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Research Article

Radiation environmental effects on the lymphoid neoplasia pathology

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Abstract. Objective: This study aims to assess the effects of the radiation environment in the vicinity of a sealed Romanian uranium mine over the number of patients with lymphoid neoplasia pathology, during 2009-2010, in comparison with a witness area. Material and method: Two groups have been created: people exposed and unexposed to the radiation environment, made up by the population in the towns of Stei and Marghita (from Bihor County) and the dosages of various radio nuclides, the calculation of the incidence of lymphomas for both groups, the relative risk (RR) and the attributable risk (AR) have been carried out. Results: A higher lymphoma incidence has been obtained in generally and on the different lymphoma types: Non-Hodgkin Lymphoma (NHL), Hodgkin Lymphoma (HL), Chronic Lymphocytic Leukemia (CLL) and Multiple Myeloma (MM) in the exposed zone, in comparison with the unexposed one. We found statistically important differences ($p<0.001$) between the results from the beta global analyze to water and vegetables from population's own gardens, without significant differences between the alpha global analyze for water and vegetables from their own gardening. Conclusion: The data within this study shows the importance of the radioactive environment and its assessment in the lymphoma development.

Key Words: epidemiology, lymphoma, radiations, risk.

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Introduction

The necessary information for making up a type of epidemiological study is recorded most frequently in sample derived from the target population. The sample is used because the procedure of gathering information is much more accessible than gathering information for the whole population, the necessary time becomes shorter, the obtained information is more accurate and the error level introduced by sampling is measurable (Brumboiu 2005).

The biological variability occurrence can modify the results of the measurements made during the epidemiological studies; therefore the statistic methods must be used for comparing the samples of population and for making causal deductions. The statistic method intervenes from the moment of organizing the study to the analyzing part of the results and it represents the basis of the medical interpretations (Brumboiu 2005).

The cohort studies represent analytical studies where subgroups (cohorts) of a well-defined population face exposed persons to a determinant element and, respectively, unexposed persons to that determinant element, in order to assess the probability of a disease or other health events to arise (Brumboiu 2005). They are also called follow-up or incidence studies and they represent the most exact form of non-experimental epidemiological studies (Sabau 2005).

The purpose is to show the importance of a factor in the etiology of a disease, by proving some significant connections based on statistic tests and by quantifying these connections (Sabau 2005).

The uranium, the heaviest natural element on Earth, is a radio-active element. It has a global concentration of approx. 2-4 mg/kg in the Earth's crust, thus the natural uranium being 1000 times more common than gold and 10 times more widespread than other heavy metals (also toxic), such as cadmium (0.3 mg/kg) or mercury (0.4 mg/kg) (Turekian and Wedepohl 1961). Besides the uranium natural oxide (UO_2) and pitchblende (a mixture of UO_2 and UO_3), the most extracted common types of uranium ore are the secondary ones, such as phosphates, silicates and vanadates.

In the uranium mining zones, this is released from the lithosphere in larger quantities than the natural ones, the high aquatic mobility of uranium results in the frequent pollution on a large scale of the surface and deep water, and like all heavy metals, the uranium is not biodegradable. It is accumulating into the biosphere, having significant concentrations in the soil, sediments and biotic, more than the standard natural levels (Winde 2003), and these secondary accumulations exceed the original source of pollution.

The contamination of the agricultural soil using phosphate uranium fertilizers on a long term leads to an increase of uranium in various water supply systems, in the vegetal ones and not only, that is why the chances of contamination get higher (Winde 2010).

From the three natural isotopes of the uranium, U238 represents the main mass of 99.3 weight per hundred (wt %), the other two isotopes U234 (0.005 wt %) and U235 (0.7 wt%) being

responsible for nearly half of the total radio-activity, approximately 25.4 Becquerel/kg (Bq/kg), despite the fact that they make up less that 1% of the natural uranium mass.
The electrons ejected during the process of radioactive disintegration represent one of the main radiation forms and are called beta particles. Alpha particles are in fact the nuclei H+ with two protons and two neutrons coming from the more complex forms of disintegration of the unstable isotopes, such as the U235. The third main radiation form is not related to a particle but it is X-ray of high energy, also called radiation gamma, released during the radioactive disintegration of isotopes, such as cobalt 60, cesium 137 and iodine 135. Under the influence and action of such physical phenomena, the cells' deoxyribonucleic acid (DNA) is destroyed. The regulator genes, which control the normal division and death rate of the cells, may work improperly, and the cells may become "immortal" and get multiplied to an abnormal rate, leading to an out of control increasing of a line of abnormal cells. In other words, we can say: "this is the cancer" (Jaworowski 1999).
A frequent observation found in the scientific researches shows that "there is not a minimum" or a "limit" of safety for the unfavorable effects of radiation over the DNA of the biological systems, so that small doses of radiation with long persistence cause a cumulative effect and toxicity with consequences in anomalies. Most of the tissues may produce cancers in the case of a sufficient destruction determined by radiations; among these, there are the cells with a high division capacity, very vulnerable, such as the hematopoietic line which makes up the blood and produces leukemia. The risk of producing cancer within the general population is estimated to approximately 0.06 cases in a million of micro Sieverti (mSv)– the dose absorbed by the tissue (Jaworowski 1999).
Thus we can observe that during our normal daily activity, we are continuously exposed to ionizing radiation, from sources both natural and due to certain human activities.
The passing of the ionizing radiation through the body can produce biological effects, which are very damaging as they come from primary emanation of certain springs like the active or in preservation uranium mine exploitations, the equipment or the uranium enriching plants. The effects are mainly due to the genetic material damage inside of cells, the DNA or the "double-stranded" molecule which carries out the genetic information. In the areas with uranium and radium ore sources, short-life substances of dissolution are emanated continuously, such as the radon (Rn222) with a much higher specific radioactivity, which extra increases the radio-toxicity related to the uranium.

