

Second international symposium on epidemiology in occupational health

Montreal, 23–25 August 1982

arranged by the Scientific Committee on Epidemiology in Occupational Health,
Permanent Commission and International Association on Occupational Health

The Scientific Committee on Epidemiology in Occupational Health, one of the committees of the Permanent Commission and International Association on Occupational Health, commenced its activities with a symposium in Helsinki in 1981, which, in addition to being a very rewarding meeting, stimulated international interest in the Committee's activities. As a result over 150 people have registered with the honorary secretary for future mailing information, and a second meeting was held in Montreal, Canada, on 23–25 August 1982 at the McGill University. Prof JC McDonald supervised the arrangements, and 168 participants from 20 countries attended the meeting at which 75 papers were presented. The abstracts of these papers follow this brief summary of the meeting; they are arranged under the headings of the sessions held at the symposium.

There was unanimous agreement among the delegates that such activities of the Permanent Commission are very useful. There is widespread interest in the use of epidemiology to investigate occupational health problems, and the participants represented not only occupational health practitioners, but also epidemiologists, biostatisticians, occupational hygienists, and occupational health nurses. In addition to sessions concerning the reporting of studies, there was particularly active interest in the methodology sessions which, as in Helsinki, clearly formed a major focus of interest for people attending these meetings. It appears, therefore, that this scientific committee has filled an important hiatus in the Commission's activities, and great interest has been expressed in further meetings.

It is important that the venue for such symposia be distributed around the areas of the world most active in this subject. With this in mind, the Committee was particularly pleased that Prof WO Phoon has agreed to host the third meeting in Singapore on 28–30 September 1983, immediately preceding the International Epidemiological Association's meeting in Singapore. In response to the enthusiasm expressed among the participants, the Committee felt it necessary to take the unusual step of planning the 1985 and 1986 meetings. These are provisionally arranged to take place in Italy and the United States, respectively. Although there will be no meeting the year of the triennial international congress, the Committee is looking forward to organizing part of the Dublin program for 1984. It is not the intention of the Scientific Committee on Epidemiology in Occupational Health to encourage the growth of its symposia to be much larger than they currently are. It is felt that a three-day conference with some 150–200 participants and 50–70 papers is the optimum size for scientific communications in this subject. In short, this latest of the Permanent Commission's committees has already had two successful symposia, and the interest for further activities is considerable and worldwide.

Prof JM Harrington, secretary

WORK AND PREGNANCY

Detectability of unfavorable reproductive outcome among occupationally exposed groups

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In the Negev region of Israel, population 300,000 with a centralized health care and health data system, we are testing the association of occupational exposure with the following unfavorable reproductive outcome (URO) (approximate rates in parentheses): infertility (10 %), spontaneous abortion (10 %), stillbirth (1 %), pregnancy complications (5 %), specific birth defects (1 %), all birth defects (5 %), low birth weight (5 %), neonatal mortality (1 %), neonatal morbidity (5 %), and all URO (25 %). The critical covariates include smoking, age, contraceptive use, coexisting disease, parity, spouse's exposures, and past reproductive history. Currently exposed women include 150 in hospital operating rooms, 200 in laboratories, 75 in chemical production, and 20 in a mercury thermometer factory; exposed men include 5,000 in chemical production, 1,000 in agricultural chemical use, 100 in chemical laboratories, and 200 in university and hospital laboratories. Taking into account employment turnover rates, we have estimated overall exposures which have risks of increased URO to be about 5,000 for men and about 1,000 for women. Since priority in research resources goes to the most feasible detection and prevention combinations, we have examined the expected minimal detectable risk ratios for population sizes and the expected incidences for a two-year cohort study with an estimated one "exposed pregnancy" per five person-years in this young population. Using the Schlesselman relationship and a cut-off of $p = 0.05$ for false positive and $p = 0.1$ for false negative, we have estimated the minimal detectable relative risk for various sample sizes and the expected prevalence rates from 0.01 (stillbirths, infant mortality, specific birth defects) to 0.25 (low birth weight, all URO). The sex ratio changes represent a relatively sensitive outcome. Application of these criteria in general and to workplace exposures to dioxins and anesthetics are shown, along with methods of estimating detectability for pooled data.

Congenital malformations and occupational exposure to disinfectants: A case-referent study

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Since 1976 the Finnish Register for Congenital Malformations has been linked to a special project which investigates possible associations between congenital defects and chemical and physical exposures during early pregnancy. A personal interview of 1,047 mothers of defective children (289 defects of the central nervous system, 421 oral clefts, 200 structural malformations of the skeleton, 137 cardiovascular defects) and an equal number of their referents brought forth an occupational exposure to disinfectants (handwashing agents or surface disinfectants) for 89 mothers who had worked in hospitals, 37 mothers in health centers, and 14 mothers in homes for the aged. The information on exposures was classified blindly as to the case-referent status of the pairs. The case-referent distribution was 33/44 for the discordant pairs exposed to handwashing agents (chlorhexidine, hexachlorophene, iodine containing, etc) and 51/55 for the discordant pairs exposed to surface disinfectants (amphoteric compounds, chlorine, chlorhexidine, halocarbene, phenols, quaternary ammonium compounds, etc). Six case mothers and six referents had been exposed to hexachlorophene. A scrutiny of the case-referent status of

the mothers did not suggest meaningful associations between exposure to disinfectants and the occurrence of congenital defects.

Activité professionnelle pendant la grossesse et prématurité

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Face au développement massif de l'activité professionnelle, se pose la question d'une politique de conciliation du travail et de la maternité. Doit-on considérer qu'un travail fatigant constitue un facteur de risque pour l'issue de la grossesse et faut-il, dans ces cas, proposer des mesures de protection des femmes enceintes en milieu professionnel afin de réduire leur risque d'accouchement prématuré? Une enquête spécifique sur le thème "TRAVAIL ET GROSSESSE", a été réalisée en France en 1977-78 auprès de 3500 femmes enceintes et a conduit aux résultats suivants:

- l'exercice d'une profession "en soi" ne peut être retenu comme un facteur de risque de prématurité, les femmes au foyer présentant un taux de naissances prématurées légèrement supérieur à celui des femmes qui exercent une profession (7,2 contre 5,8 %);
- parmi les femmes qui exercent une profession, certaines catégories sont exposées à un risque de prématurité plus élevé que les autres: il s'agit des employées de commerce, des personnels, des services médicaux sociaux, des ouvrières spécialisées et des personnels de service (8,3 %);
- la quantification de la fatigue professionnelle exprimée par l'intermédiaire de 5 indices caractéristiques de 5 sources de fatigue professionnelle (postures, travail sur machine, effort physique, contexte psychique, environnement) permet de mettre en évidence une liaison significative entre le taux de prématurité et le nombre d'indices élevés (de 3,5 % en l'absence de sources de fatigues importantes à 11,5 % en présence de 3,4 ou 5 sources de fatigues simultanées);
- une durée hebdomadaire excessive apparaît être, elle aussi, un facteur de risque de prématurité, alors que le travail à temps partiel s'accompagne d'un taux particulièrement bas (3,6 %);
- une prévention de la prématurité en milieu professionnel pourrait consister à réduire la durée hebdomadaire de travail des femmes enceintes soumises à plusieurs sources de fatigue simultanées.

2,4,5-T/Spontaneous abortion study: Suggested finding based on faulty data

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The Alsea II (Oregon) study was originally reported to show evidence that spontaneous abortions occur more frequently in a region where 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) herbicide was sprayed than in a comparison area without such spraying. The number of hospitalizations for spontaneous abortion per 1,000 live births for area residents had been compared for the six-year period 1972-1977. An audit of this study has now revealed marked deficiencies in the live birth count in each area and an undercounting of cases in the comparison area. The live birth count was deficient by 20 % in the 2,4,5-T area and 35 % in the comparison area because the original analysis ignored live births when the residential zip code was unspecified. Reanalysis of the study showed no difference in the indices of hospitalized spontaneous abortions per 1,000 live births (HSAI) for the 2,4,5-T and comparison areas. In addition the diagnosis was confirmed in only 70 % of the comparison area cases and in only 40 % of the cases in the 2,4,5-T area's critical peak. This study thus failed to demonstrate any increased risk of hospitalization for spontaneous abortion in the region where aerial spraying of 2,4,5-T occurred.

NONRESPIRATORY DISEASES I

Skin telangiectases in workers at an aluminum plant

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This epidemiologic study conducted among 588 workers in a Canadian aluminum plant revealed an increased number of skin telangiectases on the upper chest, back, and shoulders of 40 % of the workers with a relation between the occurrence of lesions and the duration of occupational exposure. The "at risk" occupations in the electrolysis department were the jobs that required the men to be in close contact with open reactors. The presentation will discuss how epidemiology was used in the investigation of this occupational disease. To be presented also are the results of further research on the causal agent responsible for the telangiectases and a comparison of postmedical records of a group of affected and unaffected men.

An epidemiologic study on carbon disulfide angiopathy in a Chinese viscose-rayon factory

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For the clarification of the effects of long-term carbon disulfide (CS₂) exposure on the retina and on coronary risk factors (blood pressure, cholesterol, etc) 354 exposed workers from a rayon staple factory and 178 age- and sex-matched nonexposed workers from a textile machine producing factory were examined. Personal exposure monitorings were performed simultaneously with a passive dosimeter. The results obtained in the study can be summarized as follows: (i) monochromatic fundus photography revealed no CS₂ retinopathy characterized by microaneurysms among Chinese CS₂ workers, (ii) no effects of CS₂ on blood pressure and cholesterol were found, (iii) the personal exposure monitorings explain the negative results of the study [ie, the daily average exposures measured varied between 0.01 and 12.8 ppm, with a mean of 1.7 ppm; the dissolver operators were exposed to the highest average concentration of CS₂ in the factory (4.1 ppm)], and (iv) from the present study, as well as a cross-sectional medical and industrial hygiene survey of workers exposed to CS₂ by the US National Institute for Occupational Safety and Health, an extremely low level of exposure of less than 2 ppm (8-h time-weighted average) is suggested as a no-effect level for the development of CS₂ retinopathy.

Prospective neurobehavioral study of lead toxicity

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To assess long-term neurologic and behavioral effects of occupational lead exposure, we evaluated 102 exposed and 61 reference workers with a medical and work history questionnaire, a physical examination, nerve conduction testing, and a battery of neurobehavioral performance tests. A cross-section of the two groups was tested in 1980, and a portion retested in 1981. In the first year of study we identified dose-dependent adverse impacts on verbal intelligence, memory, psychomotor function, and mood. Significant

alterations were observed in workers with blood lead levels between 40 and 60 µg/100 ml (1.93 & 2.90 µmol/l, respectively). Nerve conduction changes consisted of a modest reduction in motor response amplitude and a slowing of sensory velocity. Second-year results were similar to those seen previously, ie, dose-dependent changes in behavior were noted again. A reduction in the exposure level resulted in improvement in selected tests of behavioral function, while little change was seen in the nerve conduction parameters. These studies demonstrate significant behavioral changes attributable to lead-induced neurotoxicity at low exposure levels; these changes may reverse upon reduction in exposure.

An occupational epidemiologic survey of three lead plants in Cairo

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The purpose of the study was to find the effect of lead hazard in the work environment upon the health condition of workers. An epidemiologic survey of three lead plants in Cairo was carried out. The lead concentration in the air of the work environment was measured in each plant. Workers in each of the three plants were subjected to a clinical examination and laboratory investigations of hematological changes. The work environment showed a high lead concentration in air (more than 0.15 mg/m³); 2–68 % of the workers showed signs of lead absorption; and 3–17 % of the workers showed signs of lead intoxication as evidenced by the presence of the blue line, intestinal colic, and constipation with high cell counts and high coproporphyrin urinary excretion. The results indicate a positive correlation between the concentration of lead in air and the severity of ill effects in the workers.

