CONSTITUTION OF A GROUP OF CZECH AND FRENCH URANIUM MINERS IN ORDER TO ESTIMATE LUNG CANCER RISK LINKED TO LOW CHRONIC EXPOSURE TO RADON DECAY PRODUCTS.

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SUMMARY

West Bohemian and French uranium miners are characterized by a long duration of exposure to radon and its decay products, in comparison to most of the other groups of miners, studied in the recent international joint analysis by the National Cancer Institute (NCI) in USA. This analysis has confirmed the linearly increasing risk of lung cancer by cumulative radon exposure, describing the different factors that may influence this dose-response relationship. One of the main factors presently discussed is the influence of the exposure-rate effect: in other words, has the same cumulated exposure spread over 10 years the same risk of lung cancer as if it is cumulated in 2 years ? The implication of an inverse exposure-rate effect for low chronic exposures as well as some methodological approaches will be discussed and tested by using the data of the Czech and French cohorts. These two cohorts present annual exposures varying by a factor of 5 to 10, French exposure rates being close or even less than 0.1 Working Level during the last 20 years. The project is integrated in a larger European project on uranium miners, co-ordinated by IPSN.

INTRODUCTION

Cohort studies of uranium miners in the Czech Republic and in France have demonstrated a clear increase of lung cancer risk linked to occupational radon exposure. Both studies contributed substantially to an international joint analysis co-ordinated by the National Cancer Institute (NCI) in Bethesda (USA). The results of this analysis, based on more than 2,700 lung cancer cases observed on 65,000 miners, demonstrated a linearly increasing risk of lung cancer deaths with cumulated exposure to radon decay products for all the cohorts. Factors able to influence this dose-response relationship have been discussed recently in a paper which summarizes the results of this joint analysis (1). An inverse dose-rate effect has been observed in 10 out of the 11 cohorts (2). This inverse dose-rate effect has not yet been demonstrated for low cumulated exposures (< 50 WLM*). Its implication in the extrapolation of the risk coefficient obtained in these miners studies to the risk estimated for domestic radon could be of main importance, because it would lead to higher risk estimation for low chronic daily exposures protracted over the whole duration of life than for the same total exposure cumulated in only a few years. The purpose of our project is to focus on the different factors involved in the study of a low chronic exposure: precision of individual dosimetry, comparability of the cohorts in dosimetric survey, duration of exposure, confounding factors.

EUROPEAN PROJECT ON URANIUM MINERS STUDIES

A European project has been accepted for the next 4 years by the Commission of the European Union (DG XII), in order to study more precisely the different components able to influence the dose-response relationship obtained by the miners studies.

In the large joint analysis, realized by the NCI, not only uranium miners were included but also other miners (iron, tin.....), the criteria of inclusion being the existence of measured information about radon exposure for at least part of the working period. In the European project, only uranium miners will be included, in order to eliminate components which may be present in other types of mines and could influence the dose-response relationship between lung cancer and radon exposure.

The following uranium miners groups will contribute to this European project:

1. Two cohorts of miners from the Czech Republic, defined by the period of entry in the mines and by the region;

2. Two cohorts of uranium miners in France, characterized by the period of entry and, in parallel, by the precision of exposure estimation;

3. A very large group of uranium miners from Germany, having experienced a more or less precise survey of exposure depending on the period of work.

The results concerning the Czech and French uranium miners cohorts have already been partially published and these cohorts are presently undergoing an extension of follow-up with a new estimation of the risk coefficient next year. The German large group needs more time to be followed up in a precise way and the first step decided in the European project is a case-control approach with the aim of identifying other components, like tobacco, able to influence the risk of lung cancer amongst uranium miners.

Consequently the European project is supporting two parallel approaches: the first is estimating the dose-response relationship and its modifying factors, the second is a case-control approach, testing first the feasibility of the collection of different factors directly or indirectly linked to the mining environment. The different steps of the cohort approach are described hereafter.

EXPOSURE ASSESSMENT

The first step of the Czech-French collaboration will be a critical examination of the individual exposure estimation for the different periods of work. This exposure assessment will be discussed not only for radon and its decay products, but also for gamma and long lived uranium dust exposure. A job matrix will be elaborated, mainly to test consistency of the individual exposure for the periods during which direct measurements were rare.

Both the Czech and French cohorts are characterized by a long duration of exposure, giving the opportunity for testing the risk for different durations of exposure and, giving in parallel some guaranty for describing the whole history of an individual mining experience. Indeed, in the joint analysis of NCI, a previous experience of some other mining activity was a modifying factor of the dose-response relationship. Including in this joint analysis mining populations with a very short duration of underground mining (for example less than 2 years) as well as those having passed all their working activity in the same type of mine may also have introduced some bias, these populations being probably different with respect to many other factors.

