

Abstracts

Oral 12 Radiation

○12.1 RADIATION EXPOSURE FROM WORK RELATED MEDICAL X RAYS AT THE PORTSMOUTH NAVAL SHIPYARD

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Introduction: Previous analyses suggest that worker radiation dose may be significantly increased by routine occupational x ray examinations. Medical x ray exposures for 570 civilian workers employed at the Portsmouth Naval Shipyard (PNS) at Kittery, Maine were estimated to determine the contribution of work related chest x ray (WRX) relative to conventional workplace radiation sources.

Methods: Methods were developed to estimate absorbed doses to the active (hematopoietic) bone marrow from x ray examinations and workplace exposures using data extracted from worker dosimetry records (8468) and health records (2453). Misclassification from the omission of occupational x ray examinations was evaluated and dose distributions were examined for radiation and non-radiation workers.

Results: Photofluorographic chest examinations resulted in 82% of the dose to active bone marrow from medical x ray sources. On average, radiation monitored workers received 26% of their dose from WRX and received 45% more WRX exposure than non-radiation workers.

Conclusions: WRX can result in a significant fraction of the total bone marrow dose, especially for radiation workers who were more likely to be subjected to routine medical monitoring. Omission of WRX from the exposure assessment can cause misclassification, which may attenuate the risk for cancers induced by workplace exposures.

○12.2 A NESTED CASE CONTROL STUDY OF LEUKAEMIA AND IONISING RADIATION AT THE PORTSMOUTH NAVAL SHIPYARD

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Introduction: Previous studies of workers at the Portsmouth Naval Shipyard (PNS) produced differing results for the relation between external ionising radiation exposure and leukaemia mortality. This case control study analysed this relation using novel exposure assessment methods for external radiation, including work related medical x rays. The study also included more thorough evaluation of benzene and carbon tetrachloride exposures.

Methods: This study employed a nested case control design, with 115 leukaemia cases and 460 age matched controls. Radiation exposures from all occupational sources including work related medical x rays were assessed for the analysis. The potential for benzene and carbon tetrachloride exposure was assessed using workers' job information and industrial hygiene records. Conditional logistic regression was used to analyse the exposure-response relation between external ionising radiation exposure and leukaemia mortality.

Results: A significant positive association was found between leukaemia mortality and external ionising whole-body radiation exposure (OR=1.08 at 10 mSv; 95% CI 1.01 to 1.16) adjusting for sex, radiation worker status, and benzene or carbon tetrachloride exposure duration. Benzene or carbon tetrachloride exposure duration was also found to be significantly associated with leukemia mortality (OR=1.03 at one year of exposure; 95% CI 1.01 to 1.06). The incorporation of estimated doses from work related medical x ray exposures did not change the leukaemia risk estimate per unit of exposure.

Conclusions: This study found that workplace exposure to external ionising radiation was associated with increased risk of death from

leukaemia among PNS workers. Although confidence intervals are wide, the estimates of risk per unit of exposure found in this study are greater than those observed in the extensive risk analyses of A-bomb survivor and medical therapy studies.

○12.3 WORKERS EXPOSED TO LOW DOSES OF IONISING RADIATION: A REVIEW

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Introduction: Epidemiological studies of the carcinogenic effects of ionising radiation have led to early guidelines in radiological protection at the workplace. Most of those guidelines have relied on results of the life span (survivors of the atomic bombings of Hiroshima and Nagasaki). This population has been exposed at a high exposure rate which differs from typical protracted exposures encountered at the workplace. Since the 1970s, studies were conducted directly on working populations. This communication makes a systematic review of these studies.

Methods: Studies were listed through medline without restriction on date of publication. More studies were added through references included in the first list of papers. The focus was made on cohort studies.

Results: Radiologists and radiological technologists were among the first to be occupationally exposed to ionising radiation. Excesses of leukaemia, and lung and skin cancer were observed for older registration years. For more recent years, epidemiological data lack sufficient statistical power to conclude. Among uranium miners, the lung cancer dose-effect relation is well established. Effect modifiers have also been observed for time since exposure and age at exposure. Excesses of malignant melanomas and breast cancers were observed among airflight attendants. This population is exposed to cosmic radiation, irregular working schedule, and frequent jetlags. It is difficult to relate these excesses to these different factors though lifestyle or reproductive life factors seem to be insufficient to explain excesses of such magnitude. Finally, among nuclear workers, pathologies with more frequent dose-effect relationships are: leukaemia except chronic lymphoid leukaemia and multiple myeloma, the order of magnitude of excesses relative risks being 2 and 4 per Sievert respectively. Lung cancer is also suspected but caution should be taken on potential confusion factors (internal radiation and other occupational factors particularly).