Occupational exposure to arsine: An epidemiologic reappraisal

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To evaluate chronic arsine (AsH₃) exposure, we conducted a medical and industrial hygiene survey at a lead-acid battery manufacturing plant. We obtained personal (breathing zone) air samples for the measurement of arsine and particulate arsenic and area samples for arsenic trioxide (As₂O₃). To quantify the absorption of arsenic, we determined total arsenic content in duplicate 24-h urine samples. Arsine exposures in 177 breathing-zone air samples ranged from non-detectable to 47 µg/m³. The highest exposures were found in battery formation, where arsine is generated by the reaction of battery acid with lead-arsenic alloy. Exposures to particulate arsenic (maximum 5.1 µg/m³) and to As₂O₃ (maximum 0.44 µg/m³) were generally lower. Urine analysis showed that eight (20.5 %) of 39 production workers had arsenic concentrations (corrected to a specific gravity of 1.024) of 50 µg/l or above, levels indicating increased absorption of arsenic. None of eight office staff had elevated urinary arsenic levels. There was a close correlation between urinary arsenic concentration and arsine exposure (N = 47; r = 0.84; p = 0.0001). No correlation was found with exposures to particulate arsenic or to As₂O₃. Consumption of neither seafood nor contaminated drinking water accounted for the urinary arsenic results. Arsine exposures above 15.6 µg/m³ were associated with urinary arsenic concentrations in excess of 50 µg/l. We conclude that the current arsine exposure standard, 200 µg/m³, fails to prevent chronic increased absorption of arsenic. Because arsenic is a human carcinogen, the arsine standard should be revised downward.

EPIDEMIOLOGIC METHODS I

Cohort definition and its effect on comparing results of different studies

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The composition of cohorts of industrial workers exposed to the same substance varies between different studies reported in the literature. For example, the selection of individuals to be included is often influenced by factors such as duration of service (those of short service being excluded), year of entry to the industry (those who entered recently being excluded), sex (women being excluded), and occupation (certain types of workers being excluded). In addition the length of follow-up and the calculation of mortality indices generally vary. These differences make comparisons of the reported incidence and death rates between cohorts difficult to interpret, as rates tend to vary with these selection factors (Enterline, J occup med 18 (1972) 150–156). Some examples will be mentioned. To investigate the potential importance of such effects, a detailed analysis of a complete cohort of 6,722 workers exposed to amosite asbestos in the United Kingdom has been undertaken. Some of the contrasts show that these selection effects may have marked influences on the interpretation and comparison of cohort studies. For example, the standardized mortality ratio from lung cancer among men increased from 185 to 344 when a subcohort with more than 15 years of follow-up, more than 1 year of service, heavier exposure, and entry into the industry more than 20 years earlier was considered.

Un important biais dans les études épidémiologiques en milieu professionnel: La sélection

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La nocivité d'un risque professionnel est difficile à mettre en évidence lors des études transversales réalisées chez des sujets au travail car l'exposition est, en soi, sélective. Cette sélection, qui intervient lors du choix du métier ou à l'embauche mais aussi durant toute l'histoire professionnelle de l'individu, tient tout à la fois à une sélection des sujets par des contraintes extérieures qu'à une auto-sélection plus ou moins consciente. Un essai de quantification de ce biais sera fait à partir d'exemples d'enquêtes transversales et longitudinales pris dans le domaine des affections respiratoires chroniques. Le cas où la maladie est qualitative ainsi que celui où l'on considère un trouble quantitatif seront envisagés. L'importance de ce biais de sélection nécessite d'en tenir compte dans toute enquête réalisée en milieu professionnel. Ceci peut se faire au moment du protocole (favoriser les enquêtes longitudinales ou rétro-prospectives "trohoc"), lors de l'analyse des données (ajustement adéquat), à minima lors de l'interprétation des résultats.

Exposure measures and the potential for over-matching in occupational cancer case-referent studies

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Aside from considerations of efficiency and validity, matching can be advantageous for increasing power in small sample size situations. It allows the control of potential confounders at the design stage. In a study of upper respiratory cancer among refinery and chemical plant workers, the hypothesis tested was one

associating disease with a specific chemical agent. Matching was carried out on race, sex, year of birth, year of starting employment, and duration of employment. The latter three matching variables are time-related. Historic exposures were estimated without regard to case or referent status on a scale graded from zero (representing no exposure) to five (representing very high exposure) for each unique job-location-era encountered in the work history records. Five variously differing summary worklife exposure measures were calculated, each having specific limitations peculiar to the methods used for handling different exposure concentrations and their respective durations. Measures containing time in their dimensions are shown to constrain cases and referents to be so similar in their summary worklife exposure as to diminish real differences, the result being a significant over-matching bias. Estimates of relative risk are shown to be biased from fivefold excesses (using nontime-dependent exposure measures) to that of the null state (using time-dependent exposure measures). The most discriminating exposure measures are shown to be those that are independent of time. In particular, the measure calculated as a mean grade, given exposure, is recommended for such designs.

To bias or not to bias: That is the question

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We have previously reported an exposure-response relationship (in a case/referent analysis of lung cancer mortality to end-1975 in a birth cohort of 11,000 chrysotile miners and millers) with exposure expressed in fiber concentrations and duration of employment. With the aim of improving these environmental measures, we made "blind" field inquiries to check the accuracy of the recorded work histories of 641 deaths, due to selected causes, and 1,927 referents. Less than 5 % were untraced and, after reported discrepancies had been checked against company files, we found need for (usually slight) amendment in one-fifth of the histories. Most changes were additions of previously unrecorded periods of asbestos employment, mainly in one mining area where movement between mines had been common. The additions were slightly less frequent and the few deletions slightly more frequent for cases than for referents. Contrary to what might have been expected, the average net increase in accumulated exposure was substantially greater for the deceased referents (32 % of the total) than among referents who were alive in 1976 or among the cases. The incorporation of the changes in work histories made the gradients of the exposure-response lines about 15 % shallower than when uncorrected histories were used; this situation is also contrary to what would have been expected had the corrections been of "random" errors of measurement of exposure. The question is whether leaving known errors uncorrected would lead to better estimates of risk or to biased overestimates. Our dilemma is whether or not to correct the known errors in work histories.

NONRESPIRATORY DISEASES II

A mortality study of British pathologists, 1973–1980

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The previous mortality study of British pathologists covering the period 1953–1973 revealed an excess incidence of lymphoma and suicide (Harrington & Shannon 1975). The present study has updated this

investigation with the dual purpose of confirming or disputing the previous results and of investigating the subspecialties which may be at particular risk of excess mortality. A population of 2,733 pathologists obtained from registers of the Royal College of Pathologists who were alive on 1 January 1973 were followed to death or the end of 1980, whichever was the shorter. One hundred and thirty-nine pathologists were reported by the College as having died in that period, and death certificates were obtained for 134. The overall mortality experience of the group was more favorable for male pathologists than for the national population (males: observed 123, expected 215 - females: observed 16, expected 17.8), though excess death rates were again noted for suicide and other violent deaths. The standardized mortality ratio for male suicides was 360 (8 observed), and for females it was 870 (2 observed). Only two lympho-hemopoietic neoplasms (ICD 200-203) were noted, a finding which does not support the previous contention of an occupationally related excess. However, four brain tumors were noted in male pathologists, whereas 1.34 were expected. Apart from chance, possible explanations for this excess include exposure to solvents. In view of the possible carcinogenicity of formaldehyde, it is interesting to note that no nasal tumors were apparent and the standardized mortality ratio for other respiratory tract sites was low. Infectious diseases were responsible for one death, a case of serum hepatitis.

Prevalence of hand dermatitis: The role of occupation as risk factor analyzed with logistic regression

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Most patients of occupational dermatology clinics present themselves with advanced stages of eczema/dermatitis of the hands. For the detection of risk factors associated with the milder, earlier stages, dermatitis of the hands was studied among the general population. Prevalence rates of hand dermatitis were obtained from two population-based samples (in two different geographic areas) consisting of a total of 3,140 adults in The Netherlands. Between these samples/areas the crude prevalences for males were not significantly different. Age seemed to be important, but adjustment for age suggested that there was a difference between the two samples/areas for which other factors might be responsible. The males could be classified into six major occupational groups. Age tended to be associated with occupation. The distribution of the males over the occupational categories was also different in the two areas. To disentangle the relative importance of age, occupation and area, a stepwise logistic regression of dermatitis prevalence was performed on these factors. The results showed a significant contribution to the model by the factor occupation. The age factor was not significant before and after correction for occupation. Also the contribution by the factors area of residence and age-occupation interaction was insignificant. Three major occupational groups could be identified in which prevalences of hand dermatitis were relatively high: chemical industry 14.4 %, metal industry 10.7 %, building/construction 7.1 %. In all these categories more irritant (toxic) than allergic dermatitis was observed. For further investigation of occupation-related risk factors, studies are planned in these high-prevalence occupations. In the construction industry a cross-sectional study with an internal case-referent design is well on its way. Preliminary results confirm that irritant (toxic) rather than allergic factors are important in the early stages of hand dermatitis, especially among bricklayers and plasterers.

Dysmenorrhea among poultry slaughterhouse workers

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Although many studies have looked at the relationship between the menstrual cycle and work production, few have analyzed the effects of work conditions on menstruation. The prevalence of dysmenorrhea and its relationship to specific environmental and organizational factors in the workplace constituted an important aspect of a cross-sectional study on the effects of work conditions on the health of workers in eight poultry slaughterhouses. A questionnaire comprising 45 questions specific to women was administered to the women workers and to the wives of the male workers. Of this latter group only the full-time housewives were retained for comparison. The sample analyzed consisted on 213 workers and 105 housewives who were menstruating normally. There was no significant difference in their age distribution, oral contraceptive use, or menstrual regularity. The frequency of multiparous women was higher among the workers than among the housewives. Dysmenorrhea was evaluated for the last menstrual period by the presence of lower abdominal pain (menstrual cramps); its prevalence was analyzed in both groups with respect to age, oral contraceptive use, menstrual regularity, and parity. The prevalence of dysmenorrhea was very significantly higher ($\alpha < 0.001$) among the slaughterhouse workers (73.2 %) than among the housewives (52.4 %). Menstrual discomfort obliged 25.7 % of the dysmenorrheic workers to take sick leave for at least a part of a day during this period. An analysis with respect to specific factors present in the workplace showed that dysmenorrhea was significantly related to cold exposure ($\alpha < 0.03$). Moreover, 75 % of the women who took sick leave during their last menstrual period worked in a very cold environment. Dysmenorrhea was not related to smoking. Cold exposure clearly increases the frequency of dysmenorrhea and may affect its intensity.

A multidisciplinary study of Danish semi-skilled construction workers

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The purpose of the study has been to identify and investigate central aspects of the work environment of Danish semi-skilled construction workers (SCWs), especially the long-term wear-and-tear effects. The technological development of the trade was investigated by the use of interviews, questionnaires, public statistics and literature. It was found that the total load on the low back has not decreased during the period 1950-1980 although the character of the loads has changed - less lifting and carrying, but increased heavy pushing and pulling, more frequent "unexpected strain" ("microtrauma"), and increased exposure to vibration. Health problems were studied by means of questionnaires sent to present and former SCWs and to early retired SCWs. Reference groups were included. Seventy-two percent of the present SCWs and 73 % of the reference group returned the questionnaire. Sixty-five percent of the SCWs reported low-back pain in comparison to 53 % of the reference group ($p < 0.05$). Thirty-two percent of the SCWs, against 19 % of the reference group, were classified as severe cases. Through a register link-up the occurrence of awarded disability pensions during a five-year period within a cohort of 2,937 male Copenhagen SCWs was compared to two reference groups. The SCWs had a significantly higher rate of disability pensioning ($p < 0.05$), especially originating from a larger number of disability pensions awarded due to musculoskeletal diseases ($p < 0.05$).

The epidemiology of building illness

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Since the outbreak of Legionnaires Disease in 1975 government agencies, universities, and independent consulting firms across North America and Europe have responded to complaints of ill health from building occupants with more than 100 epidemiologic and industrial hygiene studies of specific buildings. A review of these studies and of some of their data has been undertaken including interviews with a number of the original investigators. All relevant information has been converted to standard tabular form and stored as a machine readable data bank. This form simplifies comparison between existing buildings and additional new ones. When reviewed in this context the similarities of complaints between buildings is startling. Two generic types of symptomatology are evident, specific and nonspecific. Specific symptoms such as coughing or body rashes have frequently been attributed to exposure to specific agents such as residues from carpet shampoos, or fibers coming in through the ventilation system. Nonspecific symptoms are however, more common and have recently been termed "building illness." Symptoms include eye irritation, fatigue, malaise, and respiratory problems. The agents responsible for these symptoms have not yet been determined. The results of a review of the epidemiologic studies of building illness currently included in the table will be presented, a standardized methodology for the investigation of building-related health and comfort problems will be suggested, and antecedents of building illness which need further investigation will be discussed.

