

Epidemiological Studies of Lung Carcinoma Incidence in Uranium Miners (Accumulation and Retrospective Use of Diagnostic Data)

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Abstract: The paper attracts attention to the question of accumulation and retrospective use of diagnostic data in the early epidemiological studies of lung carcinoma incidence in uranium miners in Schneeberg, Saxony, and in Jáchymov (Joachimsthal), Bohemia.

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1. Carcinoma of the lung affecting long-term employees in uranium mining became the third case of occupational health damage which was traced to the carcinogenic effect of ionizing radiation, with the first two being the cases of skin cancer and leukaemia in medical radiologists.

Allusions to a particular lung disease affecting miners at both the Saxon and Bohemian part of the Erzgebirge mountains (Krušné hory) date back to historical sources of the 16th century (Agricola 1500, Mathesius 1559). For a very long time, the disease, called (in German) *Bergkrankheit*, *Berg-* or *Lungsucht*, remained without a proper medical classification. It was just made responsible for miners' premature death. In 1879, the disease was diagnosed as a lung cancer for the first time based on a thorough clinical examinations and autopsies of miners in Schneeberg carried out by medical doctors F. H. Härting and W. Hesse [1]. The "arsenic dust" present in the mine air and breathed in by miners during their work, was supposed to be the main noxa of the disease. In that time, no one could suspect radioactivity, which was still waiting for its discovery.

The first epidemiological studies of the lung carcinoma incidence in uranium miners were carried out in Schneeberg, Saxonia, and in Jáchymov, West Bohemia, in the 1920s and 1930s. Similar research followed in other parts of the world later on, partially as result of an initiative of the Health Department of the League of Nations. Since then it is continually subject of scientific interest (including the Czech Republic), which is based on a long-term systematic monitoring of health (and mortality) of large occupational groups. Modern research employs various diagnostic methods and broad inter-disciplinary cooperation.

There is also a close relation between the epidemiological and the historical studies. On one hand, the former can profit from historical sources in its search for early data. On the other hand, the long-term series of data accumulated by medical examinations can serve as a valuable source for historians because they reflect progress in science, changes in the health, and social care as well as general historical and political development.

2. The early epidemiological studies pursued the following main objectives:

- 1) to examine the frequency of lung cancer of miners in uranium mines;
- 2) to identify a cause of the occupational disease;
- 3) to propose protective measures for given occupational groups (and, if possible, to introduce a sort of indemnity for the occupational risk factor);
- 4) to study the relations between a radiation exposure and the incidence of the cancer with respect to more general aspects of the radiation protection.

The systematic examinations of miners in Schneeberg and Jáchymov organized in the 1920s and 1930s proved an existence of the specific occupational disease (lung carcinoma). The first protective measures introduced in Jáchymov aimed at decreasing the dust and radon concentration in mining work places (by means

of an artificial ventilation, water-irrigated pigs instead of pneumatic ones, charcoal-filter respirators), as well as at an improvement of general hygienic conditions such as showers, alimentation bonuses etc.

Lung cancer caused by working in uranium mines was included among occupational illnesses (with the right for an indemnity) by the Czechoslovak Law No. 99 in 1932. In Germany the same legislative arrangement was taken seven years before. Application of this legal measure, however, was not smooth, because it frequently encountered obstacles concerning the diagnosis of the disease in living patients.

Further research made in the mid 20th century in various parts of the world proved that the disease was not caused by radon itself but by its decay products inhaled in form of radioactive aerosols and captured in lung epithelium. Czech physicist F. Běhounek was one of the first scientists who understood this fact [2].

3. The research into “miners’ disease” in Jáchymov started at the turn of the 1920s and 1930s. A special Czechoslovak inter-ministerial and inter-disciplinary committee was established to pursue the investigation. Both Czech and German experts took part in it [3].

The work of the Commission was interrupted by annexing of the Czechoslovak border areas to Germany in 1938 and later by the World War II [4]. Continuation of the research after the war was negatively affected by a demographic change in the Jáchymov mining area. It was also complicated for several decades by a turbulent history of the uranium mining in Czechoslovakia, which was carried out under a Soviet supervision, being kept the top secret and making use of forced labour of political prisoners [5].

