Cancer Mortality among Nuclear Workers in Belgium

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INTRODUCTION

Animal experiments and epidemiological data in humans have provided evidence that high doses of ionising radiations can induce cancer (1). However, cancer risk estimates available so far, are based mainly on studies about short term exposure (acute) to high radiation dose, e.g. among radiotherapy patients and atomic bomb survivors (2-7). Cancer risk estimates after chronic exposure to low doses of ionising radiation are, in most cases, obtained from extrapolation to low doses of the data observed after high-dose exposure. Radiation protection regulations and current practices are based on these extrapolations (8). Such types of extrapolation imply of course assumptions, in particular concerning the shape of the initial part of the dose-effect relationship. Therefore, cancer risks after low radiation exposure are difficult to evaluate and current estimates remain controversial.

Because it is important to know if the present radiation protection measures are adequate and safe to protect the public as well as the radiation workers, there is a need to measure the cancer risk directly on populations chronically exposed to low doses, such as e.g. radiation workers. The present report is dealing with nuclear workers: this group has been selected because these workers are occupationally exposed to low doses of radiation during several years, and individual data on exposure are available.

Most of the studies that have been done in nuclear workers investigate cause specific mortality rates in workers of different dose categories. They include workers of several types of installations such as nuclear research centers, reprocessing plants, power plants, military installations. But they have some common characteristics as well: most of the workers are exposed to low doses of external radiation (X and gamma radiation) and individual yearly dosimetry data have been registered and kept since the years 1940-50. Only a minority of workers has been exposed to neutrons, or has been at considerable risk for internal contamination.

When total mortality (all causes of death) or cancer mortality (all types of cancer) are compared for the nuclear workers and the general population, only few studies find a significant higher mortality. No specific cancer type is consistently associated with cumulated dose. On the contrary, many studies describe a significantly lower mortality than in the general population, probably influenced by the so called "healthy worker effect", a selection bias. When looking for association with cumulated dose, some positive trends have been found, some of them significant. Leukemia mortality is most frequently associated with dose (9-13). Concerning internal contamination, most of the studies only flag the workers monitored for internal contamination, but have no individual data. Some research has however been done on particular radionuclides, such as plutonium (14).

The many individual studies among nuclear workers done so far often lack statistical power because the effect of low doses of radiation on cancer incidence appears small. Therefore, the International Agency for Research on Cancer (IARC/WHO) in Lyon, France, decided to pool available data. The combined data of several already published studies from Canada, the UK and the USA were analysed to obtain more precise estimates of cancer risk. No association was found between cumulative dose and total cancer mortality. An Excess Relative Risk of 2.2 per sievert cumulated dose for leukemia mortality was observed, but still within a broad confidence interval (0.1-5.7). Therefore it is concluded that so far "there is no evidence that the current radiation protection measures are appreciably in error" (ref. 15-16).

Following this combined analysis, IARC set up a multicenter study, coordinated by Dr. E. Cardis, to pool data of 14 different countries. Belgium is one of the participants.

OBJECTIVES

To investigate cause-specific mortality with emphasis on cancer in Belgian nuclear workers, the Nuclear Research Center (SCK.CEN) in Mol set up a retrospective cohort study in the five largest nuclear facilities in Belgium. Mortality among radiation workers is studied in relation to their occupational exposure to ionising radiation. An additional objective of this epidemiological research is to make recommendations to facilitate the conduct of retrospective cohort studies in Belgium. As mentioned above, this study is part of the "International Collaborative Study on Cancer Risk among Radiation Workers" (IARC/WHO).
METHODS
To reach these objectives, cause specific mortality is studied retrospectively (1953 – 1994) in a cohort of workers from the following 5 nuclear facilities in Belgium:
- the Nuclear Research Center in Mol: follow up period 1953-1994
- Belgoprocess (BP), treating nuclear waste in Mol: follow up period 1985-1994
- Belgonucléaire (BN), a MOX fuel production facility in Dessel: follow up period 1957-1994
- Electrabel NV, the nuclear power plants of Doel (KCD) and of Tihange (CNT) : follow up period 1974-1994
During the period 1953-1994, all workers registered for at least one month in the personnel register of one of the participating facilities, were included in the study (n= 7361). All staff members thus meet the inclusion criteria, but no contract workers. A pilot study showed that too many of the latter would have been “lost to follow up”.
For each worker, we collected the following set of data, using different information sources:
- demographic data (identification, sex, age..): mainly from the personnel registers
- occupational history and job description: from personnel registers, medical records, Ministry of Labour
- exposure to ionising radiation: mainly extracted from the dosimetry records available in the facilities (annual effective dose, flaggings for neutron exposure, internal contamination risks) and from medical records. To assess the transfer doses, the National Radiation Registry kept by the Ministry of Labour was consulted. Collection of dosimetry data before 1973 was essentially done manually from paper files.
- vital status on 31-12-94: assessed through the National Population Registry & local authorities, pension funds and the facilities social services
- causes of death, extracted from the death certificates: information (underlying and direct causes of death, ICD9 encoding) was obtained from the National Institute of Statistics, the French and Flemish Community. Written informed consent of next-of-kin was required to obtain information from the death certificates (home visits). Unfortunately, in Belgium individual death certificates are no longer available before 1969. For the earlier period, only family reported causes of death - obtained through home interviews – are available.
- smoking habits: a smoking survey was done among current workers.

