



Scand J Work Environ Health [2002;28\(1\):1-88](#)

Issue date: 2002

Cancer risk by occupation and socioeconomic group among men - a study by The Association of Swiss Cancer Registries

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Refers to the following texts of the Journal: [1999;25\(2\):125-130](#)
[1999;25 suppl 2:1-116](#) [1998;24\(3\):161-164](#)

The following article refers to this text: [2004;30\(6\):425-437](#)

Key terms: [cancer registry](#); [cancer risk](#); [environment](#); [malignant neoplasms](#); [man](#); [occupation](#); [social class](#); [socioeconomic group](#); [The Association of Swiss Cancer Registries](#)

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/11871426



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The main focus of the study was to describe the socioeconomic and occupational variations in cancer risk systematically. This section presents, for each cancer site, results of and commentaries on cancer risk by socioeconomic status and occupation. The results are presented for socioeconomic status by figure 2 (beginning on page 34) and for occupation by table 8 (beginning on page 39) at the end of this section.

Large socioeconomic differences in cancer risk were observed. These patterns should be carefully interpreted in view of the extent and causes of social inequalities in cancer occurrence (10, 35).

For the United States, the proportion of cancers attributable to occupational factors is estimated to be 5% or less (36). It is likely that similar figures apply to developed countries in general. For most cancers, most cases are in fact linked to other environmental conditions, in particular to life-style. To highlight this fact, the main risk factors for each cancer site are briefly recapitulated, and commentaries are given in order to compare the patterns observed with known or suspected risk factors.

Lip

As there were only 199 lip cancer (ICD-O 140) cases, all occupational groups could not be studied. A strong socioeconomic gradient was observed with a twofold increased risk for unskilled workers and an approximate twofold lowered risk for professionals, when compared with nonmanual employees. Farmers and animal producers, cleaning and personal service workers had the highest risk (OR 2.2 and 3.2, respectively). Bricklayers, stonemasons, tilers and related occupations also had a borderline significant increased risk. Indoor occupations, such as those involved in trade, administration, and computer-related sectors, showed a lower risk. Adjustment for socioeconomic status moderately modified the observed associations.

These results for lip cancer agree with those previously observed (37, 38, 39), and they fit the actual knowledge on lip cancer etiology (ie, the joint effect of outdoor work and smoking habits) (40, 41).

Oral cavity and oropharynx, hypopharynx and other pharynx

In all, 1984 cases of oral cavity or pharyngeal cancers (ICD-O 141, 143–6 148–9) were included in the study. The risk of these cancers increased with decreasing

socioeconomic status. The risk of oral cavity and oropharyngeal cancers was higher in occupations related to construction (OR 1.3), hotel and catering (OR 1.7), and driving (OR 1.6). On the contrary, workers in technical, trade, administrative and computer-related occupations, as well as professionals and teachers, experienced lower risk. For hypopharyngeal and other pharyngeal cancers, similar patterns were observed in occupations related to construction (OR 1.9) and hotel and catering (OR 1.6). Increased risk was also observed in occupations in metallurgy and electrotechnology (OR 1.5). In general, occupational differences were attenuated when the risk was adjusted for socioeconomic status. However, after this adjustment, an increased risk for hypopharyngeal and other pharyngeal cancers appeared for media professions (OR_{SES adjusted} 4.0), and for oral cancer in art-related occupations (OR_{SES adjusted} 2.2).

Alcohol and tobacco are the main risk factors for both oral cavity and pharyngeal cancers (41, 42). In developed countries, differences in the prevalence of the use and the level of consumption appear to explain partly the socioeconomic and occupational gradient observed for both oral cavity and pharyngeal cancers (43, 44, 38, 39, 45). As in mortality statistics, analyzed by occupation (1, 2) or by region (46), these incidence data show very similar patterns for other tobacco- and alcohol-related cancers.

Salivary gland

Salivary gland cancers (ICD-O 142) were rare, with only 96 cases available. No clear socioeconomic pattern was observed. As discussed in the section on limitations and interpretation (pages 13–20), the excess risk observed for poorly represented sites should be interpreted with caution. Based on five or more cases, a 2.5-fold increased risk was observed for bricklayers, stonemasons, tilers, and related workers, and a 3.5-fold increased risk was found for artistic occupations.

The etiology of salivary gland cancers is largely unknown. Only ionizing radiation has been consistently identified as a risk factor, in particular repeated medical and dental irradiation (41). This etiology cannot be evaluated from these data.

Nasopharynx

Only 75 cases of cancer of the nasopharynx (ICD-O 147) were found in our series. An excess risk among cooks was based on only three cases.

Except among Chinese, Filipinos, and some other populations in southeast Asia, in Maghreb and among Inuits, this cancer is very rare (29). In this study, no ethnic factor could explain this occupational pattern, notably because none of the three cooks were of Asiatic origin.

Causes of nasopharyngeal cancer relate to host factors, Epstein-Barr virus infection, and dietary habits. Concerning occupational risk factors, formaldehyde and intense occupational exposure to carcinogen-containing fumes, smoke, and dust have been suspected to play a role (47–48, 49). Only large studies would be able to investigate such a putative association in low-risk European populations.

Esophagus

In this series of 817 incident cases, the risk of esophageal cancer (ICD-O 150) was higher in low socioeconomic classes. The occupation-specific risk was increased among building workers, in particular bricklayers (OR 1.7), joiners, cabinetmakers and related occupations (OR 1.7), machinists and related occupations (OR 1.8), and cooks (OR 2.5). Lowered risk was observed for engineers, entrepreneurs and managers, and occupational groups involved in health and teaching. After adjustment for socioeconomic status, the risk remained elevated only for cooks, and it became significant for artists and related occupations.

Esophageal cancer is internationally known as being associated with a low socioeconomic status, poverty, and malnutrition. In western Europe and North America, the majority of esophageal cancer cases has been attributed to alcohol and tobacco consumption (50, 51). Very similar occupational patterns have been observed in other European studies (38, 39, 45). The overall contribution of occupational exposures to esophageal cancer occurrence is judged to be modest. In this study, as well as in mortality data (2), the pattern of cancer risk was largely similar to that of oropharyngeal cancer with one noteworthy exception, namely, the increased risk of cabinetmakers (in the incidence data) and of woodworking occupations (in the mortality data). Although already observed in a few other studies (52), the excess of esophagus cancer risk among these workers is a less well documented phenomenon. The role of wood and asbestos exposure in esophageal cancer occurrence warrants further investigation (53). Additional analyses by histological subtype showed that occupational patterns for esophageal cancer are mainly applicable to squamous-cell carcinomas, representing over 80% of the esophageal cancer cases in our series. For adenocarcinomas (126 cases in our series), for which

risk factors are largely unknown, an excess of risk was observed for plasterers and painters (N=7, OR 2.6, 95% CI 1.2–5.6) and (not significant) for joiners and cabinetmakers (N=5, OR 2.1, 95% CI 0.9–5.2).