The political relief in the 1960s contributed to a revival of the epidemiological studies concerning people employed in the uranium industry. The new research was pursued in Czechoslovakia in the 1960s and the 1970s within a framework of a more generally conceived research into “Protection against Ionising Radiation” by the Institute of Hygiene and Epidemiology, Dpt. of Radiation Hygiene, Prague, and the Health Institute of Uranium Industry, Institute of Industrial Hygiene in Uranium Industry, Příbram [6]. These studies collected and analysed available data concerning the state of health, mortality, and radiation burden of workers employed in the Czechoslovak uranium industry after 1948 [7].

The uranium industry workers have been under monitoring ever since, within the legal supervision in the area of radiation protection [8]. The new data serve for refining results of prior epidemiological studies [9]. They also provide feedback regarding efficiency of the radiation protection measures introduced in the uranium industry workplaces [10]. Comparison of results on an international level has become one of the most important tasks.

4. The following illustrations try to demonstrate the notable number of medical examinations involved in the epidemiological studies of the lung carcinoma incidence in uranium miners, as well as the progress in applied diagnostic methods.

In Schneeberg, between 1922–1925, 154 miners (who had been employed in Schneeberg mines for 10–15 years) underwent a detailed clinical and X-ray examination. The results were compared with examinations of the state of health of two control groups: 176 employees of cobalt dye factory in the nearby Oberschlema and 186 other local inhabitants. In addition to that, 22 autopsies of deceased miners were carried out [11].

The first survey of the state of health of uranium mine employees in Jáchymov was organized between 1928 and 1929. The examination point was established in the Jáchymov state spa and two spa physicians (J. Markl and A. Pirchan) were involved. By January 1929, a total of 323 active and 83 retired employees of Jáchymov mines were examined. In 1929–1930, a total of 13 autopsies (out of 22 deceased employees of Jáchymov mines) were carried out. They took place at the local cemetery with participation of the pathological anatomist Prof. H. Šikl from Charles University. In 1933, Prof. L. Borovanský (from the same university) completed the medical examinations of the Jáchymov miners using the blood count. As a result of this first stage of research lasting up to 1937, H. Šikl determined 24 cases of lung cancer incidence in Jáchymov's miners [12].

In the post-war period in 1952, Dr. E. Petráček from the Central laboratories and the Outpatients' Department for Occupational Diseases at the Regional Institute of National Health (KÚNZ) in Karlovy Vary reported results of his research into the lung cancer incidence in Jáchymov uranium miners in 1946–1951 which was based on 877 clinical studies. Among them, however, only a small group of 66 persons represented workers with the average period of exposition at least 15 years. E. Petráček resumed the applied diagnostic method as follows: "*Prompt changes in the workers hemogram were noted and attention called to the Brdička reaction, metabolism of proteins in the blood, remanent nitrogen, and sedimentary celerity of red corpuscles*" [13].

The report by doctors J. Švec, V. Plaček and others on results of the research into "Lung carcinoma and exposition to inhaled radiation", presented in 1978, was based upon monitoring the state of health of 4,327 workers of the Czechoslovak uranium mines; 56 % of the workers started their work in uranium mines in the period between 1948–1952 and were monitored for an average period of 26 years [14].

In the 1960s, attention was also turned towards the state of health of workers employed at the outward uranium processing in Czechoslovakia (whose number was increasing due to the Czechoslovak atomic power plant programme) [15].

5. The organization, results and difficulties of the first examinations of miners in Jáchymov can illustrate a report by the physicians J. Markl and A. Pirchan written in February 1929 and presented to the Presidium of the Czechoslovak Ministry of Public Health. It reads: *“A total of 323 men presented themselves for an examination. They underwent a general examination, X-ray of thorax and if necessary blood, sputum and urine tests. Records were kept in 4 copies, one of which stays with the institution; others are presented to the Central Management of the state spa, the Ministry of Public Work and the Mining Management.*

The records were kept as follows: the Mining Management provided data concerning the work contracts and length of employment to avoid incorrect data given by the examined persons. Anamnestic data were provided by the examined persons themselves; this information was often only partial since the examined workers knew nothing in particular about their familial illnesses. When stating that the father died of the miner’s disease – Bergmannskrankheit – and if the disease description corresponded to lung cancer, the information was recorded in the cancer section. It must be noted that people here generally agree that if a younger miner dies, he dies of the miner’s disease regardless the symptoms; and even physicians used to say this to the local people [...].

Generally, it can be stated that examinations of active workers did not bring especially positive results. It must be noted that overall nutrition of all miners based upon height/weight comparison is poor. Not a single suspicion of bronchial Ca was discovered in the persons examined. Based upon our existing experience, this was expected since it is not the active miners that die with the symptoms of bronchial Ca but the ones retired after 15–20 years of service” [16].