Material and method

In a prospective cohort study for the year 2009-2010, the population from Stei was considered as exposed, due to its neighboring with the closed uranium ore exploitation (Baita, closed in 1998) and the radioactive waste deposit (since 1987) inside of two galleries of the old uranium mine. Stei is located at 15 km distance from the location of Baita mine, exploited between 1950-1998. The witness population was selected from the town of Marghita, situated at 200 km from the source of radiation. Following the eligibility criteria applied within this study, 63 persons from the population of Stei have been selected – those representing the group of exposed people and 71 persons from the population of Marghita – representing the unexposed group. Both towns take part of Bihor County, located in North-Western Romania. They all got an evidence paper which included a case history, the general objective exam on apparatus and systems, paraclinical investigations: the blood count, liver and renal assessment, ESR (erythrocyte sedimentation rate), glucose, proteinemia, immunogram, coagulation, imaging (abdominal ultrasound and EKG). To the patients with suspicion of a lymphoproliferative syndrome the investigations extended with: immunophenotyping; anti-erythrocyte antibodies hot and cold; immune-electrophoresis with immunofixation; beta 2 micro globulin; Bence-Jones protein; medulogram; osteo-medullary biopsy; lymph node biopsy with histopathological examination (HP) and immunohistochemistry examination (IHC); computed tomography (CT); magnetic resonance imaging (MRI); thoracic radiographic examination; and R-bone graphics – skull, intercostals space, cervical-back-lumbar spine, pelvis, proximal epiphysis of long bones.
The radio nuclides alpha and beta from the drinking water and vegetables from their own gardening have been distributed to compare for the two towns and legal normal values were reported in accordance with the National Law 458/2002.
In our study we were looking for the incidence of lymphomas in the population selected from both towns, as well as the relative risk (RR) and attributive risk (AR) for each lymphoma.
We considered that a statistically significant result (Healy 2009) is one in which the observed p-value is less than 5% ($p< 0.05$). The statistical significance of the p-value shows the probability (1-p) to obtain differences between the two groups, exposed and unexposed. In this respect, if $p<0.05$, this probability is over 95%.
We searched for the following lymphoma types: Non-Hodgkin Lymphoma (NHL), Hodgkin Lymphoma (HL), Chronic Lymphocytic Leukemia (CLL) and Multiple Myeloma (MM).
The study was made under the advice of the Ethical Comitee, with signed informed consent of the patients and the granted access to the medical records archive from the managers of the Hematology departments of Oradea and Cluj Napoca.

Results

No significant statistically differences have been noticed in the two groups selected for the present study regarding the distribution by gender and age. From the 63 persons in the Stei group, 34 (53.97%) were female and 29 (46.03%) were men. From the 71 persons in the Marghita group, 38 (53.52%) were female and 33 (46.48%) were men, as shown in Figure 1.
The distribution by age of the two groups was, as shown in Figure 2. In the Stei group there were 6 persons (9.52%) between 19-30 years, 12 persons (19.05%) between 31-40 years, 12 persons (19.05%) between 41-50 years, 20 persons (31.75%) between 51-60 years and 13 persons (20.63%) between 61-73 years. In the Marghita group there were 12 persons (16.90%) between 19-30 years, 10 persons (14.08%) between 31-40 years, 14 persons (19.72%) between 41-50 years, 21 persons (29.58%) between 51-60 years and 14 persons (19.72%) between 61-73 years.
We found 14 lymphomas in the Stei group, 4 (6.35%) NHL, 2 (3.17%) HL, 5 (7.94%) CLL and 3 (4.76%) MM. In the Marghita group we found 9 lymphomas, 3 (4.23%) NHL, 1 (1.14%) HL, 3 (4.23%) CLL and 2 (2.28%) MM, as shown in Figures 3 and 4.