Stomach

In this series including 2400 stomach cancers (ICD-O 151), a strong socioeconomic gradient was observed with a higher risk in lower classes. Increased risk was observed for farmers (OR 1.3), occupations in the pelt, leather and fur industries (OR 1.6), building workers, particularly bricklayers (OR 1.4), chemical workers (OR 1.9), drivers (OR 1.3), other occupations related to railways (OR 1.5), and workers in hotel and catering sectors (OR 1.3). In contrast, white-collar occupations showed generally a lower risk. After adjustment for socioeconomic status, the excess risk persisted only for chemical workers.

Studies have consistently shown an association between stomach cancer and low socioeconomic status (54, 55). This cancer is not usually thought to be related to occupational exposure. Occupational patterns probably reflect sociocultural differences in life-style, particularly dietary habits (54, 56). The results from our series appear to confirm this hypothesis, except for chemical workers, for whom the risk remained elevated after adjustment for socioeconomic status. An excess of stomach cancer among chemical workers confirmed the result from a cohort study on workers in the fragrance and flavor industries in Geneva (57). Similar results persisted after the cases from the Geneva cancer registry were excluded, and similar results were also observed in recent analyses of Swiss mortality data (GS). However, an excess of stomach cancer risk among these workers has not been documented in other national statistics, and no definite inference can be drawn from our data.

Our study also confirmed the well-documented excess of stomach cancer risk among agricultural workers, already reported in Switzerland (1, 2, 6), as well as in Finland (38), Denmark (39), Italy (45), and Quebec (58). The study also gives additional support to an excess risk for drivers, previously observed in a cohort study on professional drivers carried out in Geneva (59) (similar results persisted after the cases from the Geneva cancer registry were excluded), as well as in Swiss mortality data (1, 2).

Cancers of the cardia are known to differ in their etiology from cancers of other parts of the stomach (60). In this respect it is interesting to compare the occupational risk pattern of cardia carcinoma with that in other parts of the stomach. In this study, cancer of the

cardia showed almost no social class gradient. No excess of cardia cancer was observed in occupations belonging to the agricultural sector, in industries dealing with wood, cork, paper, chemistry or plastic, or among hotel and restaurant workers. This last observation is at variance with the often discussed hypothesis that alcohol is a main etiologic factor for cardioesophageal adenocarcinoma.

Small intestine

Malignant tumors of the small intestine (ICD-O 152) were rare, accounting for 276 cases in this series. The trend of an increasing risk with increasing socioeconomic status was not significant. An excess of cases, based on five or more cases, occurred among salespersons and representatives (OR 1.7), in occupations related to printing and graphic arts (OR 2.3), and the media (OR 4.2).

This cancer has been observed to occur more frequently among upper socioeconomic groups (38, 55). The etiology of small intestinal cancer is largely unknown (61). In this series, similar to those from other western industrialized nations (62), approximately 15% of small-bowel cancers were classified as lymphomas, which share a specific etiology (ie, human immunodeficiency virus). The excess risk observed was not due to a higher prevalence of small bowel lymphoma. The occupational pattern that appeared in our study remains unexplained.

Colon

In this series of 3766 cases of colon cancer (ICD-O 153), a clear socioeconomic status gradient was observed with a low risk for blue-collar workers. A slight excess risk was observed for engineers (OR 1.2), entrepreneurs and managers (OR 1.3), and teachers (OR 1.4). Farmers and related occupations and construction workers showed a lowered risk. Adjustment for socioeconomic status strongly weakened the excess risk among white-collar occupations and yielded a higher risk for mechanics (OR_{SES adjusted} 1.3) and typographers (OR_{SES adjusted} 1.7).

This study showed the typical pattern of colon cancer observed in western countries in which the highest incidence rates are found in the upper income classes (37, 39, 55, 63). Occupational studies have not shown consistent patterns for colon cancer. As in our study, most of the reported increased risks could be attributed to sedentary occupations (37, 38, 64, 65, 66).

The elevated risk (after adjustment for socioeconomic status) among typographers in this series and the

excess risk for Finnish printing workers (38) remains unexplained.

Rectum

The study series comprised 2541 cancers of the rectum (ICD-O 154). No significant variation of risk was observed between the socioeconomic or occupational groups, except for a 1.6-fold increased risk among architects.

The absence of socioeconomic variations in rectal cancer is in line with the general experience that a lack of physical activity is not a risk factor for rectal cancer, in contrast to colon cancer (66).

Liver

Among the 1172 cases of liver cancer (ICD-O 155) of the series, 1047 were histologically confirmed, and 905 were hepatocellular carcinoma. Compared with employees, professionals and managers showed a lower risk. Increased risk was observed for plasterers and painters (OR 1.4), and hotel and catering personnel (OR 2.0), in particular cooks (OR 2.6). Adjustment for socioeconomic status did not modify these occupational patterns, except in the group of dentists, veterinarians and pharmacists, who experienced a 2.8-fold increased risk. The few low-risk occupations were farming and breeding (risk adjusted for socioeconomic status), entrepreneurs and managers (risk not adjusted for socioeconomic status).

Most western studies have shown an association between chronic alcohol abuse and hepatocellular carcinoma, by far the most common type of liver cancer (67). The results of our study fit the alcohol hypothesis. In particular, in recent Swiss mortality statistics, similar patterns by occupations (and also by regions) were observed for liver cancer and liver cirrhosis (46), also with huge excesses among hotel and catering workers (GS).

Direct occupational factors may be possibly hidden behind the strong effect of alcohol. The high risk among painters probably reflects an excess of alcohol intake rather than specific carcinogenic exposure. In particular, Gubéran et al (68) have documented an increased prevalence of alcoholism-related disorders for Geneva painters in comparison with the general population.

Hepatitis B or C viruses are important etiologic factors for liver cancer, not only in developing countries, but also in well-developed ones. In our study, adjustment for socioeconomic status enhanced an elevated risk for "dentists, veterinarians, and pharmacists". All eight cases observed in this occupational group were dentists,

professionals for whom the prevalence of viral hepatitis infections is suspected to be high (69).

We also observed nine cases of liver angiosarcoma, a tumor for which association with vinyl chloride has been established (67). The occupational distribution did not allow any conclusions on vinyl chloride exposure for these cases.