6. In most documents on the research of the lung carcinoma incidence in Jáchymov in the interwar period it was repeatedly stated that the only reliable diagnostic method for the lung carcinoma proved to be an autopsy of a deceased. The following case of a retired miner is a telling example: The person died on January 28, 1930 at the age of 53 years. He had been employed with the Jáchymov mining works for 23 years; beginning in 1900 and leaving for retirement in 1923. For the first two years, he was employed in the uranium factory and then worked as a carpenter at the Werner Mine. The autopsy which was carried out in the morgue of Jáchymov municipal cemetery by the already mentioned pathological anatomist H. Šikl from Prague (with participation of Dr. A. Pirchan, the Head Physician of State Radon Spa in Jáchymov; Dr. F. Mahler, the Jáchymov District Physician, and Dr. E. Kretschmer, the Municipal Physician in Jáchymov), proved death due to a lung carcinoma. Nevertheless, even the last examination of the person, which had been carried out ten days before the person died was unable to diagnose the lung carcinoma! [17]

7. Results of the miners examinations in Jáchymov were recorded on special blankets. They were worked out according blankets used in Schneeberg for the same purpose. The survey contained following items: name and date of birth; from when was the person employee of the mines and at what positions; his previous employment; height and weight; cancer incidence in the family; personal health complaints; X-ray examination of thorax; additional examinations if necessary; examination of sputum, blood count, urine analysis, examination of abdominal cavity. Suspected or more complicated cases were sent to a more detailed examination at the Internal Clinics of the Czech or German Universities in Prague (to Prof. J. Pelnář or Prof. W. Nonnenbuch respectively).

The complex investigation of the Jáchymov miners' disease in the 1930s was completed by a chemical and a radio-physical analysis of incinerated organs of deceased miners to identify the noxa of the disease. Physicist F. Běhounek from the State Radiological Institute in Prague together with analytical chemist O. Tomíček, professor of Charles University in Prague were responsible for this part of research.

8. A set of the early examination records and autopsy certificates concerning Jáchymov miners is preserved in the National Archives in Prague. (The X-ray examinations, however, are documented only by a verbal description.)

For a historian of science, these documents represent an interesting material, which can provide a wide spectrum of information on the history of Jáchymov mines, on the health care, medical science and, relations between the Czechs and the Germans in the interwar Czechoslovakia.

Conclusion

I do not feel competent enough to speculate about a possible range of use of the early resources for the modern epidemiological studies. Only medical specialists can answer this question. In my paper I have just tried to remember some, more or less, known facts, namely:

- 1) The epidemiological studies of lung carcinoma incidence in uranium miners have a long tradition in Czechoslovakia, originating in the late 1920s.
- 2) Preserved archives sources indicate that diagnostic methods available in the interwar period generally encountered serious difficulties in diagnosing the lung carcinoma in living uranium workers, who often suffered from other ailments due to their hard work and humble living conditions (tuberculosis, silicosis, malnutrition, most of them were hard smokers etc.).
- 3) The archives sources also document that the so called uranium miners' disease never was a mere medical problem. It always covered (and still covers) a lot of aspects in a wide cultural context.