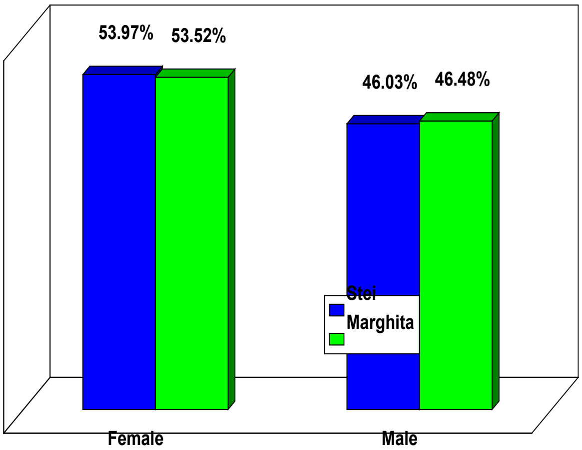

Figure 1. Distribution by gender of the Stei and Marghita groups

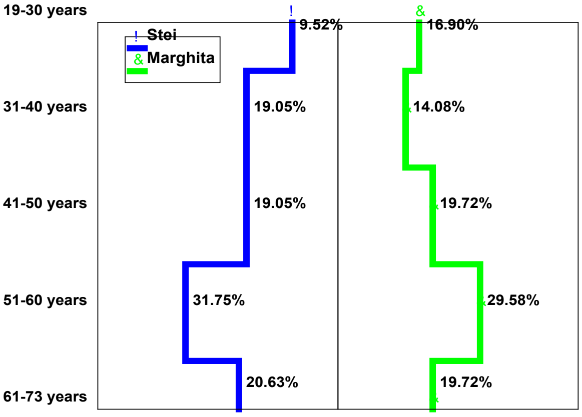

Figure 2. Distribution by age of the two groups from Stei and Marghita towns

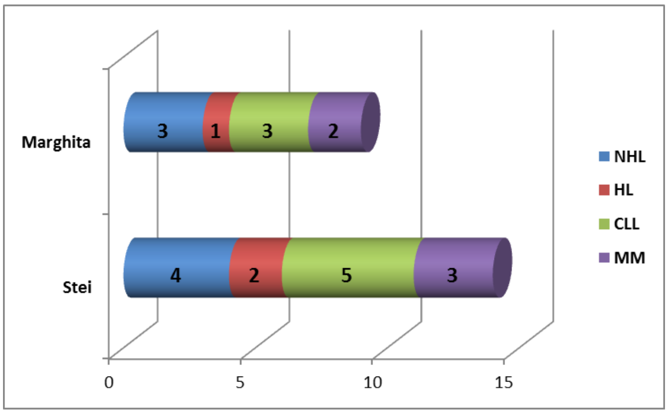

Figure 3. Number of lymphomas cases found in each group: Stei and Marghita between 2009-2010

The incidence of lymphoma in general and on types of lymphoma was significantly higher in the area exposed than in the unexposed one, as it appears in the Figures 5-9.

The incidence of lymphoma is 22.22% in Stei zone and 12.68% in Marghita (p=0.003 statistically high significant). The risk of lymphoma is 1.8 higher in Stei zone than in Marghita (RR=1.753, AR = 0.095), as shown in Figure 5.

The incidence of NHL is 6.35% in Stei zone and 4.23% in Marghita zone (p=0.023 statistically significant). The risk of NHL is 1.5 higher in Stei than in Marghita (RR=1.503, AR=0.021), as shown in Figure 6.

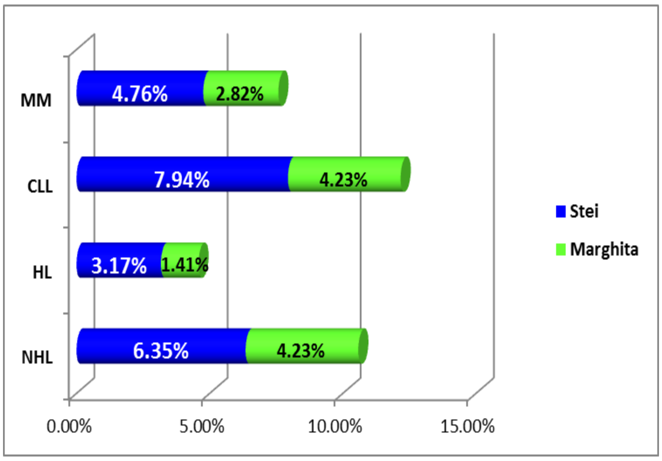

Figure 4. Distribution of lymphoma types found in the two groups Stei and Marghita between 2009-2010

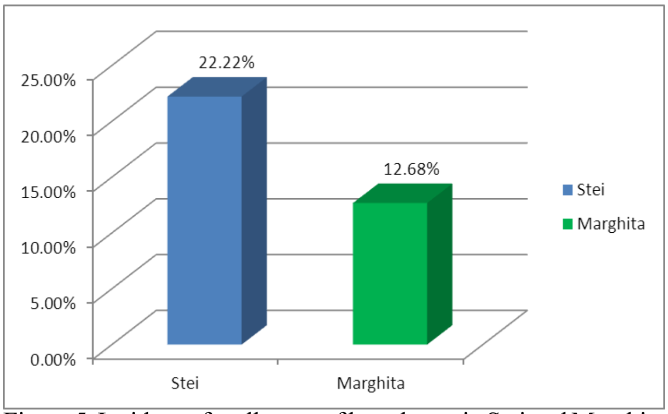

Figure 5. Incidence for all types of lymphoma in Stei and Marghita

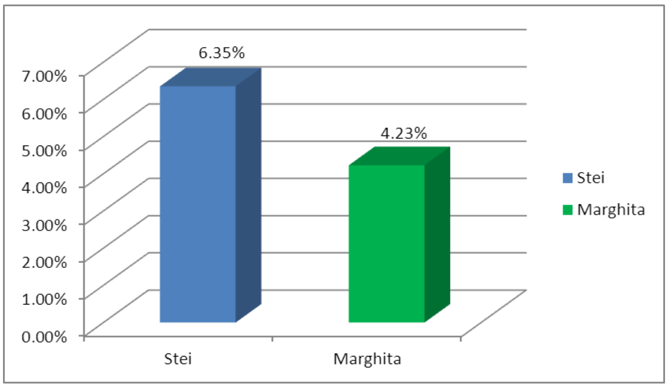

Figure 6. Incidence of NHL in Stei and Marghita

The incidence of HL is 3.17% in Stei zone and 1.41% in Marghita zone ($p<0.001$ statistically very high significant). The risk of HL is 2.3 higher in Stei than in Marghita (RR=2.254, AR=0.018), as shown in Figure 7.