Gallbladder and biliary tract

In our study, cancers of the gallbladder and biliary tract (ICD-O 156) (369 cases), including gallbladder and extrahepatic bile ducts, accounted for less than 2% of all cases. No clear-cut socioeconomic gradient was observed, although unskilled workers presented lowered risk. There were few occupations with odds ratios significantly greater than 1.0. Risk was about doubled among electricians (OR 1.9) and tripled among physicians (OR 3.4). A marginally significant excess of cases was also detected for occupations related to trade and administration sectors (OR 1.5) and among clerks (OR 1.3).

When analyzed separately, gallbladder and biliary tract cancers presented almost no similarity in their risk patterns, except for physicians and people in trade and commerce, who presented an elevated risk for both subsites. For cancer limited to the gallbladder, an excess of cases occurred among graphic art occupations (OR 3.1). These comparisons were based on only a few cases.

In developed countries, gallstones are the most recognized risk factor for gallbladder cancer (70), and there is only limited evidence on the role of occupational exposure.

The excess risk among electricians and physicians remains to be confirmed. For electricians, the excess of cases in our study mainly concerned extrahepatic bile duct cancer.

Pancreas

There were 1347 cases of pancreatic cancer (ICD-O 157) in this series. Almost no variation of risk by socioeconomic status was found. A higher occupation-specific risk was observed for hotel and restaurant managers (OR 1.9), and professors and teachers (OR 1.6). Lowered risk emerged for turners and metal workers, technicians and foremen. These results were slightly modified when adjusted for socioeconomic status.

Although pancreatic cancers are highly lethal, the risk patterns by occupation differed between incidence data and the recent analyses of Swiss mortality statistics (GS). This difference could have perhaps been due

to the poor quality of death records related to pancreatic cancer, or to the small occupational effect, and hence to the low power.

The risk factor most clearly associated with pancreatic cancer is smoking. Studies have also suggested that a high consumption of animal fat is directly associated with a risk of pancreatic cancer (71). Differences in smoking habits between occupational groups do not appear to explain the occupational pattern observed in our study. It strongly differed from the occupational pattern of other tobacco-related cancers. Numerous occupations have been reported to be associated with a moderate increase in risk, but an obvious common exposure has not been detected (71).

Peritoneum

Among the 100 cases of peritoneal cancer (ICD-O 158) under study, all except one were histologically verified. There were 53 (52.0%) sarcomas, 15 (14.7%) mesotheliomas, 7 (6.9%) lymphomas, and 16 (15.7%) seminomas, teratocarcinomas or embryonal carcinomas. An excess of cases observed for stone and earth trade workers, chemical and plastic workers, as well as chemists, were each based on less than five observations. A marginally significant excess of cases was also detected for occupations related to law and security, and a deficit of cases was shown for entrepreneurs and administration department managers.

Little is known about the very rare cancers of this site, which are composed of heterogeneous neoplasms. Each histological subtype probably shares a specific etiology. A sizeable fraction of not only peritoneal mesotheliomas, but also of some retroperitoneal sarcomas is probably due to asbestos exposure (72). In this respect, the two cases recorded for stone and earth trade workers were mesotheliomas.

Nose and sinuses

Sinonasal cancer (ICD-O 160) affects only a few persons (125 in this series). Risk was strongly elevated for pelt, leather and fur workers (OR 8.7), joiners and cabinetmakers (OR 6.9), and typographers (OR 7.6). However, the last result was based on only three cases. Turners also experienced a 2.5-fold increased risk of sinonasal cancer, however, of borderline significance ($P=0.054$).

Contrary to most other cancers in humans, sinonasal cancer has had little evidence produced to relate it to nonoccupational causes. A causal relation between

wood dust and sinonasal adenocarcinoma has been established (49, 73), and the relation between leather dust exposure and sinonasal cancer is highly suspected (74). In our study, 17% of the sinonasal cancers occurred among wood or leather workers. This association has already been described on the basis of Swiss mortality data (75). Other specific occupational risk factors, such as exposures to metal dust, nickel compounds and chromate pigments, have also been suspected in sinonasal cancer etiology (73, 74). This type of etiology may explain the higher risk observed among turners. Most of the sinonasal cancers among wood-related workers were adenocarcinomas, whereas all the sinonasal tumors of turners were squamous-cell carcinoma or melanoma, which usually occur on the skin. (See also the section on turners and related occupations on page 68.)

Larynx

There were 842 cases of laryngeal cancer (ICD-O 161) in this study. A clear trend of increasing risk with decreasing socioeconomic status was observed. An excess of cases was found for occupations related to construction (OR 1.5), metallurgy and electrotechnics (OR 1.3), hotel and catering (OR 1.6), and driving (OR 1.4), and a deficit of cases appeared for the technical, teaching and scientific sectors. Occupational differences were attenuated when the risk was adjusted for socioeconomic status, although art-related professionals then presented an increased risk of laryngeal cancer (OR_{SES adjusted} 2.2).

The difference in risk by socioeconomic status was one of the largest among all the sites considered in this report. Epidemiologic studies have clearly shown that tobacco smoking and excessive alcohol consumption, particularly hard liquors, increase the risk of laryngeal cancer (76). Most of the high risks in our study, as well as in other studies (38, 39), are expected to be accounted for by smoking and drinking. In particular, the occupational patterns were very similar to those observed for pharyngeal cancer. Occupation-specific exposures may also be identified for some occupations, such as for construction and metal processing. In particular, an increased risk of laryngeal cancer has been observed for occupations exposed to cutting fluids, asbestos, nickel refining, and sulfuric acid mist (38, 39, 76, 77).

Lung

Lung cancer (ICD-O 162) is the most common cancer among men after prostate cancer, and the 9106 cases constituted up to 15% of all the cancers in our series.

The risk was lower for white-collar occupations, while higher risk was observed for blue-collar workers, especially in "dusty" occupations. In fact, a high risk of lung cancer (with OR values ranging between 1.2 and 2.2) was observed for mining and quarrying, metal and construction, and also many occupations involving cleaning and personal services, transport, and telecommunications, as well as among machinists and related occupations. A higher risk was also observed for chemical workers (OR 1.5) and gardeners (OR 1.3). A lower risk was generally found for farmers, technical personnel, and teaching, health and science professionals. After socioeconomic status was accounted for, an excess of cases persisted at a significant level for bricklayers, foundry workers, and machinists. Entrepreneurs and artists, with a rather low risk in the unadjusted analysis, showed an increased risk after adjustment for socioeconomic status.

Analyses by histological type showed that most of the occupational risks in our study were associated with epidermoid carcinoma. Small-cell cancer behaved like squamous-cell carcinoma, as did, to a lesser extent, large-cell carcinoma. Adenocarcinoma was found to be the least occupational-related morphological type. Contrary to squamous and small-cell carcinoma, the occupational patterns of large-cell carcinoma and adenocarcinoma were practically not affected by adjustment for socioeconomic status.