Conclusion: This review highlights the importance of results obtained from occupational ionising radiation epidemiology. Studies should continue in order to confirm observed dose-effect relations and better understand some of the excesses observed. It confirms the need for systematic epidemiological surveillance and post-occupational health monitoring of populations concerned.

○12.4 UPDATED MORTALITY IN THE FRENCH COHORT OF URANIUM MINERS: 1946-99

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Introduction: Previous cohort studies have demonstrated an excess of lung cancer death among uranium miners. A French cohort of uranium miners has been established in order to evaluate the mortality risk of miners exposed to low levels of radon and its decay products and to other occupational hazards. The follow up of the cohort has been recently extended up to end of 1999. We present here the first analysis of the mortality of the extended cohort.

Methods: The French cohort of uranium miners includes men employed as miners for at least one year since 1946 at the Commissariat à l'Énergie Atomique (CEA) and since 1974 at the Compagnie Générale des Matières Nucléaires (COGEMA). Causes of death have been determined according to the International Classification of Diseases. For each miner, yearly radon exposure has been reconstructed. Standardised mortality ratios (SMRs) were computed using national mortality rates as external reference adjusted for age and calendar year.

Results: The cohort comprised 5098 miners with a mean duration of follow up of 30.1 years (total of 153 272 person-years). Miners lost to follow up represented only 1.4% of the cohort. A total of 1471 deaths were observed among miners aged less than 85. The analysis showed

no excess for all causes mortality (SMR = 1.02; 95% CI 0.97 to 1.07). A significant excess of cancer mortality was found (540 observed deaths, SMR = 1.18; CI 1.08 to 1.28) depending mainly of an excess of lung cancer (159 observed deaths, SMR = 1.42; CI 1.21 to 1.66) and kidney cancer (19 observed deaths, SMR = 1.90; CI 1.14 to 2.97). No excess was observed for other causes of death except for silicosis (23 observed deaths, SMR = 7.11; CI 4.50 to 10.67).

Conclusion: The excess of kidney cancer has not been observed in previous analysis and should be analysed in more details regarding potential risk factors. This analysis confirms the existence of an excess risk of deaths from silicosis and lung cancer. The analysis of the association of risk with radon exposure and other occupational hazards is ongoing. Compared to other miners cohorts, the long duration of follow up will allow a detailed analysis of the age related risk of death.

012.5 MORTALITY AMONG FRENCH COGEMA WORKERS MONITORED FOR EXTERNAL IONISING RADIATION EXPOSURE

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Introduction: This study analyses the mortality of a 9287 nuclear workers cohort employed at the French nuclear company COGEMA. It consists of workers hired for more than one year between 1976 and 1994 and monitored for external ionising radiation.

Methods: Administrative data, individual x and gamma ray exposure, and vital status were reconstructed for each worker. As a first stage, standardised mortality ratios (SMR) were computed to compare the mortality of COGEMA workers with the French national population. As a second stage, trend tests were computed to assess the correlation between mortality and radiation exposure.

Results: Of the 9287 workers, 93% were men. Workers were followed up for an average of 13 years for a total number of person-years of 120 606. The percentage of subjects lost to follow up was less than 1%. 441 deaths occurred during the follow up period. 96% of the causes of death were identified. The mean cumulative dose among the whole cohort was 15.1 mSv and 27.6 mSv among exposed workers. A strong healthy worker effect was observed for all causes of death (SMR = 0.58; 90% CI 0.54 to 0.63) and for cancer mortality (SMR = 0.74; 90% CI 0.66 to 0.83). No significant excess was found for any of the considered causes of death. A significant dose-effect relation was observed for lymphomas (200–203 ICD 9, $p=0.03$ for eight deaths). This result is mainly due to the dose-effect relation found for non-Hodgkin's lymphoma ($p=0.001$ for four deaths). For this disease, no link with ionising radiation was found in the literature.

