



A COHORT STUDY OF LUNG CANCER MORTALITY OF URANIUM MINERS IN SOUTHERN BULGARIA (TOWN OF BANSKO)

D. Apostolova

Medical University, Center of Occupational diseases, Sofia, Bulgaria

ABSTRACT

This study examines the mortality among uranium workers, residents of the town of Bansko, located in Southern Bulgaria. Case-control and historical cohort studies were initiated in 1985 among workers of the uranium mines and residents of the town of Bansko, located adjacent to mine operations, in order to estimate the patterns of risk more precisely. The investigation period continued till 1996.

A preliminary case-control study of 17 lung cancer mortality cases of uranium miners between 48 and 70 years (average age 57,2) and age-matched controls were carried out among a group of 152 workers of under- and overground mines, residents of Bansko, exposed to Rn-222 and its decay products.

Radon exposure was also estimated in working level months, based on the work histories and available radiation hygiene data. The average exposure for uranium miners was 1250 WLM. The examination carried out among uranium workers have clearly shown that the risk of lung cancer increases with the radon-222 and its decay products exposure. The absolute risk of lung cancer among uranium workers was $1,1 \cdot 10^{-1}$, and $7,7 \cdot 10^{-6}$ person-years WLM⁻¹.

Among 152 uranium workers 17 cases of lung cancer were observed ($R_1=0,11$) against 0,0081 expected (R_2) in the period 1985-1996. The observed to the expected cases ratio was 3,8 ($OR=R_1/R_2$).

Key terms: cohort study, radon daughters, lung cancer mortality, risk estimate.

INTRODUCTION

Uranium mining and milling development in Bulgaria started in the 50's early. This industry was operational till 1991, and is presently in a process of closing. Studies of under and overground uranium miners have clearly shown that the risk of lung cancer increases with exposure to Rn-222 and its short level decay products (1,2).

In 1995 the Centre of Occupational diseases, Sofia, Bulgaria, initiated a series of epidemiological studies including a large case-control study of cases of lung cancer mortality among uranium miners. The population subject to this study was under observation for the period 1985-1996.

MATERIALS AND METHODS

Case-control and historical cohort studies were initiated among uranium workers and male residents of the town of Bansko (Blagoevgrad province) located adjacent to uranium mine operations, in order to estimate patterns of risk precisely (3). In the town of Bansko an ecologically pure area - the male population was 4800 persons. In addition there were 152 native residents uranium workers and 58% of them addicted to tobacco. The criteria for inclusion in the cohort study were as follow: resident of Bansko, availability of personal and work description data, under or overground work for 5 years or more. To identify diagnosed lung cancer cases among cohort members for the period of this study, the National residential

registry and the local registry of death of the town of Bansko were used. For all cases of lung cancer mortality a detailed work history has been created, including work area, work unit, initial and final data of work, tobacco use (3,4).

Exposure to radon was measured in units of working level months (WLM). For each uranium worker, WLM exposure was estimated taking into consideration occupational history (years of work in the mine), working level (WL) concentration, duration and period of work. For "working months" calculation we assumed that workers were directly exposed to radon 6h/d for 285 d/y or 170h/mo. Dose-exposure conversion factor is 3.9 mGy/WLM (2).

To calculate the statistical data and estimate the risk we used the methods, described in (5,6).

RESULTS

The average WLM exposure received by the uranium miners, during work is 1250 WLM (7). WLM was estimated with substantial error due to inaccurate or missing records, incomplete measurement data for WL, and problems in extrapolation and interpolation of WL to unmeasured areas and times. The total number of mortality cancer cases in the town of Bansko for the period 1985-1996 was 162 persons. The observed lung cancer death cases among 4800 male residents of Bansko for the same period was 39. The annual mortality probability of lung cancer cases among male residents in Bulgaria and in Bansko during the period 1985-1996 was nearly $1,3 \cdot 10^{-3}$. The annual mortality probability of lung cancer cases among uranium miners (town of Bansko) during the period 1985-1996 was $5,5 \cdot 10^{-2}$. The observed number of lung cancer deaths of uranium workers from Bansko for the same period was 17 of 152 (table 1).

