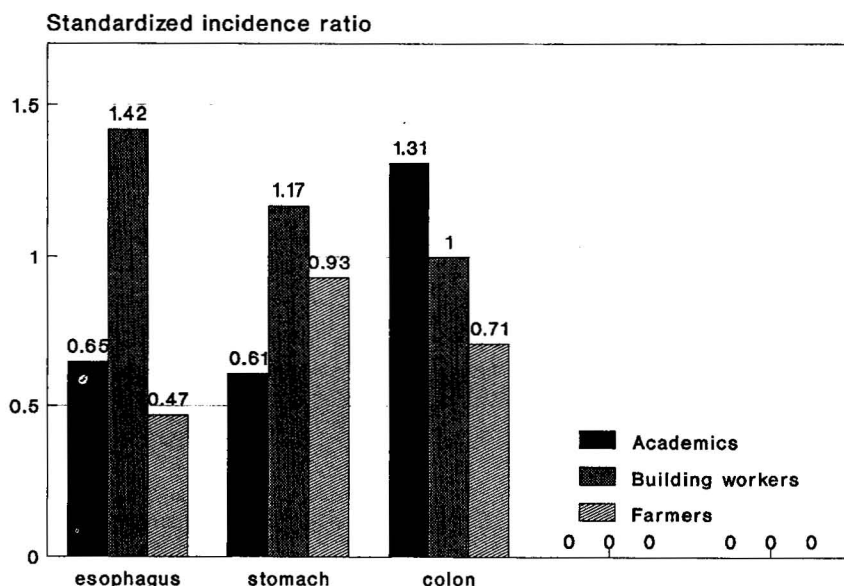


Figure 1. Standardized incidence ratios for selected digestive tract cancers among men in selected socioeconomic groups in Denmark in 1970-1980.

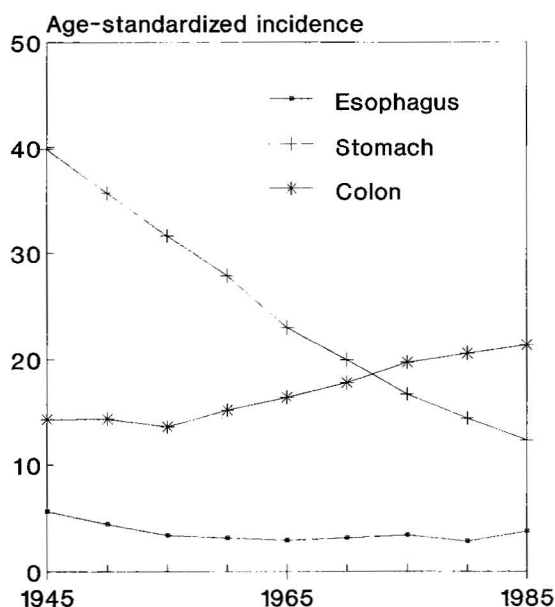


Figure 2. Age-standardized incidence rates for selected digestive tract cancers among men in Denmark in 1943-1987. Note: age-standardized incidence per 100 000 (world standard population).

of this development in that the academics now have the lowest stomach cancer morbidity and the highest colon cancer morbidity. The socioeconomic distributions of cancer, as illustrated in this report, serve the same hypothesis generation purpose as the cancer maps.

Search for excess risks related to specific exposures

Occupation is only a proxy measure for exposure. Potential carcinogenic exposures may, however, be delineated in linkage studies through the tabulation of data by very detailed occupations. For this purpose the Danish data were divided into 492 occupations, and the tables for each cancer site were screened for high-risk occupations.

This procedure revealed, for example, a cluster of occupations in engineering work with an excess risk of laryngeal cancer, with SIR values in the range of 1.5-1.9 (10). Engineering work covers the manufacture, fitting, and repair of a broad variety of machines and will thus imply various workplace exposures, including welding. Welding as a risk factor for laryngeal cancer has previously been studied in a case-referent study in Denmark. This study showed a moderately increased risk (relative risk 1.3) (11). The two studies in combination therefore point to the presence of other carcinogenic exposures in the work environment of engineering workshops.