EPIDEMIOLOGIC METHODS II

Unaccounted variables in hypothesized asbestos carcinogenesis

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Critical factors that contribute to the development of cancer in humans, particularly lung cancer, have not been evaluated in studies on the possible carcinogenic effects of asbestos among asbestos workers. As a result, some of the carcinogenic effects ascribed to asbestos may not be valid. Unaccounted variables in the carcinogenicity of asbestos in humans include (i) details of the smoking history such as number of pack-years, type of cigarettes, butt length, and mouth versus "ash tray" time, (ii) carotenoid intake, (iii) amount and type of fat in diet, (iv), alcohol intake, and (v) side-stream or "bystander" smoke. These variables can influence cancer rates significantly, and they have not been included in asbestos-cancer studies, wherein asbestos alone or asbestos as a synergistic factor with cigarettes has been investigated. Smoking details are of importance, and epidemiology studies from the United Kingdom, the United States and Japan have shown that carotenoids may significantly affect rates. Furthermore the composition of the diet can affect immune competence since high polyunsaturated fat intake is immunosuppressive and a combination of high dietary fat with a low fiber intake will predispose to cancers of the colon, rectum, and other sites. Alcohol, in combination with cigarettes, constitutes the predominant risk factor for cancer of the mouth, pharynx, larynx, esophagus, and liver (aside from the lungs, urinary bladder, kidneys and pancreas accounted for by cigarettes alone). Studies have shown that "bystander" cigarette smoke poses a risk, and, although one of these studies has been criticized

methodologically, there is still sufficient reason to include this factor, particularly in considerations of the effects of "bystander" smoke on the nonsmoking asbestos worker who is working within confined quarters together with several other workers, all of whom smoke. For the development of objective evidence for the stated carcinogenicity of asbestos in the pharynx, larynx, lungs, stomach, colon, kidney, and other alleged sites, it is essential to control for these variables through a complete questionnaire. It may be found that the profile of many asbestos workers includes patterns of smoking and dietary habits that predispose to cancers at many sites, independently of any asbestos exposure.

Mean latency period to cancer development

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It is well recognized that a considerable period of time, probably varying from 5 to 50 or more years, can elapse between initial exposure to a carcinogen and the development of cancer in man. In the practical situation of epidemiologic investigations this period of time is usually referred to as the latency period. Furthermore, it has often been suggested that specific carcinogenic exposures are associated with specific mean latency periods, that is, some agents are associated on the average with short latency periods, while others are associated with long latency periods. In this presentation the appropriateness of the mean latency period as a specific measure of the time relationship between exposure and the development of cancer is questioned. First the large variability in the reported mean latency period between studies for specific agents is illustrated. Differences in study design which contribute to these differences are discussed. Second the conceptual basis of the mean latency period measure is considered, in particular, with regard to the multistage model of carcinogenesis. Analyses of disease development over time are compared using this "numerator" data measure with those measures which incorporate expected occurrence of disease (excess risk, standardized mortality ratio), as suggested by the multistage model. The results and the interpretation of data are compared for these methods. The mean latency period is shown to be informative in only limited circumstances.

A theoretical model for dust exposure-lung effect relationships

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An approach is proposed for integrating industrial hygiene, toxicologic, clinical, and epidemiologic data into a two-part computer model of the processes that may lead to lung disease. The first part of the model estimates the amount of respirable dust in two lung locations (the alveolar surface and the interstices) as a function of time, exposure level, cytotoxicity, and rates of dust clearance and movement within the lung. The second part of the model expresses the accumulation of effects (opacities in chest radiographs and losses in pulmonary function) as a function of time and the amount and location of dust in the lungs. Data from laboratory exposures and pathological and clinical studies were used to form the model and to estimate the rate constants. The model was used to analyze exposure and epidemiologic data from workers producing silicon carbide. It predicted significant differences that were observed in the timing and risk of chest radiographic opacities per unit of exposure for smokers and nonsmokers. Two alternative forms of the relationship between tissue dust

levels and pulmonary effects were explored. A model with a limited nonlinear response to tissue dust fit the epidemiologic data better than a linear response.

Physiological and toxicologic concepts emerging as risk assessment factors

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Risk assessments establishing criteria for acceptable levels of toxic substances in water have been based on epidemiologic studies of workers with inhalation exposures. Such methodology assumes that risks are similar, whether exposure is by inhalation or ingestion. We present considerations of physiological differences due to route of entry that affect the degree of exposure to the target organ and thus the magnitude of the risk involved. Inhaled substances are absorbed from the lungs and pass through the blood to reach specific target organs, such as the bone marrow. Ingested substances must pass the gut flora, gut wall, liver, and lung before reaching the bone marrow. Metabolic trapping and exhalation can both decrease markedly the proportion of ingested substance reaching the target organ. For instance, toxicologic data suggest a 10- to 100-fold dose reduction factor for ingested benzene. The associated risk reduction may be even greater, depending upon the analytic model considered. Thus emerging toxicologic and physiological findings must be considered in assessments of human health risks from the ingestion of toxic substances. While epidemiologic studies may serve as the basis for risk assessment, their interpretations must consider physiological and toxicologic factors also.

RESPIRATORY DISEASES

Effects of low-level formaldehyde exposure on pulmonary status

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This is a report of the health effects of low-level formaldehyde exposure among 21 police department employees. The remaining 18 workers in the same workforce who were not exposed formed the comparison group. The exposure occurred over 34 months in two trailers used as temporary office facilities. Area monitoring data for formaldehyde was obtained at intervals. A modified ATS questionnaire regarding work history, symptoms, and cigarette use was administered to each subject. A wedge spirometer was used for pulmonary function tests. The formaldehyde levels varied between 0.12 and 1.6 ppm. The exposure group was slightly older than the comparison group (mean age, 38 versus 30) and included more men (67% versus 50%). Their cigarette habits were similar. Symptoms of upper respiratory tract and eye irritation reported to occur only in the workplace were noted only by the exposed workers (chi-square = 14, $p < 0.001$). Few workers in either group complained of cough, sputum, or wheezing. Four of 21 exposed workers reported chest tightness at least once a week compared with none of the 18 nonexposed (chi-square = 2, $p = 0.15$). When sex and cigarette use was controlled for, the groups were not different in isoflow volume, ΔFEF_{50} (air/helium), or the percentage of the predicted values of forced expiratory volume in 1s, forced vital capacity, and forced expiratory flow rate at 50 or 75% of the forced vital capacity. This report suggests that eye, throat and nose irritation, headache,

and fatigue are common following exposure to formaldehyde at levels below the hygienic standard. This study did not demonstrate an effect of formaldehyde on pulmonary function.

A longitudinal study on the significance of chronic inhaled burdens for the bronchopulmonary system

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The German Research Association (DFG) performed a multicenter epidemiologic study in 1965–1977. A total of 13,000 persons was examined for this study on the significance of chronic inhalative burdens for the bronchopulmonary system. In a follow-up study we examined 1,723 persons employed in the steatite and fine ceramics industry. Our cross-sectional studies were combined into a longitudinal study, as the methods applied were all the same [detailed anamneses/questionnaire of the ECSC, clinical examination, chest radiography, electrocardiography, lung function analysis (FVC, FEV₁, R_{aw}, IGV, $\bar{p}_{aO_2}$)]. Gravimetric measurements were performed for total and fine dust. Based on this data different decision trees were established for classification models for anamnestic and clinical indicators of bronchial reaction, for functional indicators of obstructive ventilation disorders, and for a combination of both. The most important determinants, ie, smoking habits, dust exposure, and age, were classified, and the standardized prevalence, incidence, and time prevalence were calculated for all groups, male and female. Our results agree in general with the statements already published (Valentin H & Smid U, ed. Research report chronic bronchitis and occupational dust exposure. Boldt, Boppart 1978. Part 2: Chronische bronchitis, Boldt, Boppart 1981). The ranked examinations based on different models and calculations showed that continued dust exposure at the workplace has an adverse effect on the pulmonary system. The analysis showed that some cases of chronic bronchitis deteriorated over time, while some improved. In this population occupational dust exposure had less effect than cigarette smoking and age on the development of chronic bronchitis.

Cross-sectional study on the respiratory symptoms and pulmonary functions of rayon textile workers with special reference to hydrogen sulfide exposure

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A prevalence study of respiratory symptoms in 6,670 Japanese male workers in 18 rayon plants was performed to detect the effects associated with viscose exposure, especially exposure to hydrogen sulfide (H₂S). It was also supplemented by a short-term study on pulmonary functions, the forced expiratory flow volume test being used to detect the effects on 30 matched pairs of exposed and nonexposed workers before and after an 8-h day shift. The H₂S exposure was 2.0 to 53.7 ppm-h for the rayon-exposed workers and was undetectable for the referents. The mean concentrations of H₂S and carbon disulfide in the workrooms were 0.3 to 1.1 ppm (0.4 to 1.5 mg/m³) and 0.8 to 2.9 ppm (1.1 to 4.1 mg/m³), respectively. No significant difference in the 8-h pulmonary function changes was found between the pairs, nor was there any correlation between the individual pulmonary function changes and individual H₂S exposure levels of the exposed workers. The prevalence rates for the respiratory symptoms of 2,736 exposed and 3,934 referents were surveyed with the use of a self-administered method using a modified version of the British Medical Re-

search Council's questionnaire, and 62 of the workers were interviewed one month later with the same questionnaire. The prevalence rates did not show, by regression analysis, any associations with viscose exposure, duration of rayon work, or anthropometric variables, except for smoking factors. Slightly higher prevalence rates were observed for the principal respiratory symptoms with the self-administered method than with the interview. Forced expiratory flow volume tests were administered to 324 workers in 3 of the 18 plants. The percentage-predicted pulmonary functions, compared by the prediction equations obtained from our other studies on the working population, appeared to be generally better in exposed nonsmokers than in nonexposed nonsmokers.

Pulmonary effects of exposures in silicon carbide manufacturing

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Chest radiographs, smoking histories, and pulmonary function tests were obtained for 171 men employed in the manufacturing of silicon carbide. A lifetime exposure to respirable particulates (organic and inorganic fractions) and sulfur dioxide was estimated for each worker. Chest radiographic abnormalities were related to respirable particulates (round opacities) and to age and smoking (linear opacities). Pulmonary function was affected by respirable particulates (forced vital capacity) and by sulfur dioxide and smoking (forced expiratory volume in 1s). Pleural thickening was related to age. No exposures exceeded the relevant standards; we therefore conclude that the current standards do not provide protection against injurious pulmonary effects, at least in this industry.

Chronic respiratory disease mortality in a cohort of English cadmium workers

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A cohort study was initiated to evaluate the effect of occupational exposure to cadmium on mortality from cancer, respiratory and renal disease, hypertension, and related disorders. Seven thousand men who were born before 1940 and who had worked for at least one year on, or in the vicinity of, a cadmium process between 1940 and 1970 were identified, and their vital status was ascertained. For each relevant time period, jobs were categorized into one of the following three exposure groups: "high," "medium," and "low." Over 2,000 deaths had occurred by 1979. Underlying causes have been analyzed, the person-years at risk method involving the computation of standardized mortality being used. Deaths with diseases of interest noted on the death certificate, but not coded as underlying cause, were examined in age-standardized comparisons of groups within the cohort. A statistically significant excess of deaths coded as chronic bronchitis or emphysema among those workers who had experienced "high" levels of exposure was observed (12 observed, 2.5 expected). A relationship between duration of exposure and risk was apparent. We conclude, after consideration of possible alternative explanations, that the excess, among those with "high" exposure, is not likely to be causally related to cadmium. These were the only clear positive results to emerge from the study. No significant excess of deaths was observed from prostatic cancer, lung cancer, renal disease, hypertension, or associated conditions. Full results will be reported elsewhere.