The incidence of CLL is 7.94% in Stei zone and 4.23% in Marghita zone (p=0.004 statistically high significant). The risk of CLL is 1.9 higher in Stei than in Marghita (RR=1.878, AR=0.037), as shown in Figure 8.

The incidence of MM is 4.76% in Stei zone and 2.82% in Marghita zone (p=0.019 statistically significant). The risk of MM is 1.7 higher in Stei than in Marghita (RR=1.690, AR=0.019), as shown in Figure 9.

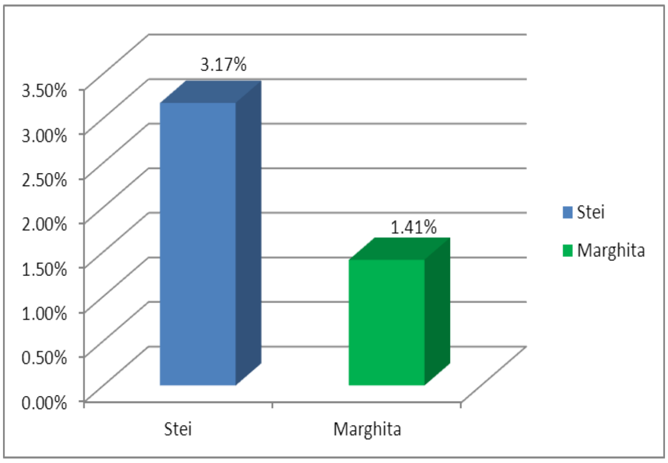

Figure 7. Incidence of HL in Stei and Marghita

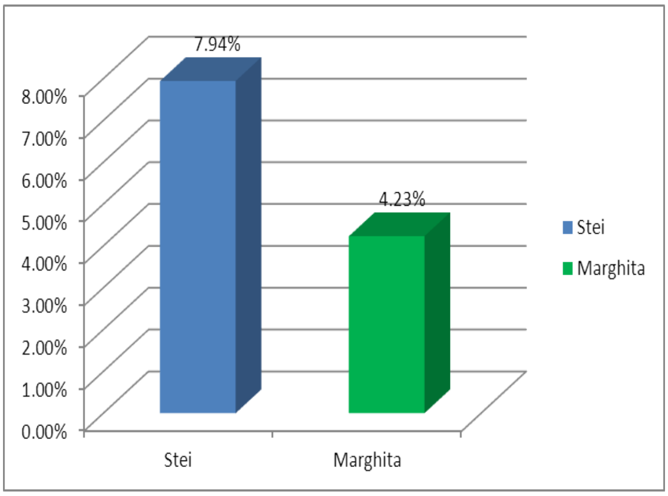

Figure 8. Incidence of CLL in Stei and Marghita

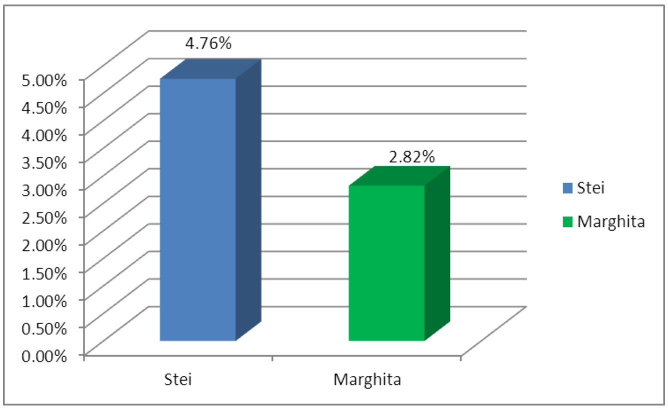

Figure 9. Incidence of MM in Stei and Marghita

The data obtained following the radio-chemical analyses made in the two zones, Stei (exposed) and Marghita (unexposed), did not highlight significant differences for the radionuclide alpha (Am 241), but they highlighted statistically high significant differences ($p<0.001$) for the global beta radionuclide (KCl) from the drinking water and vegetables from personal gardening, as we can see in Table 1.

Discussion

Because the ionizing radiation is carcinogen, the populations living in the neighboring territories become more studied on large groups of affected persons, but the results are quite contradictory. Based on the epidemiological studies made on the miners who have worked in the uranium mines, we know that the radon causes lung cancer (Řeřicha & Šnajberk 1966), yet it is not clear if the radon also causes other types of cancer including the one of the hematopoietic and lymphatic system. In support of this supposition there are results which indicate that the myeloid leukemia and the acute lymphoblastic leukemia have been related to the external radiation in the studies made on the Japanese survivors of the atomic bomb (Preston 1994; Pierce & Preston 2000). Similar associations have been experienced to patients exposed to therapeutic and diagnostic irradiation (Hart & Wall 2002).

The Scientific Committee of the United Nations regarding the effects of atomic radiation in the studies on the series of workers in the nuclear industry accepts the association with leukemia, but excludes the CLL as a result of external exposure to radiations (Cardis et al 2005, Muirhead et al 1999, UNSCEAR 2000).