The risk pattern for lung cancer by occupation in the Swiss incidence data is typical for this tumor, with higher incidence rates in occupations exposed to inorganic dusts or fumes from fossil sources. Almost all national routine statistics in Europe or the United States show very similar risk patterns for lung cancer by occupation (1, 2, 8, 37–39, 45, 58, 78–80). But this series also showed an elevated risk for occupations such as chemical workers and horticulturists, whose risk elevations appear inconsistently in international statistics.

The impact of smoking is so important in lung cancer causation that weaker factors, like occupational ones, tend to go unnoticed. Several times it has been shown that adjusting for smoking does not eliminate the typical lung cancer risk differences between occupations (58, 81–83). In this study, some important risks remained elevated also after adjustment for socioeconomic status, especially for construction workers, foundry workers, and drivers. Mortality statistics also demonstrated a clearly elevated risk for these groups (2, 84). The increased risk of foundry workers was already known in Germany as early as 1913 (85), and the elevated risk of construction workers, painters, and metalworkers (foundry, furnace, and probably also welding) can be traced back to the 1930 mortality statistics of the United Kingdom. This was a period when the effects of smoking were barely visible, and lung cancer among

men did not yet reveal a negative socioeconomic gradient.

The main occupational lung carcinogens known to date were already almost entirely enumerated by Hueper 50 years ago. They include polycyclic aromatic hydrocarbons (coke oven emissions, pitch, tar fumes, diesel exhausts and chimney soot), arsenic, chromium, nickel, asbestos, radon, and chloromethyl ethers (86). Crystalline silica has recently been found to be a weak lung carcinogen (87, 73). For some agents (asbestos, arsenic, and alpha-radiation in mines), the occupational exposure interacts with smoking and displays more than merely additive risks (88, 89). Asbestos fibers are among the most well-established occupational carcinogens (47, 73). In this series, workers exposed to asbestos, such as bricklayers, stonemasons, tilers, plasterers, painters, electricians, stone and earth trade workers, miners and quarriers, showed a higher risk of lung cancer. Swiss foundry workers with lung cancer were also found to be exposed to asbestos, and construction workers with lung cancer had past exposure to silicosis (90). Some of the excess of cases was probably also related to welding and other metal fumes among foundry workers, to chromate pigment among painters (68, 91, 73), and to diesel exhaust among truckers (73, 92).

Pleura

In this study, among the 310 recorded cases of pleural cancer (ICD-O 163), 215 (69%) were histologically confirmed to be mesothelioma. A strong socioeconomic difference was observed with a higher risk of mesothelioma among blue-collar workers. In particular, unskilled workers had about a fourfold increased risk when compared with employees. We observed a 13.8-fold increased risk among stone and earth trade workers and a 4.7-fold increased risk among joiners and cabinetmakers. An elevated occupation-specific risk was also observed for metallurgy and electrotechnical workers (OR 2.6) (in particular foundry workers and electricians), in the group of other engineers (mainly composed of electrical or electrotechnical engineers) (OR 1.9), and railway workers (except locomotive engineers) (OR 2.0). The risk of mesothelioma among farmers and trade- or administration-related occupations was significantly low. After adjustment for socioeconomic status, a higher risk also appeared for jewelers (OR_{SES adjusted} 15.8), although this result was based on only four cases.

Until 1960, when Wagner et al (93) reported a large case series among South African crocidolite miners and neighboring residents, pleural mesothelioma was rarely noted. Since then, as a result of occupational asbestos exposure, the incidence of mesothelioma has been increasing, with most tumors arising from the pleura.

Throughout the world, an increased risk has been documented among workers in asbestos mines, mills and factories, insulation manufacturing and installation, shipbuilding, railroad, machinery, paper and wood products, and workers in other occupations involving the inhalation of asbestos dust (94–97). The distribution of industries in which workers are exposed to asbestos is clearly visible on the map of pleural cancer mortality in Switzerland (46). In the same vein, all the high risks observed are known to be related to potential asbestos exposure. In particular, among Swiss joiners, cabinetmakers and related workers, an excess risk was found to be associated with asbestos (90).

In Switzerland, occupation-related mesothelioma linked to asbestos exposure is reimbursed by the Swiss National Accident Insurance Fund (SUVA). However, a study performed in the canton of Zurich, where mesothelioma patients were studied in detail, showed that a nonnegligible fraction of the cases was not notified to the National Accident Insurance Fund (72).

Because of the long latency period between asbestos exposure and the occurrence of mesothelioma, the excess of observed risk will probably not abate for several decades (98).

Bone and cartilage

Cancer arising in bone and cartilage (ICD-O 170) accounted for about 0.2% (104 cases) of the malignant neoplasms in this registry series. There was no consistent socioeconomic trend. A 2.9-fold increased risk was observed for railway-related workers. Based on fewer than five cases, other strong excesses of risk were observed in occupations related to horticulture, pelt, leather and fur workers, chemical workers, chemists, and in the heterogeneous group of other occupations related to transport.

Some occupational risk factors, such as exposure to ionizing radiation, radium, and mesothorium ingestion [during the fluorescent painting of watch hands and dials (99, 100)], thorotrast, vinyl chloride, and arsenic (101), have been suspected for bone osteosarcoma. In this series, no cases of osteosarcoma were observed among watchmakers. The interpretation of the excess of cases among both chemists and chemical workers could only be speculated upon.

Another suspected occupational risk factor for osteosarcoma is exposure to chlorophenacetic acid or chlorophenols. The presumptive carcinogenic risk of these chemicals has been suspected in several epidemiologic and case series reports, especially from northern European countries, where phenoxy herbicides have been used in forestry (102). These chemicals have been used in farming, for wood preservation, and for

waterproofing leather and textiles. In Switzerland, exposure to different herbicides or fertilizers is probable for horticulturists, and exposure to herbicides is also probable for railway-related workers (103). However, an association between this exposure and sarcoma is described for soft tissue sarcoma (102) and not for bone sarcoma as in our study (104). Recent analyses of mortality data (GS) did not confirm these bone cancer incidence patterns, although the reliability of mortality from bone cancer remains low (2), as it often includes secondary tumors metastasizing into the bone.

Soft tissue

Cancer of the soft tissue (ICD-O 171) accounted for about 0.6% (354 cases) of all malignant neoplasms in this series. No clear socioeconomic gradient was observed. An excess of cases was observed for artistic occupations (OR 2.0). The elevated risk among male nurses was based on fewer than five cases.

Phenoxyacetic acids or chlorophenol exposures and radiation have been described as the main occupational risk factors (102, 47). In this series, the excess risk observed appeared to be linked to Kaposi's sarcoma. (See the next section.)