MEASUREMENT

Estimating factory workers' cumulative exposure to low concentrations of asbestos dust

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Current estimates of effects of medium and long-term exposures to low concentrations of asbestos dust are based largely on model-dependent extrapolation from relatively high cumulative exposures. The feasibility of using an occupational group sampling strategy to estimate individual factory workers' on-going exposure to low levels of dust has been investigated. The available dust sampling resources were deployed according to a partially balanced incomplete block design. Regression methods were used to estimate components of variance between occupational groups within factories, between sampling days within occupational groups, and between individuals within occupational groups. A total of 885 personal samples (83 % of the number planned) was taken on 105 sampling days for 51 occupational groups at five factories. Systematic differences between occupational group mean concentrations were clearly distinguishable for four of the five factories despite significant variation between samples from individual workers in the same occupational groups at three factories. The results have provided the basis for initiating dust sampling strategies consistent with specified levels of precision for estimates of occupational group mean concentrations. The latter may be used to provide measures of cumulative exposure in prospective epidemiologic studies embracing about 4,500 workers at 23 establishments manufacturing or storing asbestos-containing products.

Les déterminants de la durée d'exposition au bruit en milieu industriel: Omissions dans les enquêtes épidémiologiques

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Pour prédire le risque d'atteinte à la santé lié à l'exposition à un polluant industriel dont les effets sont déjà connus, il suffit en principe de mesurer au poste de travail la concentration du polluant et la durée d'exposition à celui-ci. Or, la durée d'exposition dépend de facteurs souvent ignorés dans les enquêtes épidémiologiques parce qu'on y omet d'analyser systématiquement l'organisation du travail dans l'entreprise. Un exemple d'une telle analyse est développé en fonction de l'exposition au bruit dans une aciérie. Des mesures sonométriques ont été effectuées aux 76 postes de travail définis par la convention collective. Une histoire professionnelle détaillée a également été dressée pour 200 des 362 travailleurs syndiqués. Les données recueillies montrent entre autres a) que le temps supplémentaire habituel peut accroître la dose annuelle de bruit jusqu'à 14 dBA; b) que la mobilité interne très élevée dans l'entreprise entraîne des variations importantes dans la dose annuelle de bruit en particulier chez les ouvriers non-spécialisés. Ces données montrent la nécessité de disposer d'une stratégie d'analyse de la durée d'exposition aux polluants, laquelle doit être fondée sur une bonne connaissance de l'organisation du travail dans l'entreprise.

Comparing control of airborne solvent mixtures for the estimation of health risk

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Knowledge on exposure levels of airborne solvent mixtures is of basic importance for the estimation of

health risks. Using personal air sampling pumps, we made short-term (1-h duration) and long-term (8-h duration) measurements in several furniture factories. The analysis was performed by the headspace method using a glass capillary column. The following solvents were detected: ethyl acetate [0.4–7.9 % of the maximal acceptable concentration (MAC)], isobutyl acetate (0.7–9.3 % of the MAC), toluene (0.8–10.2 % of the MAC), isobutanol (0–21 % of the MAC). No statistical difference was found on the 5 % level between the short-term and long-term sampling techniques. If the short-term sampling technique is used, it should be assured that the air sampling is done during a representative part of the work process.

A case-referent study of upper respiratory cancer: Exposure dictionary validation

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Retrospective studies in occupational epidemiology which examine the relationship of health outcomes to specific exposures often use "best-guess" estimates of historical exposures that may be unreliable. The purpose of the present study was to validate (assess the intra- and interrater reliability) of one such exposure assessment method. A dictionary of nearly 4,000 unique plant-site, location, occupation, and calendar-year specific titles was rated on a six-point scale for exposure to each of eight substances by a single expert panel. Subsequently, a 10 % stratified sample of the dictionary titles was rerated by two panels (the original panel and a second expert panel blind to the initial rating results). With Cohen's kappa statistic as the measure of intra- and interrater reliability, there was poor agreement for both dimensions when the exposure ratings were analyzed on the basis of a six-point scale. However, the agreement improved for most variables when the analysis was based on a dichotomized "low" versus "high" exposure scaling, moderate ratings being excluded from the analysis. This finding suggests that historical exposure estimates from a single rating source may be unreliable, and, wherever possible, methodological soundness can be enhanced by the assessment of internal validity. These data also suggest that, for reliable assessments of historical exposures, qualitative "low" versus "high" dichotomized scaling may be preferable to a graded quantitative scale.

A comparison of the ILO/UC 1971 and 1980 classifications of radiographs

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In a study of current and former Quebec chrysotile workers born after 1921 and first employed in 1958–1970, 451 radiographs were read independently by three experienced readers according to the ILO U/C 1980 classification. After completion of the main reading, a preselected sample of 100 radiographs was read a second time according to the 1971 classification. The present paper compares the readings obtained by the two methods as to (combined) profusion of small opacities, their size and shape, and other features of the classifications. The prevalences of parenchymal changes at level 1/0 or worse detected by the three readers were 25 (reader A), 18 (reader B), and 45 (reader C) % for the 1980 classification and 19 (reader A), 25 (reader B), and 53 (reader C) % for the 1971 classification. There was intrareader agreement to adjacent categories of the 12-point scale of profusion for 95, 90, and 87 radiographs, respectively. A full account of the

study, including an analysis of the results for all 451 radiographs and their relation to exposure assessments, will be presented elsewhere.

RESPIRATORY CANCER

Méthodologie d'une enquête de mortalité dans l'industrie de l'aluminium

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Une enquête rétrospective de mortalité a été réalisée parmi les salariés de la Société Aluminium Pechiney, pour évaluer le risque de cancer du poumon au poste d'électrolyse. La cohorte d'enquête est composée de l'ensemble des ouvriers qui ont travaillé pendant au moins 1 an entre 1950 et 1976 dans l'une quelconque des usines françaises de la Société, soit 7000 individus. Pour chaque individu a été reconstituée la carrière professionnelle dans l'industrie de l'aluminium et ont été recherchées certaines caractéristiques du mode de vie: tabagisme, alcoolisme. Le statut vital de ces sujets au 31.12.76 a été établi par des recherches systématiques auprès des organismes d'état civil: 1000 individus étaient décédés à cette date. Pour ces sujets, les causes médicales de décès ont été recherchées auprès des médecins traitants, dans les hôpitaux et par interrogatoire de la famille. L'analyse de ces données permettra d'étudier la mortalité globalement et pour certaines causes, en fonction de l'activité professionnelle exercée.

Lung cancer mortality in a population of English foundry workers

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Following reports of lung cancer being associated with foundries, mortality among employees in nine English steel foundries was investigated. A cohort was defined of all male workers starting work between 1946 and 1965 and employed for at least one year. Ninety-eight percent of the 10,250 study population was successfully traced, and their mortality was compared with national rates. Data on smoking habits were not available. In the foundry itself, where molding, core-making and casting take place, the overall standardized mortality ratio (SMR) was 147 for lung cancer ($p < 0.1$ %) and 188 for stomach cancer ($p < 0.1$ %). In the dressing shop, where castings undergo blasting, grinding, welding and heat treatment, the lung cancer SMR was 161 ($p < 0.1$ %). Occupations other than those in these two areas showed an SMR of 109 when combined. Excess mortality of a similar magnitude has been reported in several other mortality studies of foundry workers in other countries. For the foundry and fettling shop groups lung cancer mortality increased with length of employment when mortality was compared between more or less than five years' employment. No such pattern was apparent over the full range of employment lengths. More recent entrants into the foundries studied experienced a higher lung cancer mortality than earlier, in spite of a shorter period of follow-up. There were significant differences between the lung cancer SMRs of the foundries studied. The observed deaths from lung cancer were in excess of the expected for virtually all foundry and dressing shop job categories (though only significantly so in four cases), a finding suggesting common factors. Other research has identified carcinogens in foundry atmospheres, including polycyclic aromatics in mold pyrolysis products after

casting, and dust and fumes are suspected of playing a synergistic role. Further work seeks to establish the degree to which the excess found may be due to steel foundry employment, other employment, or smoking.

Progress in mortality studies of dockyard workers (longshoremen) in Italy

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A preliminary historical study was carried out in three Italian harbors, namely, in Civitavecchia (1960–1978), Livorno (1970–1979), and Savona (1970–1979). An excess of lung cancer was shown in Civitavecchia (Proceedings of the International Symposium on Prevention of Occupational Cancer, Helsinki, April 21–24, 1981, in press). The cohorts have now been followed to 1981, and a fourth harbor (Marina di Carrara, 1961–1981) has been included (about 5,000 workers in all). Expected figures based on national age-, sex-, cause-, and calendar year-specific rates have been estimated in addition to local reference series. Current smoking habits have been evaluated through a cross-sectional sampling survey; we found a greater smoking habit among dockyard workers than among reference groups. In conclusion we can assume the existence of a higher risk of mortality from tumor (standardized mortality ratio 1.22, $p < 0.05$), especially of lung cancer (standardized mortality ratio 1.69, $p < 0.05$), among workers in commercial branches of the four harbors studied. We do not know how much of this risk is due to the higher percentage of smokers among dock workers.

Cancer in chromium plating workers

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A retrospective cohort study of mortality was carried out on 217 male workers who had been exposed for more than one year to chromic acid mists in four “hard” and four “bright” chromium electroplating plants. A total number of 2,417 person-years were followed from January 1948 until December 1981. Most of the observed workers were considerably exposed to hexavalent chromium mists in “hard” processing plants (159 workers contributing 1,651 person-years). The expected rates of death had been calculated from the male mortality rates by age and cause in Italy. The observed number of deaths was close to the expected figure both in the cohort (15 observed, 15.2 expected) and in the subcohort of “hard” plating workers (11 observed, 12.0 expected). Eight deaths from tumors were found in the cohort against 4.2 expected ($p = 0.07$). Three were from lung cancer, when 0.9 were expected ($p = 0.06$). When the subcohort of “hard” chromium platers was considered, seven deaths from tumors were observed against expected rates of 2.7 ($p = 0.02$). All the deaths from lung cancer occurred in this subcohort (3 observed against 0.7 expected, $p = 0.04$). These results suggest that exposure to hydro-soluble hexavalent chromium mists is associated with an increased incidence of cancer. Almost all the observed deaths from tumors and all those from lung cancer occurred in “hard” chromium plating workers, while no evidence of increased risk was found for those subjects involved in the “bright” type of electroplating process. The exposure to chromic acid mists is much higher in the “hard” than in the “bright” chromium plating plants.

Coke ovens and community cancer risk: Methodology and interpretation of results from ecological cancer studies

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Extrapolation of occupational cancer studies suggests risks for residents living in the vicinity of hazardous industries. Because coke oven workers have excessive rates of cancer, we evaluated whether residents in US counties where coke ovens operate have elevated cancer mortality rates. We identified 58 counties where coke was produced during 1952 and 1956–1959 and recorded the annual coke capacity from the records of the US Bureau of the Mines. We matched these counties with 58 noncoke counties and compared the age-adjusted ratios of mortality rates for whites using 1950–1969 data from the National Cancer Institute. Although the ratios were small, the following sites showed statistically significant differences ($p < 0.001$) for both sexes: esophagus, stomach, colon, rectum, liver, pancreas, larynx, lung, other cancers, and all cancers. Cancers of the mouth, esophagus, prostate, and eye among males and cancers of the liver, uterus, and eye among females exhibited “dose-response” gradients across the three categories of coke capacity. Using linear regression, we found only two sites that were significantly related to coke production ($p = 0.05$), stomach cancer and Hodgkin's disease for males. Leukemia showed borderline significance for females ($p = 0.07$). An ecological study of this type is useful for the inexpensive generation of hypotheses, but its results should not be interpreted as definitive. The present findings suggest that community-based case-referent studies of stomach cancer, lymphatic and hematopoietic cancers, and lung cancer should be undertaken to determine if lifetime residence near coke oven batteries is associated with an excess risk of cancer.