In the areas with uranium and radium ore sources, short-life disintegration products are continuously emitted, such as the radon (Rn222), with a specific radioactivity much bigger and an extra increase of the radio toxicity related to the uranium. Having all this information, a group of doctors from the Department of Internal Medicine and Community Health from the University of Stellenbosch (Tygerberg Hospital) observed that a number of patients suffering from significant hematological anomalies related to the leukemia came from a specific zone near Pofadder (Nord Cape from South Africa) and drank water from radioactive wells, where-from the loading of uranium was 4 000 micrograms/l bigger. Based on long-term blood samples from 418 residents from 52 locations from the same judicial district and on the data regarding the quality of water from 69 wells from the same zone, under the surveillance of the Atomic Energy Corporation (AEC), this study established for the first time in 1981, based on the statistics thus obtained, a correlation between the high levels of uranium in the drinking water from the tested wells and the abnormal hematologic values (big number of atypical morphological lymphocytes in the peripheral blood stream), related to leukemia (Toens et al 1998).

The CLL and pathology is linked by the uranium's bio-kinetic behavior to people, where up to 6% of the ingested uranium is reabsorbed into the stomach, and it gets accumulated into the bones (UBA 2005). Through direct dispersion from the bone wall to the bone marrow, which represents the blood generating system, the alpha radiation of high released energy of stocked uranium causes leukemia developed into 2 to 10 years, besides the high risk of bone sarcomas (Agency for Toxic Substances and Disease Registry ATSDR 2001).

Among the biological effects determined by the radio nuclides pervaded into certain tissues, the forefront is given by the destroying action over the nucleus and its organs. The chromosomal anomalies are among these. Their identification in the peripheral blood is a sign of possible malignant development. Many studies with this theme have been performed on the populations from the uranium mines, but also to those from the neighboring sources, either mining or uranium ore processing plants, but the results were quite contradictory. Such a study (Krascio 2001), which analyzed the chromosomal aberrations from the ex-miners from Wismut uranium mine, concludes that the chromosomal

Table 1. Results of the requested analysis versus radionuclide normal values from Stei and Marghita

Zone	Requested analysis	Standard Radio nuclides	Value CMA (L.458/2002)	Water	Vegetables from personal gardening
Stei	Alpha global	Am 241	0.1 Bq/l	0.008 ± 0.004	0.921±0.550
	Beta global	KCl	1 Bq/l	0.137 ± 0.045	94.778±11.418
Marghita	Alpha global	Am 241	0.1 Bq/l	0.008 ± 0.007	0.622±0.186
	Beta global	KCl	1 Bq/l	0.034 ± 0.019	17.444±5.233

aberrations of these miners are not induced by the radio-active particles inhaled during the underground mining, but just like in the case of coal mines, they are rather the result of certain factors such as the age, life-style, different diseases and used medication or possible diagnostic irradiation.

Yet another study (Wolf et al 2004) analyzed the chromosomal aberrations in the white blood cells from the healthy donors and those from the uranium miners with high exposures to radiations, along decades, all being employees at Wismut. The results showed a high incidence of the genomic instability in the miners' white blood cells, particularly to those with cancer, and the percentage of micronuclei with centromeres (MnC+) was considered as a possible mark of the genomic instability and predisposition to cancer.

The relations between the exposure to uranium radio nuclides and the aberrations of the lymphocytes with long-life at people, as an expression of chromosomal damage related to radiation, have been confirmed by a lot of other studies (Tomášek & Malátová 2004, Mészáros et al 2004, Nusinovici et al 2010, Kreuzer et al 2008, Smerhovsky 2002, Krascio 2001, Boice 2007, Canu 2010).

Among 10,000 Czech uranium ex-miners were discovered 30 cases of leukemia (Tomášek & Malátová 2004), which were statistically linked to the cumulated dose of 158 mSv, received by the bone marrow (risk of 1: 333). In a different retrospective study, involving 23,043 miners from the uranium mining, 177 have been diagnosed with lymphoma, myeloma and leukemia cases (including CLL), the CLL being related to the exposure to radon (Rericha et al 2006). This observation is extremely important for the fact that many studies claim that the CLL is not caused by the ionizing radiation (Dighiero 2008). Another study made on 59,000 ex-employees in Wismut (Kreuzer et al 2008, Boice 2008, Kreuzer 2010, Möhner 2006, Bünger 2003) in Eastern Germany, the longest series of miners subject to an epidemiological study up to the present (Jacobi & Roth 1997) underlines the fact that for the miners activating during 1946-1955, a significant increase of the leukemia incidence was to be expected, following an exposure period for almost 40 years. An extremely high risk for leukemia caused by an exposure to a combination of radiation, gamma and long-life nuclides for doses over 300 mSv was discovered in a case-control research on 377 miners from the Wismut series (Möhner 2006). The whole body exposure to an equivalent radiation dose of 10 mSv had as result 200-1000 deaths in one million exposed persons, linked to leukemia or cancer (Winde 2010).

In a research performed retrospectively on 23.043 miners in the uranium mines, 198 incident cases of leukemia, lymphoma and myeloma have been identified. Using the model of hazard proportioned with the function of relative risk of potency in order to estimate and test the effects of exposition cumulated at radon on the incidence rates, as a result, the incidence of all mixed cases of leukemia and the CLL alone was positively associated with the cumulated exposure to radon. The myeloid leukemia and the HL have also been associated to radon.