Kaposi's sarcoma

Kaposi's sarcoma was analyzed according to the specific morphological classification (ICD-O-M 9140), independently of the primary tumor site. This series included 288 cases. A clear excess of cases was observed for all artistic occupations, particularly artists (OR 5.5), hairdressers (OR 5.4), and male nurses (OR 3.0). A higher risk was also found for both managers (OR 2.1) and clerks of commercial and administrative sectors (OR 1.4), and also for occupations related to hotels and catering (OR 2.7). Other elevated risks were based on fewer than five cases. A lowered risk was observed for workers in building, metallurgy, and technical fields.

Today, human herpes virus 8 (HHV-8) is known to be a specific etiologic factor for Kaposi's sarcoma. But risk is extremely accentuated among people infected by human immunodeficiency virus (HIV).

Kaposi's sarcoma has occurred prominently in the acquired immunodeficiency syndrome (AIDS) from the onset of the epidemic. AIDS is particularly prevalent in Geneva and Zurich. For the period 1983–1996 the total rate of declared cases per 100 000 inhabitants was 179.8 for Geneva and 143.9 for Zurich, compared with 78.8 for Switzerland as a whole (105). In these two cantons, the incidence of Kaposi's sarcoma among the 20- to 49-year-old men was found to be 30 times higher dur-

ing the period 1993–1995 than for 1981–1983. There are striking differences in the frequency of Kaposi's sarcoma among the different subgroups of AIDS patients, the highest being found for homosexual men (106). The propensity of homosexuals to choose certain occupations probably explains the current occupational patterns.

Malignant melanoma of the skin

Skin melanoma accounted for 2.6% (1541 cases) of the incident cancers in this series. Risk increased with increasing socioeconomic status. Several occupational groups showed an elevated risk, all being white-collar occupations, namely, architects (OR 1.9), chemical engineers (OR 2.1), other engineers (OR 1.7), managers (OR 1.3), lawyers (OR 2.0), and physicians (OR 1.7). A lowered risk was observed for bakers and related occupations, workers in construction or metallurgical industries, and electronic and hotel and catering sectors. The residual occupational variation after adjustment for socioeconomic status was small, with the exception of workers in agriculture and animal production (OR_{SES adjusted} 1.4), watchmakers (OR_{SES adjusted} 2.6), and occupations related to printing and graphic arts (OR_{SES adjusted} 1.7), which then presented a significantly increased risk of melanoma. Excesses among farmers were seen for melanoma of the head and neck and, to a lesser extent, arms, but not on the trunk or legs. The excess of cases observed for watchmakers mainly concerned the trunk.

Skin melanoma has been given considerable attention due to the steep increase in incidence observed over the last 20 years, Switzerland having one of the highest incidence rates in Europe (29, 107, 108). The main etiologic factor of melanoma is intense and repeated sun exposure of the skin, in particular during childhood (109). People having a higher socioeconomic status are more likely to spend their vacation in the mountains or on the beach. As already documented, the increased occupation-specific risk strongly supports the role of sunburns in the etiology of skin melanoma (109). Almost all high-risk occupations for melanoma of the trunk or leg implicated typical indoor occupations for which the elevated risk may be due to acute sunburns acquired during leisure-time activities. In addition, the increased risk of melanoma of the head, neck, or arm among farmers and agriculture-related workers was in line with sun exposure as the main factor. The lentigo maligna melanoma type is frequent on the head and neck and has a distribution by age and site similar to that of squamous-cell skin cancer. No relationship with specific occupational factors was apparent, except possibly for an excess of melanoma of the trunk among watchmakers (OR 2.6).

Other skin

Since the Zurich cancer registry does not register basal- and squamous-cell carcinoma of the skin, it was excluded from these analyses. Among the 8293 available cases, 6516 were basal- and 2471 were squamous-cell carcinoma. Both basal- and squamous-cell carcinomas showed a socioeconomic gradient with a higher risk among professionals and a lower risk among unskilled workers.

Squamous-cell carcinoma

With regard to squamous-cell carcinoma, there were only a few occupations with significantly high or low risks. Among farmers (OR 1.6), machinists (OR 1.7), and locomotive engineers (OR 2.3), the risk was greater than 1. The excess among farmers was significant only for cancer of the head and neck. High risk was also observed for engineers (OR 1.3), health and teaching-related professionals (OR 1.4 and 1.7, respectively), and a low risk was found for metallurgy and electrotechnical workers. Rather similar patterns were observed after adjustment for socioeconomic status.

The prevailing risk factor for nonmelanoma skin cancer is chronic ultraviolet radiation (110). High rates were typically found for outdoor workers, with a tendency for skin cancer to occur on sun-exposed surfaces (38, 39). Exposure to sun during spare time activities is generally thought to explain the excess risk among high-income occupations and teachers (110).

Exposure to tar, soot, and poorly refined mineral oils (rich in polycyclic aromatic hydrocarbons) has also been linked to skin and scrotal cancer (111, 73). This association could explain part of the excess risk for squamous-cell cancer among machinists and locomotive engineers. Exposure to inorganic arsenic compounds has also been associated with the development of skin cancer (112, 73). This relationship probably does not explain the excess risk among farmers, as arsenic cancers principally involve unexposed parts of the body and unusual locations, such as the palms of the hand (113). This pattern was not observed in our data. In addition, the parallelism observed between squamous-cell carcinoma and melanoma among farmers speaks against specific occupational exposure.

Basal-cell carcinoma

An almost 30% increased risk of basal-cell skin cancer was observed for technical occupations, trade and administration, and health, teaching and science professionals. A low risk was generally found among blue-collar workers. After socioeconomic status was accounted for, the differences in risk dramatically decreased, and the highest excess of adjusted risk was then observed for tailors and related occupations.

For basal-cell carcinoma, the risk pattern by occupation in the Swiss incidence data is in agreement with that observed worldwide. As for squamous-cell carcinoma, ultraviolet radiation is thought to be the main risk factor for basal-cell carcinoma (110). Many of the high-risk occupations of skin melanoma (engineers, managers, physicians) also showed a significantly high risk for basal-cell carcinoma. The registration of basal-cell carcinoma may not be as complete as that of other malignancies (30). A better diagnostic ascertainment among the well-educated could, at least in part, explain the observed patterns.

Breast

Of the breast cancers (ICD-O 174), only 96 cases were recorded for men. An excess of cases among textile and leather workers and typographers was based on less than five cases.

The analytical epidemiology of breast cancer among men presents similarities with the etiologic profile of breast cancer among women with a potential role for hormonal factors (114, 115). Alcohol has so far only been associated with breast cancer among women. The occupations with elevated risk in this series of breast cancer among men were not known to be correlated with alcohol-related diseases. No consistent association with occupations has been reported in the literature (114, 116), and a clear occupational pattern could not be drawn from this series either.