STATISTICAL METHODS

Methodological issues of the standardized mortality ratio

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While the standardized mortality ratio (SMR) is a well-established form of summary statistics commonly employed in occupational cohort studies, misconception and confusion as to the merit and correct use of the SMR still persists. This paper attempts to clarify many methodological issues of the SMR, such as when it can be compared, whether it is equivalent to relative risk, whether it bears any relationship to life expectancy and to statistics from direct standardization, and how it is affected by the standard population and length of observation. These issues, and a number of others, are illustrated in this review based on mathematical derivations with empirical examples. For example, a correction procedure is proposed to permit direct comparisons of SMRs when age distributions are not similar. The SMR is mathematically shown to be inversely related to life expectancy if certain assumptions are met. Although mathematically equivalent when the choice of the comparison population is the same, the SMR has several advantages over statistics from direct standardization, especially in occupational studies. Since the SMR will continue to be widely used, a thorough understanding of SMR characteristics is essential to ensure accurate interpretations.

Ascertainment and correction of selection bias in an occupational cancer case-referent study

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Recent case-referent studies in Sweden have suggested that persons occupationally exposed to pesticides, including 2,4,5-trichlorophenoxyacetic acid, are at risk of soft-tissue sarcomas and malignant lymphomas. Two case-referent studies are being carried out to examine whether the Swedish findings hold true in New Zealand. The first study has involved comparing work histories of male soft-tissue sarcoma patients, identified by the Cancer Registry, with those of a reference group of other male cancer patients. It was necessary to check for selection bias arising from the use of "other" cancers as the reference category in light of the fact that some of them could possibly have also been induced by pesticides. Hence the occupational distribution of the reference group, at the time of cancer registration, was compared with the expected occupational distribution (based on national census data) of a group with the same size and age distribution. The observed occupational distribution was very close to that "expected" – in particular there were 26 agricultural workers versus 25.5 "expected" – a finding suggesting that the use of this reference group did not lead to serious bias. A method is proposed for adjusting the frequency of exposure in the reference group when it is found to suffer from serious bias with respect to occupational and/or social class.

Refinements of the serially additive expected dose model with applications to a British polyvinyl chloride cohort

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The method of the serially additive expected dose model was introduced by Waxweiler in his doctoral dissertation and subsequent publications. It is an advanced technique for the isolation of a single hazard in a cohort study of a population exposed to many candidate agents. Its reliance on a t-test of significance can be criticized because the values being analyzed are not independent and are far from normally distributed. The records for one of the companies that participated in the British study of polyvinyl chloride have been subjected to the same technique for several diagnoses at death so that covariances and nonnormality can be assessed. With the use of Waxweiler's technique as published, no relationship was evident between exposure to polyvinyl chloride dust and lung cancer. Calculations for lung cancer and the vinyl chloride monomer demonstrated the importance of the metric for exposure, as the t-value could vary from a very small positive value to one that was nearly significant at the 0.05 level.

Methodology for the evaluation of acute pulmonary change in industrial workers

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Short-term (shift) changes in lung function are being increasingly used to assess respiratory response to industrial exposures. We made several measurements over the shift; hence an analysis different from the classical pre/post shift was needed. The data analyzed in this report was gathered in a study of 277 potroom

workers (90 prebake, 187 Sodeberg) and 108 non-exposed workers loosely matched for age, length of service, and smoking. All had performed lung function tests at 0, 2, 4, 8 and 96 h after the beginning of a workweek. Three tests ($FEV_{1.0}$, $\dot{V}_{max50}$, MEF_{25-75}) were selected as representative of the pulmonary response to the environmental contaminants. The following three methods were used to assess within-shift variation: (i) standard variation relative to the base line (mean of measurements at 0 and 96 h) expressed as two ratios (downward : total and downward minus upward : total); (ii) pattern of change consistent with a progressive shift effect (several patterns were defined and for each subject's data the best fit pattern was selected by the least-squares approach); (iii) change relative to measurement at 0 h expressed either as a ratio or as a percentage difference. With method i the prevalence of increased variation was increased in the exposed group in comparison to the non-exposed group, especially smokers, with a slight increase in the value of the ratio downward : total. With method ii the exposed group showed a higher prevalence of shift variation than the nonexposed workers with similar smoking habits. With method iii the overall comparison of the groups showed significant between-group differences, but none of the a priori contrasts of exposed versus nonexposed and smokers versus nonsmokers were significant. In addition a Student-Neuman-Keuls test showed that for all three functions there were two groups, one composed of all nonsmokers and referent smokers and the other comprised of the exposed smokers and any one or both of the exposed nonsmokers. Thus conclusions about the relationship of within-shift variation to exposure in this sample of workers was similar irrespective of the approach used.

Statistical methods for analyzing temporal effects on cancer risks

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Cancer rates have been shown in a variety of settings to be affected by such temporal effects as age at first exposure, duration of exposure, age at comparison of risks, and interval from first or last exposure to risk. Rarely, however, are such effects studied in combination or in relation to any theory of the carcinogenic process. Recently developed statistical methods were applied to case-referent data on lung cancer in relation to asbestos exposure and smoking habits. The following two approaches were compared: (i) multivariate logistic analysis incorporating simple exposure indices together with additional temporal variables and their interactions, and (ii) direct fitting to two carcinogenic models – (a) a two-stage initiation-latency model and (b) the Armitage-Doll multistage model. From approach i average age at exposure, age at risk, and duration of exposure were found to contribute main or interaction effects. With model ii(a) the median latent period (assuming a log-normal distribution of intervals between each increment of exposure to smoking or accumulated asbestos and times at risk) was estimated at 7.54 years and was not significantly related to either asbestos or smoking. With model ii (b) the best fit was obtained with accumulated asbestos and current smoking, both acting additively at the fifth of six stages. While biological mechanisms cannot be inferred simply by comparing the fits of several statistical models, these models are useful for exploring different kinds of hypotheses about temporal effects and for providing a range of estimates of projected lifetime risk for standard setting.

NONRESPIRATORY CANCERS

A case-referent study of chemical exposures and brain tumors in petrochemical workers

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This report describes an investigation of the relationship between chemical exposures and deaths attributable to primary brain tumors among employees of a Texas petrochemical plant. The cases consisted of 21 deaths with an underlying cause confirmed as primary brain tumor. Two reference groups of 80 employees each were randomly selected from 450 decedents known to the company in June 1979. Potential exposures while employed were compared between the cases and referents for five known or suspect carcinogens. Exposure potentials were also compared for an additional 37 chemicals to which at least four cases were potentially exposed. Overall and 15-year latency analyses were performed. The proportion of cases exposed to the five potentially carcinogenic chemicals (including vinyl chloride) was lower than or consistent with the proportion of exposed referents. No statistically significant differences between the proportions of cases and referents exposed to the 37 other chemicals were found.

Risk of colorectal cancer according to a particular occupation in a textile plant

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In our previous study we found an increased risk of colorectal cancer for males below 75 years of age who had worked in a local textile plant handling synthetic fibers. To determine whether or not this risk was associated with employment in a particular part of the plant, a case-referent study was undertaken. Two reference groups were formed. One was matched according to sex, year of birth, and date of starting employment; the second was matched also for the length of employment in the plant. For 43 patients having colorectal cancer three matched referents in each group were selected at random from company files containing 25,000 present and past employees since 1926. For each case and the selected referents the complete occupational history at the plant was obtained from the company records, checked by interview, and completed for the occupational history outside the plant. Then, we determined whether there were differences between the frequency of cases and referents having worked in a specific section, department, job, and their combinations and between the durations of employment. The results indicated that the cases worked in 8 of 24 departments and that a significantly higher proportion of cases than referents had worked in three departments: textile, extrusion "D" (cellulose acetate), and extrusion "TM" (triacetate melt process and polypropylene) (47.1 vs 21.8, $p < 0.005$). When this analysis was limited to those cases and their referents who had been employed only after the introduction of the triacetate process in 1957, the relative risk for workers employed in any one of these three departments developing colorectal carcinoma was 3.06 ($p < 0.05$); when cases diagnosed after the age of 75 years were excluded, the relative risk was 3.46 ($p < 0.05$). The mean age of these patients at diagnosis was 50 years as compared to the 60.1 years of the other patients ($p < 0.02$); and they started to work in these departments at a younger age than the referents (25.6 vs 35.4, $p < 0.01$). No particular patterns were observed in site distribution and in histopathological type of carcinoma. In conclusion

this study strongly suggests that the increased risk of colorectal cancer was related to the indicated manufacturing process.

Discovering occupational carcinogens by an exposure-based case-referent approach: Report of a pilot study

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A novel epidemiologic method was developed to discover hitherto unsuspected occupational carcinogens. A case-referent approach based on exposure histories of incident cases and referents incorporates breadth (the entire occupational spectrum), depth (capacity to pinpoint not only high risk occupations but also specific substances), and statistical sensitivity. A probing interview is carried out to obtain a description of each person's job. Chemists then translate each person's work history into a list of possible chemical exposures. Each site of cancer is a separate case series for analysis. Referents for each site are drawn from other sites and from a general population series. Periodic statistical analyses estimate the odds ratios associated with each chemical exposure and each job. A pilot study was undertaken in 17 Montreal hospitals, and many aspects of feasibility were evaluated. Since 1979 over 1,000 incident cases with any of ten different sites of cancer have been interviewed. The validity of the job histories has been assessed and found satisfactory. Chemists are able to distinguish subgroups of a job category which have distinct exposures and to group together workers in different categories who share common exposures. Their chemical assessments are reasonably repeatable. Preliminary analyses of substantive data include the following significant associations: kidney and bladder tumors with silver compounds, lung tumors with nickel and chromium compounds, and bladder tumors with cutting oils. These exposure-based results provide some leads not evident in our job title-based results and thus indicate that the method is promising.

GENERAL METHODOLOGY

Strategy for systematic follow-up for cohort studies

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Follow-up techniques for prospective historical cohort studies and long-term prospective cohort studies are discussed. A method for efficient and effective manual systematic follow-up is proposed for the Canadian setting. Tracing mechanisms include provincial driver licensing bureaus, local telephone and city directories, Statistics Canada mortality data base, and the US Department of Immigration and Naturalization. Although scientifically this strategy has not been formally tested, recent experience employing these techniques in a non-systematic fashion has resulted in a follow-up rate of 97.2 % for an occupational cohort with some subjects who had left the company up to 25 years prior to the study. It is believed that a systematic follow-up routine would result in substantial savings in time and resources, as well as in improved rates of follow-up.

Detecting delayed health risks

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Increased public awareness of the presence of carcinogenic and other harmful agents with possible delayed effects, both in mines, the workplace and elsewhere, has led to demands for information on the magnitude of the associated risks and the adequacies of current standards of protection. Described are three interrelated computer systems developed at Statistics Canada. Opportunities are discussed for improved assessment of occupational and environmental health problems through (i) the exploitation of existing administrative data files for statistical purposes, (ii) the application of newer methods of organizing microdata files that facilitate computerized searching and the integration of these files into the form of individual linear histories of events and circumstances in the lives of people, and (iii) the application of probabilistic computerized record linkage techniques. The computer systems have been implemented, and references are made to studies already conducted using the data resources, eg, a study of all Ontario miners, various Canadian uranium and nickel miners, plus asbestos and radiation workers.

Factory and health: A methodological essay

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We are of the opinion that the determination of health takes place ultimately at the level of the social relations of production, and therefore the conditions of life and work reflecting, in a concrete plane, such relations are responsible for the health conditions of the population in a certain social structure and in a certain historical moment. Accordingly the category "labor," in its various levels of abstraction, acquires fundamental importance for the full understanding of health. These considerations lead us to discussing and reconsidering the methodological aspects of studies on health, and a theoretical approach to the method is required. Our study suggests the use of diversified methods and research techniques, according to the nature of the object of investigation and corresponding to the theoretical system adopted and enunciated by the researcher. We suggest a comparison to the epidemiologic method traditionally used. The choice of factory labor (metallurgy sector) is due to its importance in the Brazilian contemporary historical formation, mainly in the large urban centers, and also due to the fact that considerable progress has already been made with respect to knowledge about this type of labor and its consequences. The following topics are approached: (i) health conditions of the worker and conditions of the work [study of the labor process in its technical and social relations and the identification of the risks (production and labor engineering and social sciences inquiry among workers) and inquiry on morbidity (clinical-epidemiologic)], (ii) health conditions and life conditions of the worker's family [inquiry on familial morbidity and concrete life conditions (epidemiologic : case-referent) and ideological representation of illness, labor and existence conditions (anthropological network)]; (iii) health services, reality and alternative (the planning of factory health services according to the subjective/objective needs researched); (iv) history and health [historical tendency of work accidents-history of the factory, inserted in Brazilian

social reality, in its evolution (1940–1982), historical series of work accidents listed (historical, epidemiologic analysis)].