Conclusion: COGEMA workers exposed to ionising radiation have a lower mortality than the French national population. An extension of the follow up is ongoing, which will increase the statistical power of this study.

012.6 RISK OF LIVER CANCER AMONG EAST GERMAN URANIUM MINERS: RESULTS OF A CASE CONTROL STUDY

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Introduction: Associations between radiation and liver cancer have been reported in studies of atomic bomb survivors and in studies of patients having received radiotherapy. In a joint analysis of 11 underground miners cohort studies a statistically significant increase in mortality for liver cancer was observed, but there was little evidence of a trend with

cumulative radon exposure. The present study aims at verifying the relation between occupational exposure to radon and risk of liver cancer using a large scale industry based case control study of uranium miners in East Germany.

Methods: The medical records of the former workforce of the closed uranium mines are stored in a Health Data Archive operated by BAuA. The records of about 360 000 miners form the study base—that is, the cohort of Wismut employees, involved in mining for at least several months between 1950 and 1989. Liver cancer cases were ascertained by record linkage of the study base with the Common Cancer Registry of the six Eastern states of Germany. Finally, 424 cases of liver cancer and 790 individually matched controls were included in the study. The cumulative exposure for each subject was estimated using occupational records in combination with a detailed job exposure matrix (JEM) established by the Statutory Accident Insurance Company for the mining industry in collaboration with HVBG. Moreover, information about important confounders such as alcohol consumption and hepatitis were abstracted from medical records.

Results: A clear trend with increasing exposure to radon is seen in the crude risk estimators, up to OR = 1.86 (95% CI 1.25 to 2.78) in the category ≥ 1000 WLM. In 126 cases and 4 controls a cirrhosis was diagnosed, yielding a crude odds ratio of 118.8 (95% CI 29.3 to 482.7). After adjusting for cirrhosis and hepatitis the trend in risk estimators for radon disappeared.

Conclusion: Lifestyle factors such as heavy drinking mainly accounts for increased risk of liver cancer in radon exposed miners.

012.7 NO ASSOCIATION BETWEEN URINARY 6-SULFATOXIMELATONIN AND 50 HZ MAGNETIC FIELD EXPOSURE IN WORKERS

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Introduction: Melatonin has oncostatic, immunological, and antioxidant properties. A suppression in nocturnal production of this hormone has been hypothesised as a possible biological mechanism to explain adverse effect of extremely low frequency-magnetic fields (ELF-MF), including cancer, but the results of research are inconsistent.

Methods: We studied 59 workers (26 men and 33 women, mean age 42 (SD 8) and 46 years (SD 9) respectively), exposed to different levels of ELF-MF, but not to chemicals interfering with melatonin kinetics. Occupational ELF-MF exposure was evaluated throughout three complete work shifts using personal dosimeters, sampling MF every 10 seconds. Environmental exposure was also measured. Urinary 6-hydroxymelatonin sulphate (6-OHMS) in morning samples, considered an indicator of night time melatonin production, was measured. Urine was collected twice on Friday and on the following Monday.

Results: According to the results of monitoring, workers were classified into three groups: low exposed to ELF-MF (TWA ≤ 0.2 μ T), intermediate (<0.2 μ T $1>$) and higher exposed (TWA ≥ 1 μ T). In Friday samples, mean values of 6-OHMS (SD) in the three groups resulted 24.8 ng/ml (9.6), 26.6 ng/ml (10.8), and 32.1 ng/ml (10.7) respectively: the difference among groups was not significant ($p>0.01$). Also considering Monday samples no difference in 6-OHMS values was observed among the groups: 24.5 ng/ml (7) v 27.5 ng/ml (9.3) and 27.6 ng/ml (6.9) respectively in low, intermediate and higher exposed. In addition, values of 6-OHMS were not related to exposure at multivariate analysis. The ratio between 6-OHMS in Monday versus Friday samples was also calculated, to test the hypothesis of a possible variation in pineal function after two days interruption of occupational ELF-MF exposure: again, no exposure related difference was observed.

Conclusions: Our results do not support the hypothesis that occupational exposure to ELF-MF can significantly decrease nocturnal melatonin production in workers.