Prostate

The mean age of patients is high at the time of diagnosis of prostate cancer (ICD-O 185). Because this study was limited to cases in a population younger than 65 years in two of the five cantons considered, 8.5% of the prostatic cases were excluded. (See the Materials and Methods section beginning on page 6.) In this series, prostate cancer (N=9126) was the most common cancer site. There was a weak, but consistent socioeconomic gradient for prostate cancer risk, with an increased risk among upper socioeconomic groups. Only slight differences in risk were observed between occupational groups, but, because of the great number of prostatic cancers, even a slight increase or decrease in risk reached significance. Entrepreneurs, managers in trade and administration sectors, law and security professionals, police officers, and teachers experienced about a

10% to 30% elevated risk. A high risk was also observed for watchmakers (OR 1.7) and men involved in food, beverage and tobacco sectors (OR 1.2). Low risk was documented for workers related to construction and stone, earth and glass trades. After adjustment for socioeconomic status, a high risk appeared for farmers and bakers, and low risk was observed for health care occupations.

The etiology of this very common cancer remains uncertain. Endocrine factors, nutrition, sexual and reproductive factors, and family history are suspected to be linked to this cancer, although these associations remain inconclusive (117). Occupational studies of prostate cancer have mainly focused on cadmium exposure, although epidemiologic studies have provided only very limited support for this hypothesis (117, 118).

Our analysis is in line with the hypothesis that factors other than occupation may be the major determinants of this tumor. The trend of increasing risk with increasing socioeconomic status could be explained by social class differences in life-style factors, but also by diagnostic activity (ie, frequency of screening by thin-needle biopsies or prostatic specific antigen dosing of occult carcinoma).

Testis

Testicular cancer (ICD-O 186) accounted for 1.9% (1112 cases) of all cancers in this series. A consistent positive association between testicular cancer and socioeconomic status was observed, the highest socioeconomic group having the highest risk. Elevated risk was observed for architects (OR 1.8), chemical engineers (OR 3.5) and other engineers (OR 1.4), technicians and foremen (OR 1.7), media workers (OR 2.1), and physicians (OR 2.2). A low risk was found for occupations related to construction, hotel and catering work, and cleaning. After adjustment for socioeconomic status, a high risk persisted for technicians, foremen and physicians and appeared for electricians (OR_{SES adjusted} 1.6).

In Switzerland, testicular cancer incidence is among the highest worldwide (29, 119). To date, the main established risk factor for this cancer is cryptorchidism (120). Most studies have shown the highest incidence of testicular cancer in the highest socioeconomic classes, with rates approximately twice as high as in blue-collar occupational groups (38, 39, 55). Such observations may indicate that risk factors correlated with socioeconomic status rather than occupational exposures are responsible for the excess risk of testicular cancer (120). Our analysis supports this hypothesis.

Other male genital organs

Among the 200 cases belonging to the group other male genital organs (ICD-O 187), three-quarters were cancers of the penis (151 cases in our study series), and only 17 cancers originated in the scrotum. There were slight differences with respect to socioeconomic status, with an exception for a lowered risk among unskilled workers. A 2.2-fold increased risk was observed for artists. The other observed excesses of risk were based on fewer than five cases.

Most studies indicate that penile cancer occurs more frequently in countries with a relatively low standard of living or in the lowest socioeconomic stratum (121). The inverse pattern observed in this study remains unexplained. Sexual transmission of an infectious agent, especially human papilloma virus, is the most recognized risk factor of penile cancer. This possibility could explain the excess observed in occupations with artistic profiles. In our study series, none of the 17 scrotal cancer cases were observed in occupations exposed to polycyclic aromatic hydrocarbons or mineral oils (53, 122).

Urinary bladder

There were 3014 cases of infiltrating urinary bladder cancer (ICD-O 188) in this study series. Almost no social class variation was observed. Urinary bladder cancer patterns by occupation were rather similar to that observed for all other cancers considered together. Only a few occupations showed an elevated risk, namely, mechanics (OR 1.3), policemen (OR 1.4), occupations related to cleaning (OR 1.3), and hairdressers (OR 1.5). Low risk was observed for occupations in the agricultural sector, foundry workers, railway employees (except locomotive engineers), and media-related occupations. The risk patterns did not change much after allowance for socioeconomic status.

On the basis of early observations that led to the identification of a number of carcinogenic aromatic amines in the dyeing and rubber industries, occupation has, in addition to smoking, traditionally been implicated as a major risk factor for urinary bladder cancer (47, 73, 122–124). An excess risk has also been consistently reported for the leather industry (123). It is noteworthy that these occupational risks, with the most solid epidemiologic evidence of causality, were virtually absent in our data. This lack could be the consequence of the elimination of bladder carcinogens in the relevant industries but may also be due to the limitations of our study. (See the section Limitations and Interpretation beginning on page 13.) For example, around 1970, a cluster of urinary bladder cancers was described in a Swiss rubber

plant in the canton of Uri (125), but, since no cancer registry covers this canton, it was impossible to confirm or refute this previous observation. This study was also unable to evaluate the formal association between employment in "dry cleaning" and bladder cancer (126), as there were only 33 cancer cases recorded in occupations related to laundering, dyeing and dry cleaning (ASCR code 172).

An excess of cases among hairdressers, already documented in Geneva (127), could be related to aromatic amines, used in brilliantines and hair dyes (128, 129). An elevated risk among electricians has also been documented (38, 78, 123). However, these findings require corroboration. The low risk for agricultural work is also a common feature in other national statistics (37). The elevated risk for policemen was an isolated finding.

Kidney and urinary tract

Of the kidney and urinary tract cancers (ICD-O 189), in this study, cancer of the renal parenchyma (renal cell) (1356 cases), of the renal pelvis (228 cases), and of the ureter or urethra (97 cases) represented 81%, 14%, and 6%, respectively, of all kidney cancers. Cancer of the kidney and urinary tract showed a slightly positive association with high socioeconomic status. The highest risk was observed for occupations related to the stone, earth and glass industries, with a 3.2-fold increased risk for miners and quarriers. An excess of cases was also observed for trade and administration, especially salespersons and representatives (OR 1.4), and for laboratory assistants (OR 1.8). The risk was rather low in the construction trades, in contrast to the risk of miners and quarriers. Accounting for socioeconomic status provided a similar pattern.

The total increased risk for all kidney cancers was, in fact, due solely to renal cell cancer (ICD-O code 189.1). With regard to renal pelvic cancer (ICD-O code 189.1), increased risk was observed for plasterers and painters (OR 2.2), machinists (OR 3.2), and for occupations related to transport (OR 2.1). After adjustment for socioeconomic status, other occupations related to cleaning showed higher risk (OR_{SES adjusted} 4.7).