Using causes of death not coded as "underlying cause" in occupational cohort mortality studies

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The underlying cause of death is defined for the International Classification of Diseases as that "disease or injury which initiated the train of morbid events leading directly to death." In most cohort studies of occupational mortality, diseases mentioned on death certificates but not coded as the underlying cause of death are ignored in the analyses. Diseases may be mentioned in this way because another disease is genuinely the underlying cause or because of misclassification, misdiagnosis, or ambiguity. In each of these cases the presence of the disease at the time of death may be related to the exposure under investigation. Thus appropriate analyses of these "other mentions" may shed light on such a relationship. One reason why "other mentions" are not analyzed in cohort studies is that national rates are not usually available, so that computation of indices of risk relative to national populations, for example, standardized mortality ratios, are not possible. These difficulties do not arise when analyses based on comparisons internal to the cohort are used. "Other mentions" of diseases of interest have been analyzed in this way in a cohort of cadmium workers. It was found that for cancer of the prostate and lung little extra information was gained through this approach, but for hypertensive disease, renal disease, and chronic respiratory disease the gain appeared considerable. The conclusion is drawn that for diseases which are not rapidly fatal, an analysis of "other mentions" is useful.

FARMING AND FORESTRY

Work and health of Finnish farmers

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"Farmers' work and health 1979" is a report based on the results of a postal survey conducted in the winter of 1979–1980. The survey was done by the Research Institute for Social Security of the Social Insurance Institution of Finland in collaboration with the Kuopio Regional Institute of Occupational Health and the National Board of Health. The purpose of the study was to provide information for the planning and the evaluation of the experiment on the organization of farmers' occupational health. Most of the 12,056 farmers included in the study were occupied in livestock production. Grain production, forestry, and pig raising were the most common types of farm production after livestock production. Most of the work required in livestock raising was manual, whereas most of the work required in grain production was mechanized. About 57 % of the sample reported chronic illness. Of the chronic illnesses one-third consisted of diseases of the

musculoskeletal system, one-fifth of cardiovascular diseases, and about 7 % were diseases of the respiratory system. About half of those with a chronic disease reported a reduced work ability or complete disability. Of all the surveyed, about every fourth farmer had reduced his work load or changed his work tasks due to illness, mostly due to the diseases of the musculoskeletal system. Performing daily tasks was the most frequently reported cause for insufficient care of illness. Health examinations, medical care, and information about work-related risks were among the most common expectations of the statutory occupational health services. The occupational health services of farmers should be aimed at the prevention of accidents and diseases of the skin, respiratory system, and musculoskeletal organs.

Acute and chronic respiratory disorders in grain farmers

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Grain farmers and nonfarmers from a rural community, consisting of a rural town and surrounding farms, were compared for a determination of whether grain farming is associated with an increased risk of developing respiratory symptoms, diseases, and chronic airflow obstruction detected by spirometry. In addition the role of factors such as smoking, atopy defined by allergy testing, total immunoglobulin E (IgE) in serum, and blood eosinophils was also assessed. Information on symptoms, diseases, smoking, and occupational and residential history was obtained by a questionnaire. The subjects studied (1,902 in number) represented 83 % of the eligible population in the community, were 20–65 years of age, and were evenly divided between the sexes. About half were grain farmers. About 43 % of the males and 72 % of the females had never smoked; these proportions were higher for the farmers than for the nonfarmers. Allergic reactions to house dust (22 %) were the most common, followed by mites (19 %), molds (15 %), grasses, trees and weeds (9 %), and *Aspergillus*, *Penicillium* and grain dust (8 %); there was no significant difference between the farmers and nonfarmers. Shortness of breath on exposure to grain dust developed in one-fifth of the farmers and was associated with atopy. History of grain fever (reported by 13 % of the farmers) was significantly more common for the nonsmokers and for those who had been exposed to moldy grain. There was an excess (10 %) of chronic bronchitis and wheezing in nonsmoking male farmers, but this excess was not related to the intensity of grain exposure. Lung function was determined by smoking, atopy, and IgE. It was worse in male farmers than in nonfarmers, particularly if they had symptoms. Results of the study show that respiratory disorders are more common in farmers than in nonfarmers. While acute respiratory symptoms (shortness of breath and grain fever) are clearly related to grain exposure, such a relationship is less convincing for chronic bronchitis and chronic airflow obstruction. In addition to exposure to environmental irritants and smoking, individual susceptibility such as atopy should be considered in prevention programs for respiratory disorders in farmers.

Chronic respiratory diseases among farming populations with respect to atopy, antibody formation and work exposure

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The study was based on data provided by 12,056 Finnish farmers. The data were gathered by a postal

survey conducted by the Social Insurance Institution of Finland. Some parts of the data were collected by clinical examinations and laboratory tests of immunology in seven health centers and the Kuopio University Hospital. According to the survey the prevalence of asthma was 2.7 % among the farmers. The prevalences of chronic bronchitis and farmer's lung were, respectively, 6.5 and 1.6 %. Asthma and chronic bronchitis were twice as common among smokers than nonsmokers, whereas the reverse was true for farmer's lung. Asthma, chronic bronchitis, and farmer's lung occurred more frequently among atopic than nonatopic farmers. There were also significant differences in the prevalences of each disease between the various types of farm production. Precipitating antibodies against *Aspergillus fumigatus*, *Aspergillus umbrosus*, *Micropolyspora faeni*, or *Thermoactinomyces vulgaris* were found in 11.6 % of the 2,470 farmers examined in the health centers. Most frequently antibodies were formed against *Aspergillus umbrosus*, in 4.8 % of the farmers. The respective findings for *Aspergillus fumigatus*, *Thermoactinomyces vulgaris*, and *Micropolyspora faeni* were 1.6, 3.9, and 1.3 %. The prevalences and relative frequencies of the four types of antigens closely correlate with the findings of previous smaller studies done in Finland, Great Britain, the United States, and Canada.

Epidemiologic methods in field studies of agricultural farm workers

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There are more agricultural farm workers in the world than any other occupational group. In many respects this group of workers has the broadest and most extensive of occupational exposures to biological, chemical, and physical agents of disease or injury. Although risks associated with certain infectious or chemical agents such as coccidioides immitis or methyl parathion are well documented from acute episodes, a clear understanding of the full spectrum of health hazards to these workers remains obscure. The reasons for this are numerous, including the wide variety of diseases and different work tasks involved, the highly changeable work environment, the frequency of mobility of work, the absence of high quality medical care, the difficulty of investigators to assess the nature and degree of occupational exposures, and the absence of measurable indices for subtle long-term health effects from work. These are some of the issues confronting the epidemiologist in designing field studies for this occupational group. This paper addresses these methodological problems, drawing upon the experience of many years of field studies aimed at assessing health effects from usual agricultural farm work. Methods to improve field worker monitoring, elucidation of subtle but avoidable biases in epidemiologic studies of these workers, and refinements in analytic approaches are some of the topics presented in this paper.

Symptoms of the vibration syndrome and radiographic findings of the wrists among lumberjacks

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Only a few controlled epidemiologic studies have concerned the relationship between age, vibration exposure, wrist-bone changes, and symptoms of the upper extremities. In the present cross-sectional

study 279 lumberjacks exposed to chain-saw vibration and a reference group of 178 peat workers were examined. The mean age of the two groups was 34.6 and 33.1 years, respectively. The lumberjacks' exposure to chain-saw vibration averaged 10.4 years. The study consisted of a questionnaire and a clinical examination including radiographs of the wrists. The prevalence of reported white finger symptoms was 18 % for the lumberjacks and 3 % for the referents, whereas that of numbness in the upper extremities was 51 and 22 % for the two groups, respectively. Cysts were found in the wrist bones of 8–9 % of both groups. Symptoms of white fingers were associated with vibration exposure ($p < 0.05$, Mantel extension) but not with age or smoking. Numbness in the upper extremities correlated with age ($p < 0.001$, Mantel extension) but not with exposure time. The prevalence of white finger symptoms among lumberjacks had decreased considerably over the prevalence reported in the 1970s (40–50 %). The lumberjacks' high prevalence of numbness in the upper extremities could not be explained by vibration exposure. Presumably other occupational factors, eg, work posture, could be involved.

OTHER TOPICS

Negative results in occupational studies – The case of acrylonitrile

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Although methods used in epidemiologic studies of occupational health have substantially improved in recent times, problems still exist. Several studies on acrylonitrile as an occupational hazard illustrate some pitfalls in procedures and difficulties of interpretation. A comparison of cohort studies from the United States (O'Berg, *J occup med* 22 (1980) 245–252; Gaffey & Strauss, unpublished; Zack, unpublished), Great Britain (Werner & Carter, *Br ind med* 38 (1981) 247–253), and Germany (Thiess et al, *Zentralbl Arbeitsmed* 30 (1980) 259–267; Kiesselbach et al, *Zentralbl Arbeitsmed* 10 (1979) 258–259; Kiesselbach et al, *Zentralbl Arbeitsmed* 7 (1980)) shows that, despite rather consistent findings, varying interpretations resulted. Although the data available suggested a positive association with certain cancers, including the lung, the lymphatic system, and the brain, methodological issues appeared to complicate the assessment of risk in the German study. A negative conclusion may have been influenced by the following: a sizable healthy worker effect for all causes of death when no such effect is seen for cancer; occurrence of cancer at unusually young ages; exclusion of "explained" cancer deaths from the analysis; and an overemphasis on statistical tests rather than consideration of the consistency of findings with results from other studies.

Diesel exhaust exposure, cardiovascular disease and an approach to allow for smoking

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The study was designed to elucidate alleged adverse health effects of diesel exhausts, particularly regarding cardiovascular disease (CVD) as perhaps related to the component of carbon monoxide. The study encompassed a cohort of the 129 men who had been employed in a bus company at any time during 1950–

1959, some of these employees being garage workers with exposure to rather high levels of exhausts in the context of service and repair work. The period of follow-up was 1951 to 1978, and the total deaths, deaths from malignant diseases, and from CVD were compared to expected deaths as calculated from national rates. The smoking habits of the cohort could not be fully established, but a questionnaire survey among currently employed workers revealed smoking to be somewhat overrepresented in comparison to the average of Sweden. Therefore a correction of the expected numbers of deaths from cardiovascular diseases was made as based on the formula $I = R \times I_0 \times P_{CF} + I_0 (1 - P_{CF})$, where I = overall mortality from CVD; R = relative risk of smokers to nonsmokers; I_0 = mortality of CVD among nonsmokers; P_{CF} = the proportion of the population who smoke (ie, the proportion with the confounder at issue). Solving I_0 and adjusting P_{CF} then provides for correction I . The results of this pilot study showed that the most heavily exposed group (bus garage workers) had a fourfold increase in risk of dying from CVD even after correction for smoking, and allowing for at least 10 years of exposure and 15 years or more of induction-latency time ($p < 0.05$). The overmortality in CVD supports the existing hypothesis about a possible connection between exposure to carbon monoxide and CVD. The study is also presented as demonstrating a way of correcting for deviating smoking habits when national rates are utilized for calculating expected numbers. However, the confounding effect from deviating smoking habits tends to be surprisingly weak and would hardly ever explain any overmorbidity of several times the normal in comparison to national averages.