References

1. See e.g. ROSTOSKI O., SAUPE E., SCHMORL G.: Die Bergkrankheit der Erzbergleute in Schneeberg in Sachsen ("Schneeberger Lungenkrebs"). *Zeitschrift für Krebsforschung* 23: 360, 1926.
2. The carcinogenic effects of radon daughters were studied e.g. by experiments on rats.
3. For more details on that history see: MÁŠOVÁ H., TĚŠÍNSKÁ E.: Science in the service of occupational health: The case of the commission for "miner's disease of Jáchymov" in the inter-war Czechoslovakia. *Prague Medical Report* 107: 447–460, 2006; TĚŠÍNSKÁ E.: Výzkum "jáchymovské hornické nemoci" a účast Státního ústavu radiologického RČS. *Práce z Archivu Akademie věd, Series A, Vol. 7, Prague, 2002, p. 65–104.*
4. No reliable data were found on a potential continuation of the epidemiological study in Jáchymov by Germans in the war time. Nevertheless, there is evidence of some interest in Jáchymov mines in the wartime by German radiobiologist Prof. B. Rajewski from KW Institut für Biophysik in Heidelberg.
5. About the continuation of the studies on lung carcinoma incidence in uranium miners in Jáchymov after World War II see PETRÁČEK E.: Radioaktivní záření a profesionální nádory plic. In: *Primární rakovina plic. Státní zdravotnické nakladatelství, Praha, 1952, p. 25–32.*
6. In 1963, problems of radioactive hygiene and protection of workers in uranium mines and plants was incorporated explicitly in the research plan of the Ministry of Public Health for the first time.
7. See e.g. ŠVEC J., KUNZ E., PLAČEK V.: Lung cancer in uranium miners and long-term exposure to radon daughter products. *Health Physics* 30: 433–437, 1976. Studies in the USA were undertaken in the 1950's on uranium miners in the Colorado Plateau area. The results began to appear in the early 1960's, and they also showed an increase in lung cancer with an increase in exposure to radon daughters. In 1974, a collection of the Canadian uranium mining data began. The Royal Commission on Health and Safety in Mines in Ontario commissioned an epidemiological study of the uranium miners in the Elliot Lake area in 1975–1976.
8. Since 1968, miners in Czechoslovak uranium industry were provided with personal dosimeters which enable more precise estimation of the radiation burden.
9. The epidemiological studies are very demanding as to the collection of the relevant data on the long-term monitored group of uranium workers (data on their state of health, diseases and causes of death after their retirement). The data have to be gathered from several reliable sources and verified to reach the maximum possible objectivity. E.g. in case of a suspicion of a lung cancer incidence, the cause of death should be verified by an autopsy or histology. See e.g. KLENER P.: Rizika ozáření. Co je překážkou racionálního vnímání rizika z ozáření. *Vesmír* 74: 365, 1995.
10. See e.g. TOMÁŠEK L., MÜLLER T., KUNZ E., HERIBANOVÁ A., MATZNER J., PLAČEK V., BURIAN I., HOLEČEK J.: Study of lung cancer and residential radon in the Czech Republic. *Central European Journal of Public Health* 9: 150–153, 2001.
11. See ROSTOSKI O., SAUPE E., SCHMORL G.: Die Bergkrankheit..., loc. cit., p. 360–361.
12. For more details see e.g. BAŠTECKÝ J.: Bronchogenní karcinomy. *Sborník lékařský* 40(64): 256–266, 1938.
13. PETRÁČEK E.: Radioaktivní záření ..., loc. cit.
14. ŠVEC J., PLAČEK V.: Report No. P17-335-236-02/04a ("Výskyt pozdních účinků ionizujícího záření u exponovaných kolektivů", Subetapa "Rakovina plic a inhalační radiační expozice"). IHE, CHZ – UP Příbram, ÚHP Kamenná, 1978. E. Kunz, J. Horáček, Z. Roth, J. Thomas, M. Šonka and M. Roškatová are named as people who cooperated in the research. The report states, among others, that the next epidemiologic study planned for 1976–1980 will study the lung carcinoma incidence in uranium miners who started work in uranium mines in Czechoslovakia after 1968.

15. See e.g. PELNÁŘ P., KUŘETOVÁ V., NOVÁKOVÁ O., ROUBAL F., ŠPLÍCHAL A.: Zdravotní stav pracovníků v třídně uranové rudy. *Pracovní lékařství* 3: 125–129, 1960. The team of authors from the Health Institute of Jáchymov Uranium Mines, state enterprise Příbram (Závodní ústav národního zdraví Jáchymovských dolů, n.p. Příbram) refer on the health status examination of workers sorting uranium ore in a non specified Czechoslovak plant. They sum up that 87 employees were examined, including 71 men and 16 women aged 19–63 years, half of whom had been doing this work for less than two years, the rest up to 14 years. All were subjected to a detailed somatic, haematological (including haemotocrit, thrombocytes, coagulation, bleeding, capillary fragility and sedimentation rate); functional examination of the kidneys and X-ray examination of lungs. In most patients hearing was examined (incl. an audiometric examination) and a neurological examination was made. In some individuals the serum cholesterol was estimated and some other biochemical examinations were made. The authors concluded that they did not reveal any damage which could be ascribed to the influence of uranium or the dustiness of the atmosphere.
16. Státní oblastní archiv v Plzni (SOA, State District Archives in Plzeň). Fond Státní báňské ředitelství (SBŘ, State Mining Direction), k. 19 (Report of the State Radon Spa in Jáchymov, No. 127 from Feb. 18, 1929). In the following part of the report, some features of the radiographs are discussed. No radiographs of that time, however, seem to have been preserved.
17. SOA Plzeň. Fond SBŘ, k. 19.