The etiology of kidney cancer remains largely unclear, except for renal pelvic and ureteral cancers, which are known to be related to cigarette smoking (130). Obesity, or a high calorie diet, has been found to be positively correlated to kidney cancer (130) and could have contributed to the socioeconomic risk variation observed.

With regard to cancer of the renal pelvis, only a few occupational associations have been previously observed, probably because of the relative rarity of these

neoplasms and the frequent inclusion in occupational studies of renal-cell cancer. Although available data are limited, the work-related risks observed for cancers of the renal pelvis and ureter resemble the occupational associations established for urinary bladder cancer (130) and are in agreement with our data. In addition, heavy use of phenacetin-containing drugs has also been clearly linked to renal pelvic tumors (122, 130). In our series, no significant increased risk was observed among watchmakers who had been given phenacetin at the workplace against common headache.

Eye and the lacrimal gland

Of the eye and lacrimal gland cancers (ICD-O 190), there were 109 cases of ocular cancer in this study series, and 75% of them were melanoma. A significant socioeconomic gradient was not observed, but upper socioeconomic groups tended to have an elevated risk. All increased risk concerned white-collar occupations [ie, architects (only 3 cases), engineers (7 cases, OR 2.3), physicians (only 3 cases), and chemists (only 2 cases)].

The etiology of ocular cancer is unclear, and there is very little evidence that occupational factors play a role (131). In light of the results of our study, with respect to socioeconomic and occupational patterns, the etiology of eye melanoma appears to be very similar to that of skin melanoma.

Brain and the nervous system

The category of brain and nervous system tumors (ICD-O 191–2) is a miscellaneous collection of very different cancers. Malignant gliomas make up approximately 80% of all nervous system tumors in men (879 cases in our series). There was no socioeconomic gradient (figure 2). The only significantly elevated risk was observed for tailors and related occupations (OR 2.5). The excess risk among the group of other engineers became significant when adjusted for socioeconomic status (OR_{SES adjusted} 1.7).

Some studies reported an increased risk of nervous system tumors in workers exposed to various chemicals in the vinyl chloride, petrochemical and rubber industries, in laboratories, and among anatomists, but most of these associations were not confirmed in other studies (38, 53, 132). This data set did not suggest that chemical exposures may be important in the causation of cancer of the nervous system. Electrical workers showed a risk equal to 0.7, which does not support the hypothesis of the role of low-frequency electric and magnetic fields in the causation of brain tumors (132, 133).

Thyroid gland

This study included 320 cases of thyroid cancer (ICD-O 193). The frequency of thyroid cancer was slightly, but not significantly, higher among professionals (figure 2). About a threefold elevated risk was observed for farmers (OR 2.7) and physicians (OR 2.6). An excess based on only two cases was also documented for agronomists. Similar results were obtained after the adjustment for socioeconomic status.

In Switzerland, thyroid cancer is of particular interest since the incidence rate is one of the highest in the world (29). Because of a particularly high prevalence of goiter and iodine-deficit-related cretinism, several programs of prophylaxis of iodine deficiency have been undertaken in this country (46, 134, 135). The influence of iodine deficiency on both the onset and progression of thyroid cancer, although long suspected, is still not completely understood (134, 136). The follicular type appears to be particularly common in areas of endemic goiter, probably due to iodine deficiency, whereas enhanced risk of papillary-type carcinoma has been observed in iodine-rich areas. In this study, the higher risk among physicians concerned mostly papillary and papillary-mixed types, whereas among farmers it mainly concerned the follicular type. In particular, follicular carcinoma represented 41% of the cases (7 of 17) recorded among farmers and 0% of the cases (of 7) recorded for physicians. Very similar patterns have been observed in Finnish incidence data (38). Pukkala et al hypothesized that differences in iodine intake between social groups could explain occupational risk patterns. Thus the excess of papillary thyroid cancer among physicians could be linked to the fact that they were more likely to start using iodine-enriched salt earlier, whereas the excess of follicular cases among farmers could, on the contrary, be linked to a past deficiency of iodine intake in rural and mountainous areas. However, part of the excess of cases among physicians can be due to differences in diagnostic ascertainment or to occupational exposure to radiation. (See the section Cancer Profiles of Selected Occupations beginning on page 66.)

Other endocrine glands

Cancers of other endocrine glands (ICD-O 194) were very rare (70 cases in our series), and no consistent trend for socioeconomic status emerged from this study. The excess risks observed for mechanics, locomotive engineers, and jewelers were based on less than five cases.

The heterogeneous category of "cancers of other endocrine glands" included several small groups of can-

cer, which probably share different etiologies. There are problems in the definition of criteria of malignancy, both in the diagnostic ascertainment and in the registration of some of these cancers (eg, in the case of pheochromocytoma and thymoma). Hereditary aspects, like multiple endocrine neoplasia (MEN) syndromes, might further complicate the interpretation of the results. No occupational factors have been suspected, and this study, as had others, provided poorly interpretable results.

Non-Hodgkin's lymphoma

In this study series, there were 1125 cases of non-Hodgkin's lymphoma (NHL) (ICD-O M 959-64; 969) arising in lymph nodes. NHL classified to have their origin in specific organs other than the lymph nodes (extra nodal lymphomas) were included in the organ-specific analyses. There was a modest gradient with lower risk in the lower socioeconomic strata. Elevated risk was observed among white-collar occupations such as entrepreneurs or administrative managers (OR 1.3), health professionals, in particular dentists, veterinarians and pharmacists (OR 2.3), teaching professionals (OR 1.5), and chemists (OR 2.7). Cheesemakers were also found to have an excess of NHL (OR 2.5). On the contrary, occupations related to the building, metallurgic, and electrotechnical industries showed a low risk. Adjusting for socioeconomic status showed interesting changes, with an elevated risk persisting for chemists and cheesemakers and appearing for butchers (OR_{SES adjusted} 1.7) and farmers (OR_{SES adjusted} 1.3, P=0.054).

Swiss incidence data follow a similar socioeconomic pattern for NHL risk, in agreement with the general experience of a positive association between NHL and social class (137).

NHL is a group of histological, immunologic, and also etiologic heterogeneous disorders. In cancer registration, the misclassification of lymphoma types is a well identified problem that highly limits the distinction of pathological subgroups of lymphomas and the search of their respective etiology. This may explain the lack of consistency in the pattern of occupational associations previously published (137, 138). Nevertheless, two main etiologic links emerge in the literature, namely, primary and secondary immunodeficiency conditions (eg, AIDS), and occupational exposure to chemicals. In particular, there is growing evidence of the role played by phenoxy herbicide exposure and, possibly, organic solvents. Our results suggest that this type of occupational background may be behind the elevated risk among farmers. The cluster of cases among chemists may also have been due to specific carcinogenic exposure, and it warrants further investigation.