Another important study (Lopez-Abente et al 1999) assessed the mortality due to hematological tumors during 1975-1993, in the locations situated closed to the nuclear sources, which consist of nuclear power plants and nuclear fuel facilities, in Spain. They found 610 deaths induced by leukemia, 198 by lymphoma and 122 induced by myeloma on the territory of 489 locations situated at 30 km round from the nuclear sources; 477 locations outside this perimeter of 30 km around, meaning between 50-100 km have been used as control zones.

Because of the contradictory nature of the results, the researches on the incidence and mortality from cancer in the areas around nuclear plants did not raise worries within the targeted population regarding the radioactive discharges emanated after the routine operation of these plants. However, a report released at the end of 1983 regarding the emergence of some leukemia cases to young residents living close to the reprocessing nuclear fuel plants in Sellafield (England) determined a series of researches. It referred to 25 year younger persons at the beginning.

The radioactive discharges close to such sources imply small doses, a lot under the level of natural ambient radiation, therefore it was claimed that these doses are not able to be responsible for the excessive risk of incidence of certain malignant tumors, fact which lead to a series of alternative hypotheses which claim the strong role of low level exposure to ionizing radiation in the cancer etiology, this still being reflected in many present debates and researches.

This study (Lopez-Abente et al 1999) reports the mortality due to leukemia, NHL and HL as well as to MM, showing in the same time the RR of death in the territories closed to the nuclear sources; it determines this risk before and after the functioning of the nuclear plant, thus establishing the relation between the incidence of malignant lymphomas on the same location, before the effect of ionizing radiations and after their functioning, managing to explain the risk modifications depending on the relative proximity of the nuclear source from the residence location, and all those put together and analyzed are going to provide extra indicators for new researches.

In the case of a nuclear electric plant, the study revealed an excessive risk for developing MM, which caused a higher mortality than expected. The RR for the closest zone to the radioactive source (0-15km) was 1.58 (CI – 0.81-3.67). The analysis of distance variable showed a statistically significant increase of MM in strict relation with the proximity from the nuclear source and a maximum RR in the 13-19 km sector. The RR for leukemia was 1.19 (CI= 0.8-1.73) and on a distance under 15km RR was 1.59. At the end of the assessment, it is mentioned that the only malignant tumor which registered a clearly gradient induced by distance and statistically significant (the effect of radiation) was the MM. Concerning the leukemia, the level before and after the functioning of the radioactive source, the mortality proved to be similar.

In the case of nuclear fuel plants, an excessive mortality was registered due to leukemia (RR was 1.3 – CI 1.03-1.64). In the sector around the plant up to 15km (RR was 1.68 with CI 0.92-3.08), respectively 14 of the 30 deaths happened in the metropolitan area (immediate around the nuclear plant).

The study was generally performed on rural locations. The distance from the nuclear source was used for assessing the incidence of lymphoma, as dissymmetric information was not possible. This study did not have an evidence of the individual level of exposure, because it was a retrospective study.

The specific work of the present paper follows the relation between the levels of radioactive contamination of the vegetal food products, the drinking and domestic water, by dosing the radio nuclides in these products and the relation of disease incidences by malignant lymphoma, depending on the proximity level of the populated area, respectively comparatively between the exposed population close to the radiant source (ex-mining exploitation at Stei) and the witness population, unexposed, situated at 200 km from the radiant source (Marghita). The methodological aspect of the present study resembles the Spanish study mentioned above (Lopez-Abente et al 1999), keeping the proportions of the Spanish study performed on thousands of subjects. Given the fact that this study was privately made, we did not have the material or technical capacity to sort all the population from the two studied towns, that is why we used a modality through which we invited the population to an auto-selection.

We initiated a cycle of 4 successive days of conferences during the bank holidays for each town. These conferences have been pursued by an increasing number of persons; the interest and cooperation of those susceptible made us fix upon convenience some days when the persons could be submitted for a general examination and selection in order to arrange specific investigations. Thus the two lots with 63 participants were made up at Stei, which was called the "exposed lot" (due to their location proximity to the active nuclear source of the uranium ex-mining exploitation) and with 71 participants in the unexposed lot (Marghita).

All the suspect participants after the selection of the two exposed and unexposed lots were completely investigated at the beginning: anamnestic examination, physical examination, biohumoral and imagistic examination, node and bone puncture aspiration, bone marrow biopsy etc. who restrained even more the group of affected subjects. This way only 14 patients from the exposed lot from Stei and 9 patients from the unexposed lot from Marghita needed more selective investigations and examinations to other specialties for determining their diagnosis. Fourteen cases of malignant lymphoma have been thus confirmed at Stei, and nine cases of lymphoma confirmed for Marghita. The report between genders in the studied lots was slightly in favor of women, 53.97% at Stei and 53.52% at Marghita, but without any significant statistically differences. The most affected age group was between 51-60 years in the two lots studied, again without any significant statistically difference.

From the group of 14 identified malignant lymphomas at Stei, 4 belonged to the NHL group, which in the foreign studies (Bithell 1994, Black 1994) are not considered associated to the radiation of radon, like the MM, while in our study the NHL is represented in 28.57% from the 14 malignant lymphomas from Stei. The NHL represents 33% of the lymphocytic malignant manifestations in the group from Marghita. The CLL is the most frequent in our country, its prevalence being of 35.71% within the malignant lymphomas from Stei. It is interesting that in many published researches it is considered not radiogenic (Black 1994). In the last decades, more and more proves uphold its occurrence after the exposure to radon (Lopez-Abente et al 1999, Rericha et al 2006), but also in the proximity of the uranium mining sources (Lopez-Abente et al 1999, Rericha et al 2006, Winde 2010).