As a first approach, Standardised Mortality Ratio’s (SMR) were calculated for underlying causes of death. The general Belgian population was chosen as the reference population, because workers originated from all over Belgium. SMR calculations were performed in collaboration with the Epidemiology Department of the University of Maastricht. The PETO programme was used. Data were corrected for unknown causes of death (assumption: no relation between exposure and access to death certificate). Workers were categorised in the following dose categories: “non measurable dose” and “measurable doses”
The cohort we describe in this paper is restricted to the period 1969-1994, and to the workers of SCK.CEN, BN and BP. As we already mentioned, individual death certificates are no longer available for the earlier period, and thus SMR’s can only be calculated from 1969 on. Only direct standardisation based on lay reported causes of death is possible for the 1953-1968 study period. The Electrabel workers cohort is not included in this paper because collection of data is still ongoing.
Further analyses of Relative Risks (RR) in different exposure categories (less than 10 mSv, 10-<50 mSv, 50-<100 mSv, 100 mSv and above) will be done in collaboration with the University of Maastricht and the Catholic University of Louvain-La-Neuve. Our data will be pooled with other data collected within the IARC study.

RESULTS
First results of SMR calculations can be presented for SCK.CEN workers for the 1969-1994 period. A total number of 3270 workers were studied during this period. Despite the above mentioned constraints, we obtained a vital status ascertainment of 95%. For underlying cause of death the ascertainment is now 80%.
Available SMR's can be summarised as follows (Table 1):
- male workers, no measurable dose (n = 785): SMR for all causes of death = 75% (95% C.I.= Confidence Interval: 61-91), SMR for all tumours = 64% (95% C.I.: 42-93), 2 leukemia deaths were observed, whereas 1 is expected;
- male workers, measurable dose (n = 1785): SMR for all causes of death = 64% (95% C.I.: 56-74), SMR for all tumours = 62% (95% C.I.: 48 - 80), 2 leukemia deaths were observed, whereas 3 are expected
- female workers, no measurable dose (n = 553): SMR for all causes of death = 94% (95%C.I: 63-135), SMR for all tumours = 106% (95%C.I.: 55 - 161), no leukemia deaths were observed
- female workers, measurable dose (n = 147): SMR for all causes of death = 100% (95% C.I.: 57-163), SMR for all tumours = 90% (95% C.I.: 29 - 208), 1 leukemia death was observed.
CONCLUSIONS

In this study performed in Belgium, SMR's in nuclear workers are significantly lower compared to the Belgian general population for all causes of death and for all tumours in males; in female workers mortality does not differ from the general population, but the number are small. No increase in leukemia mortality was observed, but only few leukemias had to be expected and few were actually observed. Other cause specific mortality rates (25 specific cancer sites, cardiovascular & respiratory diseases, external causes) did not reveal any significantly increased SMR among this worker cohort. A "healthy worker effect" (selection bias) may influence this observation. The correlation between cause specific mortality rates and radiation dose is further investigated. Retrospective collection of data and privacy protection regulations specific to Belgium hampered the conduct of this study, causing labour intensive and time consuming procedures. Written informed consent of next-of-kin is required to obtain information from the death certificates. Before 1969 only family reported causes of death are available. In order to circumvent these constraints, in the present study, novel approaches had to be developed to collect the needed relevant information. Finally this study has drawn the attention on the need to standardise feasible and appropriate procedures to consult the National Population Registry and to obtain reliable information on individual causes of death.

REFERENCES