Oncogenic viruses are known to cause lymphoma in a variety of animal models. Contact with animals has been documented as possibly increasing the risk of NHL in humans through exposure to viruses such as the bovine leukemia virus. (137). In Geneva, an excess of NHL has also been documented in a cohort study of self-employed butchers (139). Animal viral exposures could be at the origin of the excess of cases observed for butchers and also cheesemakers, although, for the latter, the type of transmission, if present, must be different (ie, by milk instead of blood). In this series, some of the high risks observed in occupations with frequent contact with human beings (patients, students) are also in line with the hypothesis of an infectious etiology for NHL.

Hodgkin's disease

For Hodgkin's disease (ICD-O M 965–6) (345 cases in this study), the patterns by socioeconomic status were inconsistent. Significantly elevated risk was observed for mechanics (OR 1.8) and entrepreneurs and managers of commercial and administrative sectors (OR_{SES adjusted} 1.5). The other excess of cases (ie, among chimney sweeps) was based on less than five observations. Adjusting for socioeconomic status did not modify this circumstance.

Hodgkin's disease is characterized by its peculiar clinical features and unusual epidemiologic picture, which is highly suggestive of an infectious, probably viral, origin (140). Among other etiologic hypotheses, some occupational exposures have been pointed out [ie, sawdust and chemicals (39, 140, 141)], but they have not been confirmed. Contrary to that observed for NHL, our figures do not support the hypothesis of an infectious etiology for Hodgkin's disease.

Multiple myeloma

Of the multiple myelomas (ICD-O M 9730–3) in our series, plasma cell malignancies accounted for 535 cases. No significant pattern was observed for socioeconomic status. A significant increase in risk was found for carpenters (OR 2.8), postal and telecommunications workers (OR 1.9), media occupations (OR 2.8), and social- and teaching-related professionals (OR 1.8).

In addition to autoimmune disorders and chronic immune stimulation, radiation, asbestos, solvents, and pesticides are suspected, but not yet confirmed, to be associated with multiple myeloma (142). Our study points out an excess risk among teachers, which could

reflect frequent infectious diseases. Numerous studies have documented an increased risk of multiple myeloma among agricultural workers and, to a lesser extent, among wood-related workers (142), but such associations are far from established. In our series, the excess of cases among farmers was not significant (OR 1.3, 95% CI 0.8–2.0).

Leukemia

All types of leukemia (ICD-O M 980–94) (1322 cases in this series) were analyzed as a whole. Chronic lymphoid leukemia and myeloid leukemia, which accounted for 39% and 41%, respectively, of the leukemia cases, were also considered separately. We also distinguished all acute cases of leukemia (29% of the leukemia cases) from nonacute leukemia (69%). A socioeconomic gradient was not observed for all types of leukemia combined or for the leukemia subtypes. An elevated risk for leukemia was observed for graphic art workers (OR 1.5), locomotive engineers (OR 2.1), physicians (OR 1.6), and chemists (OR 2.0). Viniculturists also showed an excess risk, although based on less than five cases.

With regard to chronic lymphoid leukemia, the only significant excess of cases was observed for butchers (OR 2.0) and occupations in the pelt, leather and fur industries (OR 2.5).

Concerning myeloid leukemia, an excess of cases was observed among foundry workers (OR 2.3), locomotive engineers (OR 3.3), media workers (OR 2.1), and chemists (OR 2.7). The other excess, based on less than five cases, was observed for agronomists.

For acute leukemia, an excess of cases was observed among foundry workers (OR 2.7), electricians (OR 1.9), and the whole group of science professionals (OR 2.1). The excess observed for viniculturists and agronomists was based on fewer than five cases.

The classification of leukemia has been subject to many debates, which, over time, has given rise to substantial changes in diagnostic criteria. The distinction between the leukemia subtypes used in our analysis is far from universally accepted (143), and the occupational risk pattern observed should be interpreted with due caution.

Even though leukemia has been extensively investigated, knowledge on its etiology is still rather limited (143). Except for the chronic lymphatic type, radiation has long been known to cause leukemia and has been found to be particularly frequent among radiologists (143). We documented an excess of leukemia cases among physicians, but information was not available on the medical specialty or on X-ray exposure.

In general, chemical-related cases were estimated to account for approximately 1% of all leukemias (53). Benzene is known to possess leukemogen potential (143, 73), and an excess risk has been reported for workers in the shoe, leather, rubber, and rototyping industries (143). Increased risk observed earlier for leukemia among maintenance workers in bus depots, railway workers, and professional drivers could probably also be due to exposure to benzene and, to a lesser extent, diesel exhausts (143). Benzene exposure is mainly associated with acute myeloid leukemia (143), and our study suggests such possible exposures, in particular among printing workers and chemists. However, the increased risk of leukemia reported among chemists could be related to other types of chemical exposure (143).

There has been much discussion about magnetic or electromagnetic field exposure being a cause of leukemia (143–148). Several studies have found an elevated risk of leukemia among locomotive engineers (143). Swiss locomotive engineers are exposed to high magnetic fields (149), and they also have an increased mortality rate for leukemia (150). Our findings also support an elevated risk for leukemia among the broad category of electricians (limited to acute leukemia) and for locomotive engineers. However, these results must be cautiously interpreted and compared with those from cohort studies involving electromagnetic field measurements and reliable exposure assessments.

An excess risk of leukemia has often been reported for agricultural occupations (38, 39, 143), and it is probably related to exposure to various agrochemicals (including crop and animal insecticides, herbicides and fertilizers) and animal leukemogen viruses (143). In our

study an excess of cases was observed for viticulturists, and three cases of myeloid leukemia were recorded for agronomists and forestry engineers, conferring a 5.3-fold increased risk (95% CI 1.6–17.1) to this occupational group.

For more than 80 years, information has been accumulated on the viral etiology of leukemia (143), but the role of exposure to bovine leukemia virus on subsequent human leukemia occurrence remains undetermined. This study confirms the previously reported elevated risk of leukemia among butchers observed in Geneva (139). Our excess concerned chronic lymphoid leukemia, and it persisted after the data from the cancer registry of Geneva were excluded. Morphologically, chronic lymphoid leukemia belongs to the NHL category, and an elevated risk of this type of leukemia among butchers could be placed parallel to that observed for NHL.

Uncertain primary site

There were 1232 cancer cases with unspecified primary sites (ICD-O 199), representing less than 2.1% of the cancers in our series. No clear socioeconomic gradient was observed. A high risk was observed for artists, but it disappeared after social class was accounted for. The adjusted OR values were found to be lower for health care professionals, particularly physicians.

These occupational patterns probably reflect the variation in the accuracy of diagnostic assessment between occupational groups.