Table 1. Estimation of lung cancer mortality risk among uranium miners and native male population of Bansko, during the last 12 years (1985-1996)

	uranium workers	male population (non uranium workers)	total
number of lung cancer deaths	17 (A)	39 (B)	59 (A+B)
survive	135 (C)	4800 (D)	4935 (C+D)
total	152 (A+C)	2839 (B+D)	4991
person-years	1757	16520	

R1 -Lung cancer mortality risk among uranium miners.

R2-Lung cancer mortality risk among non uranium miners.

$$R1=A/A+C=17/152=0,11$$

$$R2=B/B+D=39/4839=0.0081$$

$$OR=R1/R2=0,11/0,0081=13,8$$

Wr-Annual probability of death from lung cancer per WLM⁻¹.

The average exposure for uranium miners was 1250WLM.

$$Wr=Person\text{-}years \cdot 1250 \text{ WLM} = 1757 \cdot 1250 = 2196250 \text{ per } \cdot \text{WLM}$$

$$Wr=17/2196250=7,7 \cdot 10^{-6} \text{ WLM}^{-1}.$$

Table 1 shows the increase in lung cancer mortality risk among uranium miners in comparison with the lung cancer mortality risk among non uranium miners (male population of

Bansko). The expected number of lung cancer cases in the examined group, based on the risk among the average male population (non uranium miners) in the town of Bansko, was 0,0081 cases. The relation risk (OR) observed to expected cases of overall mortality ratio among uranium miners was 13,8. The probability of lung cancer death per WLM was $7,7 \cdot 10^{-6}$ person-years per WLM⁻¹.

CONCLUSIONS

Similar to the conclusions in some of the other studies(8,9), the results of the epidemiological study of lung cancer in Southern Bulgaria show a very high mortality among uranium miners. The average absorbed dose is 4875 mGy (1250 WLM . $3,9 \text{ mGy/WLM} = 4875 \text{ mGy}$). The relation risk (OR) of lung cancer mortality among uranium miners was 13,8, and the probability of lung cancer death per WLM was $7,7 \cdot 10^{-6}$ person-years per WLM⁻¹.

REFERENCES

- [1] BARBER, J.M FORRES, R.D. , A studies of uranium lung clearance at a uranium processing plant, Health Phys. **68** 5 (1995) 661-669.
- [2] COHEN, B.L., Radon daughter exposure to uranium miners, Health Phys. **42** 4 (1982) 449-457.
- [3] GERALD, R.P., A case-cohort study of lung cancer, ionizing radiation, and tobacco smoking among males at the Hanford site, Health Phys. **58** 1 (1990) 3-11
- [4] MOOLGAVKAR, S.H., et al., Radon, cigarette smoke, and lung cancer: a re-analysis of the Colorado Plateau uranium miners data, Epidemiology, **4** 3 (1993) 204-217.
- [5] GRAHAM, D., BRIAN, E., Clinical biostatistics, New York - Toronto, (1995).
- [6] GREENBERG, R. S., (Ed.), Medical epidemiology, Prentice-Hall Internat. Inc., USA, (1993).
- [7] IVANOV, Z., On internal dose to lungs in occupational exposure to radon and radon daughter products, and on the approach to its determination and setting of norms, Sci. Publ., Res. Inst. Rad. and Rad. Hyg., vol. 3 (1967) 77-83.
- [8] CHMELEVSKY, D., et al., Probability of causation for lung cancer after exposure to radon progeny: a comparison of models and data, Health Phys. **67** 1 (1994) 15-23.
- [9] KUSIAK, R. A., et al., Mortality from lung cancer in Ontario uranium miners, Brit. Jour. Indust. Med., **50** 10 (1993) 920-928.