Distribution of the registered exposures shows a time-dependent variation, linked mainly to the period at which radioprotective measurements were introduced in the mining environment. This period of decline of the annual exposure rate is the same in the Czech and French cohorts, close to the year 1956. Since that time, the individual registration of the exposure is complete and has been realized in time, on a regular basis. Consequently exposure assessment has to focus on different periods of exposure, but mainly on the ten first years, when individual exposure was estimated indirectly. In France, since 1956, the same approach of dosimetric survey has been applied to all the miners and has been registered in time.

For estimating the risk linked to chronic low annual exposure, limiting our cohort analysis to those miners who had begun to work underground since 1956 is probably the best unbiased approach, provided the power of our study is high enough to estimate this risk linked to low annual exposure. Increasing the number of miners by a joint analysis of the Czech and French underground miners makes this analysis more realistic. The opportunity of including or excluding those having worked before 1956 will be tested in this common approach. For those miners entered since 1956, a registration of the gamma exposure and ore dust was done in time on an individual basis in France. Approaching a risk linked to low exposure needs a high precision in the individual exposure and an accurate estimation of confounding factors, mainly of those concomitant to the radon exposure. The analysis will be realized by joining the three following cohorts:

- French miners having worked underground for at least 2 years and having begun underground work before 1972. The French cohort may be extended to a larger group in the future, the follow-up of those having entered since 1972 being not yet complete;

- Czech S cohort, including west Bohemian uranium miners (Jachymov, Horni Slavkov, Chodov), first empoyed between 1948 and 1959;
- Czech N cohort, including uranium miners in central Bohemia (Pribram), first employed between 1968 and 1974.

Considering the present endpoint of follow-up in December 1990, the French cohort is contributing with 1,785 miners for 50,000 person-years, each of the two Czech cohorts respectively for 100,000 person-years, with 4,230 miners in the S cohort and 5,625 miners in the N cohort.

The following table indicates the distribution of mean annual exposure in WLM*, from 1946 to 1990.

Table 1: Mean annual radon exposure ($WLM.y^{-1}$) in the cohorts

Period	French cohort	Czech S cohort	Czech N cohort
1946 - 1950	25.5	50.7	
1951 - 1955	30.5	21.9	
1956 - 1960	2.9	11.8	
1961 - 1965	2.9	9.6	
1966 - 1970	3.5	6.4	1.0
1971 - 1975	2.8	1.8	1.1
1976 - 1980	1.8	0.8	0.8
1981 - 1985	1.0	0.8	0.6
1986 - 1990	0.4	1.2	0.6

** WLM (Working Level Month) is a unit of exposure multiplying a concentration of radon decay products by the duration of exposure. A yearly exposure to 11 WLM corresponds roughly to a monthly exposure to 1 WL, the monthly exposure being defined as 170 working hours. 1 WL is equivalent to any combination of radon decay products in 1 liter of air, that results in the emission of 130,000 MeV of energy of alpha particles.*

METHODOLOGY OF STATISTICAL ANALYSIS

The methodology of statistical analysis is close to the one used for the joint analysis by NCI, but with two modifying points: the time dependent modelling of the dose-response relationship includes also an approach with an external reference group and a different concept of the influence of the rate effect. The usual approach to analyse the exposure rate effect is based on a variable defined as the proportion of cumulative exposure and corresponding cumulative duration of the exposure. However, due to ventilation improvement in the mines, the actual exposure rates were different not only within single studies but also during separate miners' employment periods. Consequently, to take into account the fast decline in time,mainly (between 1955 and 1956), we propose a new approach based on exposure rate windows. The individual cumulative 5 year lagged exposures at each moment of the follow-up are split into four windows according to radon concentrations, the first group being as low as achievable. In other words, if the number of cancers is high enough for the estimation of the risk linked to low doses, then the distribution of annual exposures, as described in table 1, makes it possible to estimate the lung cancer risk for radon concentrations as low as 0.1 to 0.3 WL. These concentrations are lower than those achievable in animal experiments and comparable to annual exposures of 1.1 to 3.3 WLM which correspond to annual radon concentrations indoor comprised between 200 and 700 $Bq.m^{-3}$.

CONCLUSION

We consider that the follow-up of low exposed miners will be, in the next years, the best way for testing the linear dose-response relationship and its possible modification by the exposure-rate effect in the field of low chronic alpha radiation exposure, provided that a precise information on individual exposure to radon and to other confounding factors is available.

REFERENCES

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