Excess risks of lung cancer among butchers (12) and bladder cancer among hairdressers (13) were found with the same screening procedure.

Linkage studies and job-exposure matrices

In order to overcome the lack of exposure data in linkage studies, attempts have been made to combine these studies with job-exposure matrices. In a job-exposure matrix each occupation is coded for potential ex-

posures, and the linkage study data can thus be tabulated by potential exposures in addition to the tabulation by occupation. As for occupation, the validity of the exposure assessments can be checked through the analysis of results for classic associations known from in-depth studies. No association was found between potential exposure to beta-naphthylamine and bladder cancer in a Swedish study (14), and it is therefore difficult to interpret the other findings resulting from the use of the job-exposure matrix on these linkage data.

Hypothesis-testing studies

Large hypothesis-testing studies have also been facilitated by computers. Examples are the multicenter studies on man-made mineral fibers (MMMF). A European study covered 13 plants and a total of 21 000 workers (15). A study in the United States covered 17 plants and a total of 17 000 white male workers (16). The International Agency for Research on Cancer (IARC) reviewed the combined data from these two studies in 1987 (17). A standardized mortality ratio (SMR) of 93 was found for lung cancer in the glass filament industry, an SMR of 108 was determined for the glasswool industry, and an SMR of 128 appeared for the rock/slag wool industry. The excess lung cancer risk in the rock/slag wool industry was found ≥ 10 years after first exposure. The excess risk did not increase with duration of exposure nor with estimated cumulative dose (fiber/cm³ – months). The European data showed, however, that the excess risk was particularly high for persons employed in the early technological phase, when no binders were added to the fibers (SMR 257). IARC concluded from these data that there was limited evidence for the carcinogenicity of rock/slag wool in humans.

Interface between linkage studies and hypothesis testing

The example of the MMMF studies serves to illustrate the interface between hypothesis-testing studies and background information from, for example, linkage studies.

The authors of a recent review of the MMMF studies concluded that the "evidence is inadequate for testing the hypothesis that MMMF exposure constitutes a hazard in respect to lung cancer [p 230]" (18). The authors pointed to confounding by extraneous agents in the workplace and by socioeconomic status.

The latter point illustrates the interface between hypothesis-testing studies and linkage studies. Exposed workers in MMMF production are mostly unskilled laborers, and the authors of the review stated that "a lower socioeconomic status for the exposed cohorts implies, quite possibly for reasons that go beyond smoking, the expectation of elevated SMR values for lung

cancer in particular [p 225]." SMR values for respiratory cancer for manual workers in Great Britain in 1979–1980 and 1982–1983 were used to illustrate this point, as shown in table 2.

Most of the rock/slag wool workers in the European study came, however, from Denmark. An SIR of 1.2 was found for lung cancer among male manual workers in the Danish cohort, and the SIR was 1.4 after 20 or more years since the first exposure (19). As shown in table 2, the Danish linkage study found the unskilled workers to have an SIR of only 1.1 for lung cancer. The Danish MMMF workers thus had a slightly higher lung cancer morbidity than the entire group of unskilled workers in Denmark. It should be stressed that this comparison has considerable limitations because the MMMF cohort data were accumulated over the period 1943–1982 and covered all age groups, whereas the linkage data covered the period 1970–1980 and the age group of 45–64 years. The point is, however, that the difference in lung cancer risk between the MMMF workers and the unskilled workers depends on whether the data for unskilled workers from Great Britain or the data for unskilled workers from Denmark are used for the comparison.

This example also shows that the cancer pattern at a certain point in time reflects the social history of the country. The transition from an agricultural society to an industrial one occurred much later in Denmark than in Great Britain. There were 350 000 men working in agriculture in 1950 and 95 000 men working in agriculture in 1987. The decennial census data indicate that at least one-quarter of the unskilled workers in industry in Denmark in 1970 had a background of 10–20 years of work in farming.