In the group from Marghita, the CLL is represented in 33.33% within the malignant lymphomas, two times less than within the group from Stei, which proves that the complex factors from the radiant environment contribute to the occurrence of lymphatic manifestations by the pollution with certain radio nuclides. The arguments in this regard are the results from the analyses of all vegetal food products (vegetables, greens, fruits, cereals) as well as the drinking water, which have been examined in the Laboratory of Hygiene of the Ionizing Radiations in Oradea, and which even though they respected the limit of normal values regarding the standard radio nuclides (Am 241 and KC1) provided by the National Law 458/2002, those from Stei were situated on the superior limit of the normal values, while those from Marghita were situated at the inferior limit of the normal values; as a statistic significance for the alpha global radio nuclide from water and the vegetal products, there were no significant statistically differences ($p=0.982$) between the two towns, and for the beta radio nuclide determined in the water and the vegetal products there were important significant statistically differences ($p < 0.001$).

It is well-known that the radio nuclides (inhaled or ingested, like all the heavy metals, or the uranium isotopes) are eliminated in very small quantities in time, so that they cumulate up to critical levels in different organs and operate over the neighboring tissues. Penetrating inside the body, under any form, the uranium gets stocked into the bones, leading to a blood toxic action over the blood forming zones and over the leucocytes, lymphocytic cells and over their chromosomal system, generating various neoplasia.

This is how we can explain the difference in the number of lymphocytic malignant manifestations between the two populations, one being situated in the next proximity of the direct pollution sources.

Conclusion

The Uranium, the Radium and the Radon through their ionizing radiations have a neoplastic character on the human body tissues. The present study highlights the presence of the radiant factor, measuring and assessing its effects in the occurrence and evolution of malignant lymphomas within a collectivity situated in the neighborhood of the closed Uranium mining exploitation zone, called “the collectivity of exposed”, this being the town of Stei and a collectivity situated at more than 200 km from the Uranium source, called “the unexposed”, in the town of Marghita. Although they are in the legal conventional limits, the value of radio nuclides from the territory populated in Stei was situated almost entirely at the superior limit of the normal, while in Marghita the same results were situated at the bottom limit of the normal. We obtained statistically high significant differences at water and at the vegetables from personal gardening for the beta global radio nuclide for Stei versus Marghita. The incidence of malignant lymphomas is 1.8 times higher (NHL is 1.5 times higher, HL is 2.3 times higher, CLL is 1.9 times higher and MM is 1.7 times higher) in Stei in comparison with Marghita. Through our study we tried to demonstrate the importance of the radio-active polluting environment, respectively the presence of radio-nuclides in the drinking water, domestic water, on the domestic vegetation (vegetables, greens, fruits) and assessed in the development of their effects under the form of malignant lymphomas. These results raise the attention of both, local sanitary and administrative authorities and of the population, regarding the morbid potential at the small levels of radioactive charging in the water and domestic vegetation, but with a long term cumulating potential in the tissues to generate neoplastic pathology.

References

ATSDR 2001 Agency for Toxic Substances and Disease Registry

Black RJ. Leukemia and non-Hodgkin’s lymphoma; incidence in children and young adults resident in the Dounreay area of Caithness, Scotland in 1968-91. J Epidemiol Community Health 1994;48:232-236.

Boice JDJr, Cohen SS, Mumma MT, Chadda B, Blot WJ. Mortality among residents of Uravan, Colorado who lived near a uranium mill, 1936-1984. J Radiol Prot 2007;27(3):299-319.

Boice J. Cancer incidence and mortality in populations living near uranium milling and mining operations in grants 1950-2004. J Radiol Prot 2008;28(3):303-25.

Bithell JF, Dutton SJ, Draper GJ, Neary NM. Distribution of childhood leukaemias and non-Hodgkin’s lymphomas near nuclear installations in England and Wales. BMJ 1994;309(6953):501-5.

Brumboiu MI. Metode epidemiologice de bază pentru practica medicală, Editura Medicală Universitară „Iuliu Haţieganu”, Cluj-Napoca, 2005.

Bünger M. German radiation protectin authority releases monitoring results for radiation exposure from drinking water. Raport of an Advisora Group on Ionising Radiation Doc NRPB 2003;14(1):3-117.

Canu IG. French cohort of the uranium processing workers; mortality pattern after 30-year follow-up. Radiat Environ Bioph 2010;49(1):47-55.

Cardis E, Vrijheid M, Blettner M, Gilbert E, Hakama M, Hill C, et al. Risk of cancer after low doses of ionising radiation: retrospective cohort study in 15 countries. BMJ 2005;331(7508):77.

Darby S, Tomasek L. Recent results from the study of West Bohemian uranium miners exposed to radon and its progeny. Environ. Health Perspect. 1995;103(S2):55-57.

Dighiero G, Hamblin TJ. Chronic lymphocytic leukaemia. Lancet 2008;371(9617):1017-29.

Hart D, Wall BF. Radiation exposure of the UK population from medical and dental X-Ray examinations. Chilton, UK National Radiobiological Protection Board 2002 (121).

Healy JF. The Essentials of Statistics: A Tool for Social Research (2nd ed.). Belmont, CA: Cengage Learning 2009:177–205.

Jacobi W, Roth P and Nosske D. Possible risk and probability of causation of bone and liver cancer due to the occupational alpha ray exposure of workers at the previous WISMUT Uranium Mining Company. Forschungsbericht. URL: http://www.helmholtz-muenchen.de/. Oberschleißheim, July 1997, 57 pp.