The occupational environment in relation to nutritional status

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In an industrialized country, both the under- and overconsumption of food contributes significantly to death and disease. To evaluate the situation in an active, working population, we investigated the relationship between occupational hazards and nutritional status in a cohort of 252 industrial workers followed for two years and selected from four different plants manufacturing asbestos textile, paper pulp, heavy machinery, and textiles. Nutritional status was evaluated at six-month intervals by dietary, biochemical, and anthropometric methods. Occupational exposure to noise, dust, temperature, and chemical agents was recorded for each worker by an industrial hygienist directly at the worksite. Dietary habits and daily nutrient intake varied in relation to the type of industry. Although the mean daily intake of almost all of the 29 nutrients studied was above the recommended dietary allowance, some were below even for major nutrients such as protein (3.7 %), vitamin C (6.8 %), and iron (7.9 %). In regard to exposure to selected industrial hazards the mean nutrient intake was always lower in the nonexposed group. Workers on rotating shifts had a lower intake for energy (35.1 ± 7.3 vs 31.9 ± 7.6 cal/kg; $p < 0.001$) and for carbohydrates (3.81 ± 0.98 vs 3.33 ± 0.99 g/kg; $p < 0.001$), but alcohol intake was higher for day workers (0.28 vs 0.19 g/kg; $p < 0.005$). Workers with high alcohol consumption had a significantly lower intake of vitamin C, folic acid, and calcium, but an increased intake for riboflavin and niacin. On the basis of these data we conclude that nutrient intake, as well as biochemical parameters, are modified in response to the specific needs of workers exposed to a selected occupational hazard, that rotating shifts influenced their dietary habits, and that alcohol consumption, which strongly depended on life style patterns, significantly influenced energy and vitamin intake. This

study underlines the importance of nutrition in the prevention and health promotion of industrial workers and the necessity for more-detailed studies.

Ergonomic load and status of the musculoskeletal system: Results from cross-sectional and prospective study designs

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The purpose of the study was to investigate the association between occupational status, ergonomic load, and status of the musculoskeletal system. A sample of 555 metal industry employees (office staff, workers) was followed for five years. Measurements were made twice, in 1973 and in 1978. Data on ergonomic loads were acquired by a questionnaire and ergonomic observation. A standard clinical method was used to assess the status of the musculoskeletal system. These clinical examinations were made by the same two physiotherapists in both years. Pain in muscles, joints, and intervertebral regions of the low back was assessed by palpation. In the examination of the movements of joints the normal values given by the American Academy of Orthopaedic Surgeons (1965) were used. A clinical status index score was computed for each examinee. It included pain and restriction in the movements of the joints. The results from the cross-sectional study showed that the clinical status index was on the average higher among workers than among office staff. Among workers the index was related to the level of ergonomic load. However, in the follow-up no association was observed between ergonomic load (at the beginning of the follow-up) and the change in the clinical status of the musculoskeletal system. In the follow-up no further divergence was found in the condition of the musculoskeletal system by occupational status. Methodological problems (eg, stability of exposure, reproducibility of clinical assessment of the musculoskeletal system, selection bias, length of the follow-up) related to the follow-up study design are discussed.

Neurological abnormality in Cree Indians exposed to methylmercury in northern Quebec

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Cree Indians in northern Quebec have a subsistence economy with fishing and hunting as the principal occupations. Contamination of local fish caused the Indians to be exposed to methylmercury, so an epidemiologic study was undertaken to assess the prevalence of neurological abnormality and the relationship with methylmercury exposure. For 87 % of the adults over age 30 years a medical team assessed nystagmus, coordination and gait, tremor, movements and reflexes, sensation, stereognosis, two-point discrimination, visual fields, and hearing without knowledge of the individual's exposure. Methylmercury exposure was estimated from samples of blood and hair collected at the time of the medical examinations and in a survey of exposure which had been carried out two years earlier. Tremor (seen in 25 % of the men and 22 % of the women), incoordination (in 21 % of the men and 11 % of the women), and abnormal reflexes (in 17 % of the men and 12 % of the women) were the most prevalent neurological abnormalities, but other major manifestations of methylmercury toxicity were seen infrequently. Ten percent of the subjects had a syndrome of bilateral neurological abnormality which might be compatible with previously recognized effects of methylmercury

toxicity. Cases with this syndrome had significantly higher exposure to methylmercury than normal referents in one of the communities studied, but for another, the relationship, although also positive, was not significant. Persons with an index of methylmercury in hair of at least 20 µg/g were nearly four times as likely to have the syndrome as those with an exposure index under 10 µg/g. The data do not, however, permit estimation of a threshold level of exposure above which excess neurological abnormality might occur because recent levels of exposure do not reflect those of the past. Furthermore, although allowance was made in the analysis for confounding variables, it remains possible that the neurological abnormality is not entirely attributable to methylmercury exposure. Most of the abnormalities were of mild severity; whether the abnormality will remain stable, regress, or progress can only be determined by continued medical surveillance.

ASBESTOS-RELATED DISEASES

Mortality among asbestos-cement factory workers

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Asbestos-exposed workers at an Ontario asbestos-cement factory were found to have markedly elevated mortality rates in comparison with both the general population and a reference group of nonexposed workers. The standardized mortality ratio was 175 for all causes of death, 480 for lung cancer, 240 for gastrointestinal cancer, and 300 for nonmalignant respiratory diseases; all were significantly elevated ($p < 0.05$). There were 21 deaths from mesothelioma, 12 pleural and 9 peritoneal, a proportional mortality of 15 %. Men dying of mesothelioma were significantly younger than the men dying of other malignancies. The mortality rates from mesothelioma, lung, and gastrointestinal cancers all showed increasing trends with increasing exposure.

Respiratory cancer in chrysotile production and textile manufacture

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At the last symposium, preliminary results were reported from cohort surveys in three American asbestos factories. In two plants, which had used only chrysotile, there was one malignant mesothelioma among 2,341 deaths, whereas in one which had also used crocidolite and amosite, there were 18 among 1,429 deaths (McDonald & Fry, *Scand j work environ health* 8 (1982): suppl 1, 53–58). We now report preliminary exposure-response findings from one of the two factories which used only chrysotile – a textile plant – and compare these with our earlier survey of Quebec chrysotile miners and millers (McDonald et al, *Br j ind med* 37 (1980) 11–24). In the other chrysotile factory – a friction materials plant – no clear exposure-response has so far been found, but further study is required. In both chrysotile production and textile manufacture, exposure-response relationships, apparently linear in nature, were observed, but with very different slopes. At 100 fibers/ml years, the excess lung cancer

in mining was about 4 %, whereas, in textile manufacture, it was about 120 %. There is no clear reason for this difference; it is possible however that (i) the environmental measurements did not reflect the biologically active component well or (ii) other carcinogenic agents were also present. It has been suggested, for example, that the size distribution of the fibers in the two situations may be quite different; it is also known that oils were used in the textile plant to control dust and to improve the manufacturing process. These and other possibilities must be investigated. Despite the high lung cancer risk observed in the factory, the frequency of malignant mesothelioma was very low and of a similar order to that of chrysotile miners and millers.

Recherche des facteurs de risque de l'asbestose par l'analyse factorielle des correspondances

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A partir des données recueillies par le médecin du travail des centrales thermiques de VITRY et d'ARRIGHI et portant sur la carrière professionnelle, les examens cliniques, radiologiques et d'exploration fonctionnelle respiratoire des agents d'ELECTRICITE de FRANCE – GAZ de FRANCE, une analyse factorielle des correspondances a été pratiquée. Ce type d'analyse nous a permis de mettre en évidence les relations existant entre les différents groupes de variables et d'en déduire, si ce n'est des conclusions générales sur le problème de l'exposition à l'amiante, au moins des appréciations des problèmes locaux et des idées pour planifier des enquêtes ultérieures.

Lung geometry as a risk factor in the response to asbestos exposure: A case-referent study on Quebec chrysotile workers

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A previous cross-sectional study on 1,015 current Quebec chrysotile asbestos miners and millers showed a relationship between the presence of parenchymal and/or pleural radiographic abnormality and cumulative exposure to airborne dust. However, even among those men most heavily exposed, at least half showed no radiological abnormality, a finding which suggested between-individual differences in susceptibility. To determine whether certain aspects of lung structure might have predisposed to the development of parenchymal fibrosis, a case-referent study was carried out as follows. Forty-four cases of parenchymal fibrosis were identified from the 1,015 men in the study population mentioned above; the diagnosis was based on a profusion reading of at least 1/1 for small irregular opacities by three of the six readers who had read all films in that study. For each case two referents were chosen, matched for age (within five years) and cumulative exposure (within 20 %), and a series of measurements was made on the chest radiograph of each subject to reflect the airways and airspace geometry. Differences between the cases and referents were found in a transverse measurement of the lung fields (narrower in the cases, $p < 0.001$) and in the length of the trachea (shorter in the cases, $p < 0.08$). Similar findings were obtained using preemployment chest radiographs or films taken shortly after the start of employment of the 34 cases and 63 referents for whom these were available ($p < 0.05$ and 0.02 for the lung field and tracheal length measurements, respectively). The findings lend support to the suggestion originally made

by Green et al (J appl phys 37 (1974) 67) that "certain patterns of lung structure and function may dispose towards certain pathologies" including the response to environmental exposures. Investigation of other pollutants is indicated.

DUST DISEASES

Prospective evaluation of granite dust exposure in a working population: The effect of studying "survivors"

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Six hundred and eighteen Vermont granite workers were followed for five years. Pulmonary function tests were performed annually as part of a medical monitoring program, and the rate of the decline in the forced expiratory volume in 1 s (FEV_{1.0}) was used to assess the health of the workers. (Forced vital capacities were found to be less than 6-s expirations and were rejected.) The pulmonary function test reproducibility criterion, recommended by the American Thoracic Society, was applied to each FEV_{1.0} measurement. Smoking information was obtained from a respiratory questionnaire, and complete work histories were available for each worker. Respirable dust concentrations for each job and shed in the industry were estimated from two extensive environmental surveys with an analysis of variance. Personal lifetime dust exposures were computed for each worker. The average annual dust exposure was below the current hygienic standard for dust containing 11 % free silica. The 353 workers who remained in the study cohort by continuing to work in the industry and participate in the medical surveys, and who performed a reproducible FEV_{1.0} test in the final survey, were found to be losing FEV_{1.0} at an average rate of 44 ml/year. No association was found in this survivor group between the rate of FEV_{1.0} decline and lifetime dust exposure. However, the 265 workers with incomplete follow-up were losing FEV_{1.0} at a mean rate of 69 ml/year, and a dose-response relationship was suggested within this group. Termination of employment was found to be associated with an increased FEV_{1.0} decline. The effect appeared to be stronger if job termination had been preceded by a persistent failure to perform a reproducible FEV_{1.0}. Although no dose-response relationship was found for either the terminated workers or those with persistent nonreproducible FEV's separately, an association was suggested when the two groups were combined into a single drop-out group.

Exposure to silica and lung cancer: A case-referent study

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A case-referent study was undertaken in order to establish an association between occupational exposure to silica dust and lung cancer morbidity. The cases comprised 227 patients with primitive lung cancer diagnosed in the hospital of Belluno, Italy, during the period 1 January 1972 and 31 December 1977. Only new cases were included. The referents

were 277 patients matched to the cases for sex and age and with the next date of admission in the same hospital and with a respiratory disease other than cancer; as chronic bronchitis is related to the same risk factor (occupational exposure to dust), patients with this disease were not selected. For both the cases and referents the clinical records were the source of the data: age, sex, radiographic findings of silicosis, occupational exposure to silica dust [length and type (tunneling, mining, other industry) of exposure], and smoking habits. The results are presented in the following table:

	Nonexposed	Exposed	
		No silicosis	Silicosis
Nonsmokers	1.00	0.48	0.48
Smokers + ex-smokers	6.63	6.66	13.00

The relative risk increased with the presence of both smoking and silicosis; when the two factors are combined the relative risk rises sharply and suggests a synergistic effect. Exposure to dust without silicosis does not seem to play any role.