The linkage data showed the farmers to have a very low lung cancer risk (SIR 0.4), which is then also a part of the life experience of a proportion of industrial workers. The failure to take social history into

Table 2. Standardized mortality ratios for respiratory cancer among manual workers in Great Britain in 1979–1980 and 1982–1983 and standardized incidence ratios for lung cancer among male manual workers in Denmark in 1970–1980.

Study	Age group ^a		
	45–54 years	55–64 years	45–64 years
Great Britain, all manual workers ^b			
Skilled	115	120	NA
Semiskilled	133	122	NA
Unskilled	204	169	NA
Denmark, male manual workers ^c			
Skilled	117	129	126
Unskilled, including semi-skilled	121	107	111

^a Approximate age groups in Danish data.

^b Taken from reference 18.

^c Taken from reference 5.

account may thus produce spurious results in hypothesis-testing studies.

Cancer morbidity in a service society

Cancer normally has a long latency period. Workplace exposures for which there is at present sufficient evidence for carcinogenicity in humans are primarily exposures found already before World War II. These are soot and tars, metals, dyestuffs, asbestos, and the like.

Sufficient evidence for carcinogenicity in experimental animals is at present known for more than 100 in-

dustrial chemicals for which epidemiologic data are either missing, inadequate, or limited. Many of these compounds have been used in great quantities after World War II, such as solvents and intermediates in the manufacture of synthetic rubber, plastics, and fibers and in diesel exhaust, gasoline, pesticides, and the like.

The further epidemiologic investigation of the cancer risks for humans with these industrial exposures is important, both for workers in developed countries and for workers in developing countries, and for inference about risks from environmental pollutants as well.