Jaworowski Z. Radiation Risk and Ethics. Reprinted with permission from Physics Today, 1999;52(9):24-29.

Krascio A. Chromosomal aberations with former wismut uranium miners. Int J Radiat Biol 2001;77(11):1087-1093.

Kreuzer M, Schnelzer M, Tschense A, Walsh L, Grosche B. Cohort Profile: The German uranium miners cohort study (WISMUT cohort) 1946–2003. Int J Epidemiol 2010; 39(4):980-987

Kreuzer M, Walsh L, Schnelzer M, Tschense A, Grosche B. Radon and risk of extrapulmonary cancers: results of the German uranium miners’ cohort study, 1960-2003. Br J Cancer 2008;99(11):1946-53.

López-Abente G, Aragonés N, Pollán M, Ruiz M, Gandarillas A. Leukemia, lymphomas, and myeloma mortality in the vicinity of nuclear power plants and nuclear fuel facilities in Spain. Cancer Epidemiol Biomarkers Prev 1999;8(10):925-34.

Mészáros G, Bognár G, Köteles GJ. Long-term persistence of chromosome aberrations observed in Hungarian uranium miners. J Occup Health 2004;46(4):310-5.

Möhner M, Lindtner M, Otten H, Gille HG. Leukemia and exposure to ionizing radiation among German uranium miners. Am J Ind Med 2006;49(4):238-48.

Muirhead CR, Goodill AA, Haylock RG, Vokes J, Little MP, Jackson DA, et al. Occupational radiation exposure and mortality: second analysis of the National Registry for Radiation Workers. J Radiol Prot 1999;19(1):3-26.

Nusinovici S, Vacquier B, Leuraud K, Metz-Flamant C, Caër-Lorho S, Acker A et al. Mortality from circulatory system diseases and low-level radon exposure in the French cohort study of uranium miners, 1946-1999. Scand J Work Environ Health 2010;36(5):373-83.

Pierce DA, Preston DL. Radiation related cancer risks low dosis among atomic bomb survivors. Radiol Reg 2000:154,178-186.

Preston DL. Cancer incidence in atomic bomb survivers Part III Leukemia, lymphoma and multiple mieloma, 1950-1987. Radiol Reg 1994;137(S2):S68-S97/pag 122

Rericha V, Kulich M, Rericha R, Shore D, Sandler DP. Incidence of Leukemia, Lymphoma and Multiple Myeloma in Czech Uranium Miners. A case-control study. Environ Health Perspect 2006;114:818-822.

Řeřicha V, Šnajberk J. Incidence of lung cancer in Joachimsthal uranium miners (Czechoslovakia) in relation with duration of exposure. In: Scientific Papers of the Health Institute of the Uranium Industry, Vol 4. Příbram, Czech Republic:Health Institute of the Uranium Industry 1966:21–31.

Sabau M, Golea C, Bacarea V. Epidemiologie generală, Universitatea de Medicină şi Farmacie, Litografia UMF Tg Mures, Tg. Mureş, 2005.

Smerhovsky Z. Chromosomal aberations with former Czeck uranium miners. Mutation Research 2002;514(1-2):165-176.

Toens P, Visser D, Van der Westhuizen, Stadler C, Rassmussen WJM 1998. Overberg Coastal Water Resources (vol.II): A report to DWAF on the ground water resources, current and future water requirements of the coastal strip and adjoining hinterland between Potberg and Quoin Point. Toens & Parteners feb.1998, T&P 980148.

Tomášek L and Malátová I. Leukaemia among Czech uranium miners. In: Oeh U, Roth P and Paretzke HG (eds.) Proc. 9th International Conference on Health Effects of Incorporated Radionuclides Emphasis on Radium, Thorium, Uranium and their Daughter Products, 29 November – 1 December 2004, HEIR 2004, GSF-National Research Centre for Environment and Health, Neuherberg, Germany, Institut für Strahlenschutz, GSF-Bericht 06/05:128-135.

Turekian KK and Wedepohl KH. Distribution of the Elements in some major units of the Earth's crust. Geological Society of America Bulletin 1961;72:175-192.

UBA (Umweltbundesamt) 2005 Uran and Human Biomonitoring Stellungsnahme der Kommision Human-Biomonitoring des Umweltbundes, Bundesgesundheitsbl-Gesundheitsforsch. Springer Medizin Vorlag. Gesundheitsschutz 7-2005, 48, 822-827, DOI 10.1007/S00103-005-1069-7.

UNSCEAR (United Nations Scientific Committee on the Effects of the Atomic Radiation) 2000 Sources and Effects of Ionising Radiation. Vol. II Effects. New York: United Nations 2000:122.

Winde F. Mining-related impacts on ground waters and streams-pitfallsfrom uranium mines in Europe, Africa and Australia. 3rd World Water Forum, 17-18 March 2003, Kyoto, Japan.

Winde F. Uranium pollution of the Wonderfonteinspruit, 1997-2008 Part 1: uranium toxicity, regional background and mining-related sources of uranium pollution Water SA (Online) vol.36 no.3 Pretoria Apr. 2010.

Wolf G, Arndt D, Kotschy-Lang N, Obe G. Chromosomal aberrations in uranium and coal miners. Int J Radiat Biol 2004;80(2):147-53.

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