Acute respiratory changes in aluminum pot-room workers

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Acute respiratory changes have been reported in pot-room workers in the primary aluminum industry. The purpose of the present study was to evaluate these phenomena in a Quebec aluminum smelter in relation to the type of process [Soderberg (Sod) or prebake (pre)] and the level of exposure (high or low). A representative sample of potmen (276) and nonexposed blue collar workers (108) matched for smoking habit, age, and duration of employment answered a respiratory symptom questionnaire and carried out a series of pulmonary function tests. These tests were administered in four sessions within the first day of the workweek. Five parameters were selected a priori as reflecting different aspects of pulmonary function. For each individual and for each test the session mean, standard deviation, and coefficient of variation were calculated. The frequency distribution of the coefficient of variation was computed on a 20-unit scale for each parameter, and the summation of the five values was used to develop a composite index for each individual to reflect workshift variation. Results (mean, SD) of this index for smokers (S) and nonsmokers (NS) were as shown in the following table:

	Exposure				
	High		Low		None
	Pre	Sod	Pre	Sod	
S	18.2±8.2	18.2±9.0	17.9±8.4	14.8±6.9	14.9±7.0
NS	13.4±8.3	15.7±6.7	9.8±7.3	15.0±5.0	13.8±7.9

An analysis of variance showed significant ($p < 0.05$) between-group differences for smokers only; both the high-exposure groups and the prebake low-exposure group clustered separately from the Soderberg low-exposure group and the nonexposed. We conclude that in this population of potroom workers acute respiratory changes, as reflected by variability in certain lung functions, were confined to smokers and were related primarily to level of exposure.

Epidemiology of silicosis among Egyptian phosphate miners

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The present study included 552 phosphate miners from four areas of Egypt. The overall prevalence rate of silicosis was found to be 48.19 %, a relatively high figure that could be explained by the poor hygienic conditions. The level of dust in one of these areas reached 310 times the hygienic standard. The prevalence rate of silicosis in the four areas varied greatly according to the level of dust in air. The prevalence rate of silicosis varied also with the type of work, being maximum among explosion workers and minimum among drivers. The presence of a number of silicotics among administrative workers was explained by job transfer of some mildly or moderately affected workers. When the duration of exposure was considered, high percentages of silicotics were observed with 120–240 and 360–480 months of exposure (61 and 52 %, respectively). There was a drop in the prevalence of silicosis between these two intervals which could be explained by retirement or job transfer of some silicotics with more than 20 years' exposure. A study of the age of the workers showed that the silicotics had a significantly older age when compared with that of nonsilicotics. This observation was attributed to a cohort effect.

MAN-MADE MINERAL FIBERS

Man-made mineral fiber industry: Some aspects of the International Agency for Research on Cancer's European epidemiologic investigation

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Employees in thirteen man-made mineral fiber plants in seven European countries have been historically followed until December 1977. The results of the analysis of the entire cohort have already been presented at the man-made mineral fiber conference in Copenhagen. An attempt has now been made to explore the relationship between mortality, in particular all cancer and lung cancer mortality, and length and intensity of exposure. The mortality pattern of a sub-cohort of male workers with at least 20 years of observation and one year of employment was analyzed in relation to exposure characteristics, ie, length and intensity. No discernible trend was noted for lung cancer, nor for other causes of death. The consistency of this finding is discussed in relation to the choice of the subcohort, the quality of information on exposure, and the general characteristics of the European cohort study on man-made mineral fibers.

Mortality experience of fiber glass production workers

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Man-made mineral fibers have been in production for over 40 years. Only recently animal experiments have suggested a possible carcinogenic risk of man-made mineral fibers to humans. In an effort to study this possibility the mortality experience of a cohort of Italian fiber glass production workers employed for at

least one year at any time between 1944 and 1974 was examined (1,158 males; 253 females). The vital status was ascertained as of 31 December 1980, and the follow-up was 98 % complete. Expected deaths were calculated on the basis of national and regional mortality rates in the same period, specific by sex, age, calendar period, and cause. Analysis for male employees (20,000 person-years) is presented and discussed. Overall mortality (107 deaths) was not noticeably different from expectations, while accidents were higher than expected. There was a deficit for cardiovascular and nonmalignant respiratory diseases and an excess for cirrhosis. Malignancies were significantly in excess when compared to the national rates (observed 34, expected 22.9). Ten lung cancers were observed against 8.1 and 5.9 expected. Four larynx cancer deaths occurred versus 1.52 and 0.98 expected; the latter observed : expected ratio was statistically significant. Mortality for this cause showed a clear association with duration of exposure, latency, and age first exposed; all cases had first exposure before 1960. No similar patterns were obtained for other causes. Admittedly with the small number of cases, these results suggest a possibly increased risk for larynx cancer among fiber glass production male workers. Further analysis is in progress in order to investigate thoroughly the relationships between mortality and type and level of exposure to man-made mineral fibers.

Anomalies pulmonaires et exposition professionnelle à un aérosol associant fibres de verre et styrène

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Le but de ce travail est d'étudier le retentissement sur la fonction respiratoire d'une exposition professionnelle à un aérosol associant fibres de verre et styrène. La multiplication de tels aérosols industriels rendait nécessaire une enquête épidémiologique justifiée par le travail expérimental de Morisset et col. (1979). Un groupe de 122 sujets (moyenne d'âge de 28,2 ans) travaillant dans un chantier naval fabriquant de grosses unités en polystyrène stratifié a été comparé à un groupe de 99 sujets (moyenne d'âge 30,5 ans) travaillant dans un atelier de préfabrication de navires métalliques. Un questionnaire standardisé a permis de comparer chez ces sujets la consommation tabagique, les antécédents respiratoires et les expositions professionnelles antérieures. Des courbes débit-volume en air ont été obtenues à l'aide d'un pneumotachographe (Fleisch 3), mesurant CVF, VEMS, DEMM, DP, DEM 75, DEM 50, DEM 25. Enfin, l'exposition a été appréciée par des mesures ponctuelles des concentrations et de la granulométrie des fibres de verre et styrène, 66,4 % d'anomalies fonctionnelles respiratoires ont été observées (35,2 % avec abaissement conjoint du DEM 25 et DEM 50 et 31,5 % avec abaissement isolé du DEM 25). Il existait une progression de ces anomalies en fonction de l'importance de l'exposition. A l'inverse, dans l'autre groupe, 38,4 % seulement d'anomalies (22,2 % avec abaissement conjoint du DEM 25 et DEM 50, et 16,2 % avec abaissement isolé du DEM 25) ont été observées. La différence entre les deux groupes est très significative ($p < 0.001$). Ces données préliminaires, d'autant plus intéressantes qu'elles proviennent de sujets jeunes, semblent confirmer chez l'homme le rôle toxique pour les petites voies aériennes des aérosols industriels associant fibres de verre et styrène.

EPIDEMIOLOGY IN ADMINISTRATION

A critical review of the application of methods of epidemiology, actual and potential, in the evaluation of occupational audiometry

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Audiometry involves the measurement of hearing acuity, normally by means of a pure-tone audiometer. The test is widely recommended in connection with work, to the extent that requirements for it are incorporated into certain pieces of legislation, as well as the many programs for medical monitoring and health care in connection with work. In some of its applications, occupational audiometry appears to fulfill the role of the screening test, and, accordingly, the various epidemiologic methods worked out for the evaluation of screening tests ought to be applicable in the evaluation of occupational audiometry. The paper reviews the literature in order to see how far such evaluations have in reality been carried out. There are uses claimed for audiometry which do not correspond to medical screening. The paper explores the extent to which epidemiology has methods potentially applicable in the evaluation of these other applications of audiometry. The paper draws conclusions from the two questions which lead to proposals for improvements in the methods and the application of epidemiology in the field embraced by occupational audiometry and questions whether these observations are also pertinent to medical monitoring in other contexts.

The factorial analysis of correspondence in occupational health: Five years of Quebec statistics revisited

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The correct assessment of complex situations like those encountered in occupational health requires the collection of a considerable amount of data. With the present computing power available this condition can be met rather easily at the national level, with sufficient stratification to be descriptive in detail and also with annual repetition to detect trends. The accumulation of measures can however generate such an amount of tables and charts that a synthetic understanding can be a problem in itself. The factorial analysis of correspondence (Benzecri et al) has recently demonstrated its usefulness as a descriptive technique. It favors geometrical projection on a plane of the interrelations between the data instead of the probabilistic inferential approach of classical statistics. This method is especially well suited to present visually a great quantity of data with a minimum of hypotheses made a priori. Five years of annual statistics of the Commission de Santé et Sécurité du Travail du Québec are presented to illustrate the relation between the 20 categories of lesions with or without work interruption and the 33 sectors of economic activity. This degree of relationship is graphically displayed by simultaneous projection of these variables on the same plane. The proximity expresses the similarity, be it between lesions, between sectors or between sectors and lesions. Conversely an increasing distance speaks for a higher degree of specificity. This characteristic gives a helpful criterion to initiate a strategy of preventive intervention, either against a certain type of lesion in a group of sectors or against a group of lesions in a given sector. The results confirm well-known findings like the importance of the mining sector to professional diseases, with or without work interruption.

They uncover, for example, the high specificity of conjunctivitis due to electric welding although the absolute number of reported cases is not very high.

Medical screening in the workplace: A proposed framework

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The medical screening of workers before and during employment has been widely adopted in American workplaces. Screening examinations are required by the Occupational Safety and Health Administration or recommended by the National Institute for Occupational Safety and Health (NIOSH) for workers exposed to a limited number of chemical agents; the majority of screening programs have been instituted by the employer. Hitherto, however, no framework for occupational screening has been proposed, nor have screening tests been evaluated for sensitivity, specificity, predictive value, or cost effectiveness. An analysis of industrial screening practices from data collected during the NIOSH National Occupational Hazard Survey (1972–1974) shows that the prevalence, periodicity, and content of a screening program are primarily related to the size of the plant and the major industry type and not to the presence or absence of specific chemical hazards. A framework for occupational screening is proposed which incorporates, but is broader than, that previously proposed for community screening. Most importantly, data from evaluated periodic screening evaluations, targeted to high risk groups, should be used not only for earlier and more efficacious treatment of the individual, but also even where the individual's prognosis is not improved by earlier disease detection, to evaluate and improve the efficacy of primary prevention measures (eg, standards, engineering controls), and thereby benefit other workers similarly exposed. Such an effort requires that epidemiologic analyses be performed on these data.

Health and hygiene monitoring – An epidemiologic perspective

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Systematic surveillance is becoming an increasingly important part of industry-based health programs. Its full potential will be realized only if it can link health indices to reliable measurements of employee exposure. At the same time health and hygiene monitoring systems ensure that legislative requirements are met and provide a sound data base for epidemiologic

studies and for information to employees and government. Since the programs have multiple objectives, their design is a complex problem. Planning must take into account the size of the population (past, current and future), the nature and magnitude of potential hazards, and the sensitivity and specificity of the measurement methods required. In general populations must be large, even crossing international boundaries. They must permit cohorts to be defined retroactively and provide good identifying information, systematically recorded and updated work histories, qualitative and quantitative measurements of exposure, and both baseline and periodic morbidity data. These requirements imply that the program should be computer assisted. Environmental and medical data must be collected and recorded with strict regard for quality, confidentiality, credibility, and the human rights of employees.

The role of epidemiology in the planning and evaluation of health and safety programs

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The purpose of the presentation is to emphasize the major relationships between epidemiology on one hand and the planning and evaluation of occupational health and safety programs on the other. All planning in this field requires as basic data a complete health and safety needs assessment of the population of workers, mainly consisting of data on their health status and on the risks of their work environment. Whether in the setting of general objectives and programs or in the determination of priorities of intervention or in the implementation of these programs, data generated by epidemiologic methods play a key role at the government level, as well as at the level of the firm. Any serious and comprehensive evaluation of occupational health and safety programs covers three types of activities: (i) program monitoring evaluation (assessment of the quality and quantity of inputs and practices, as well as the operational performance of the program), (ii) impact evaluation (analysis of the nature and the extent of the results, which could be measured at three possible levels, depending on the type of evaluation and availability of data: knowledge and attitudes, behavior and risk factors, health and psychosocial results), and (iii) economic efficiency evaluation (comparison of results and inputs used up in the program). Epidemiologic methods may intervene in each of these aspects, although their main use is concerned with the descriptive measurement of the health results grossly related with the program and, ideally but still rarely, with the scientific determination of the net impact of the program, after confounding effects have been removed. We will illustrate briefly the three aspects of evaluation by specific applications in the occupational health and safety field. We will conclude with a discussion of some of the actual barriers to this ideal use of epidemiology in the planning and evaluation of occupational health and safety programs.