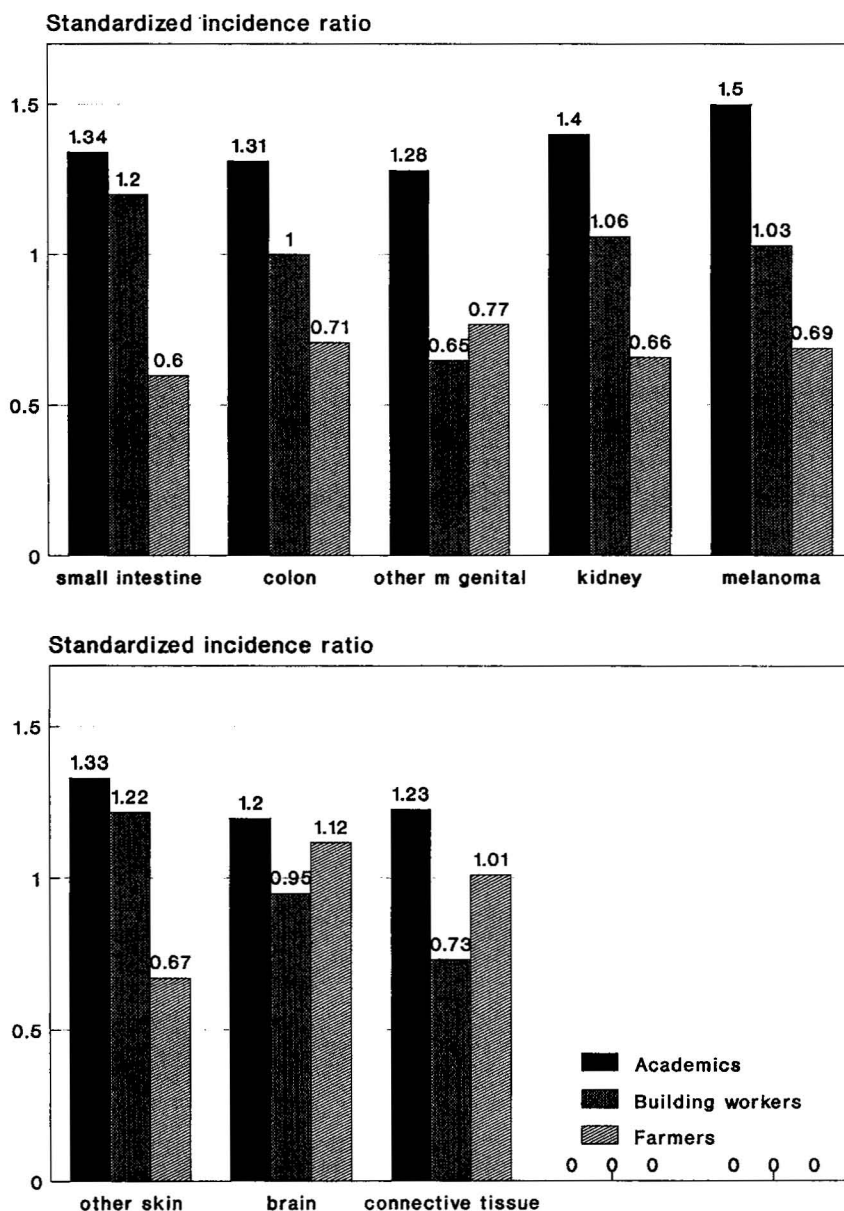


Figure 3. Standardized incidence ratios for cancer sites for which academics are at high risk among men in selected socioeconomic groups in Denmark in 1970–1980.

The labor market in developing countries is, however, changing from an industrial society to a service society. It is therefore important also to search for occupational risk factors that might have followed the changing work conditions and the introduction of new technology in the service society. This is of course a difficult task because of the long latency time found for most malignant diseases in humans.

One possibility might be to study the cancer pattern of those occupational groups which have already experienced work conditions similar to those which are now becoming common. The well-educated white-collar workers represent such a group, as they have been engaged predominantly in administrative and managerial office work during their worklife.

Linkage studies have shown, for example, an excess risk of colon cancer among such men (20–21). Further analysis of such linkage data have pointed to sedentary work as a risk factor for colon cancer (22–24). This hypothesis has later been pursued in case-referent studies in which differences in dietary factors could be controlled for. Data from the state of Utah in the United States thus suggest that physical activity and diet jointly modify their respective effects on the risk of colon cancer (25). Data for Chinese Americans in the state California show that the risk of colorectal cancer is higher among sedentary than among physically active persons when they are stratified according to their intake of saturated fat (26). Data are thus accumulating for sedentary work as a risk factor for colon cancer.

The importance of this finding is illustrated by the fact that one-third of the Danish population now reports to have sedentary work (27) and that colon cancer constitutes 8% of cancer cases (9).

Other examples of modern work exposures or environments for which cancer risks are now being studied are electromagnetic fields (28) and biomedical research (29).

Occupation and trends in cancer mortality

Age-adjusted cancer mortality rates have shown a slow and steady increase over several decades in the United States, and there was no evidence of a recent downward trend in the years through 1982 (30). Age-adjusted cancer mortality rates for European countries show similar trends for men, whereas the rates for women increased in this period in four out of seven European countries (31).

These trends cause concern because they point to an increasing risk of developing cancer and a lack of efficient treatment. The cancer mortality rates for the 20- to 44-year-old persons in Europe have recently been analyzed for a delineation of trends by examining "the cohorts on whom the future depends [p 508]" (31). Over the period 1950–1985 the overall cancer mortality for women in this age group decreased in six out

of seven European countries. However, the rates for men in this age group were lower in 1985 than in 1950 in only three out of the seven European countries included in the analysis.

The social pattern of cancer morbidity and mortality may add to considerations of future trends in cancer. The analysis of coronary heart disease by social class in Great Britain can serve as a model. It appears from these data that the rise in heart disease among men in this century first affected social classes I and II and only later involved social classes IV and V (32). The data also showed that the recent decline in heart disease among men first affected nonmanual workers (33).

It is a reasonable hypothesis that white-collar workers first experience the living conditions which later become common. Following the model of heart disease, cancers which are currently in excess among the white-collar population may thus serve as early warning signs about possible future trends in the cancer risk for the entire population. The cancer diseases with relatively high rates among the white-collar men in Denmark are shown for illustration in figure 3.

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